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PHOSPHORUS EXPORTS FROM AGRICULTURAL GRASSLAND IN OVERLAND FLOW AND SUBSURFACE DRAINAGE WATER

Volume 2

A thesis submitted to the University of Dublin in fulfilment of the requirements for the degree of Doctor of Philosophy

by Isabelle Kurz, M.Sc.

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and
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Figure 1.1 : Sampling Sites at Johnstown Castle

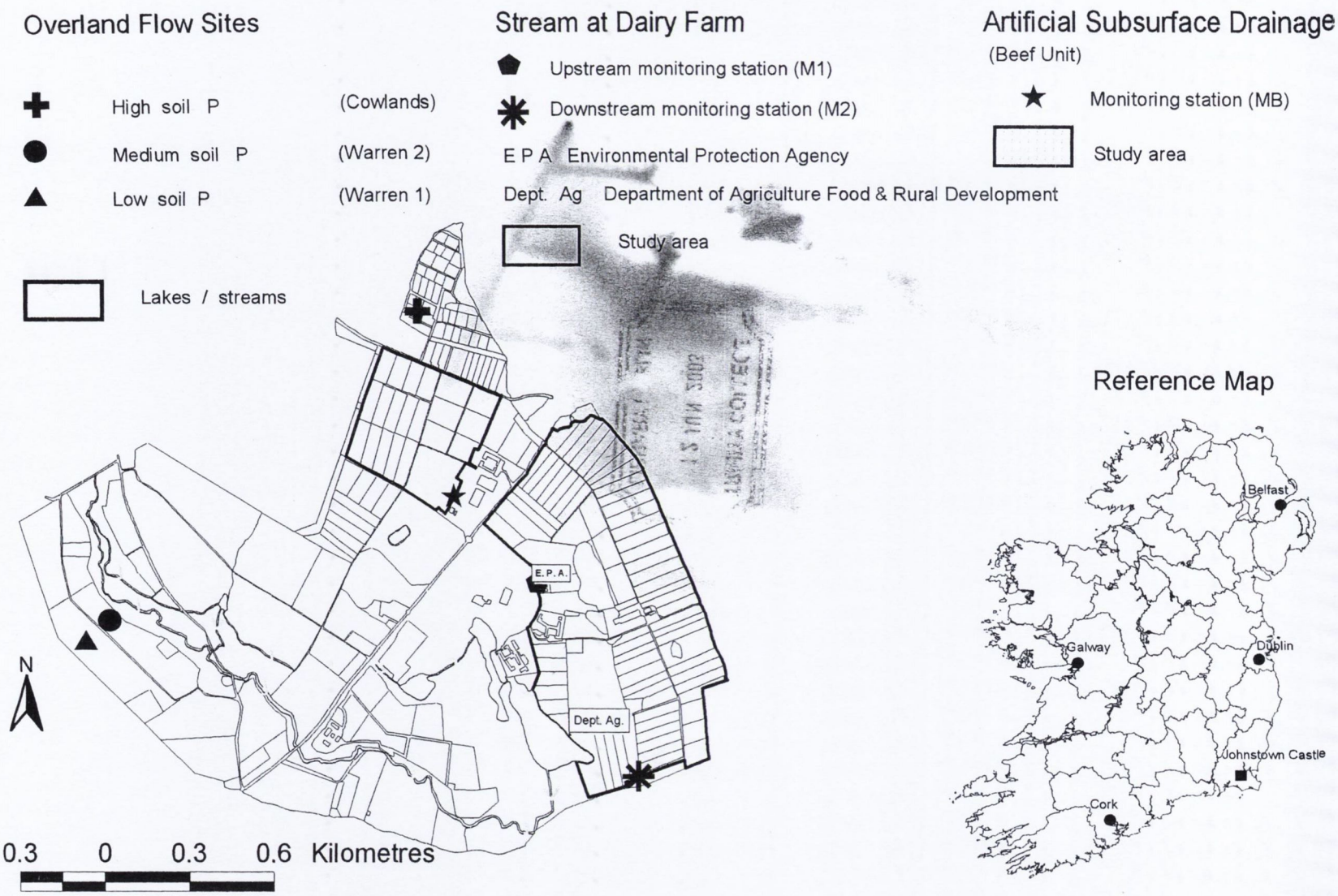


Figure 3.1: BEEF UNIT Contour Lines (Teagasc), Approximate Location of the Artificial Subsurface Drains and Estimated Subsurface Drainage Catchment Boundary

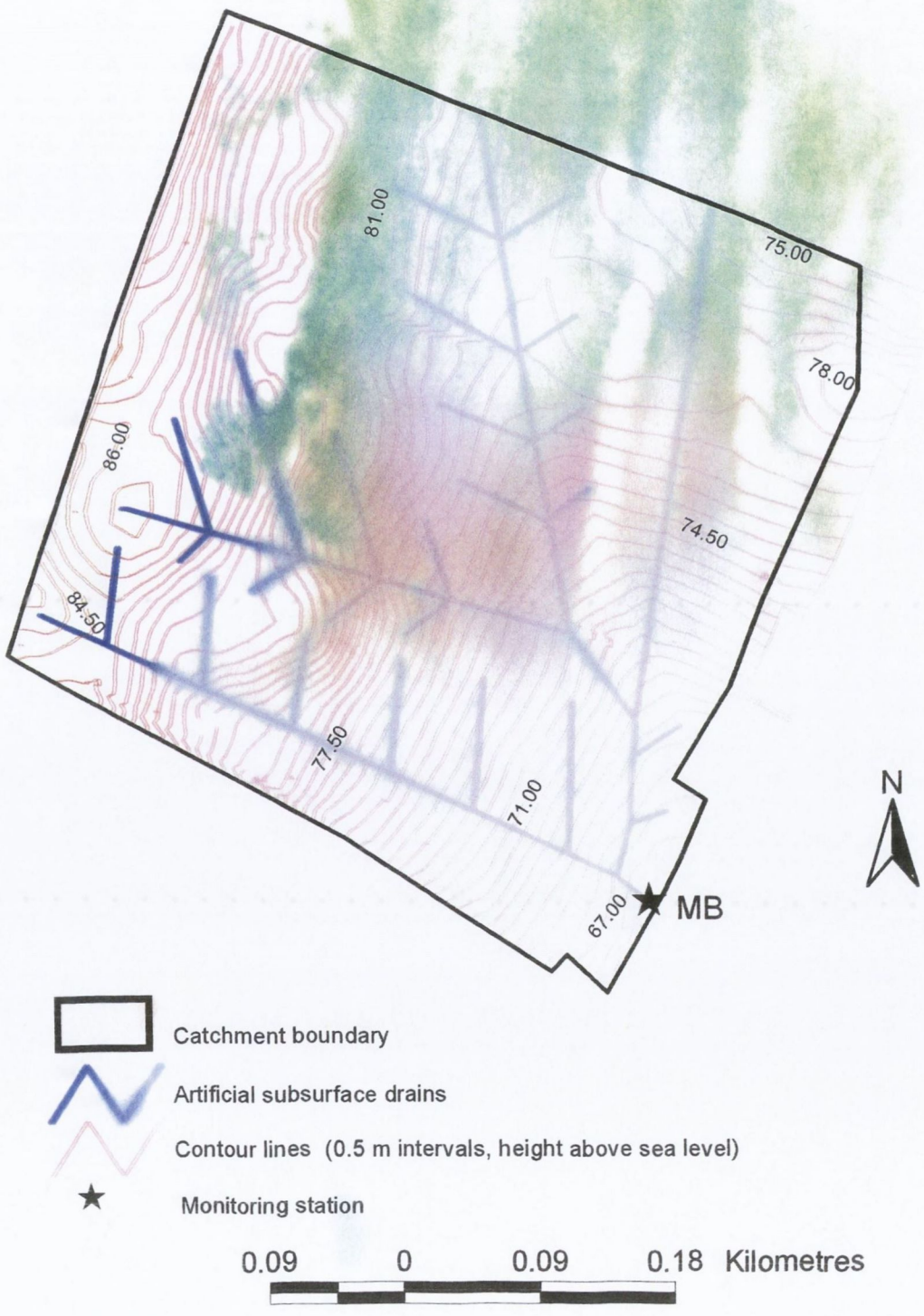
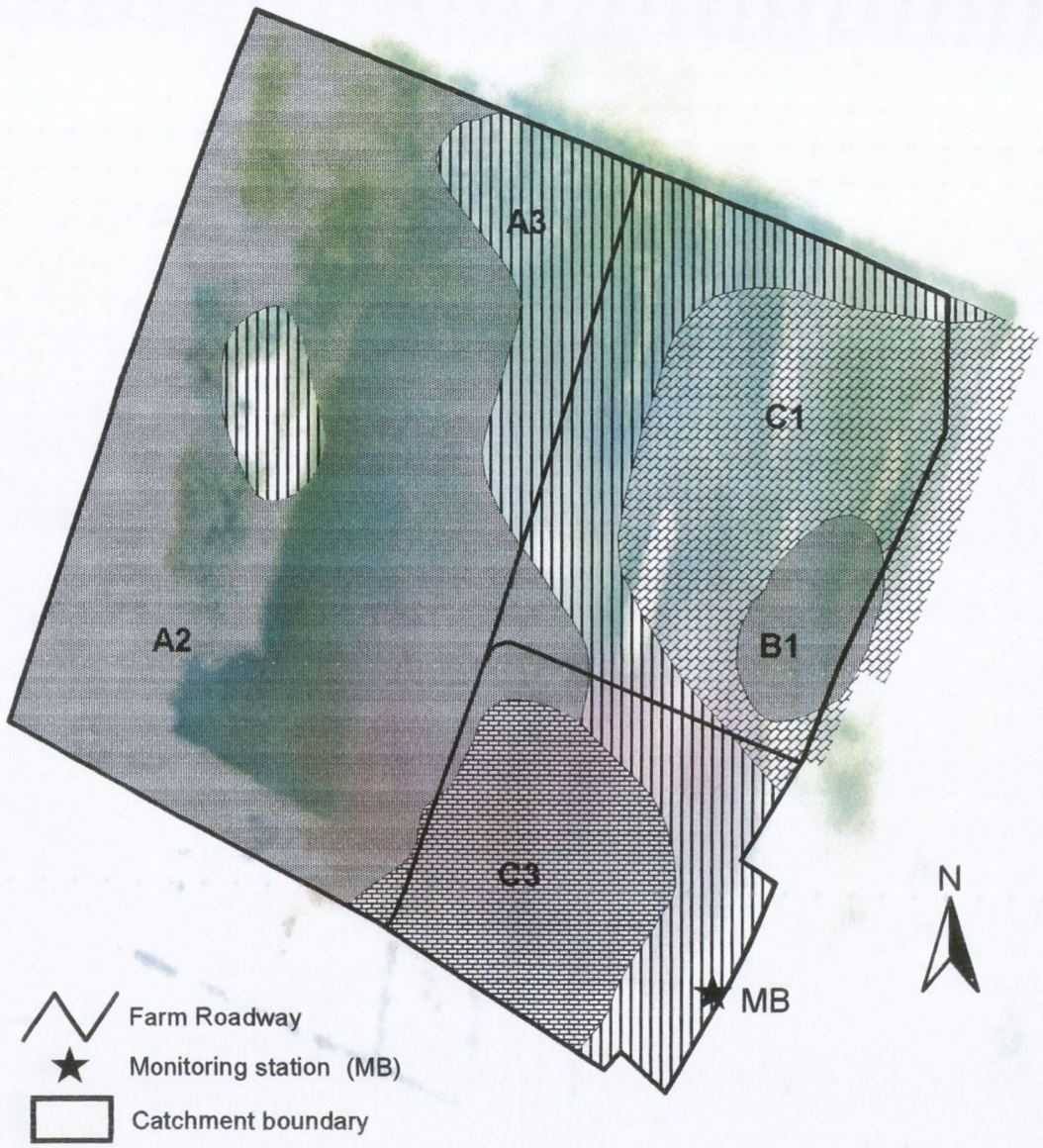


Figure 3.2 : BEEF UNIT Soils
(Culleton and Diamond, in Print)



Map Unit	Texture	Drainage	Soil Group
C1	Coarse loamy over fine loamy	Well	Brown Earth
B1	Sandy	Well	Brown Podzolic / Brown Earth
C3	Coarse loamy over fine loamy	Poor	Gley
A2	Fine loamy	Imperfect	Gley
A3	Fine loamy	Poor	Gley

0.08 0 0.08 0.16 Kilometres

Figure 3.3 : BEEF UNIT Soil P Levels (mg P / l Morgan's)

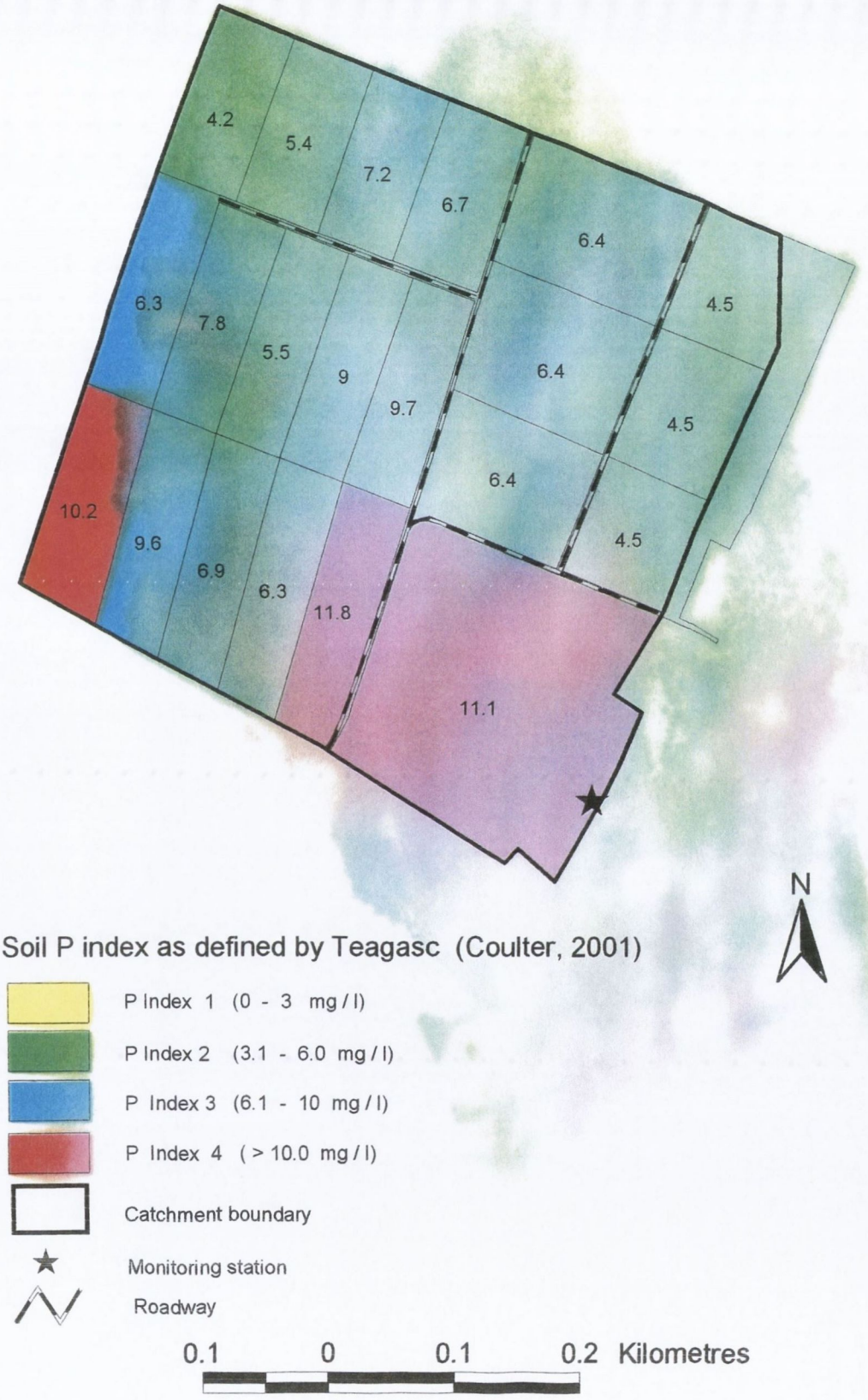
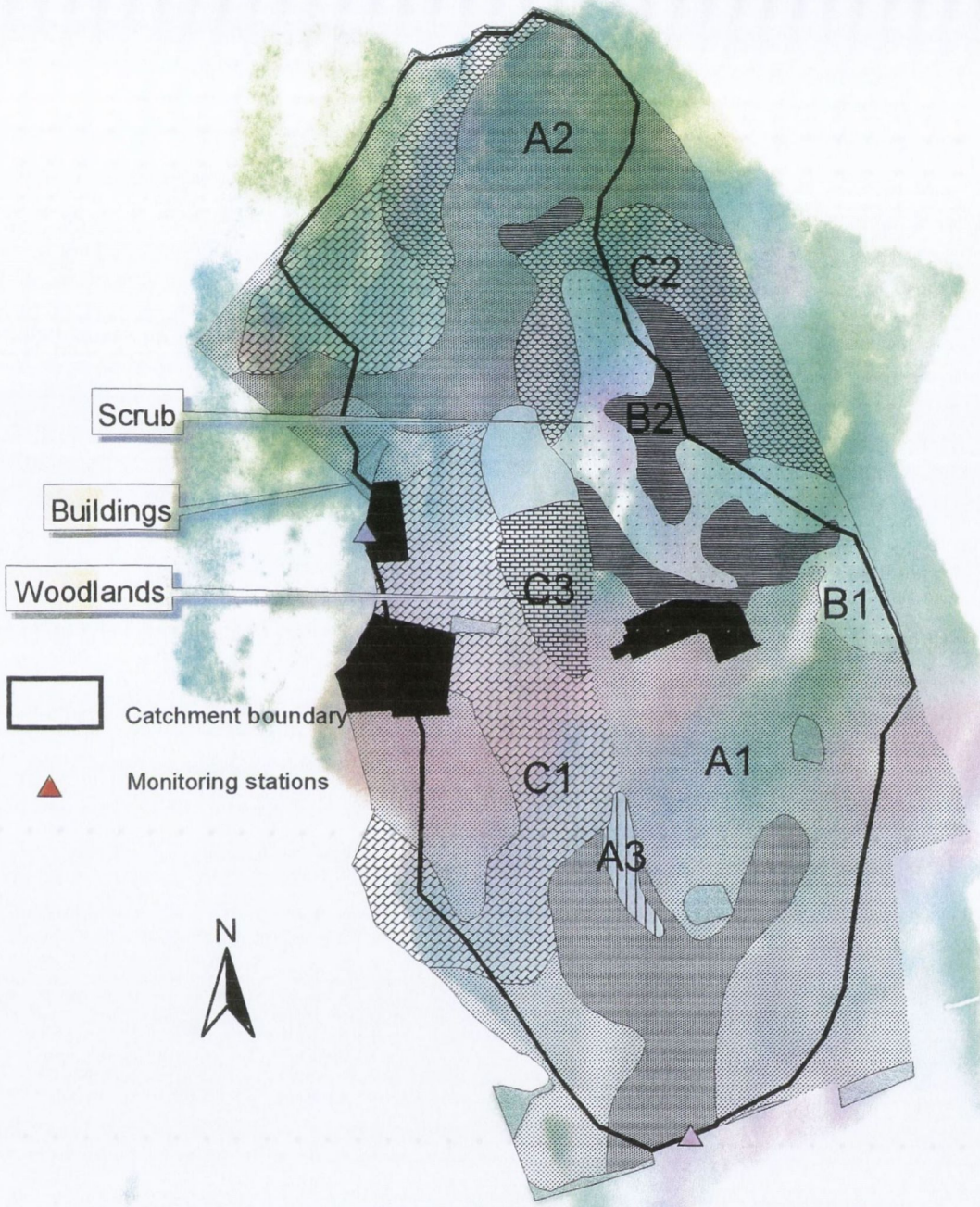


Figure 3.4 : DAIRY UNIT Soils
(Culleton and Diamond, in print)



Map Unit	Texture	Drainage	Soil Group
A1	Fine loamy	Well / moderate	Brown Earth
A2	Fine loamy	Imperfect	Gley
A3	Fine loamy	Poor	Gley
B1	Sandy	Well	Brown Podzolic / Brown Earth
B2	Sandy	Moderate	Brown Earth
C1	Coarse loamy over fine loamy	Well	Brown Earth
C2	Coarse loamy over fine loamy	Moderate / imperfect	Gley
C3	Coarse loamy over fine loamy	Poor	Gley

0.2 0 0.2 0.4 Kilometres

Figure 3.5 : DAIRY FARM Soil P Levels (mg P / l Morgan's)

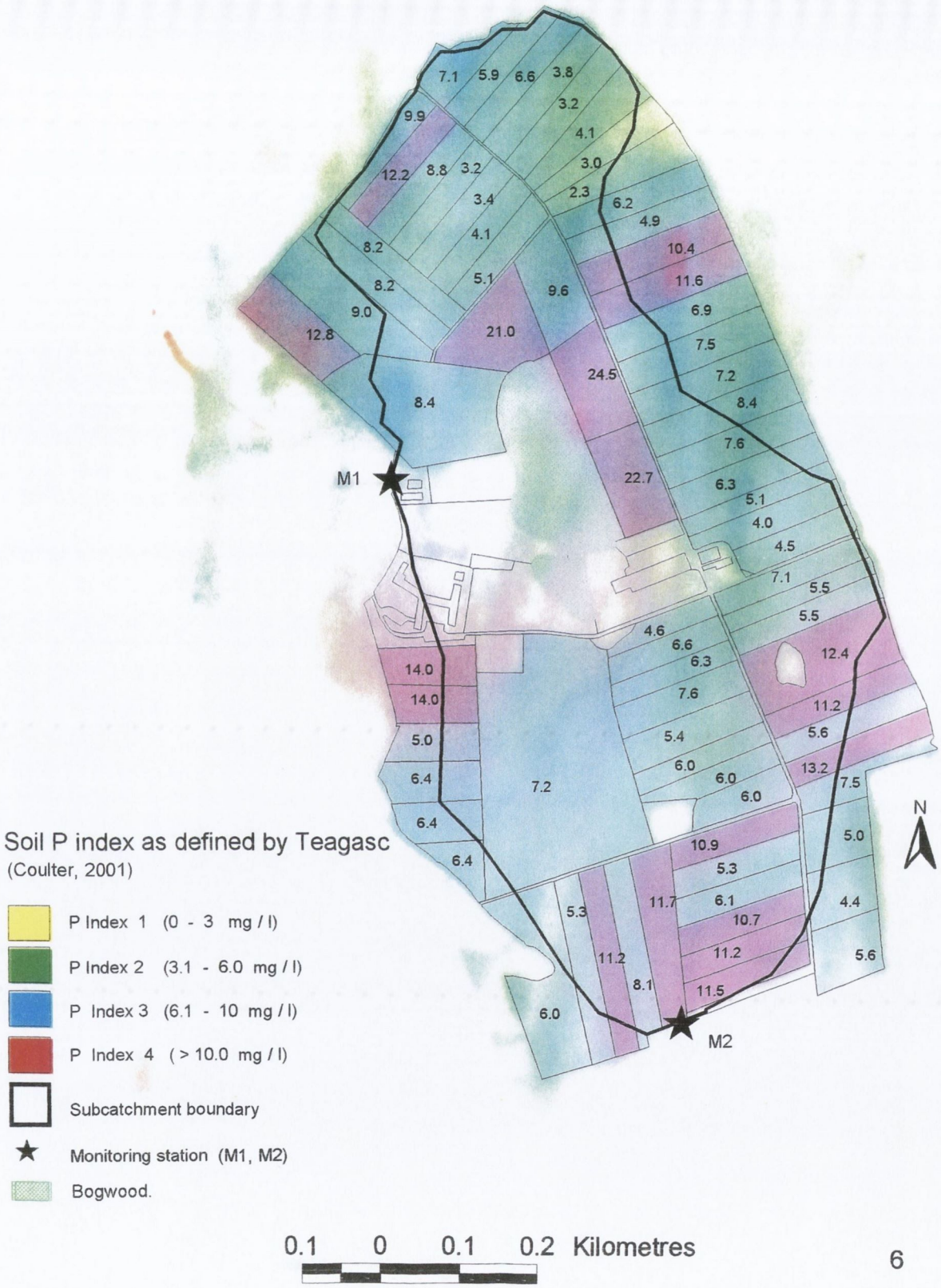


Figure 3.6: DAIRY FARM Contour Lines (Ordnance Survey), Approximate Location of the Artificial Subsurface Drains and Estimated Sub-catchment Boundary

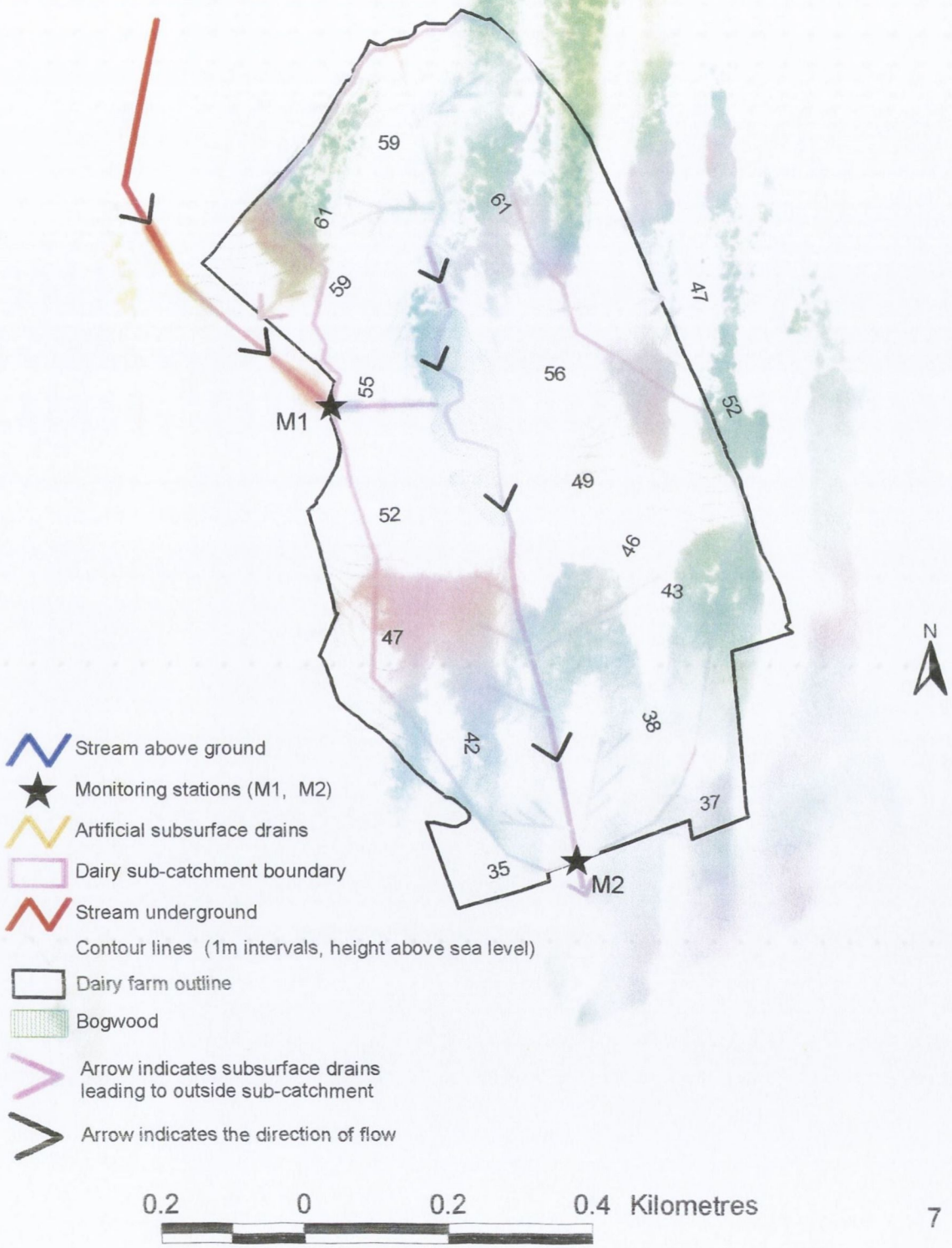


Figure 3.7: Water Quality Sampling Stations

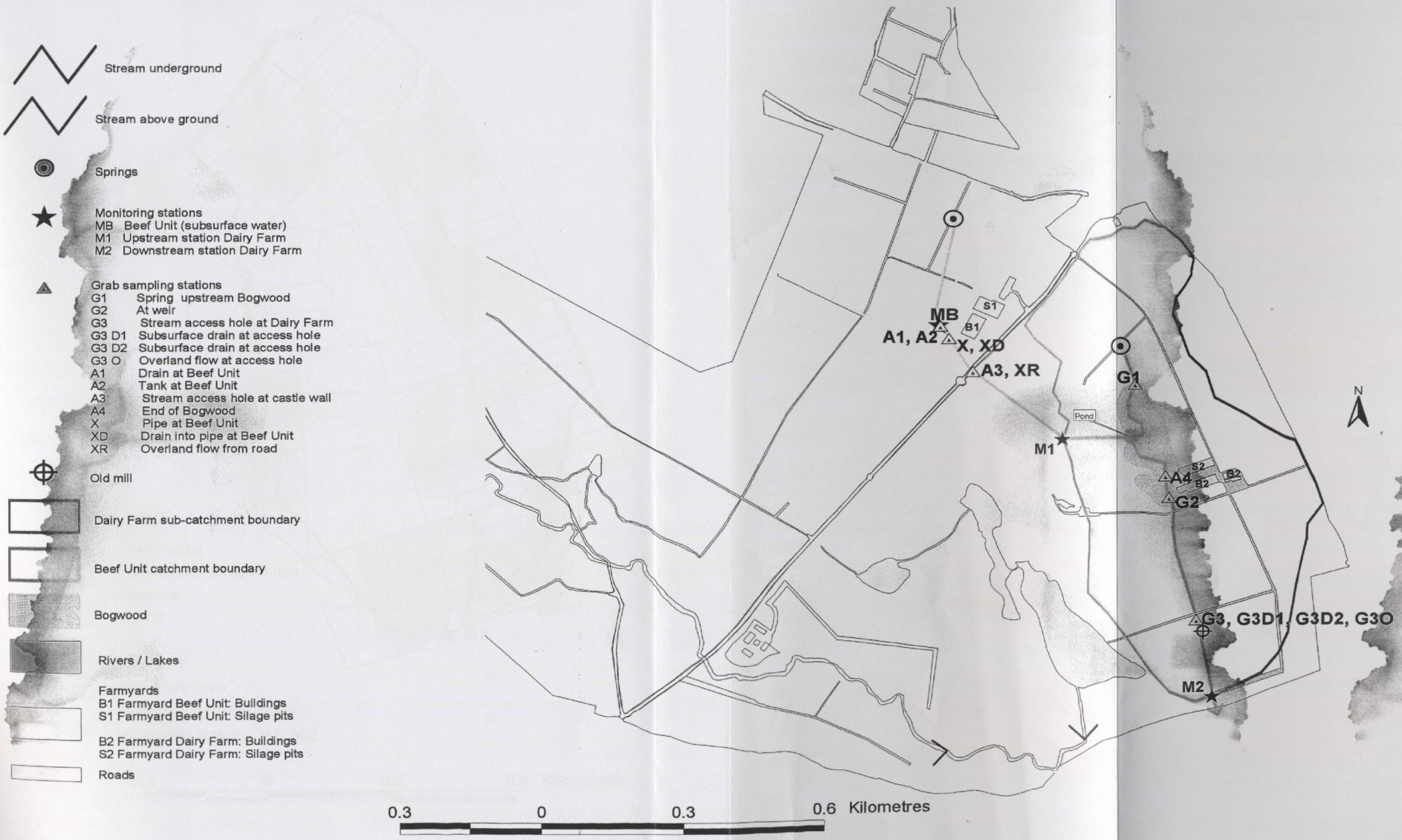
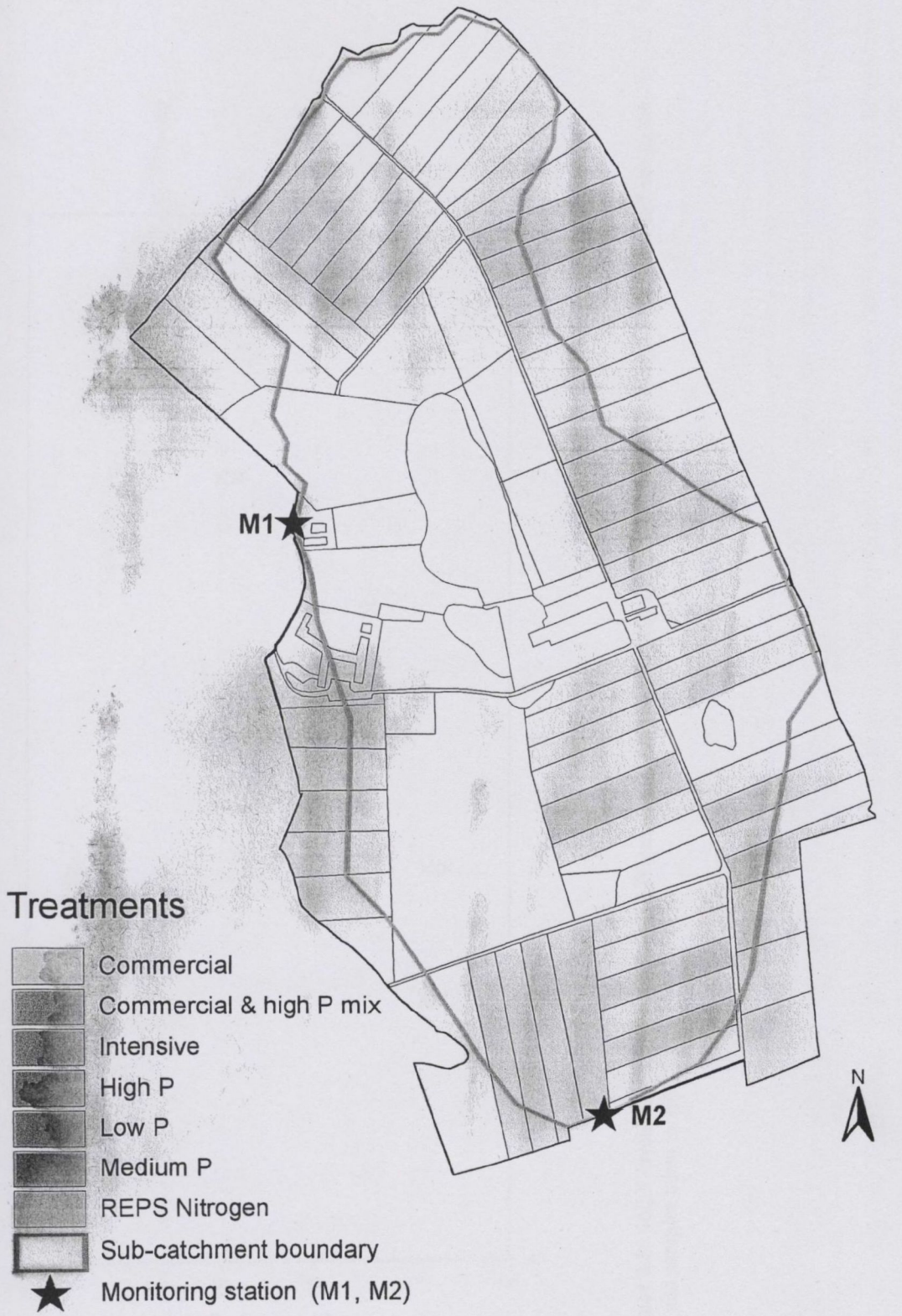


Figure 3.8 : DAIRY FARM Experimental Treatments



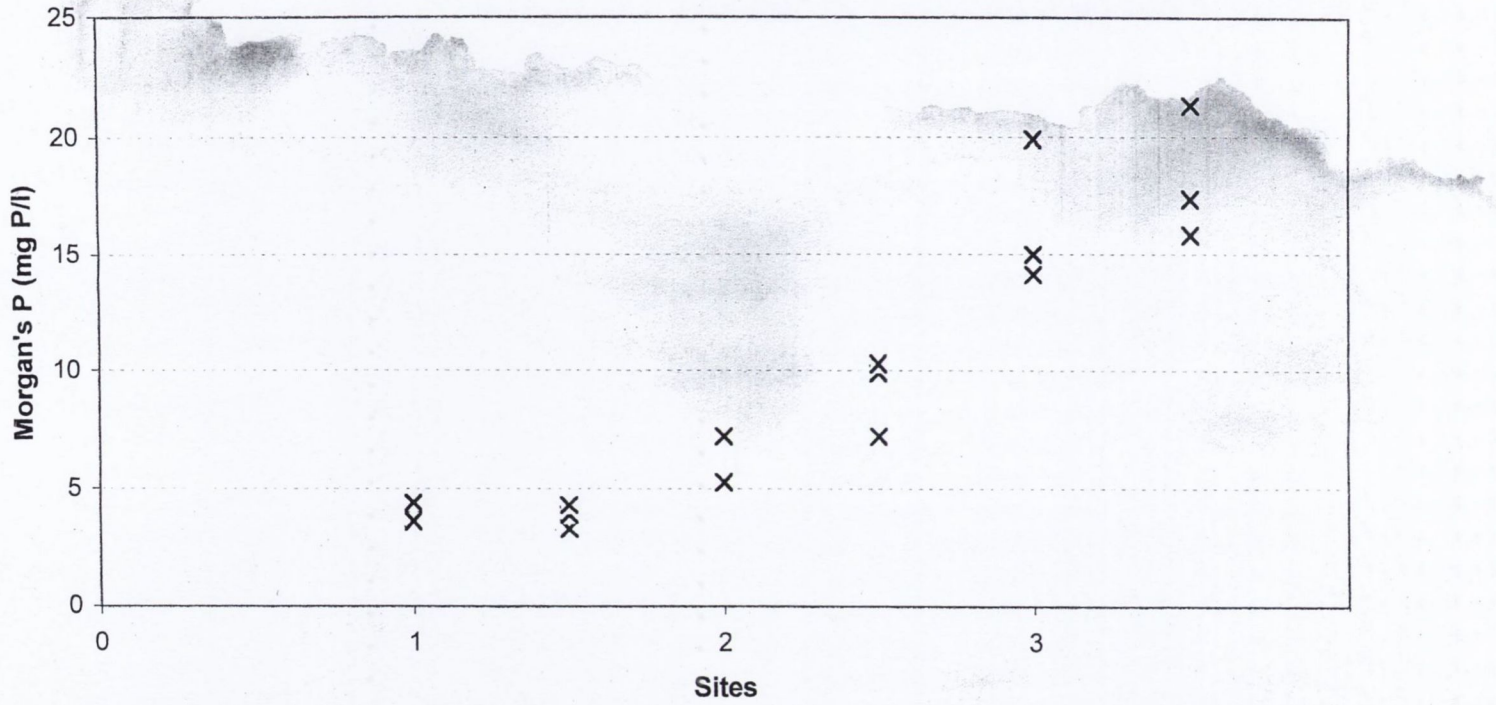


Figure 4.1: Soil P levels (mg P/l Morgan's) at the Warren 1 (1), the Warren 2 (2) and the Cowlands (3). Samples taken in 1997 are to the left and samples taken in 1998 to the right.

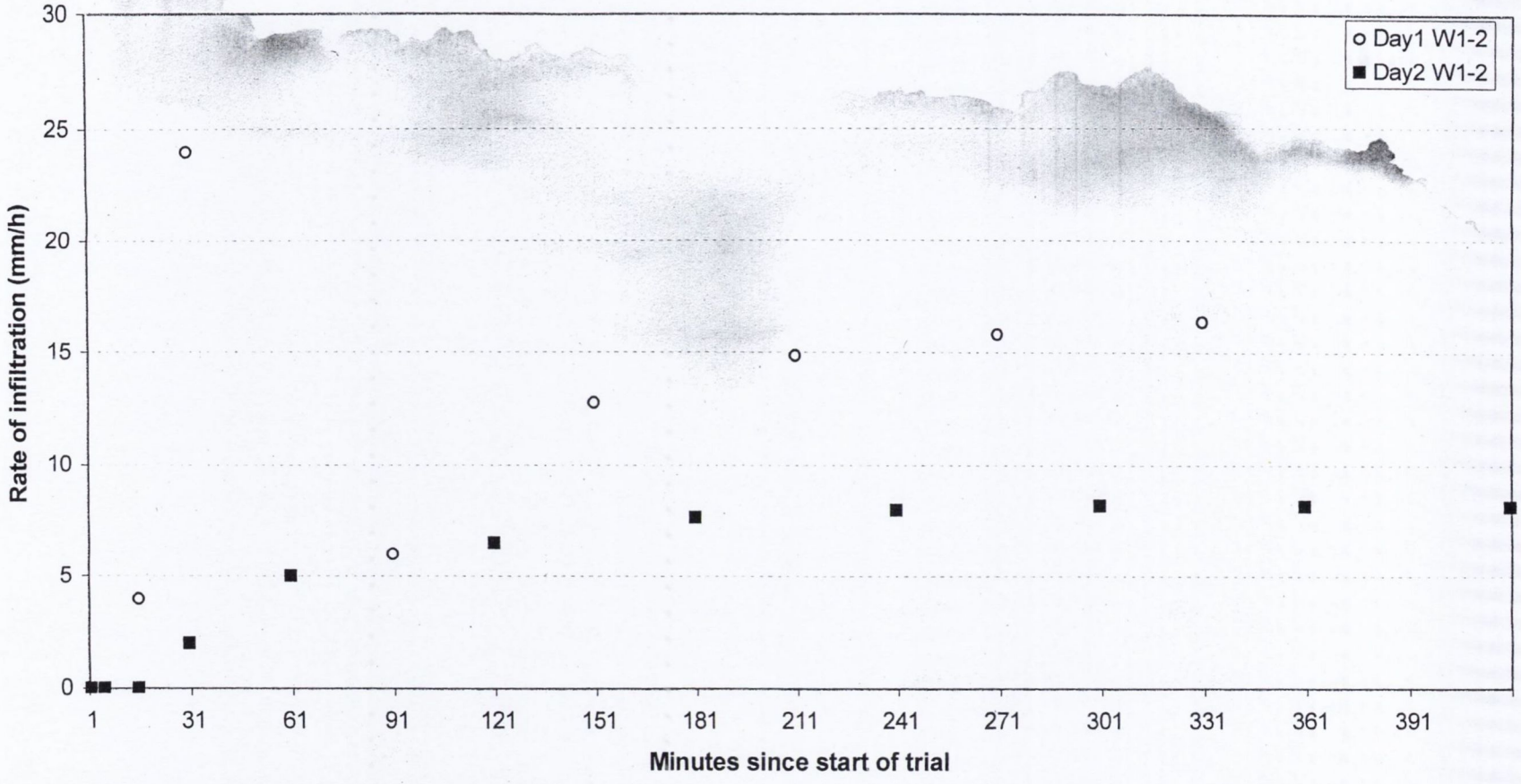


Figure 4.2: Infiltration rates (mm/h) measured on the two days of the trial in ring system 2 at the Warren 1.

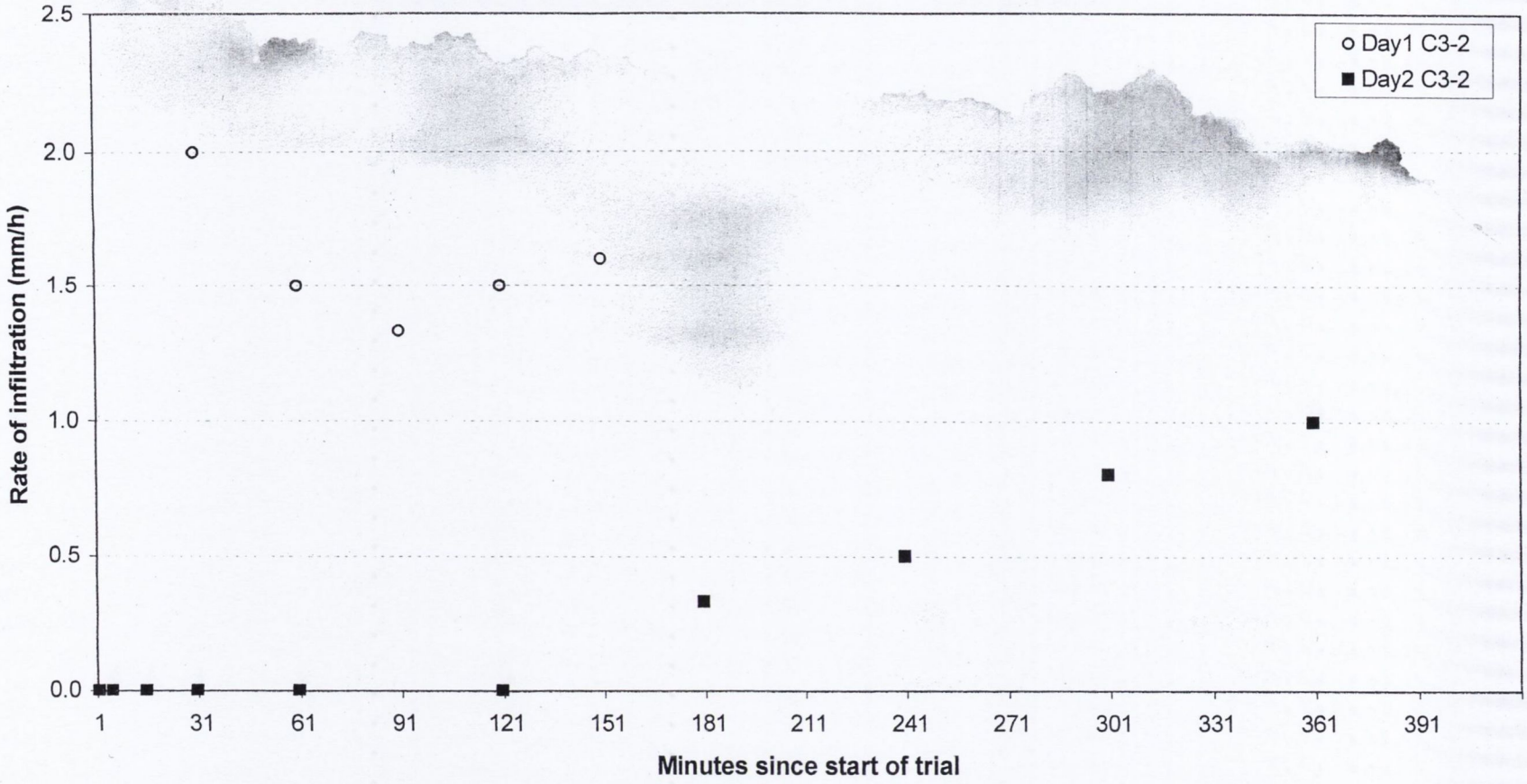


Figure 4.3: Infiltration rates (mm/h) measured on two days of the trial in ring system 2 on soil type C3 at the Beef Unit.

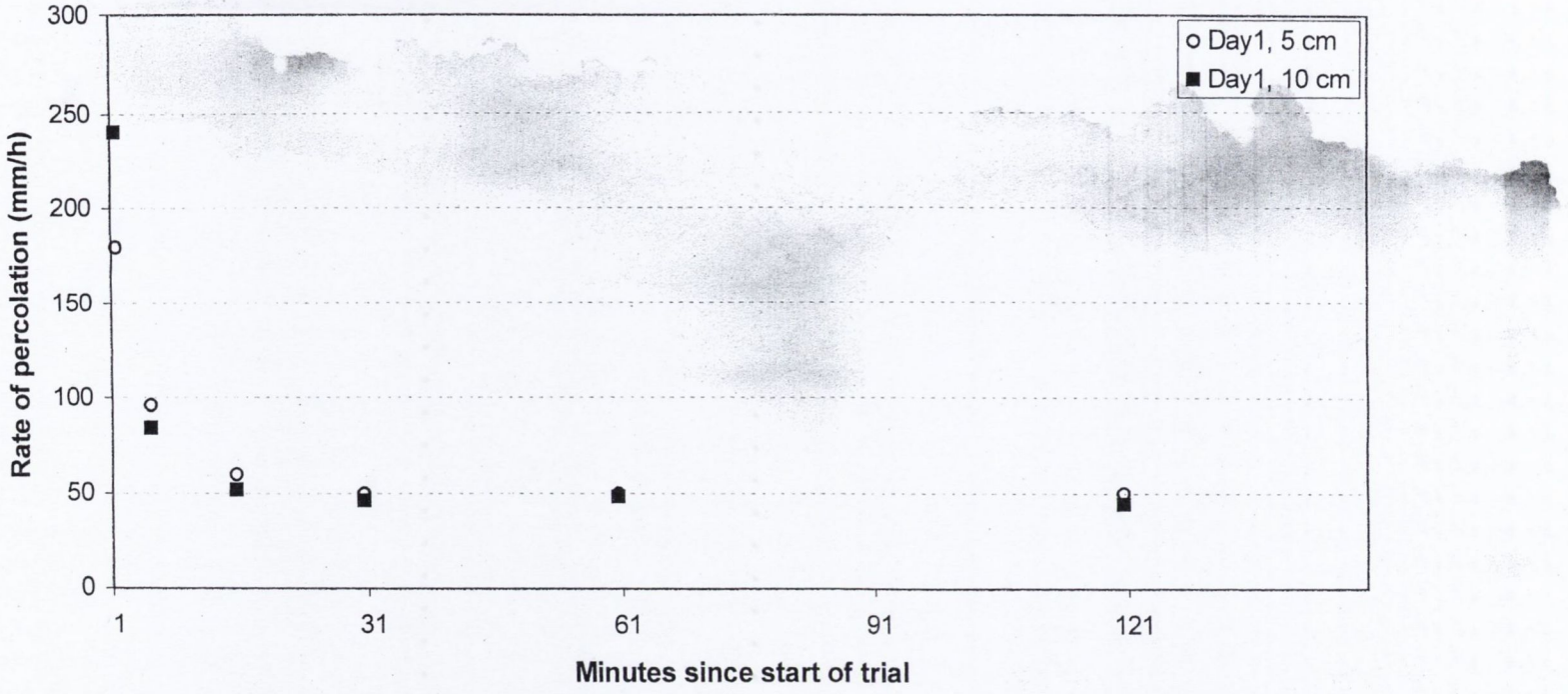


Figure 4.4: Percolation rates (mm/h) measured in 5 cm and 10 cm holes at the Cowlands.

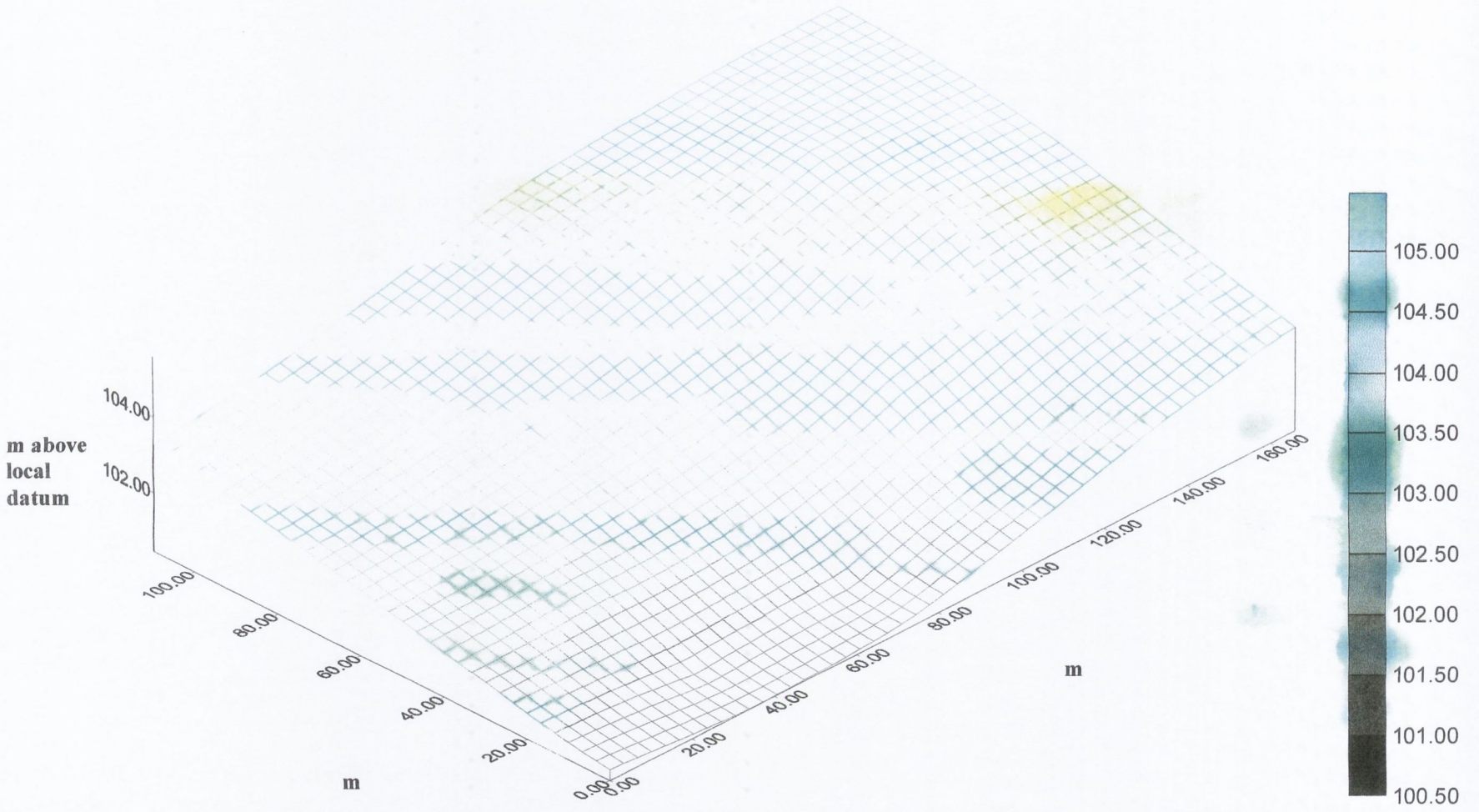


Figure 4.5: Map of the water table levels at the Warren 1 on 12th December 1996 (Figure drawn up by SWAMP personnel). Water table levels displayed in reference to local datum used for contour survey (Figure 7.1).

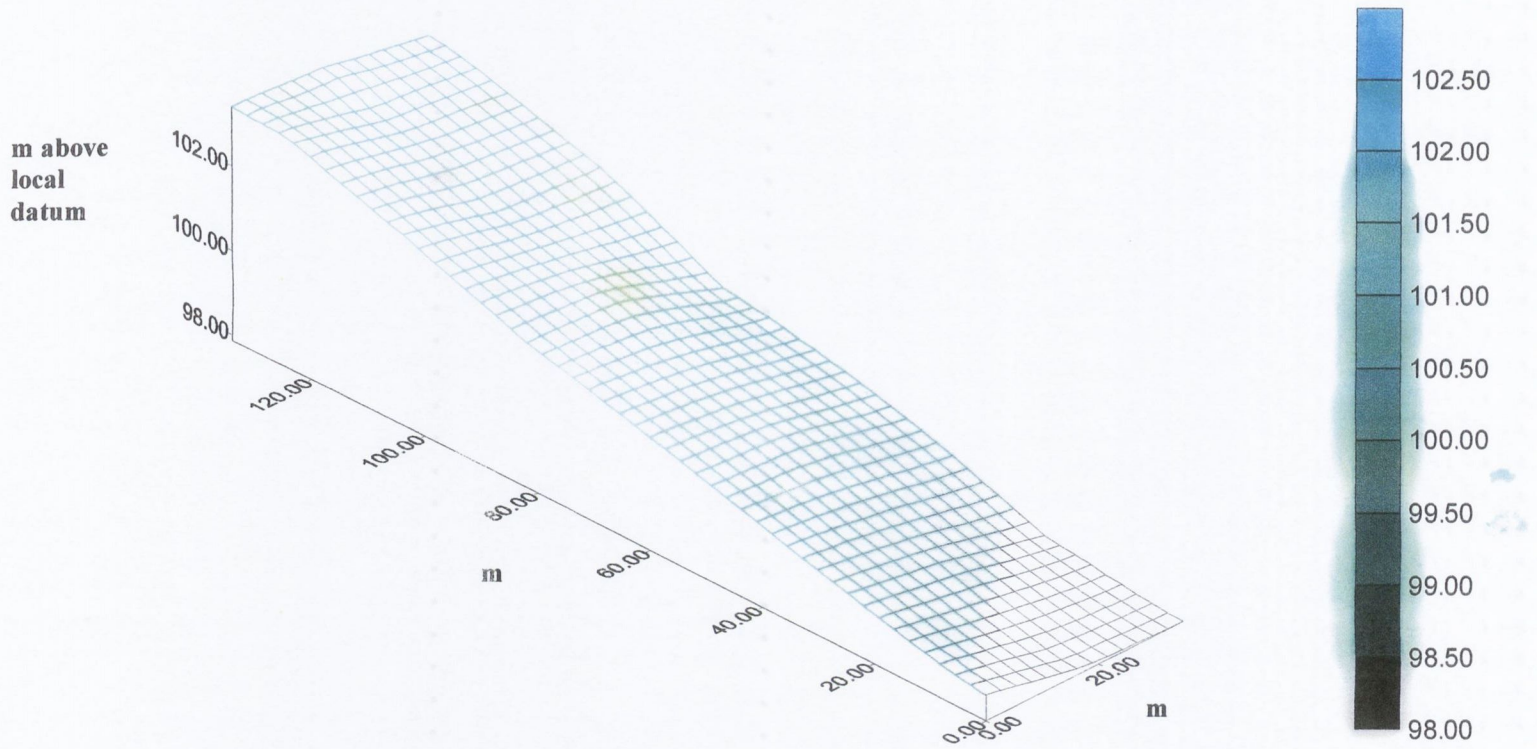


Figure 4.6: Map of the water table levels at the Cowlands on 12th December 1996. (Figure drawn up by SWAMP personnel). Water table levels displayed in reference to local datum used for contour survey (Figure 7.2).

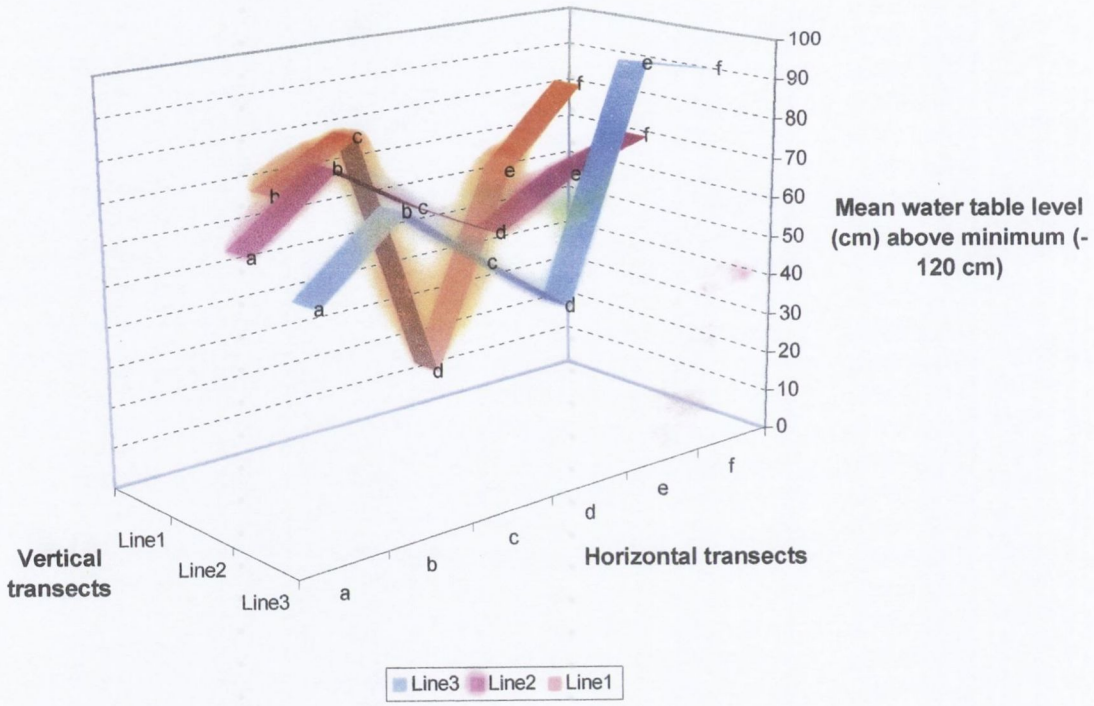


Figure 4.7: Mean water table levels (cm) above the bottom of the water table tubes (120 cm below the ground) at the Cowlands.

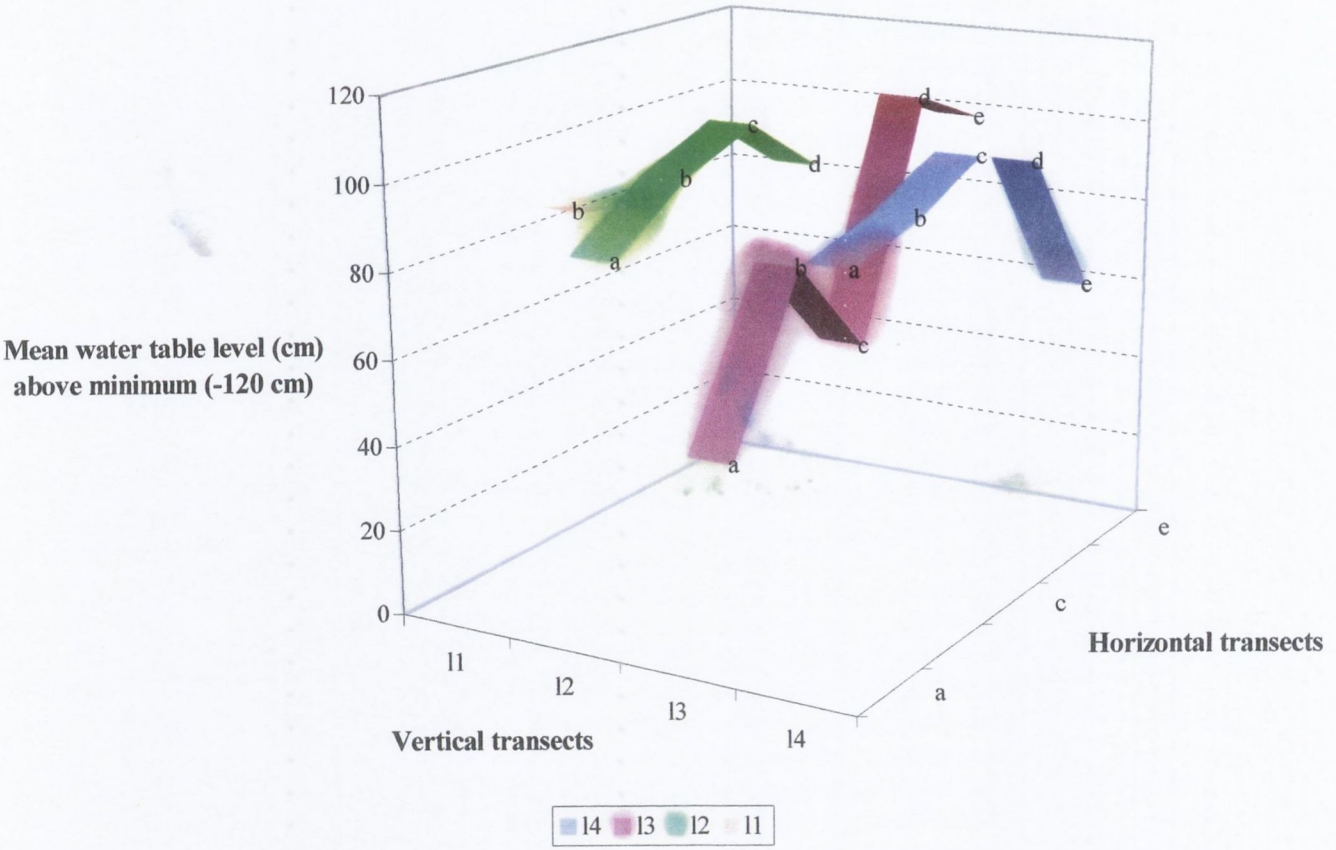


Figure 4.8: Mean water table levels (cm) above the bottom of the water table tubes (120 cm below the ground) at the Warren 1.

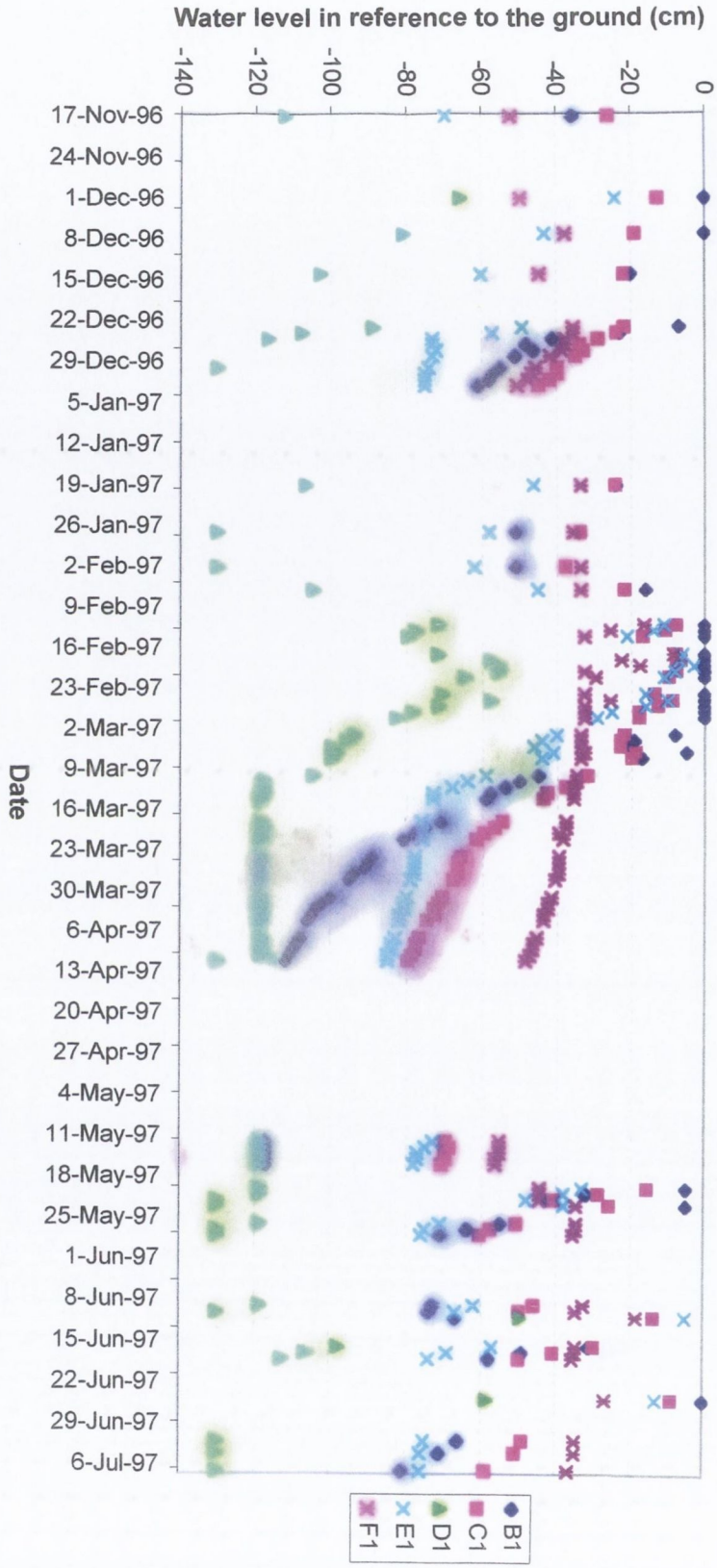


Figure 4.9: Water levels (cm) in reference to the ground in the water table tubes of line 1 at the Cowlands.

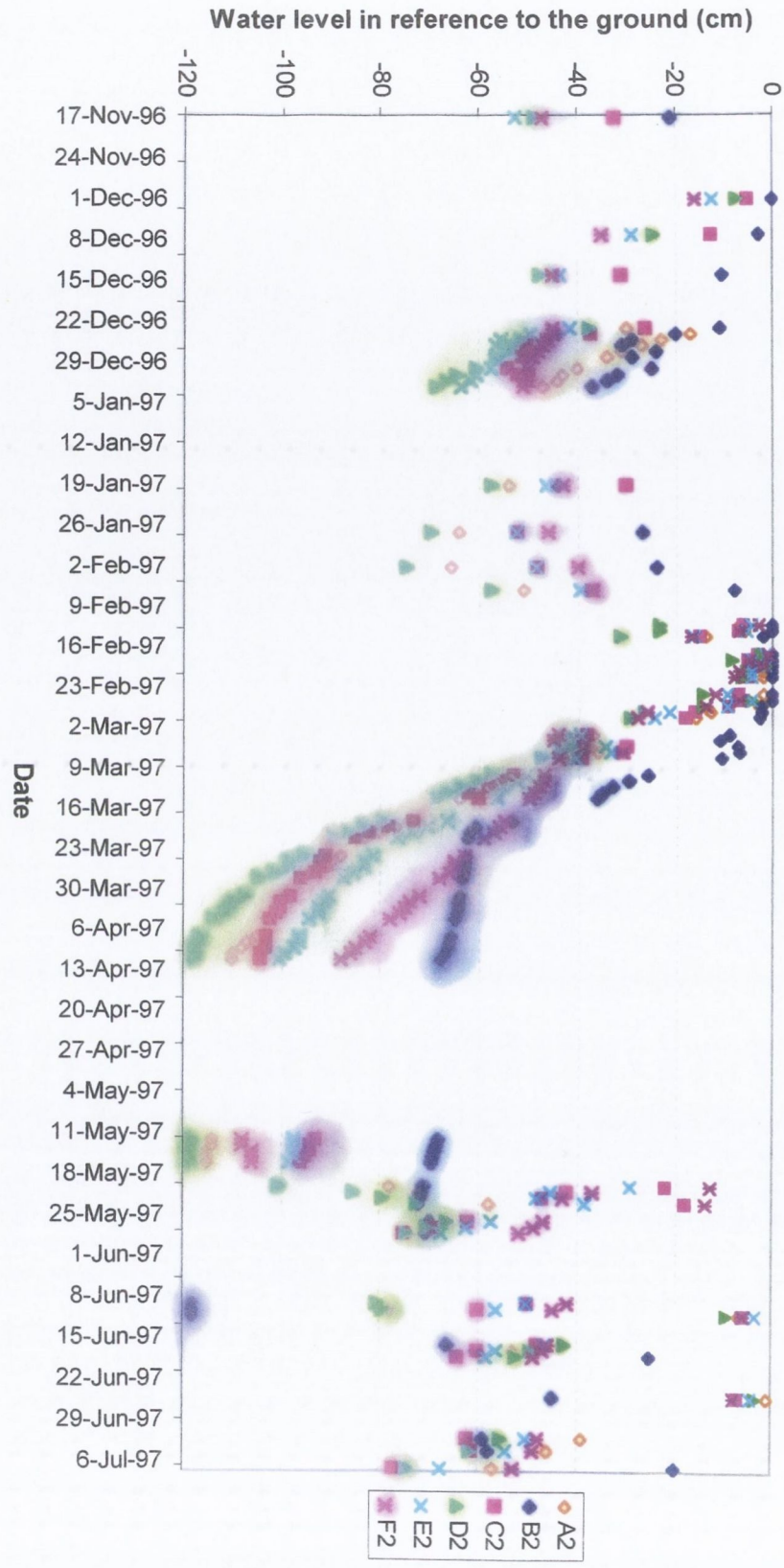


Figure 4.10: Water levels (cm) in reference to the ground in the water table tubes of line 2 at the Cowlands.

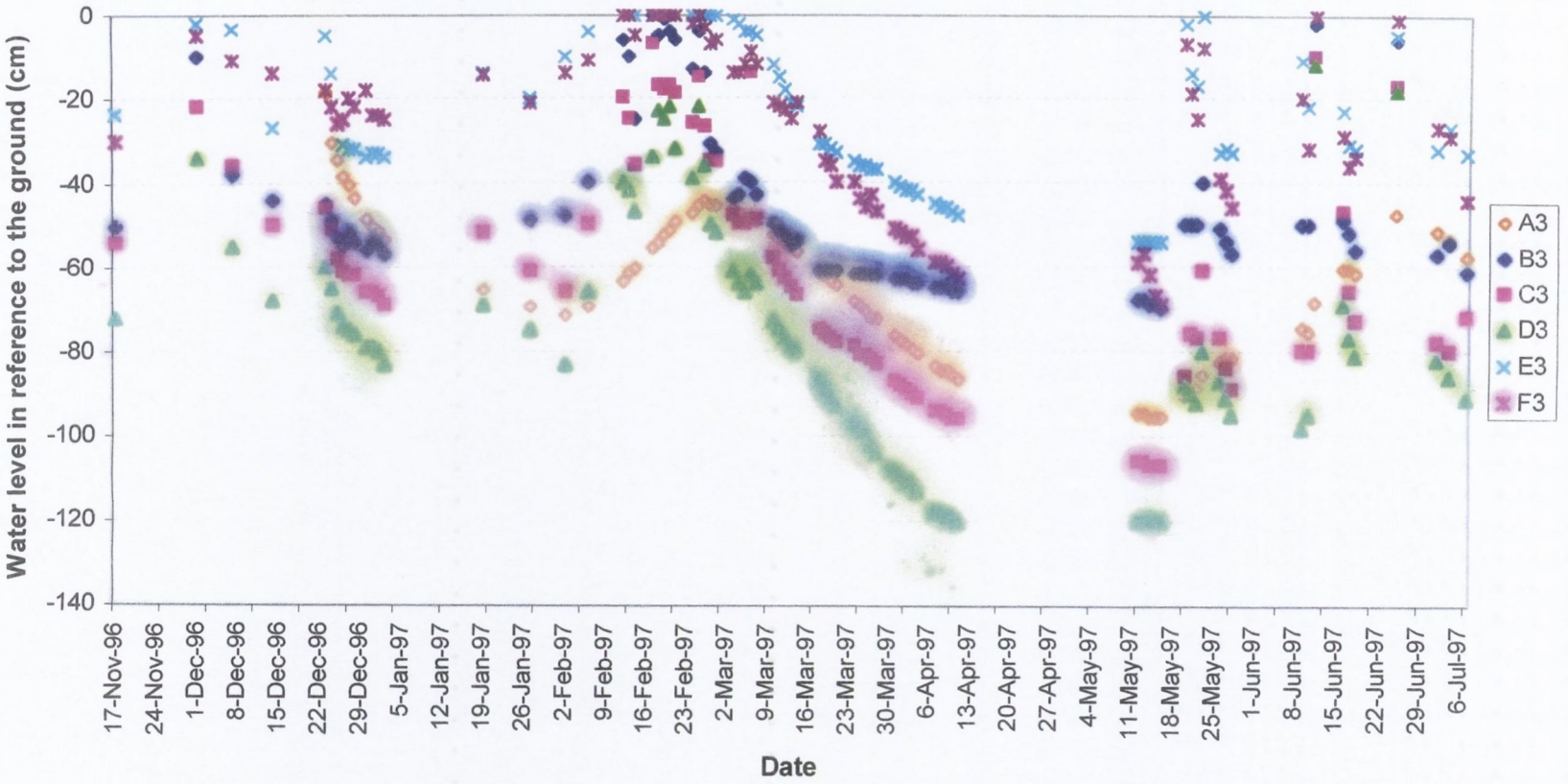


Figure 4.11: Water levels (cm) in reference to the ground in the water table tubes of line 3 at the Cowlands.

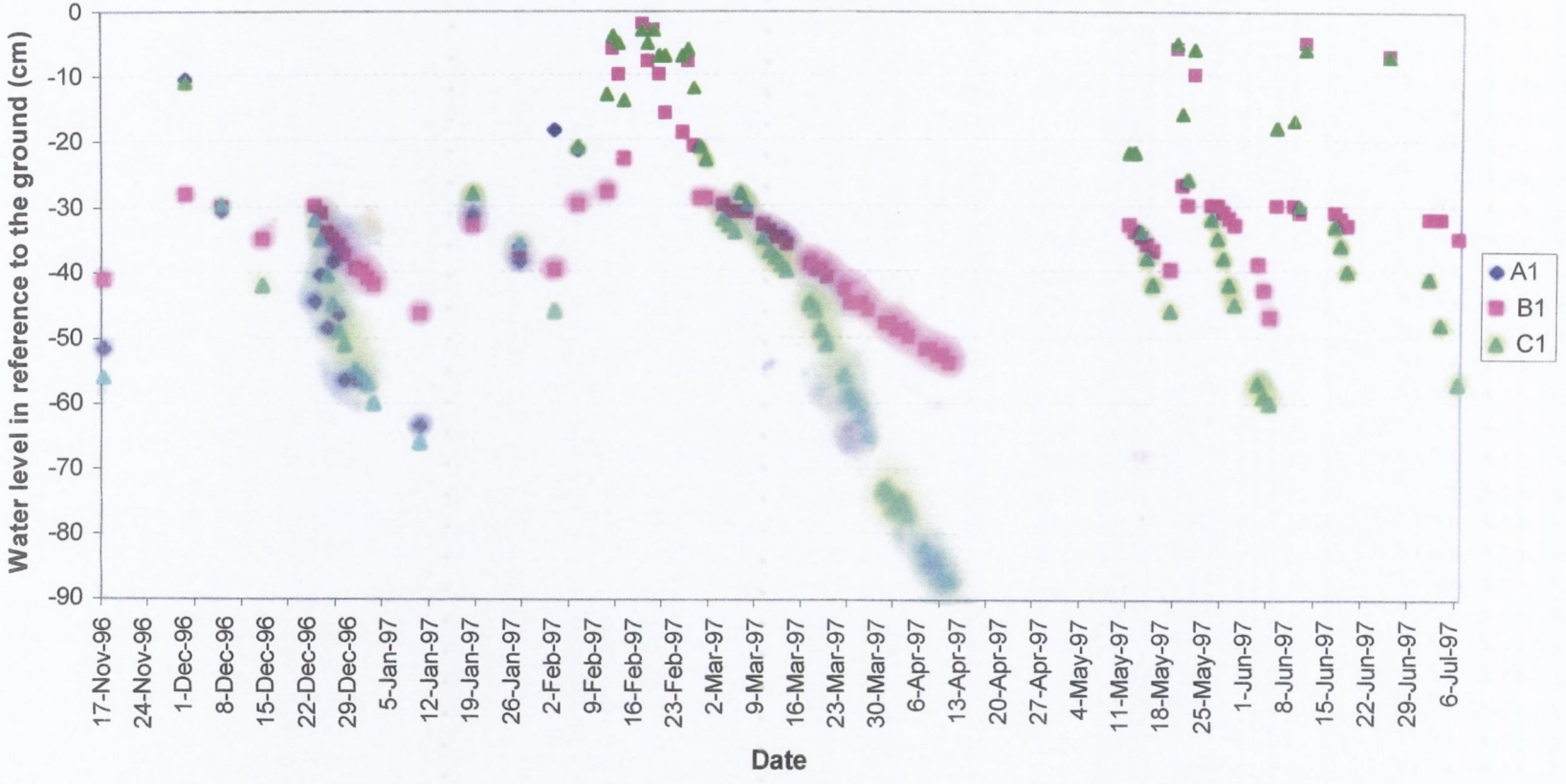


Figure 4.12: Water levels (cm) in reference to the ground in the water table tubes of line 1 at the Warren 1.

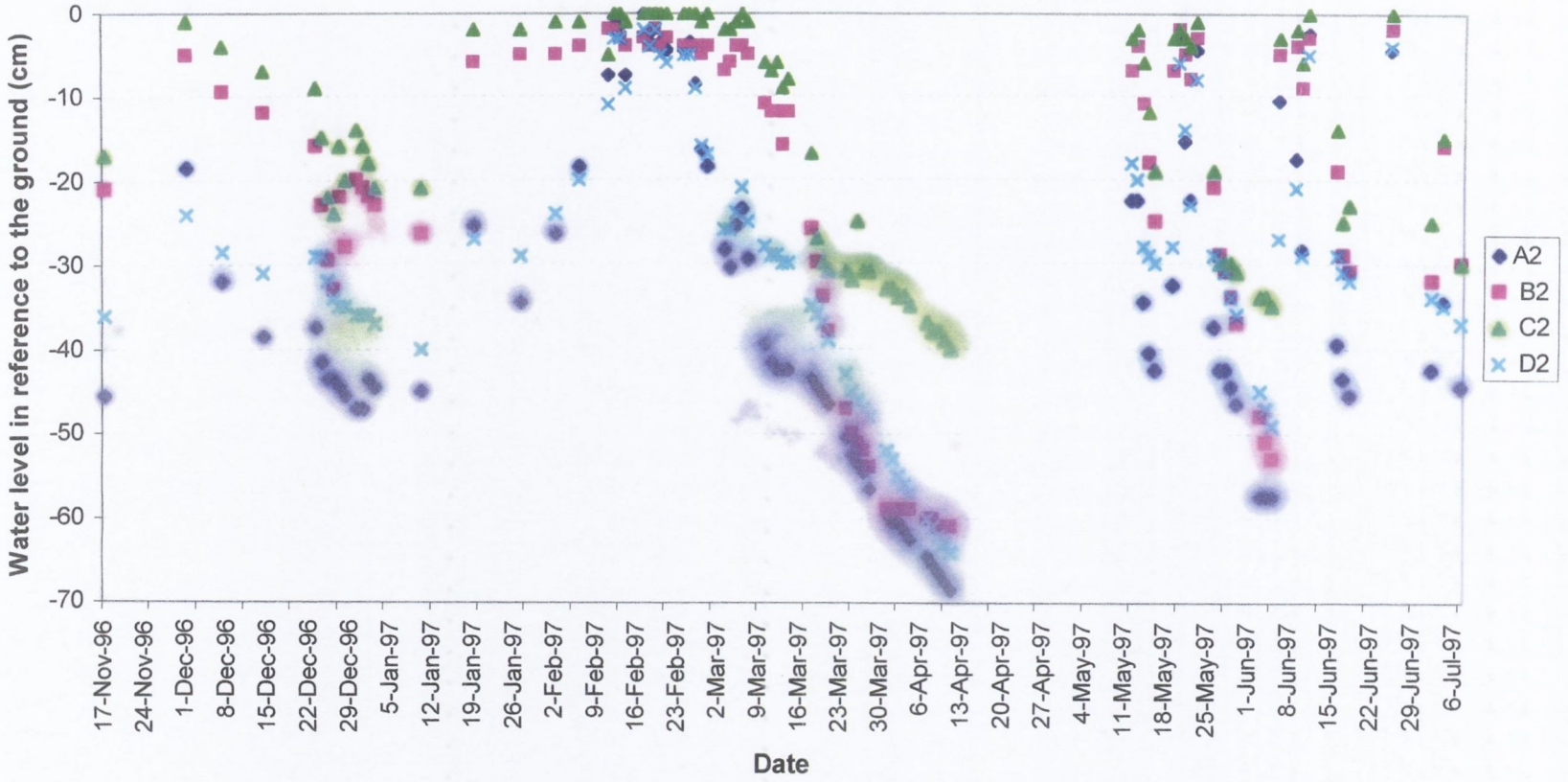


Figure 4.13: Water levels (cm) in reference to the ground in the water table tubes of line 2 at the Warren 1.

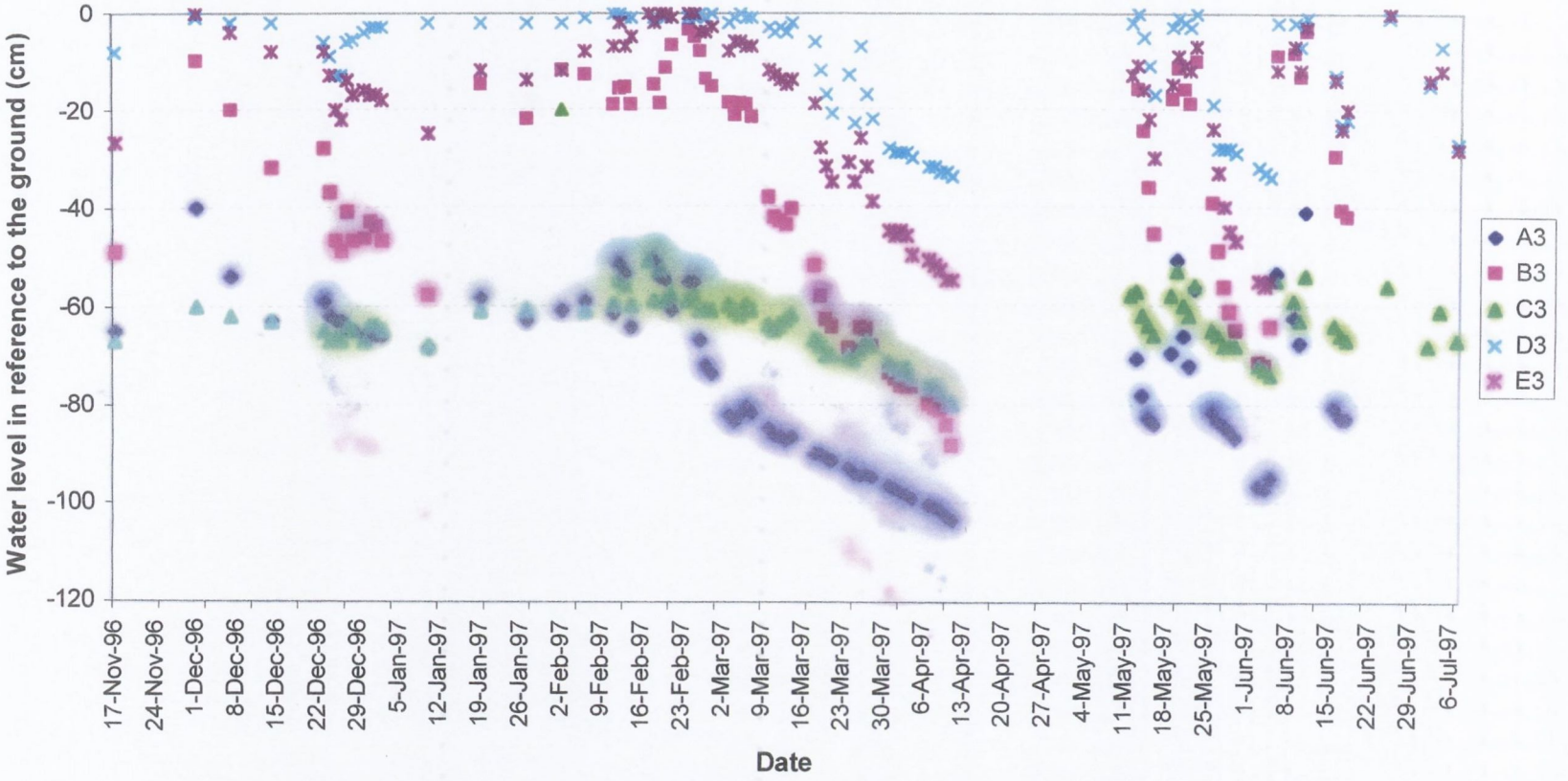


Figure 4.14: Water levels (cm) in reference to the ground in the water table tubes of line 3 at the Warren 1.

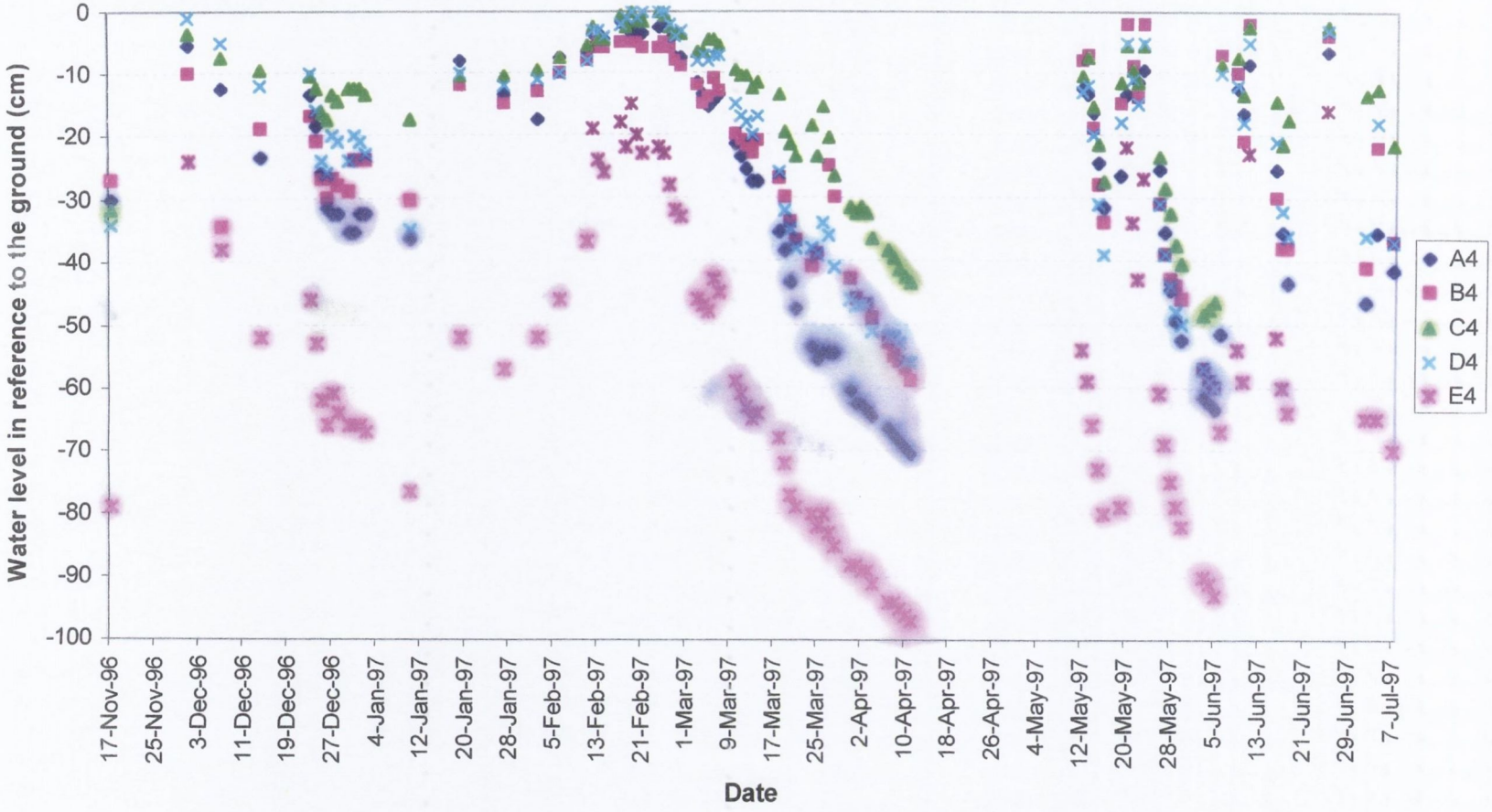


Figure 4.15: Water levels (cm) in reference to the ground in the water table tubes of line 4 at the Warren 1.

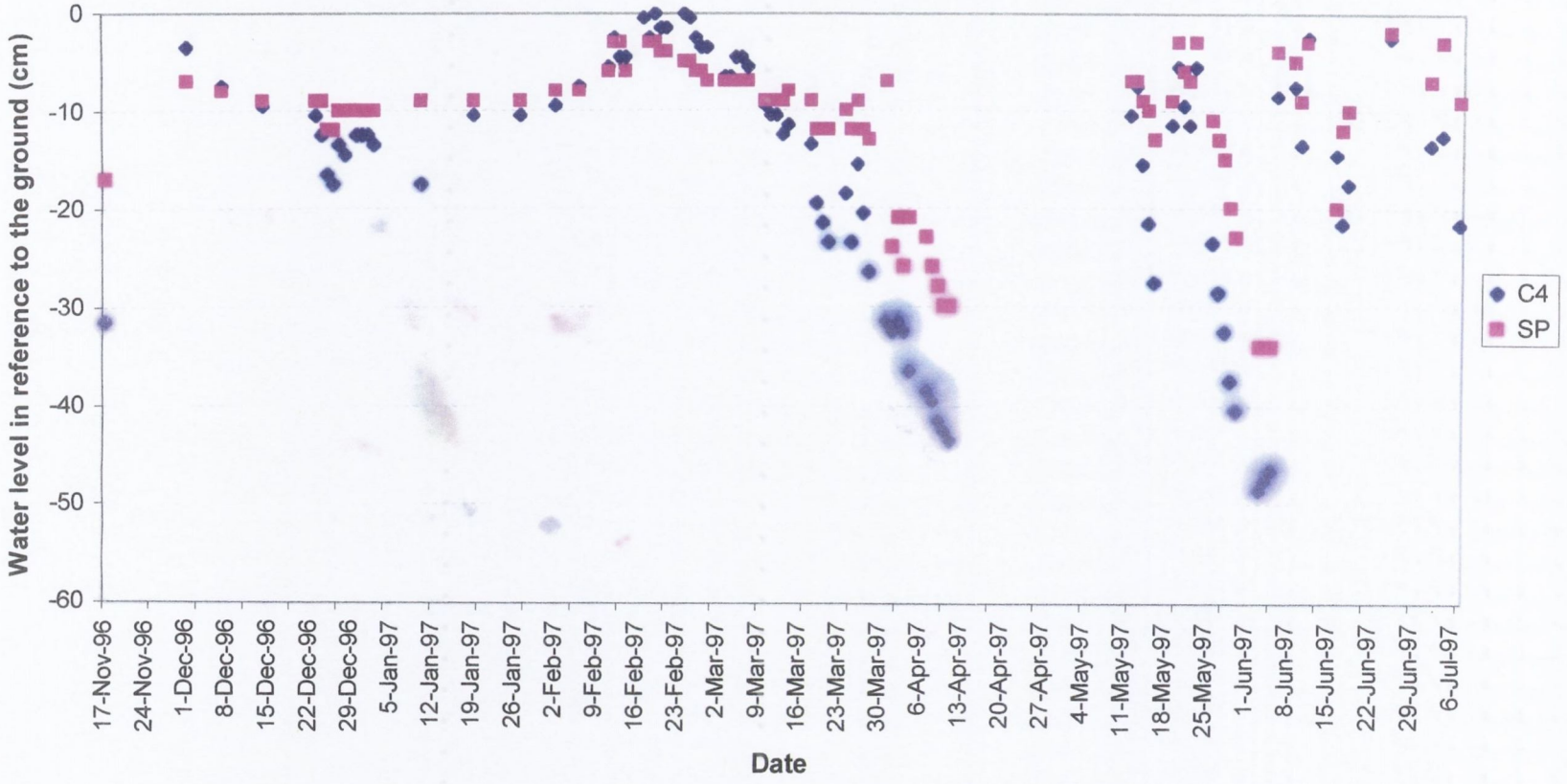


Figure 4.16: Water levels (cm) in reference to the ground in the water table tubes C4 and at the spring at the Warren 1.

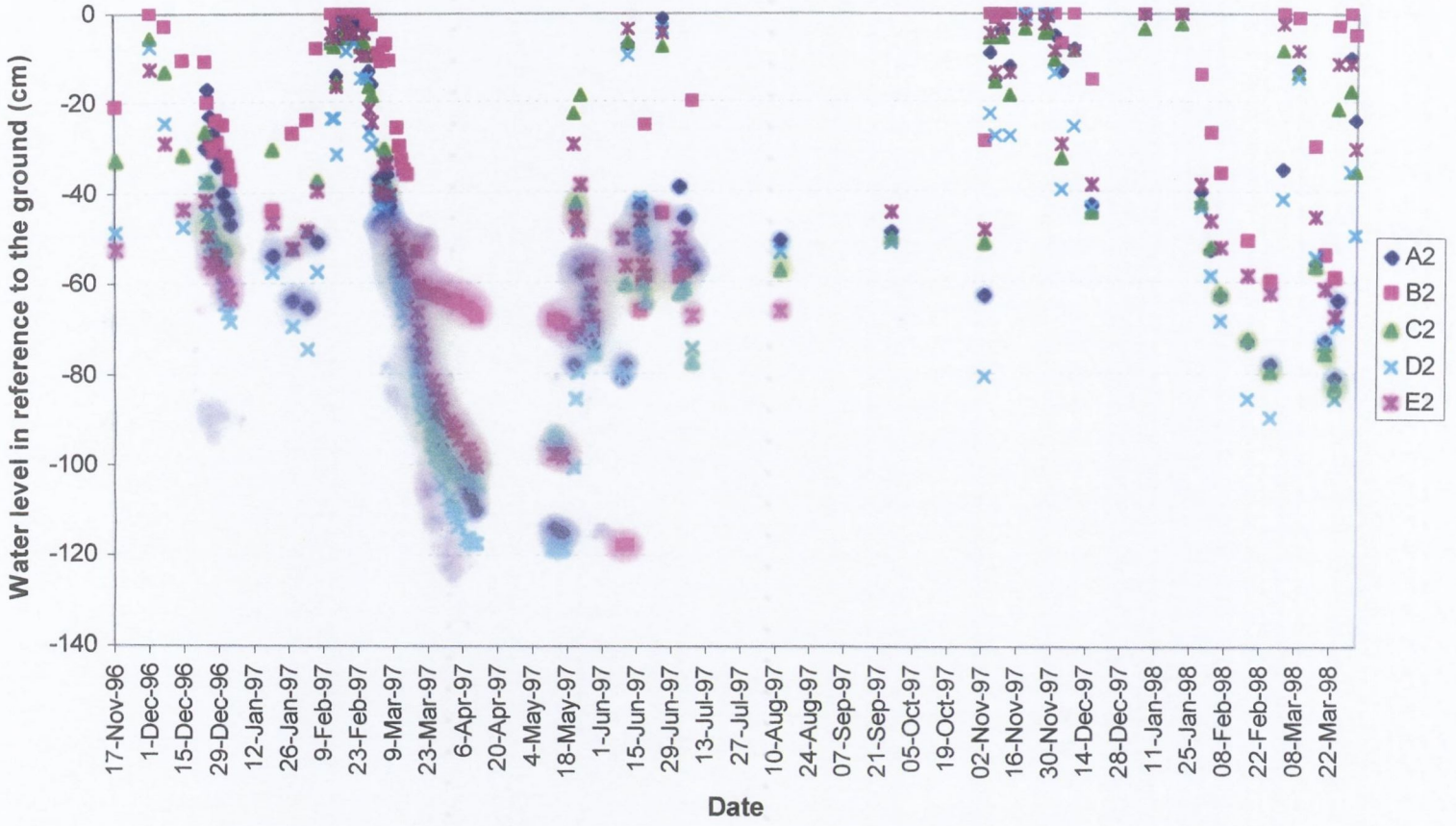


Figure 4.17: Water levels (cm) in reference to the ground in the subset of water table tubes which was monitored after July 1997 at the Cowlands.

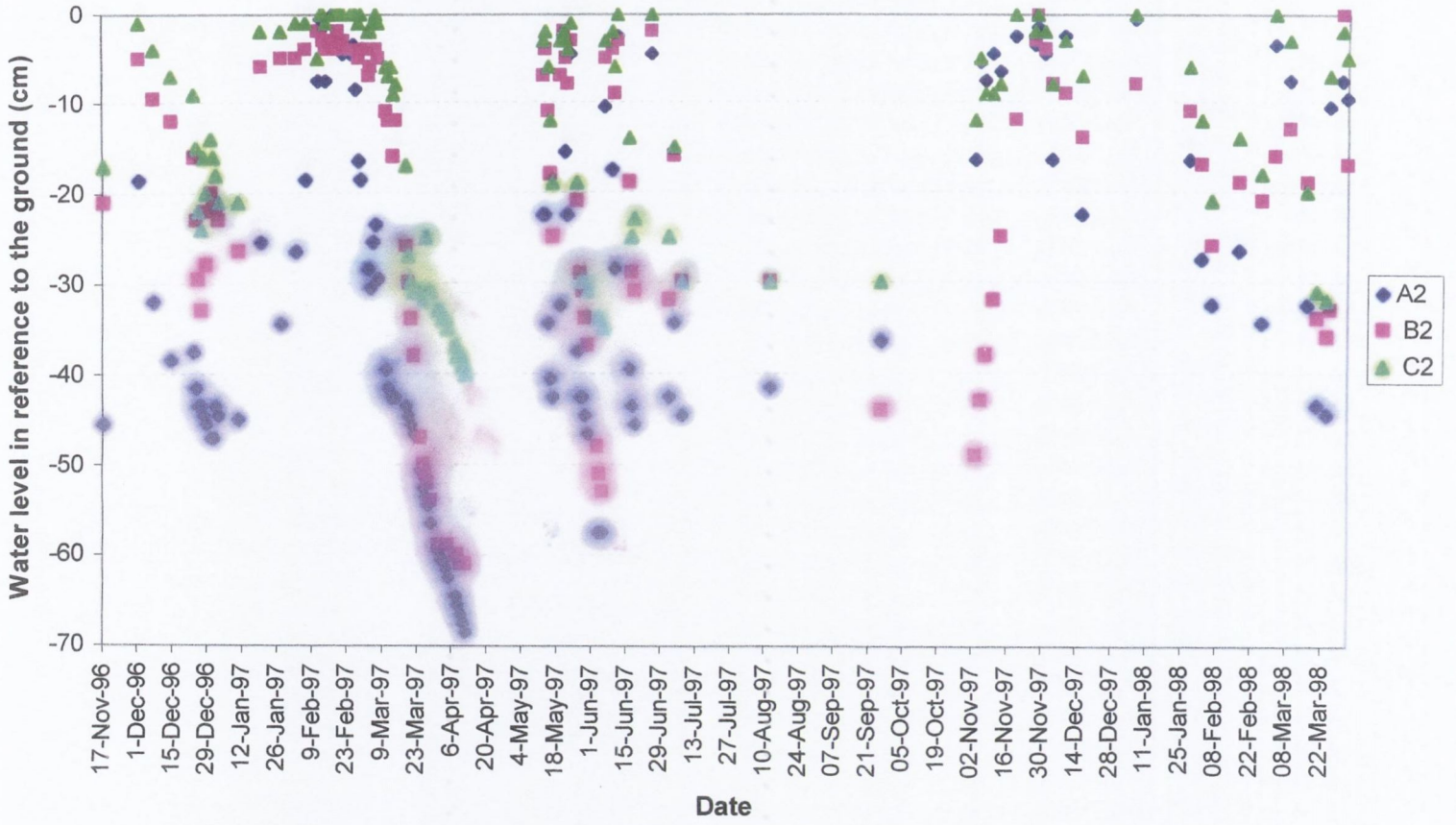


Figure 4.18: Water levels (cm) in reference to the ground in line 2 of the subset of water table tubes which was monitored after July 1997 at the Warren 1.

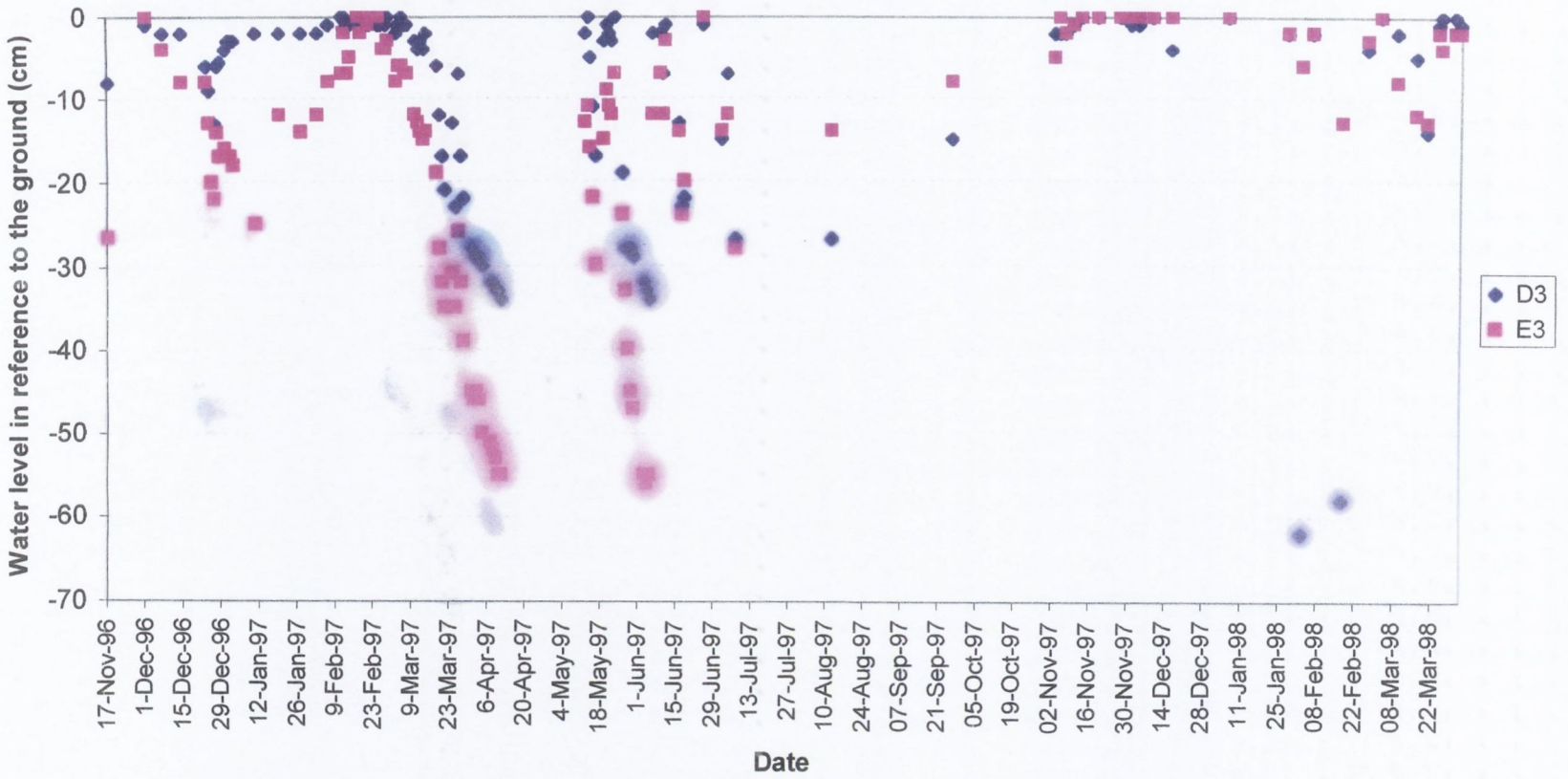


Figure 4.19: Water levels (cm) in reference to the ground in line 3 of the subset of water table tubes which was monitored after July 1997 at the Warren 1.

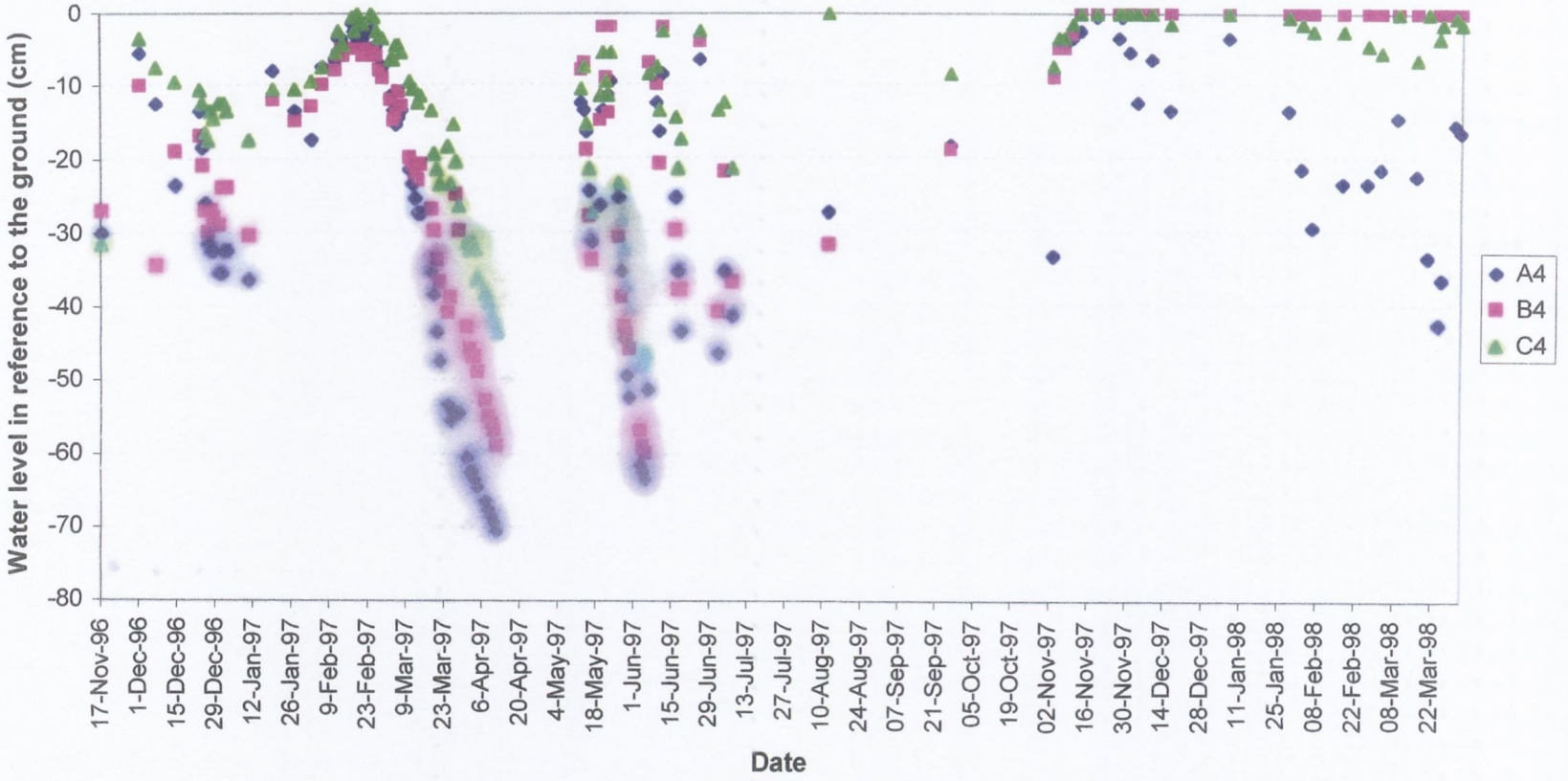


Figure 4.20: Water levels (cm) in reference to the ground in line 4 of the subset of water table tubes which was monitored after July 1997 at the Warren 1.

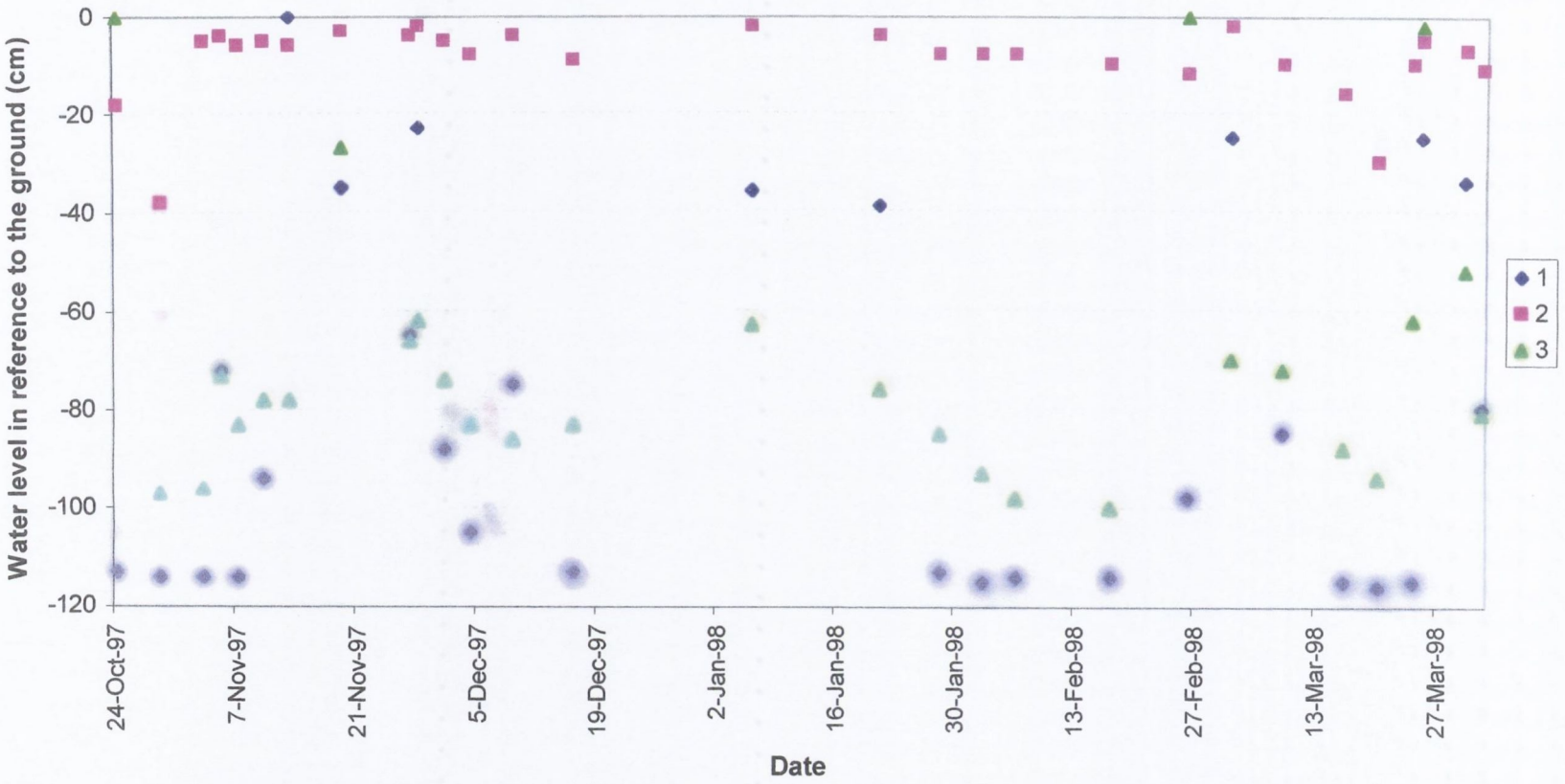


Figure 4.21: Water levels (cm) in reference to the ground in water table tubes 1, 2 and 3 at the Warren 2.

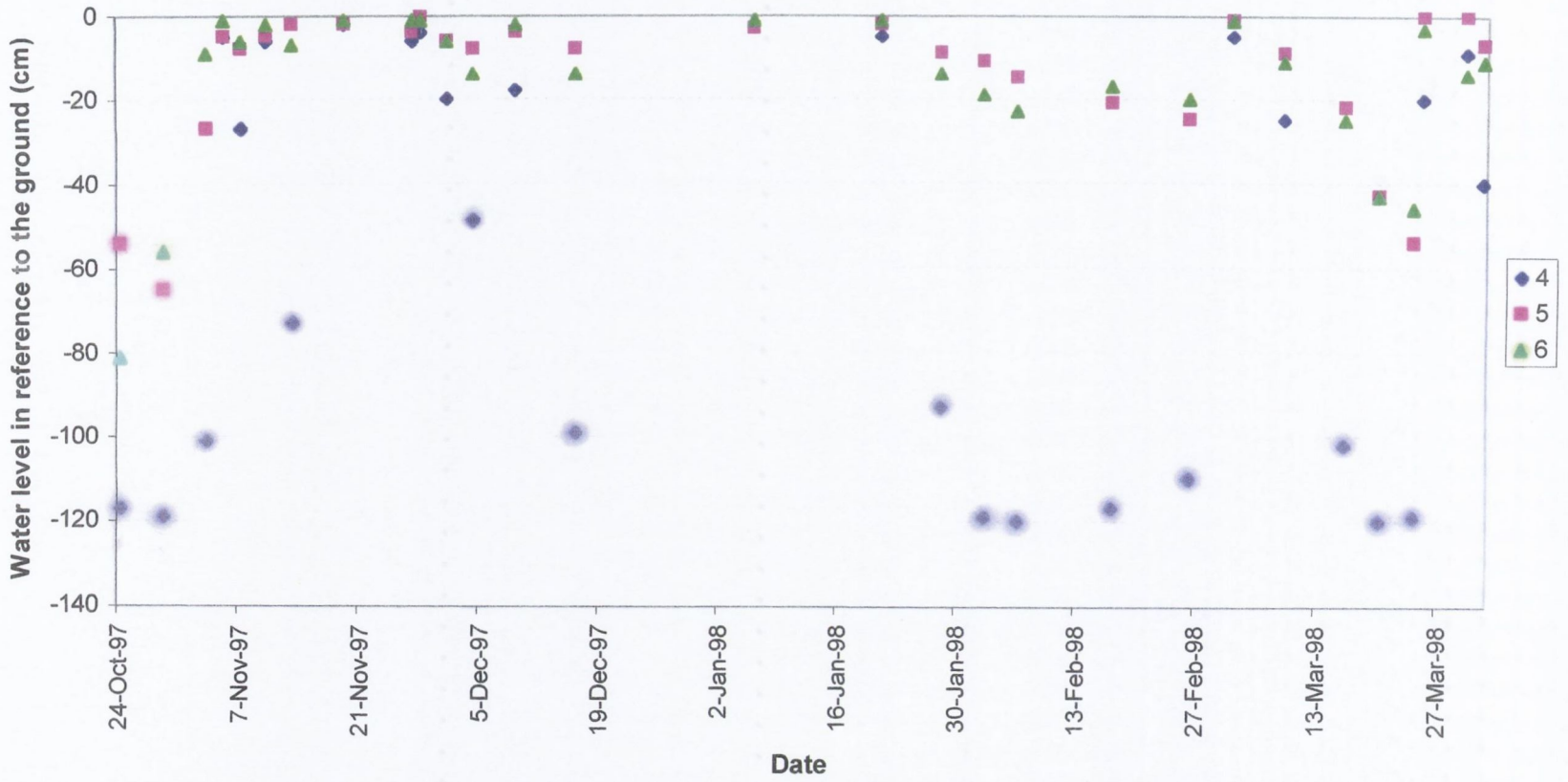


Figure 4.22: Water levels (cm) in reference to the ground in water table tubes 4, 5 and 6 at the Warren 2.

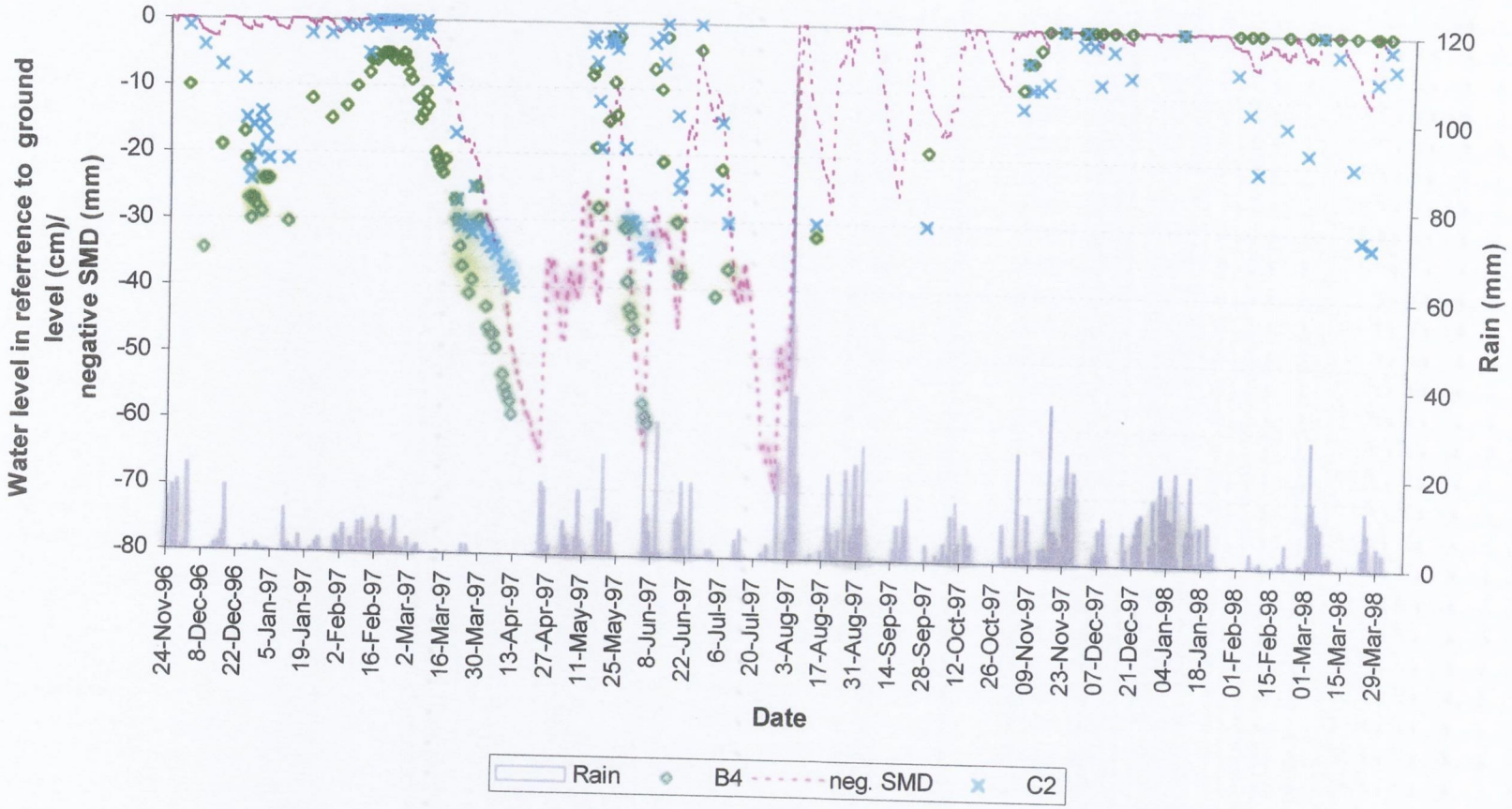


Figure 4.23: Water levels (cm) in reference to the ground in water table tubes B4 and C2 at the Warren 1 compared to negative soil moisture deficit (mm) curve and rainfall (mm).

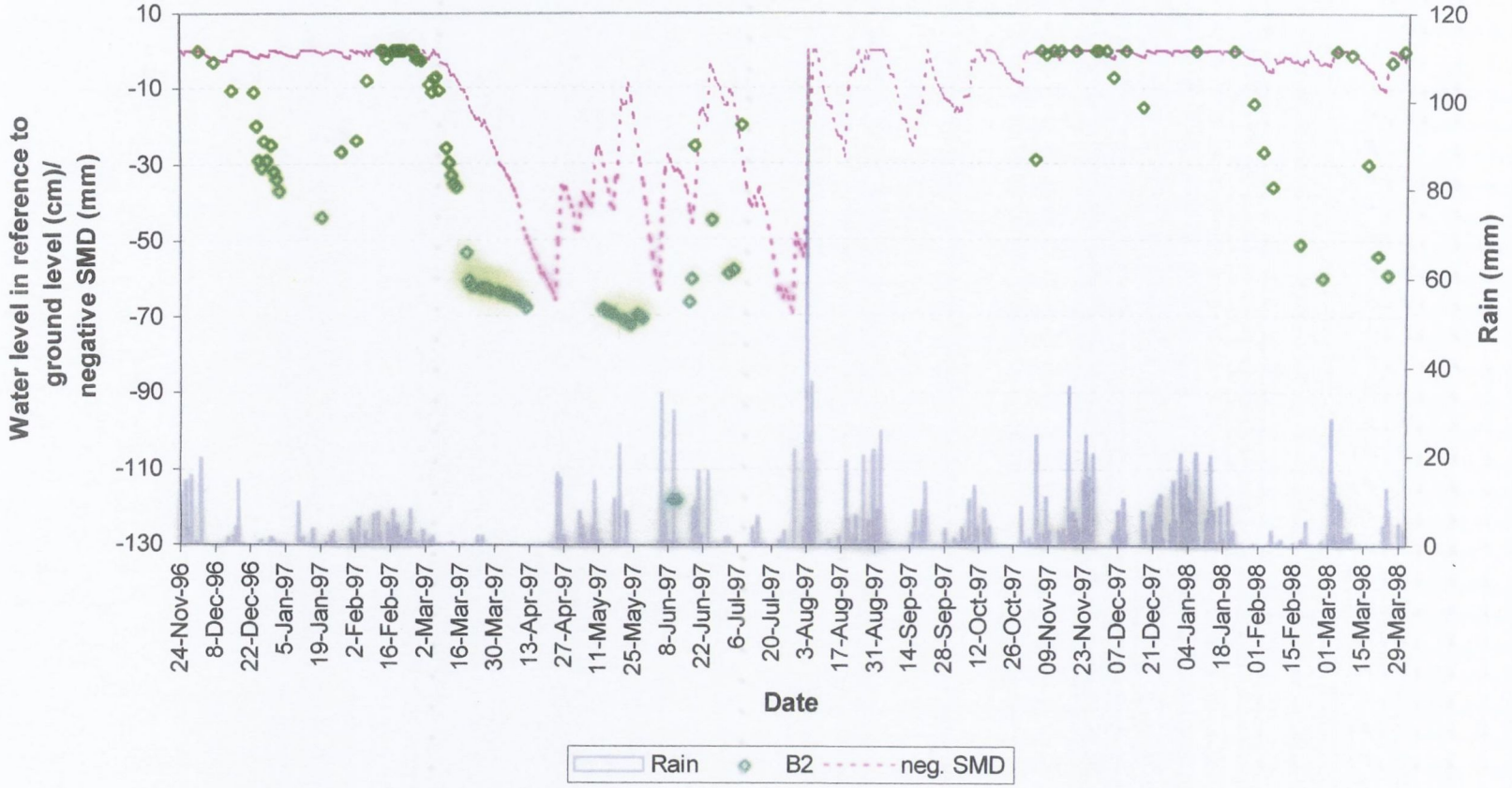


Figure 4.24: Water levels (cm) in reference to the ground in water table tube B2 at the Cowlands compared to negative soil moisture deficit (mm) curve and rainfall (mm).

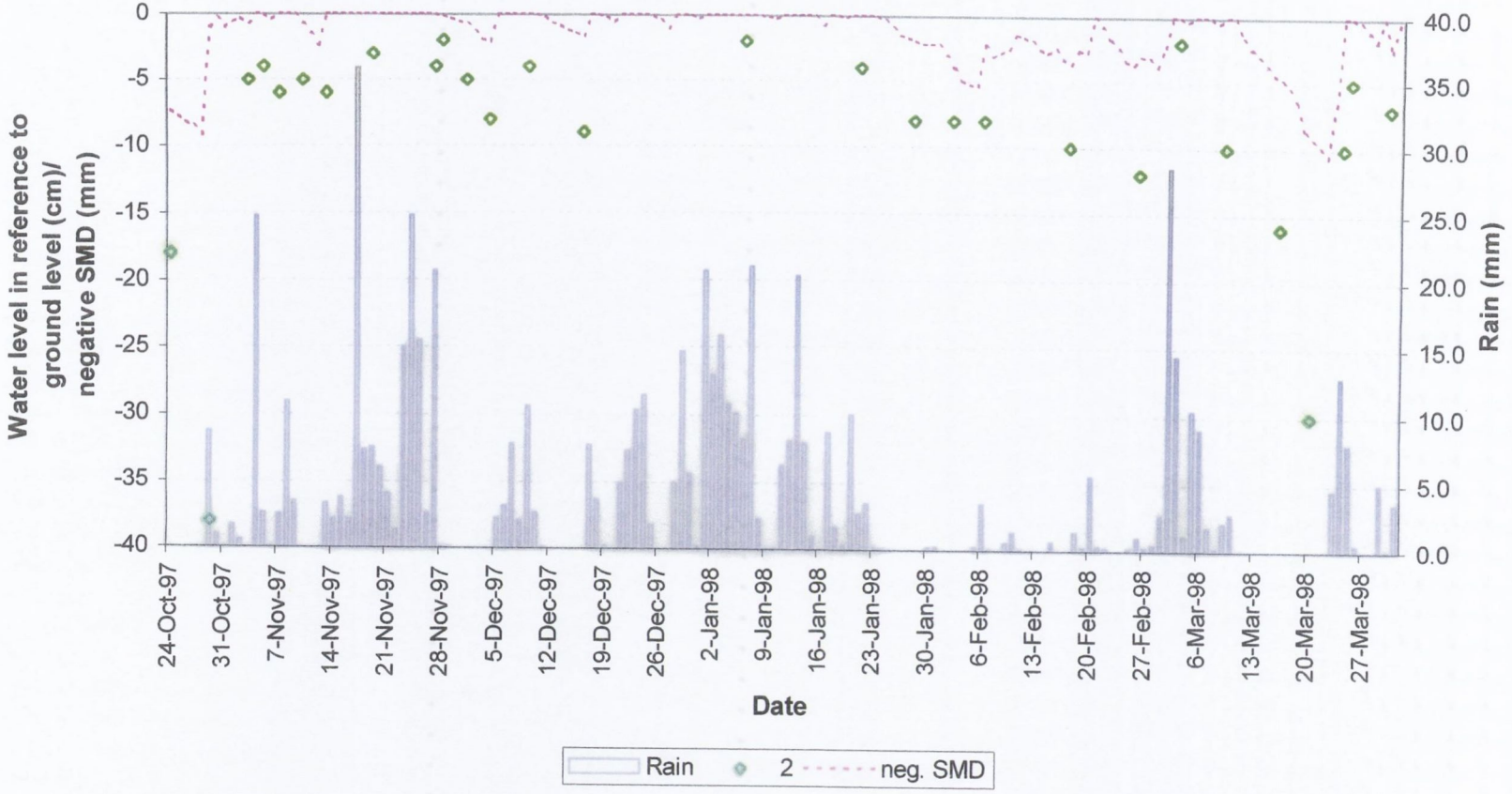


Figure 4.25: Water levels (cm) in reference to the ground in water table tube 2 at the Warren 2 compared to negative soil moisture deficit (mm) curve and rainfall (mm).

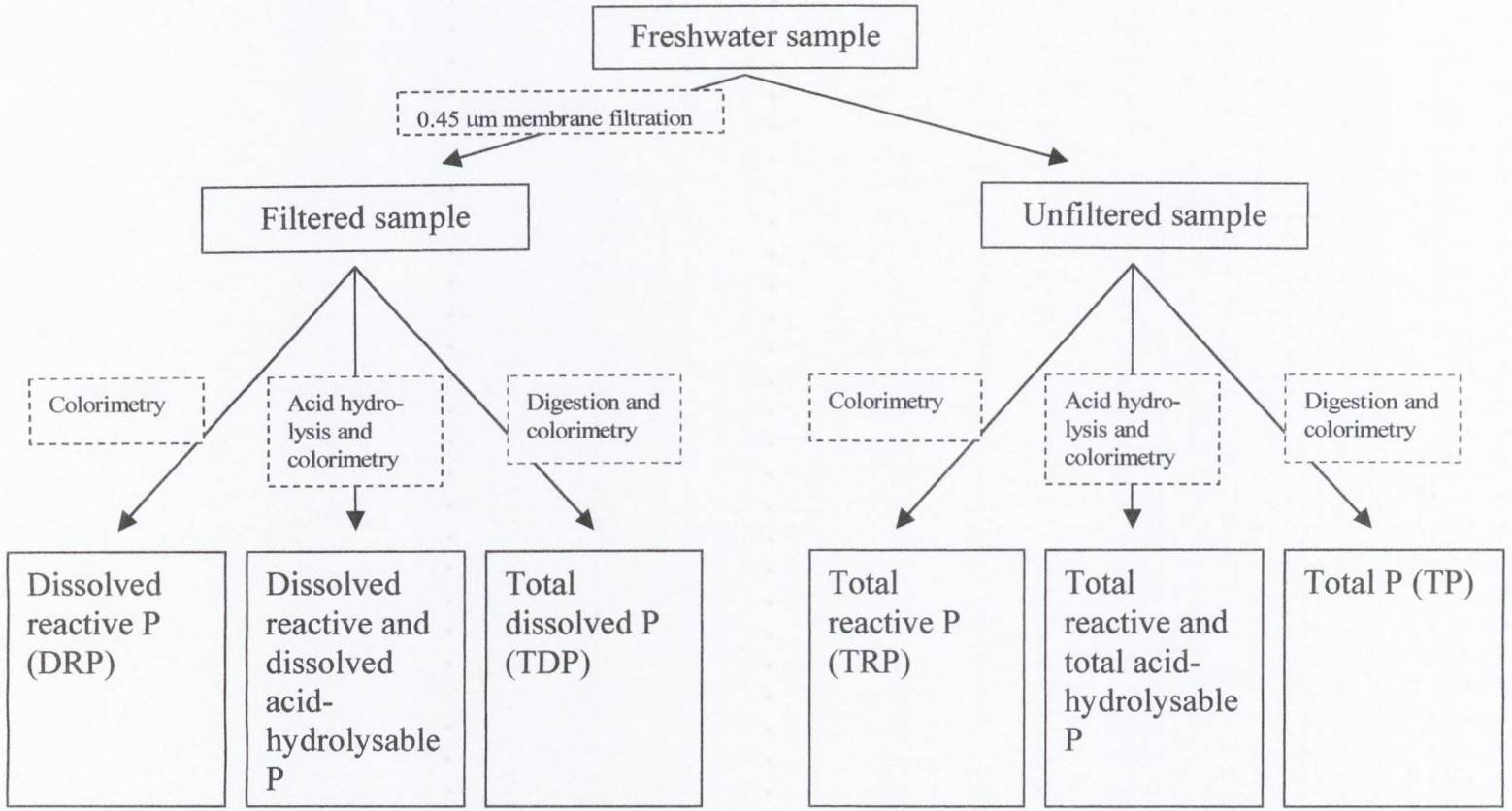


Figure 5.1: Phosphorus analysis techniques and products (based on Anon, 1995). Dashed boxes indicate procedures and drawn out boxes products of the analyses. Yellow boxes indicate types of P analysed in this project.

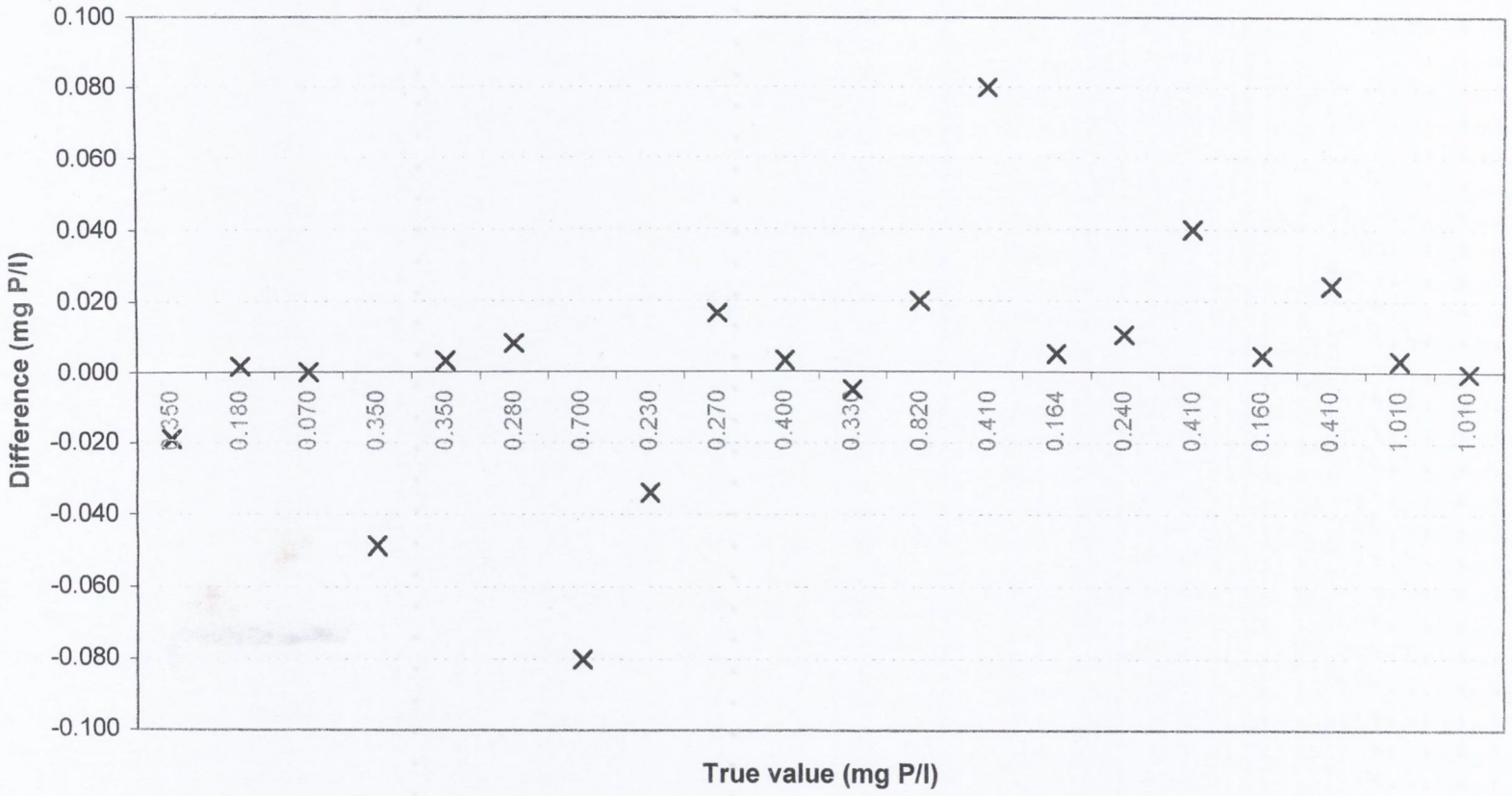


Figure 5.2: Differences (mg P/l) between mean laboratory recovery rates and true DRP values plotted against true DRP values.

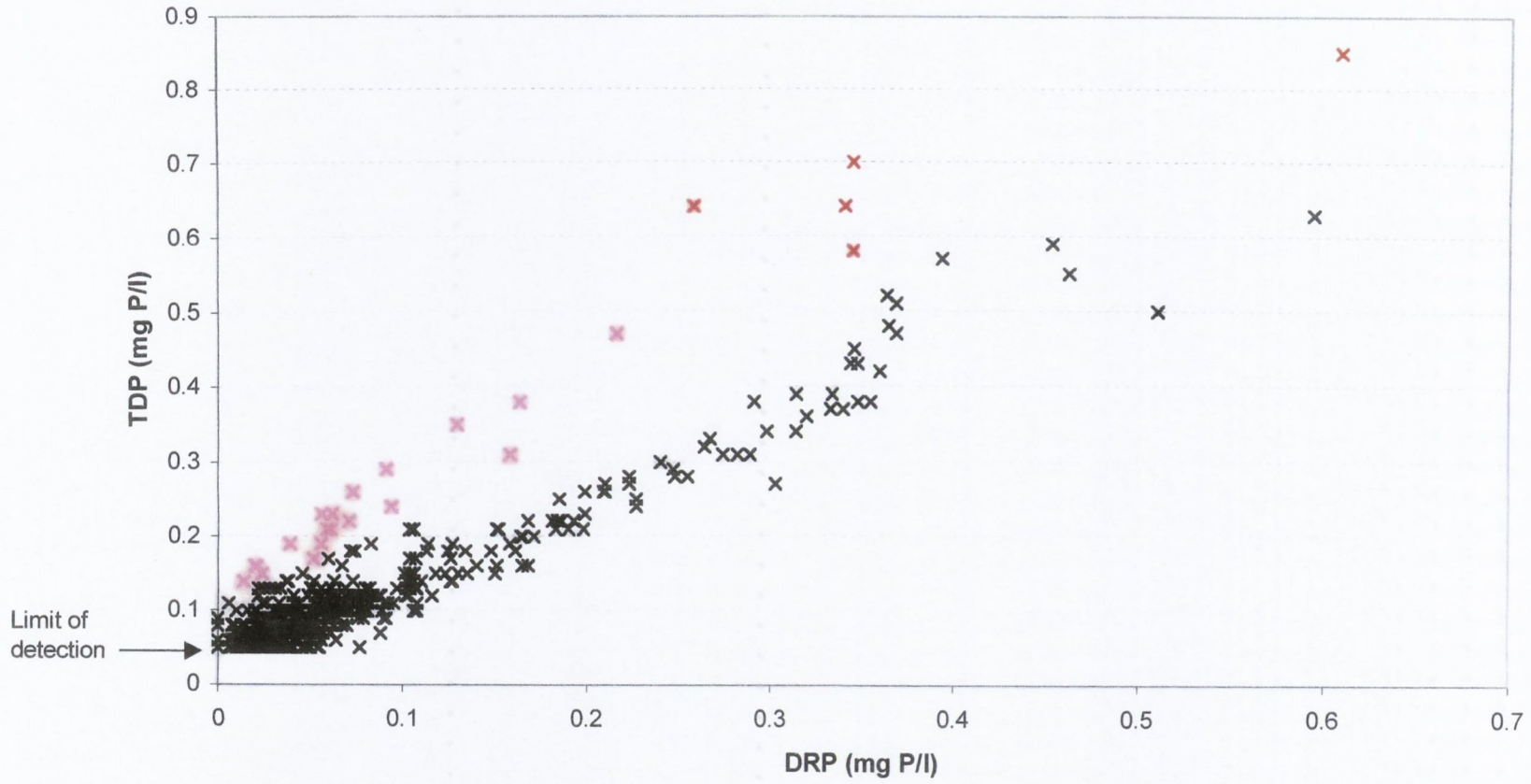


Figure 5.3: TDP concentrations (mg P/l) of the full data set at the Warren 1 plotted against DRP concentrations. Separate trend indicated by red colour. Note that samples with TDP below the limit of detection were omitted (see Section 5.2.6).

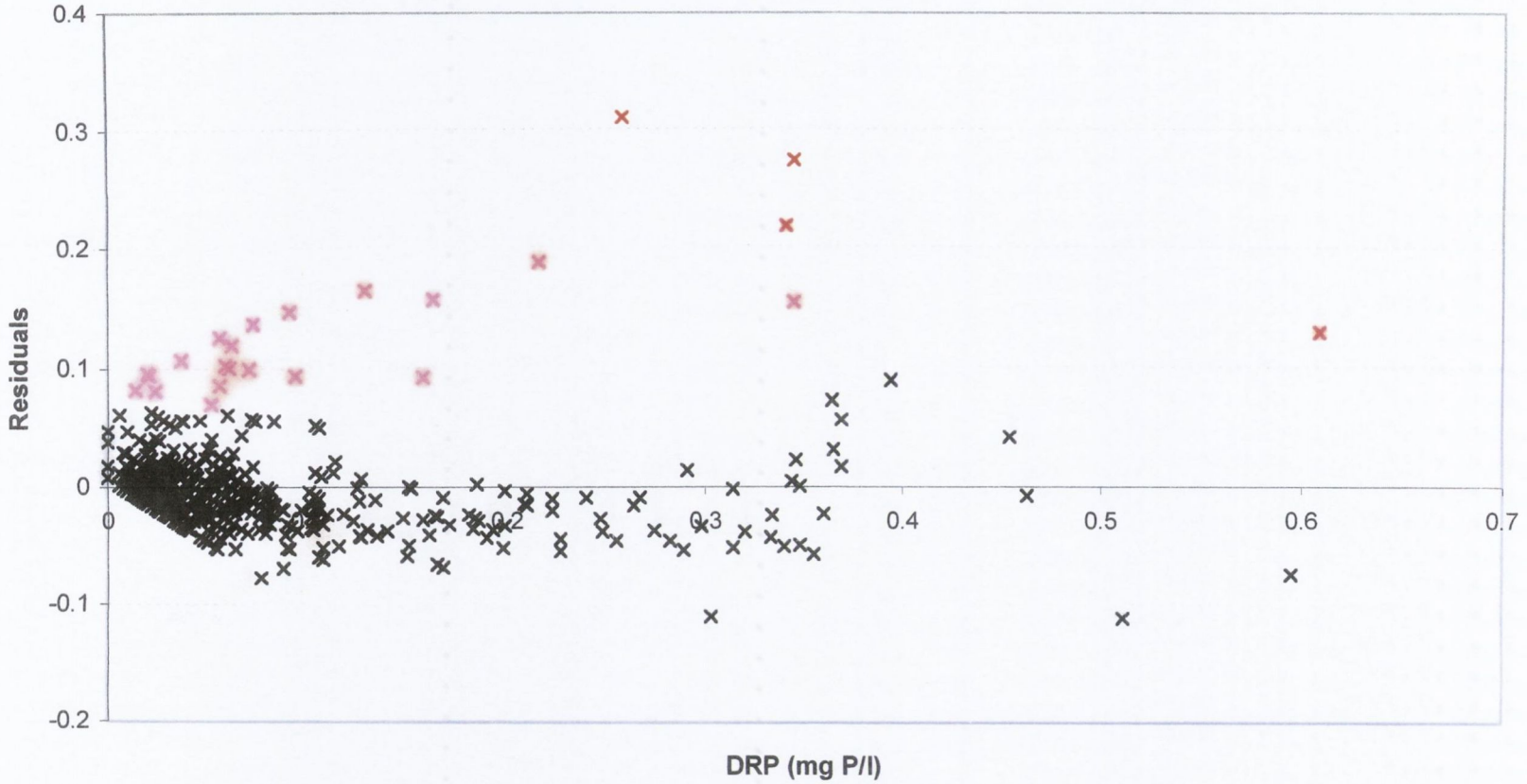


Figure 5.4: Residuals of the DRP/TDP regression of the full data set at the Warren 1 plotted against DRP concentrations (mg P/l). Separate trend indicated by red colour.

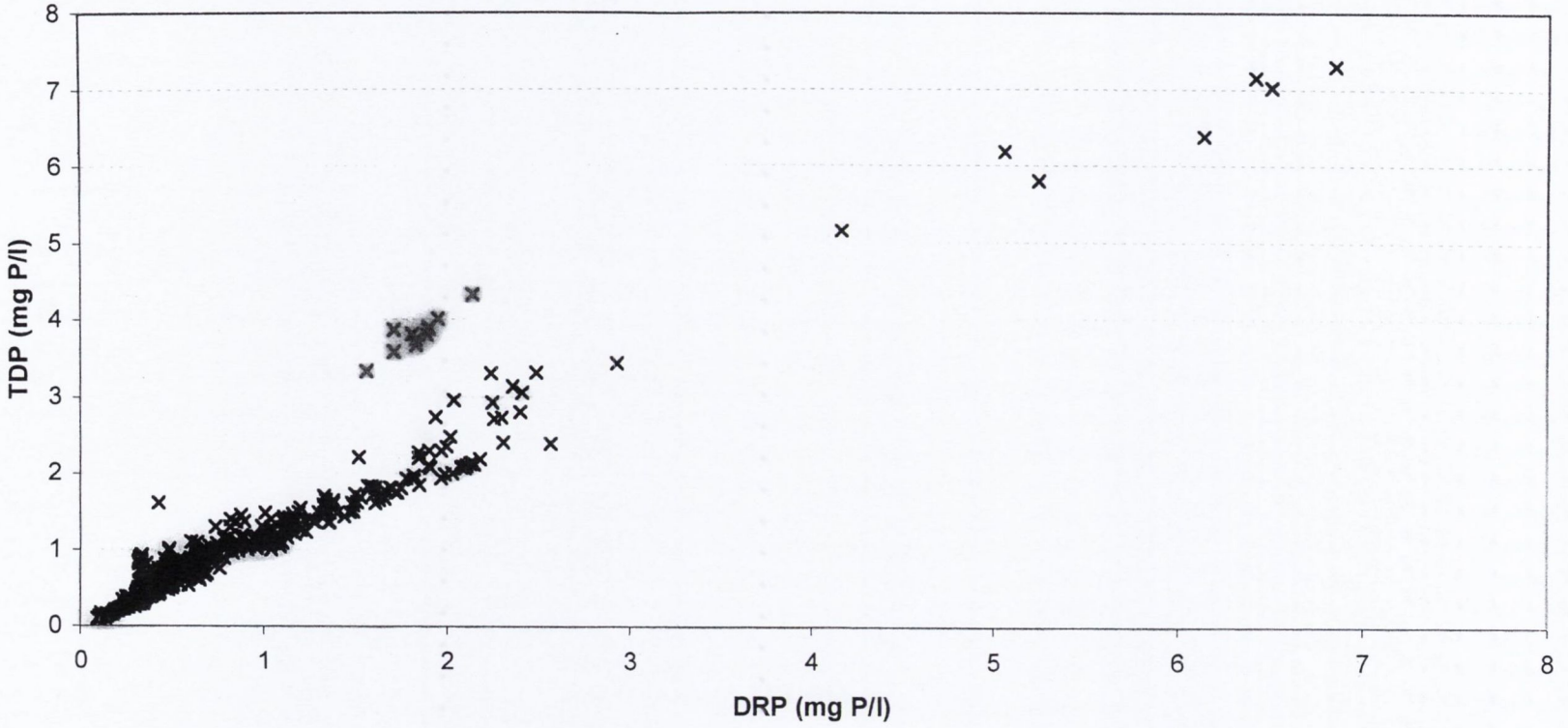


Figure 5.5: TDP concentrations (mg P/l) of the full data set at the Cowlands plotted against DRP concentrations (mg P/l). Separate trend indicated by red colour.

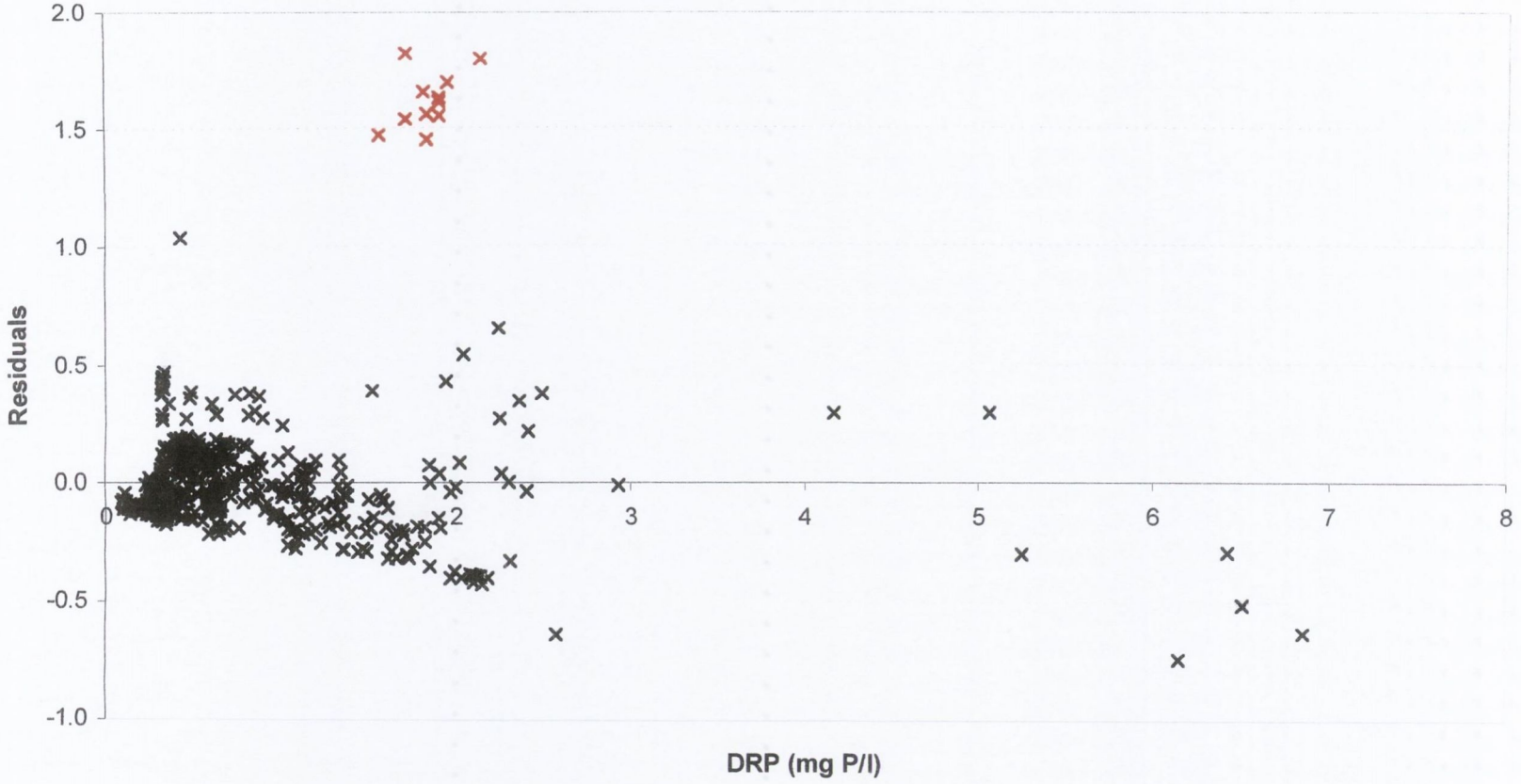


Figure 5.6: Residuals of the DRP/TDP regression of the full data set at the Cowlands plotted against DRP concentrations (mg P/l). Separate trend indicated by red colour.

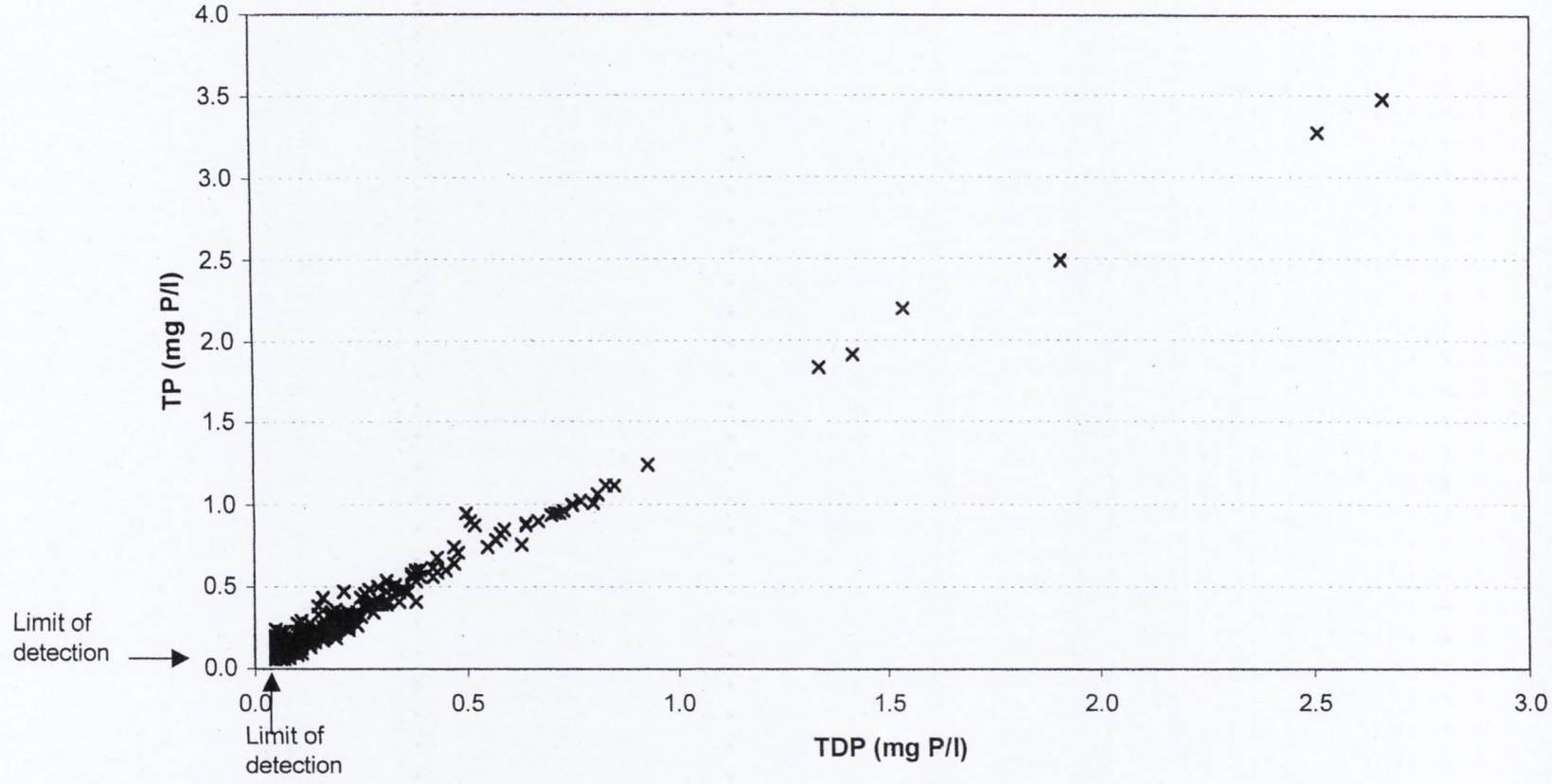


Figure 5.7: TP levels (mg P/l) plotted against TDP (mg P/l) concentrations measured at the Warren 1. Note that samples below the limit of detection were omitted (see Section 5.2.6).

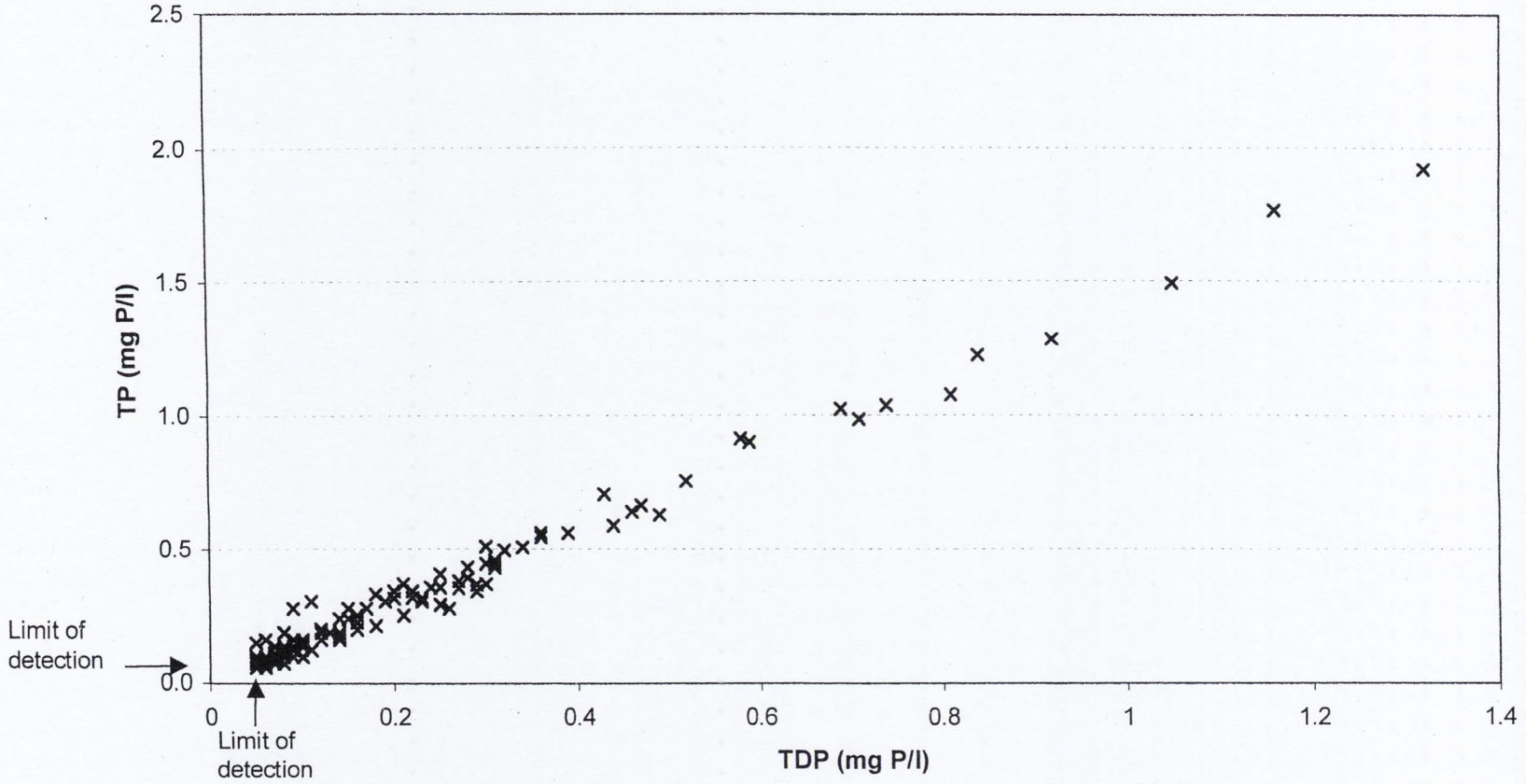


Figure 5.8: TP (mg P/l) levels plotted against TDP (mg P/l) concentrations measured at the Beef Unit. Note that samples below the limit of detection were omitted (see Section 5.2.6).

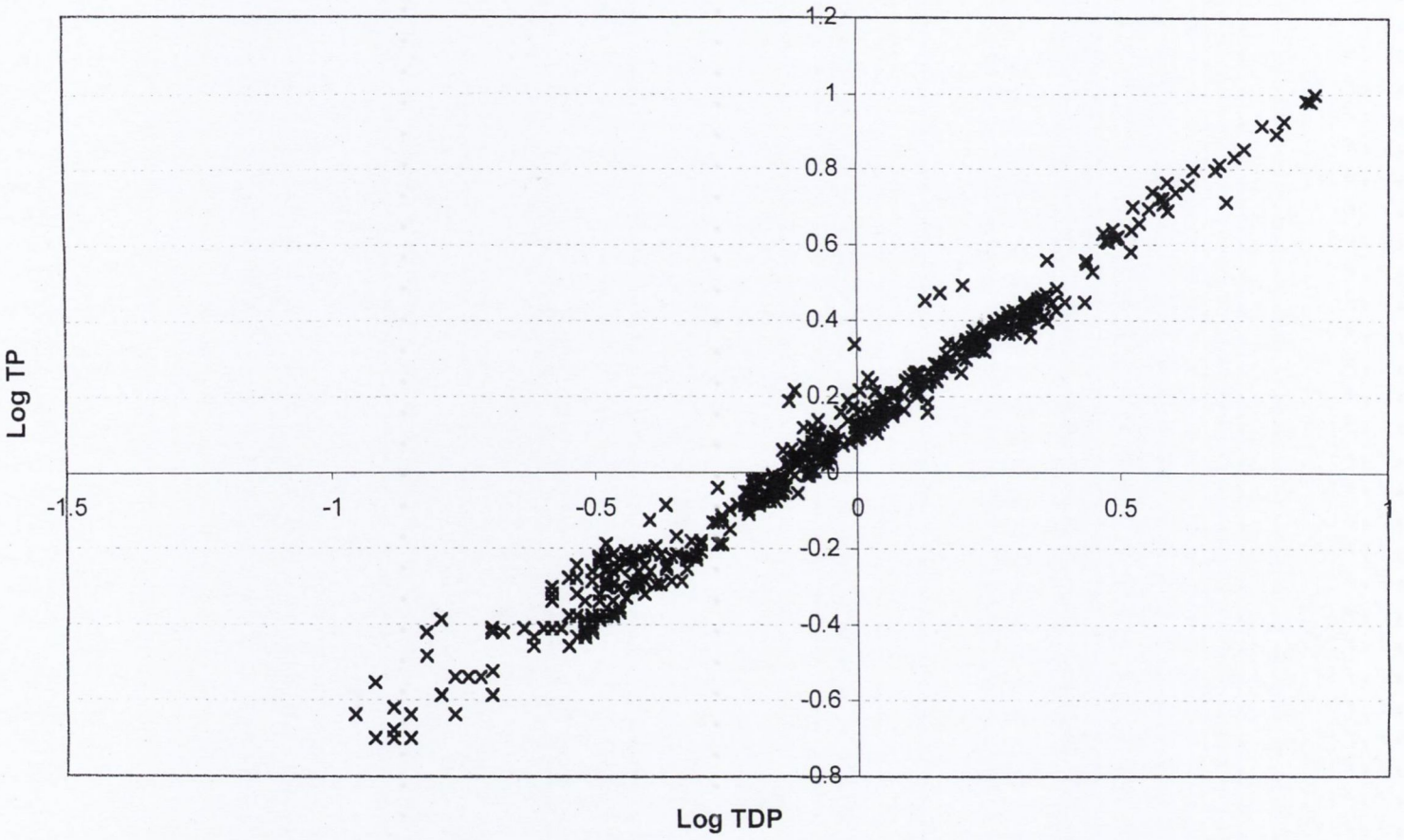


Figure 5.9: Log(10) TP levels plotted against log(10) TDP concentrations measured at the Cowlands.

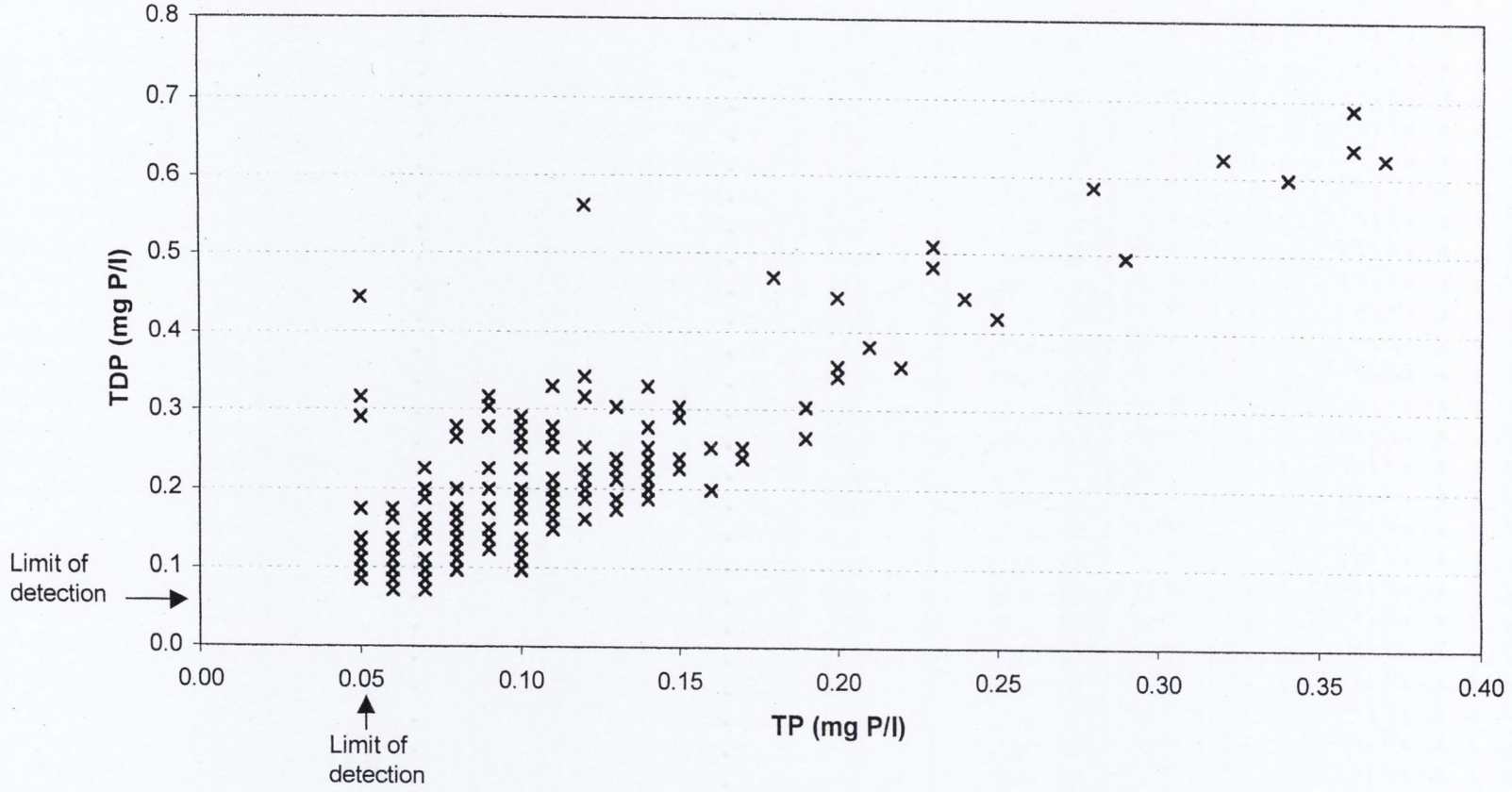


Figure 5.10: TP levels (mg P/l) plotted against TDP (mg P/l) concentrations measured at the Warren 2. Note that samples below the limit of detection were omitted (see Section 5.2.6).

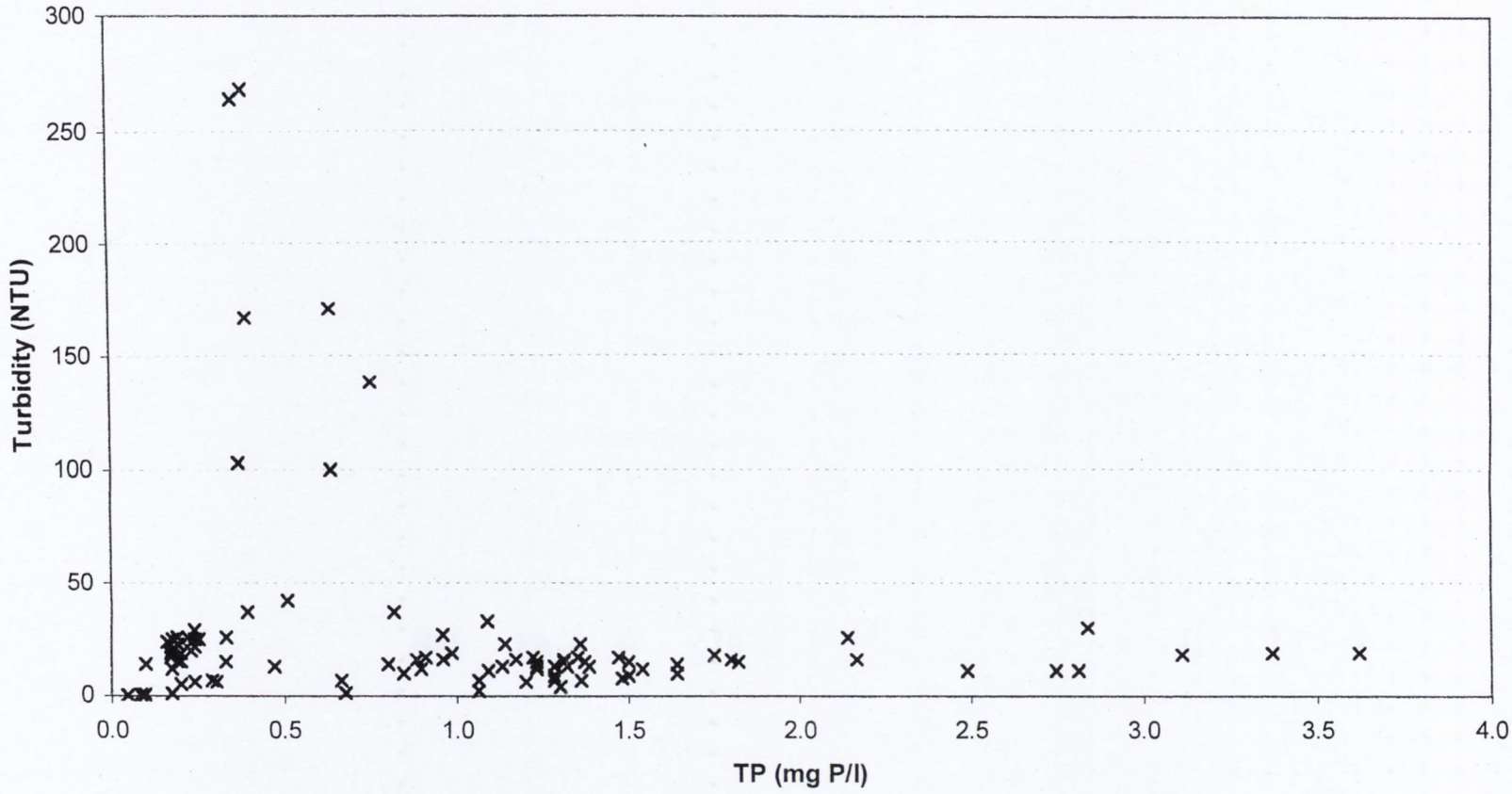


Figure 5.11: Turbidity (NTU (Nephelometer turbidity units)) plotted against TP (mg P/l) levels.

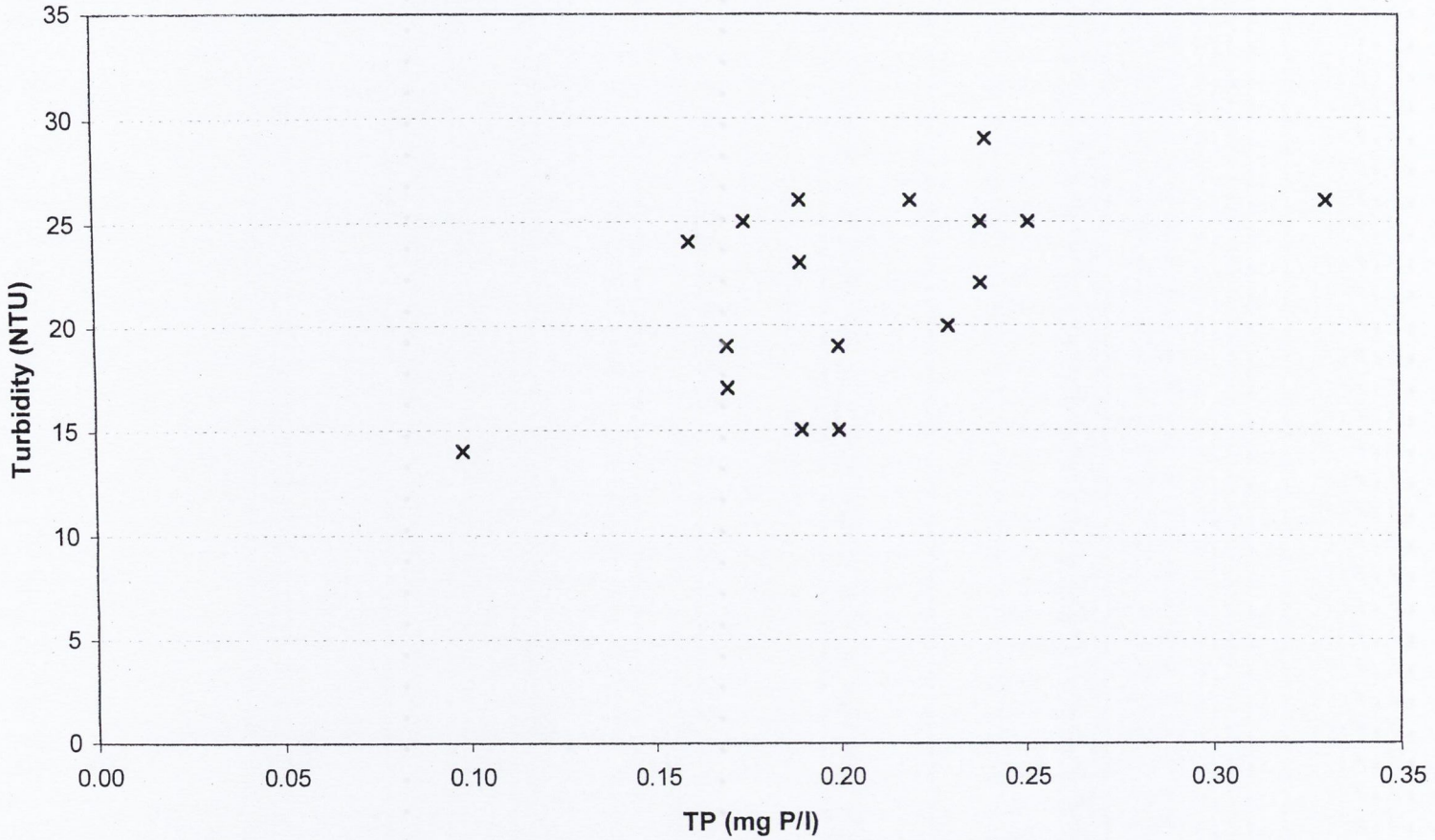


Figure 5.12: Turbidity (NTU (Nephelometer turbidity units)) plotted against TP (mg P/l) levels in samples from the Warren 1.

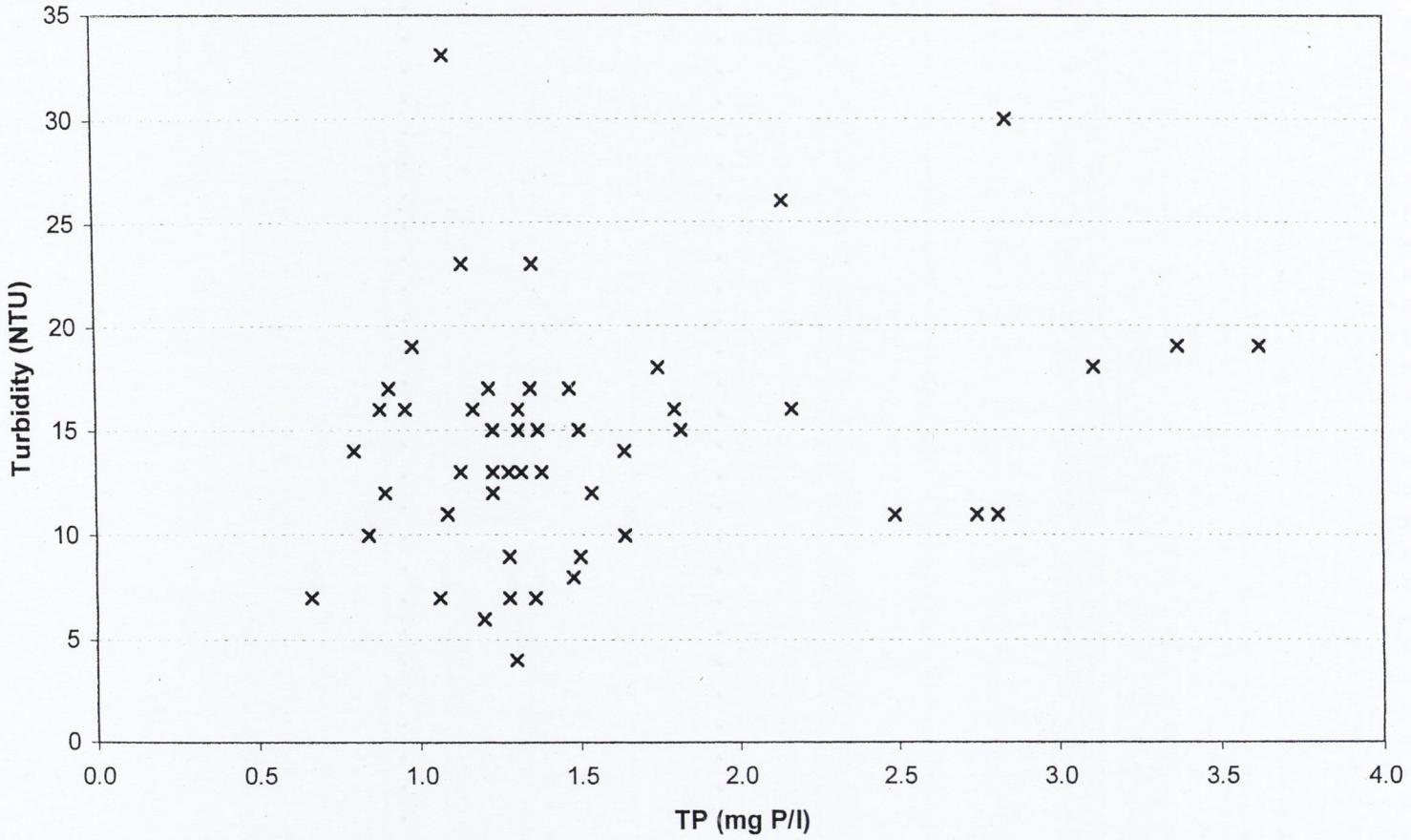


Figure 5.13: Turbidity (NTU (Nephelometer turbidity units)) plotted against TP (mg P/l) levels in samples from the Cowlands.

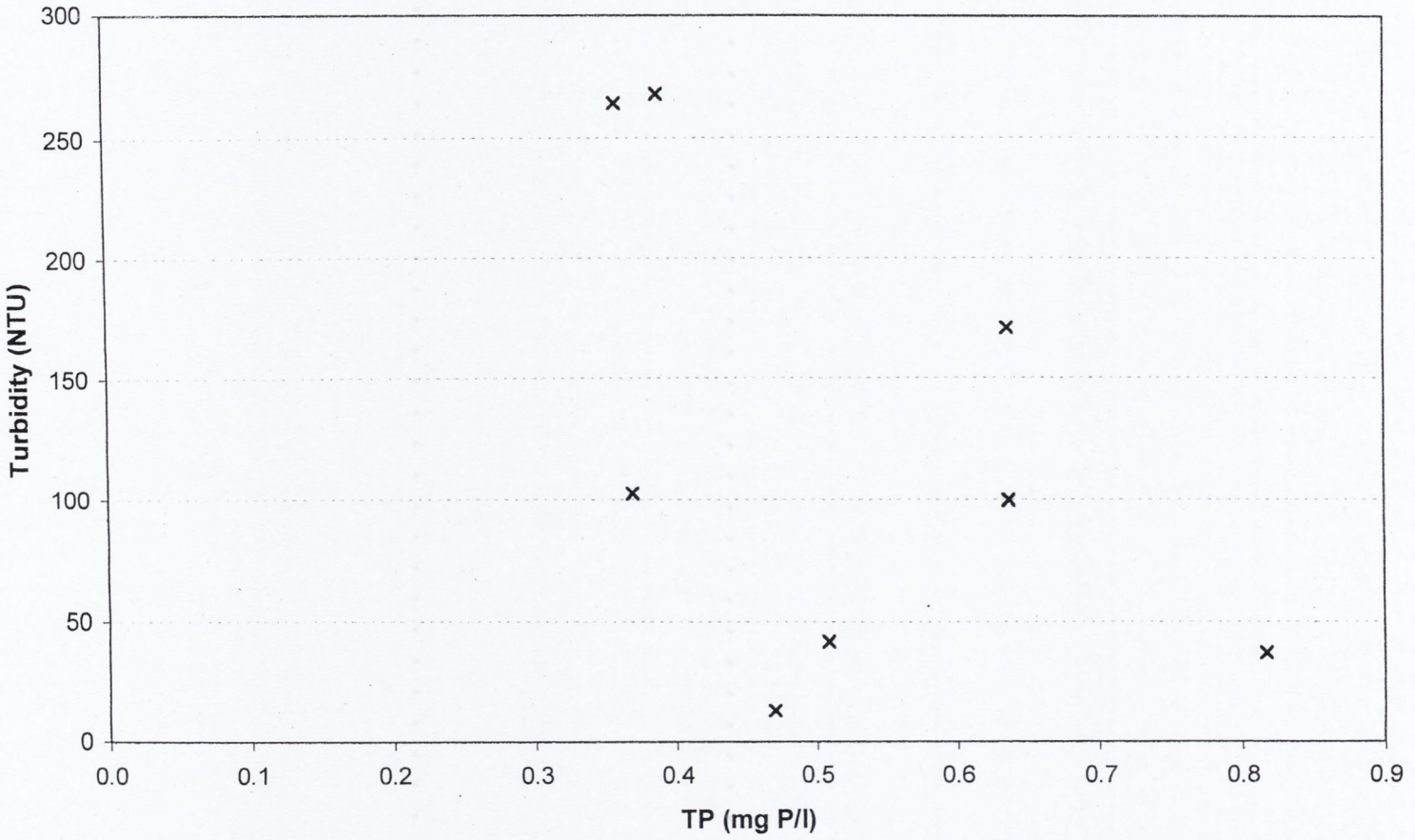


Figure 5.14: Turbidity (NTU (Nephelometer turbidity units)) plotted against TP (mg P/l) levels in samples from the upstream monitoring station at the Dairy.

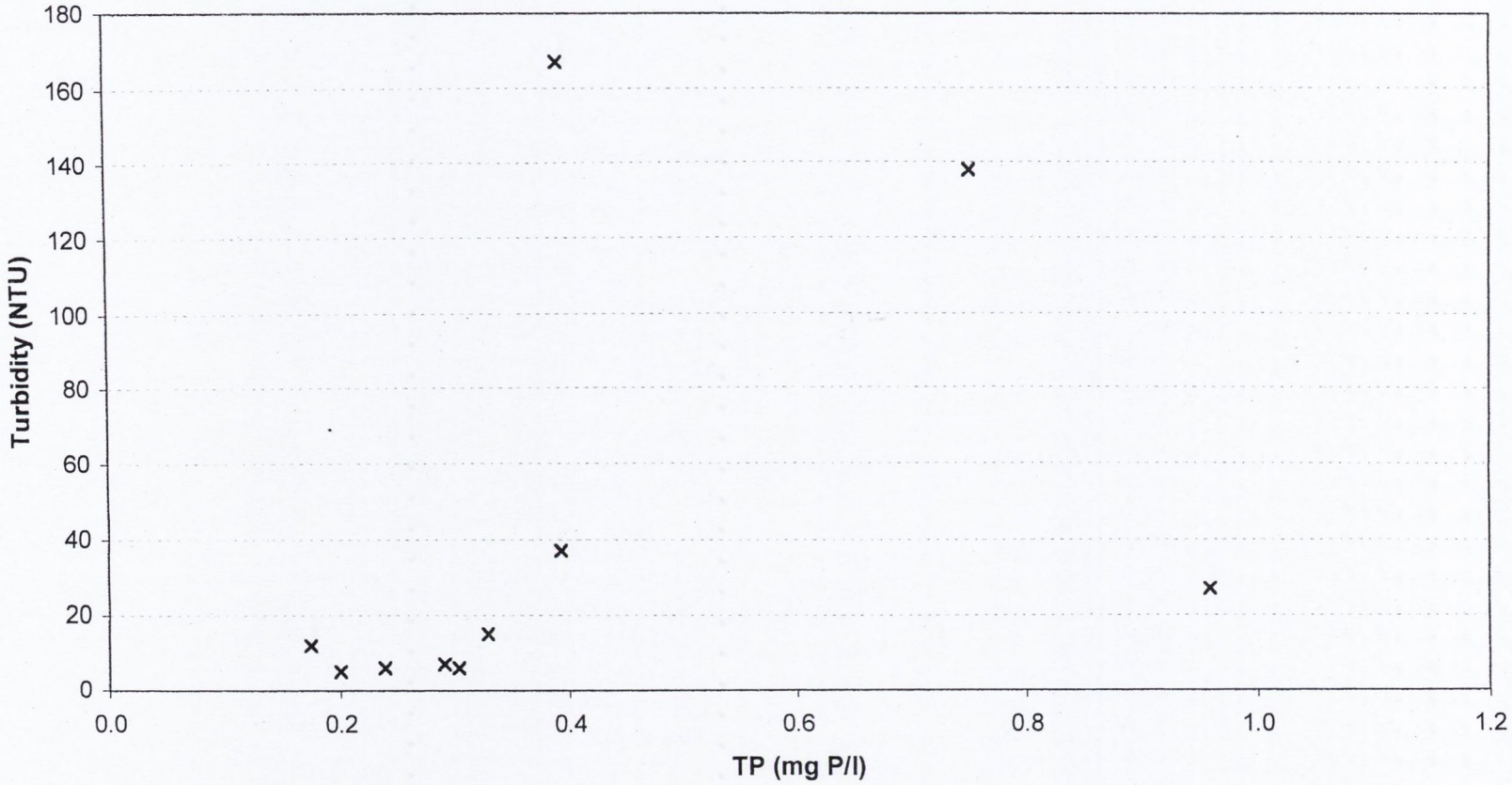


Figure 5.15: Turbidity (NTU (Nephelometer turbidity units)) plotted against TP levels (mg P/l) in samples from the downstream monitoring station at the Dairy.

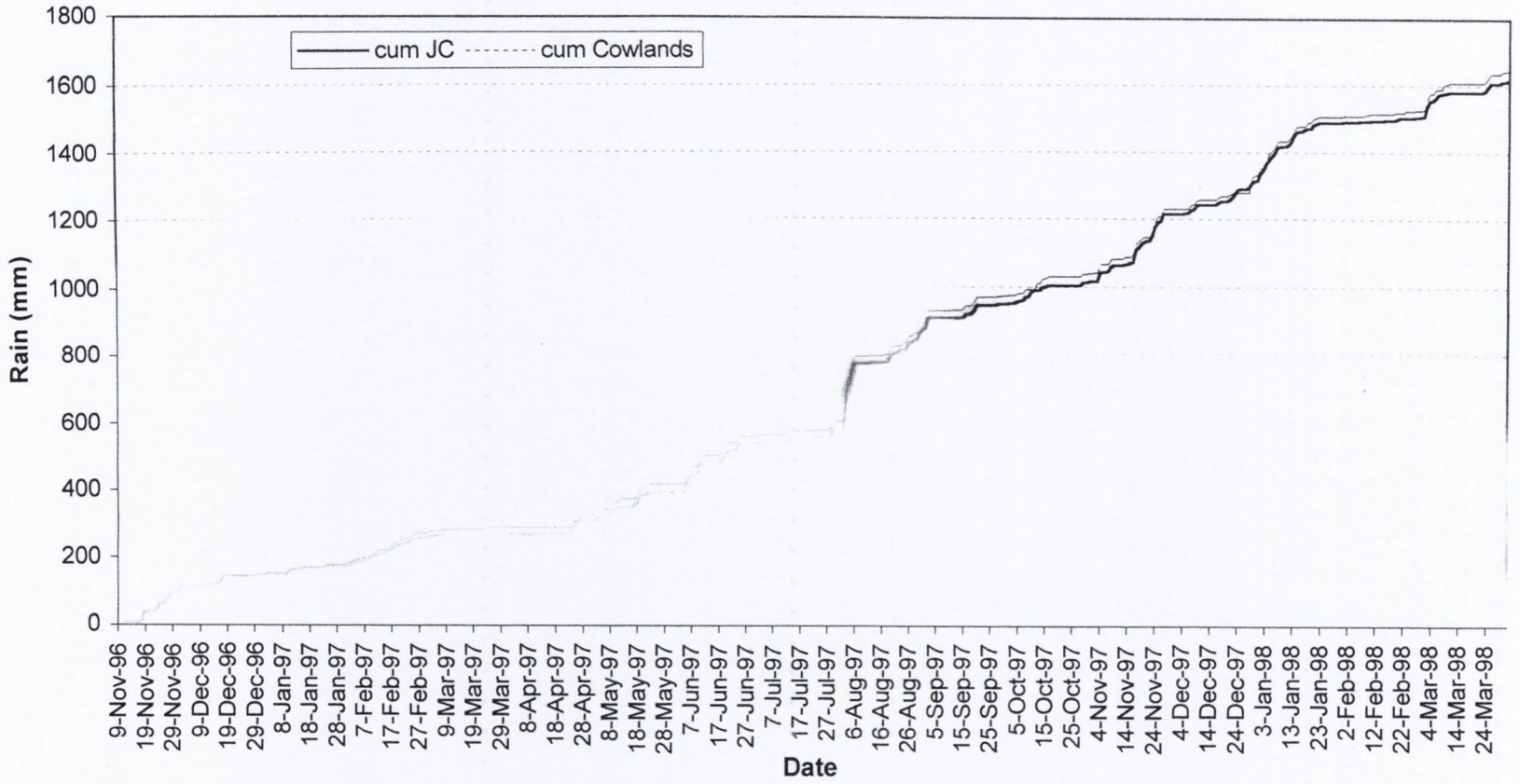


Figure 6.1: Cumulative rainfall (mm) at the Johnstown Castle meteorological station and the Cowlands.

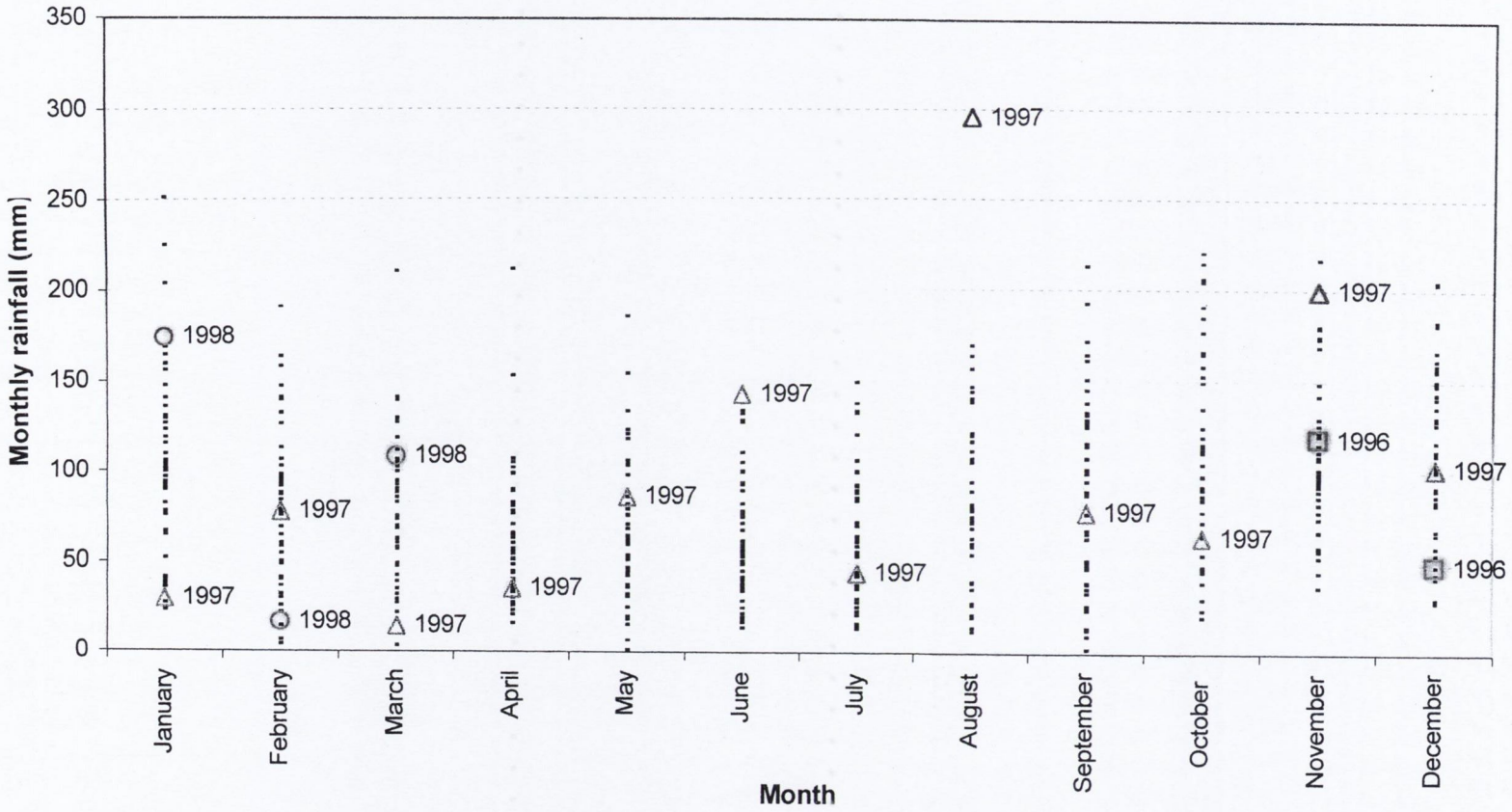


Figure 6.2: Monthly rainfall (mm) at Johnstown Castle meteorological station from January 1950 to March 1998. Values measured during the study period are indicated by red squares for 1996 (November, December), by green triangles for 1997 and by violet circles for 1998 (January, February and March).

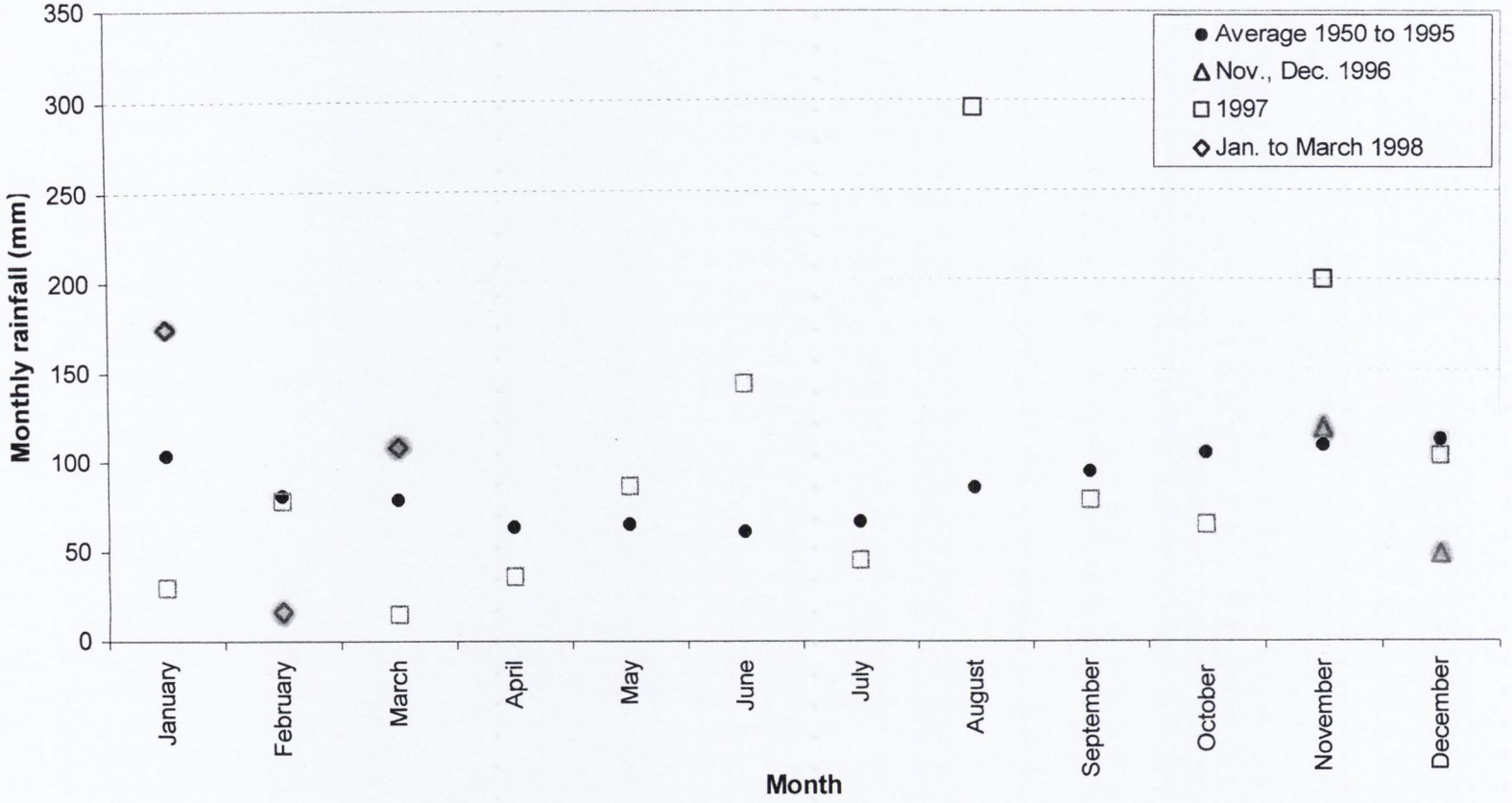


Figure 6.3: Comparison of average monthly rainfall from 1950 to 1995 and the monthly rainfall November 1996 to March 1997.

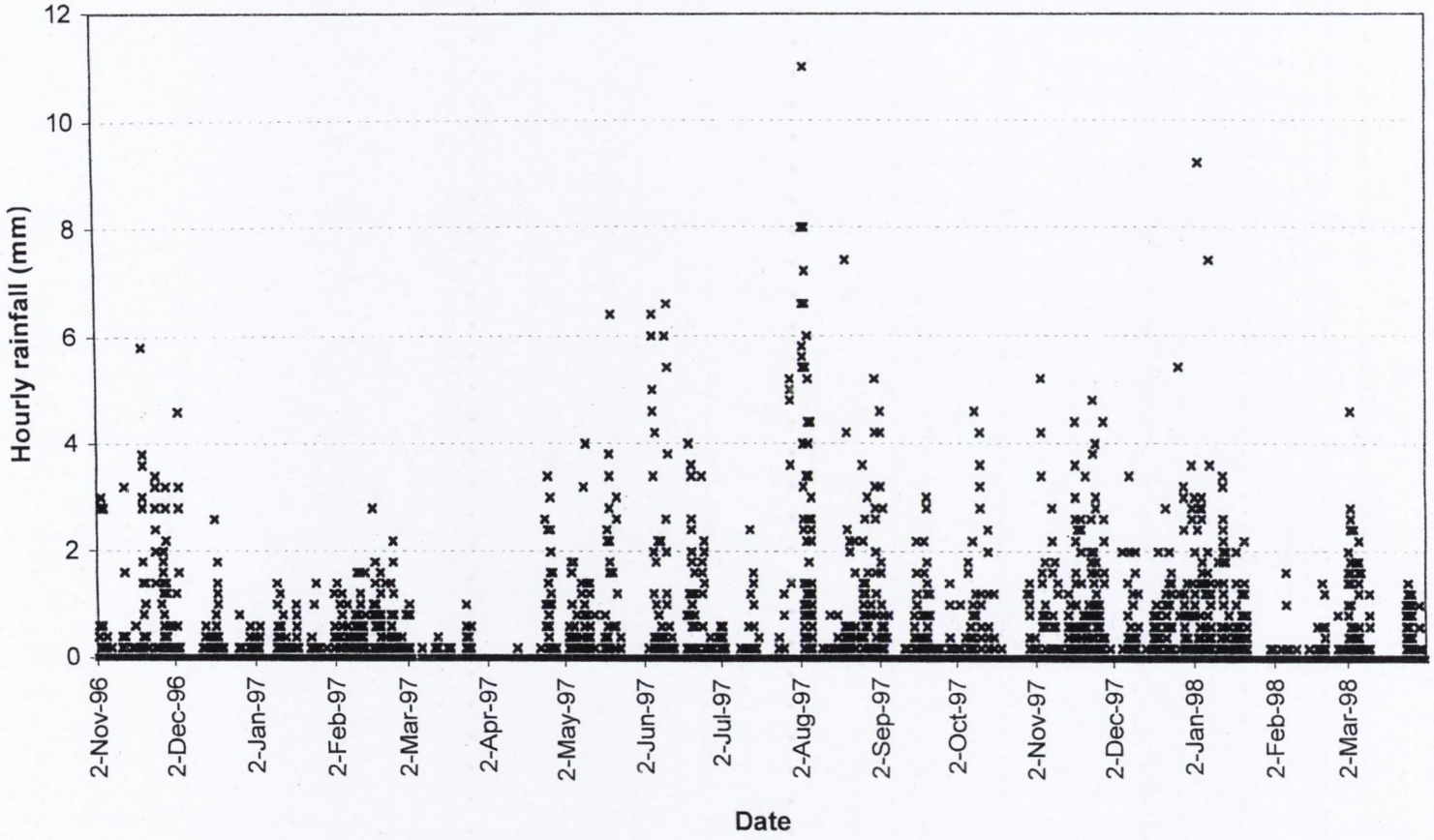


Figure 6.4: Estimates of hourly rainfall (mm) values at Johnstown Castle meteorological station (automatic rain gauge).

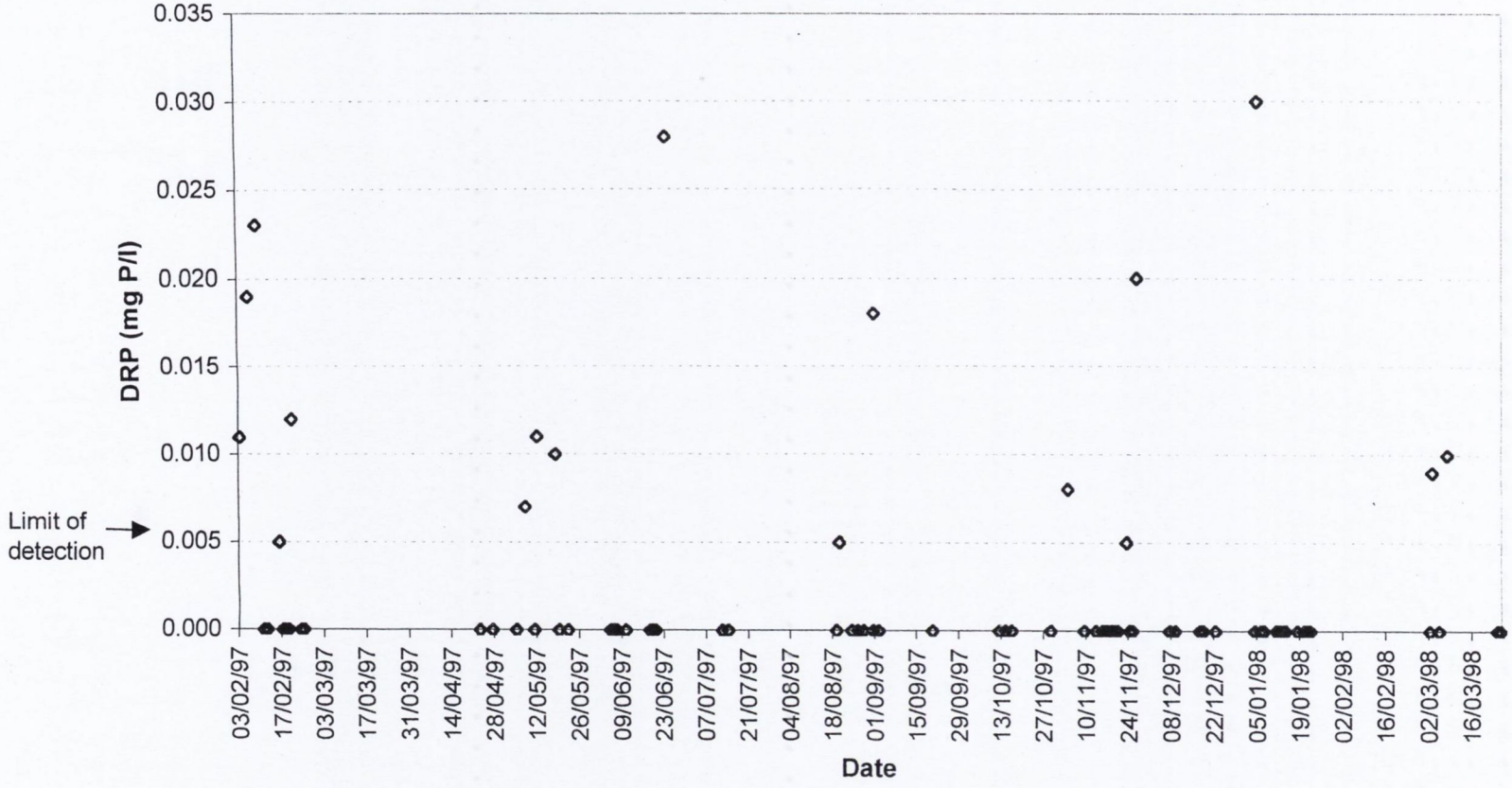


Figure 6.5: DRP concentrations (mg P/l) in rainwater collected at the Cowlands. (Note that samples below the limit of detection were plotted as zero.)

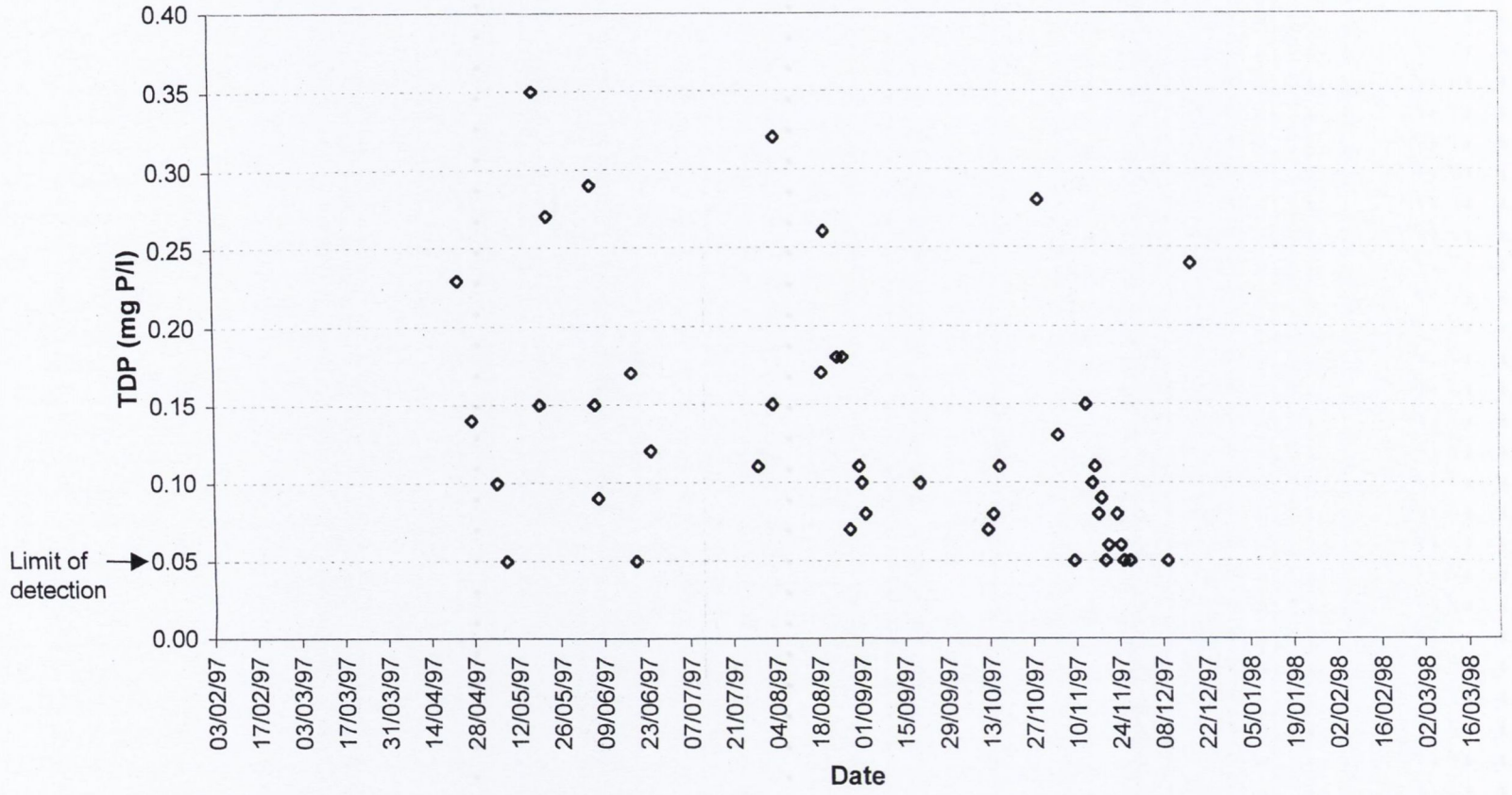


Figure 6.6: TDP concentrations (mg P/l) in rainwater collected at the Cowlands. (Note that samples below the limit of detection were omitted.)

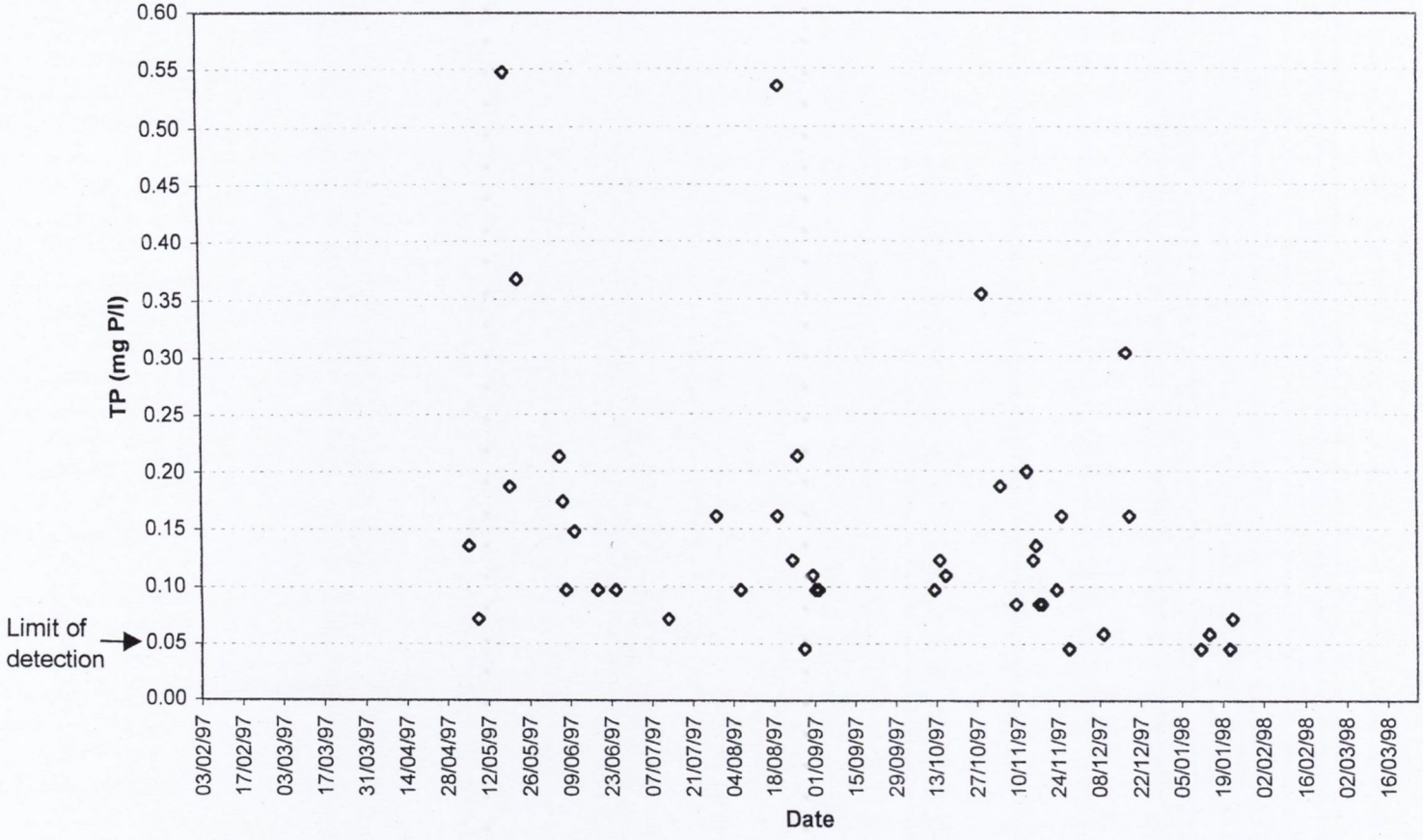


Figure 6.7: TP concentrations (mg P/l) in rainwater collected at the Cowlands. (Note that samples below the limit of detection were omitted.)

Figure 7.1: Site Map of the Warren 1 (adapted from Ryan, 1998)

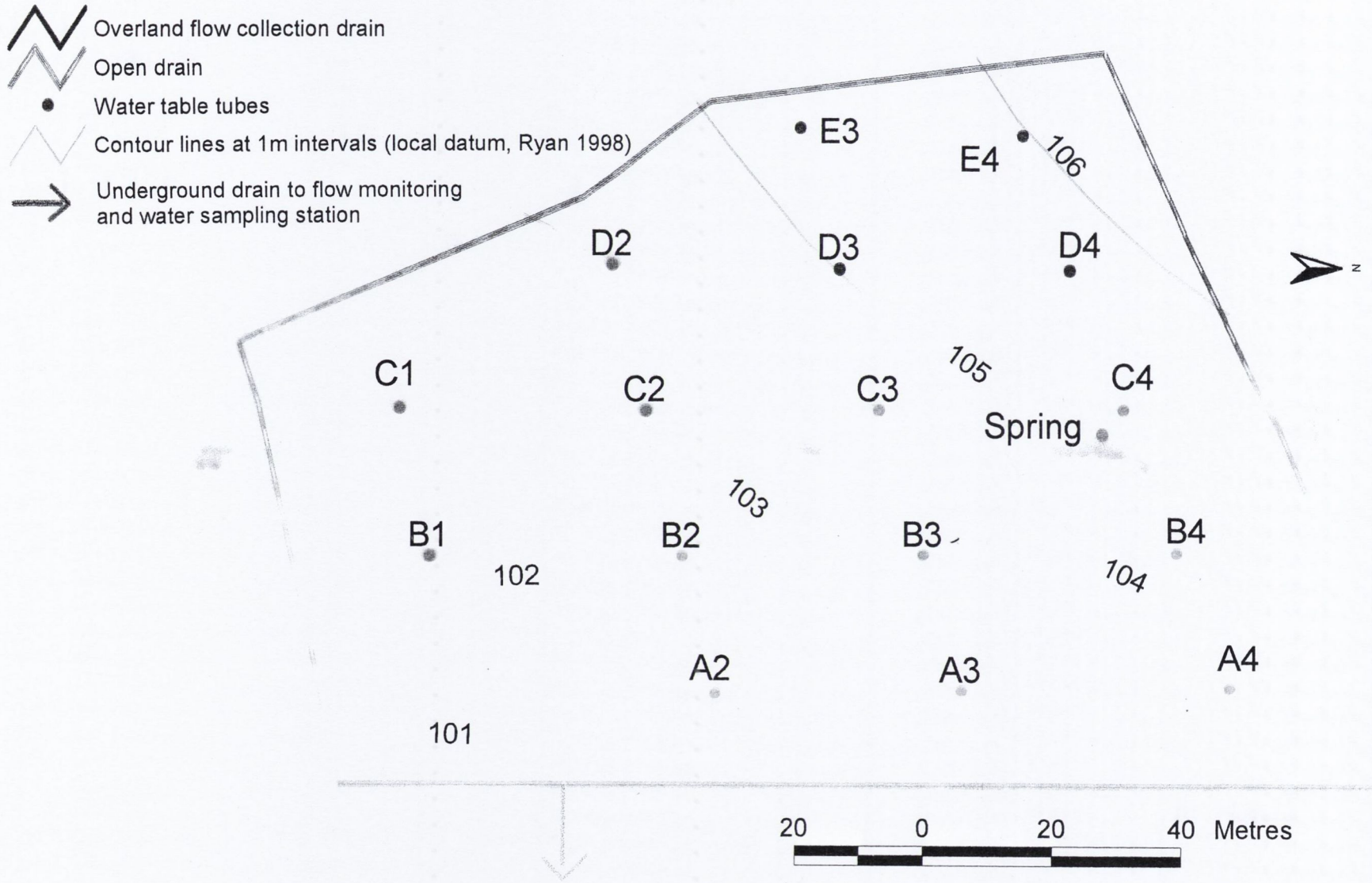


Figure 7.2 Site Map of the Cowlands (adapted from Ryan 1998)

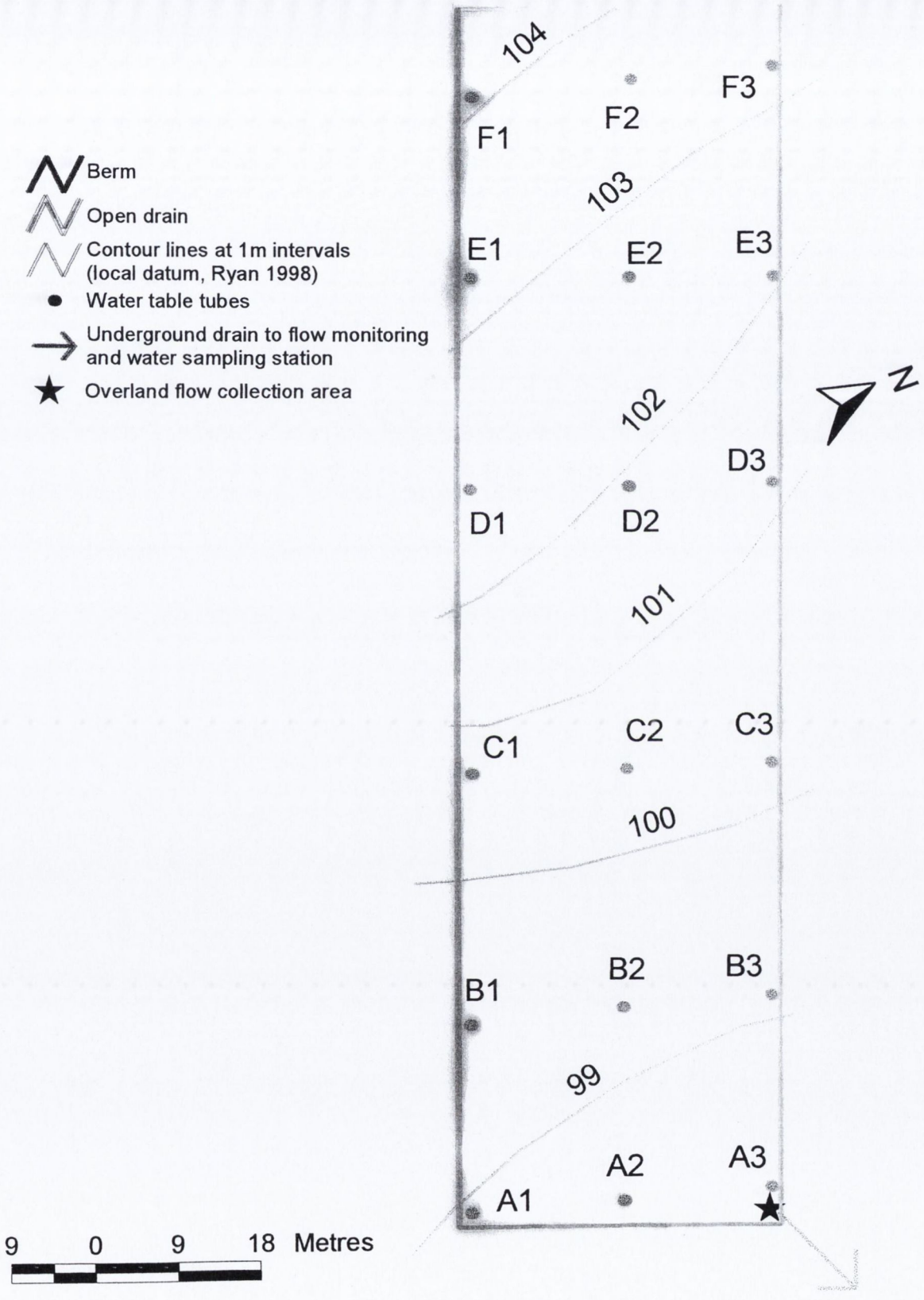
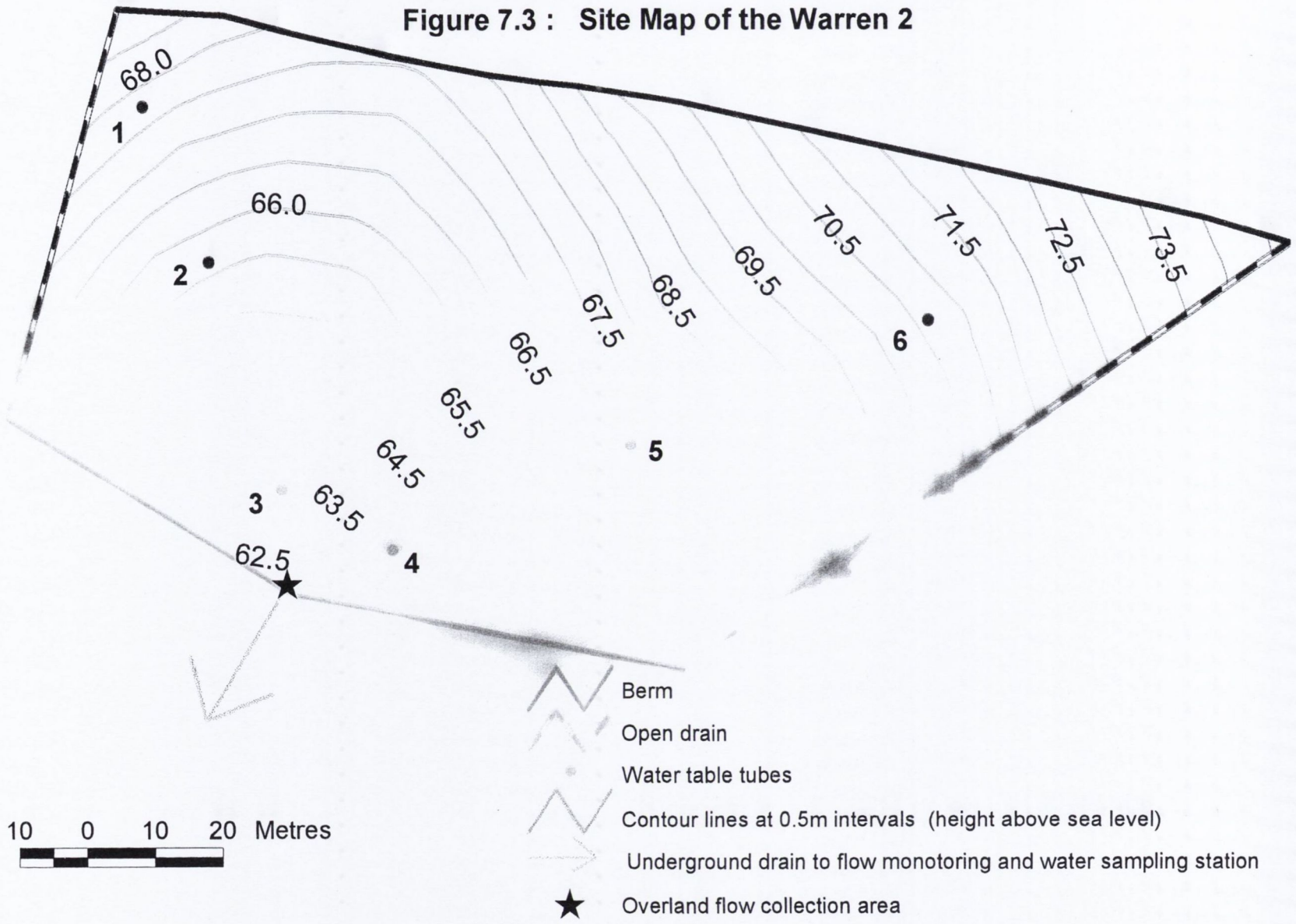


Figure 7.3 : Site Map of the Warren 2



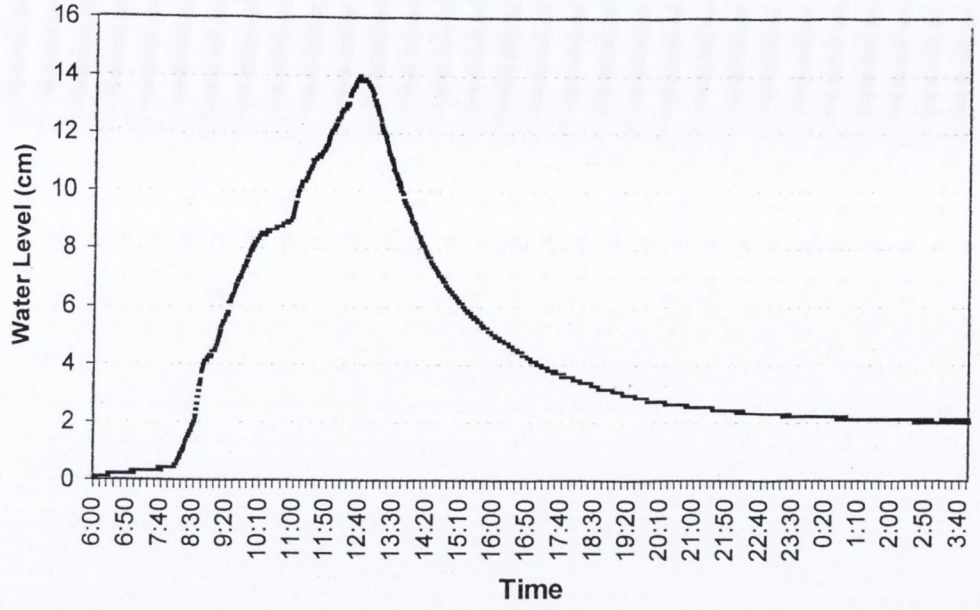


Figure 7.4: One minute logging interval at the Cowlands

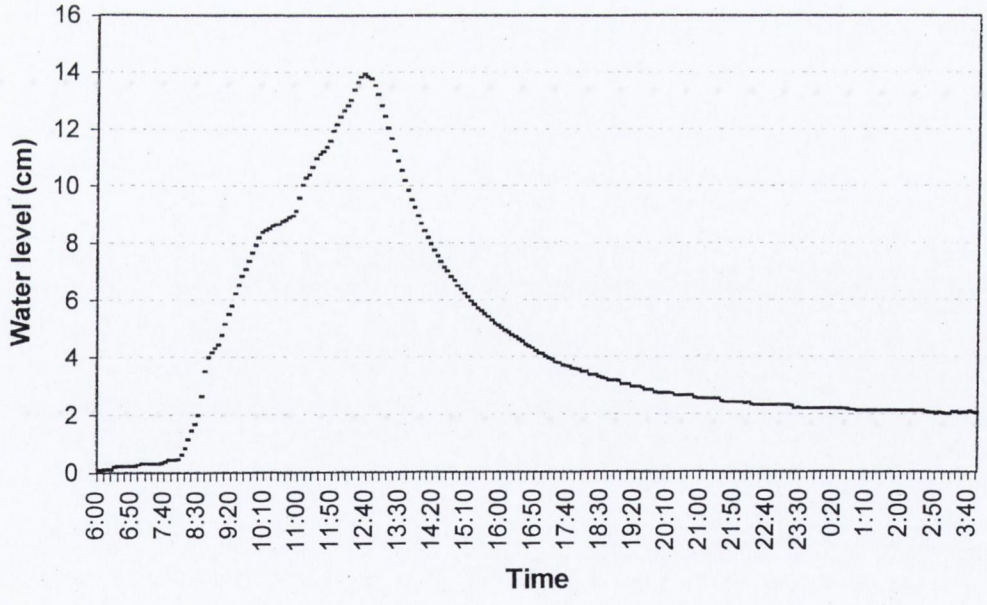


Figure 7.5: Five minutes logging interval at the Cowlands.

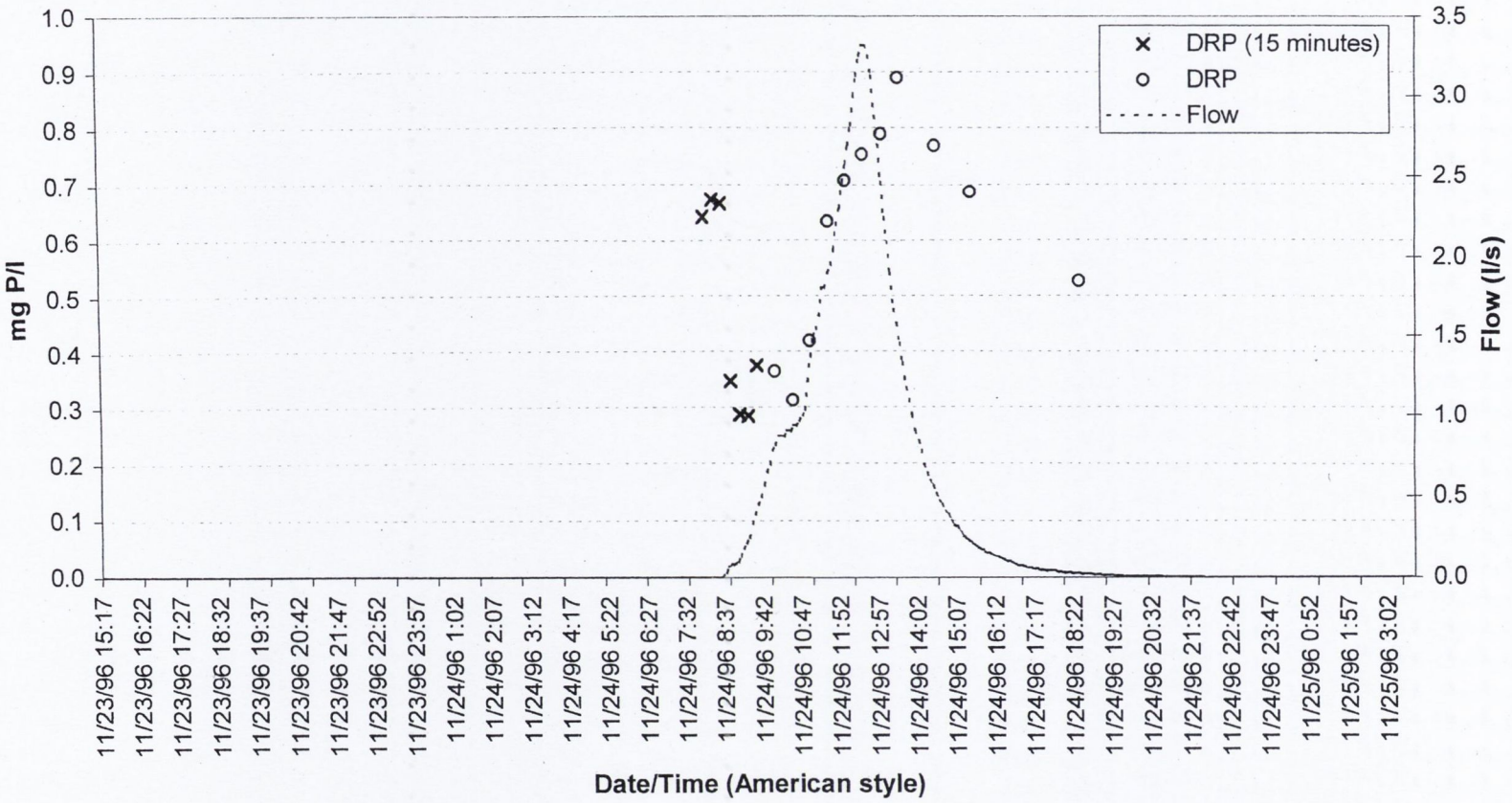


Figure 7.6: Overland flow (l/s) and DRP (mg P/l) concentrations of samples taken at 15 minute (crosses) and longer (circles) (30 minute to 8 hour) intervals at the Cowlands.

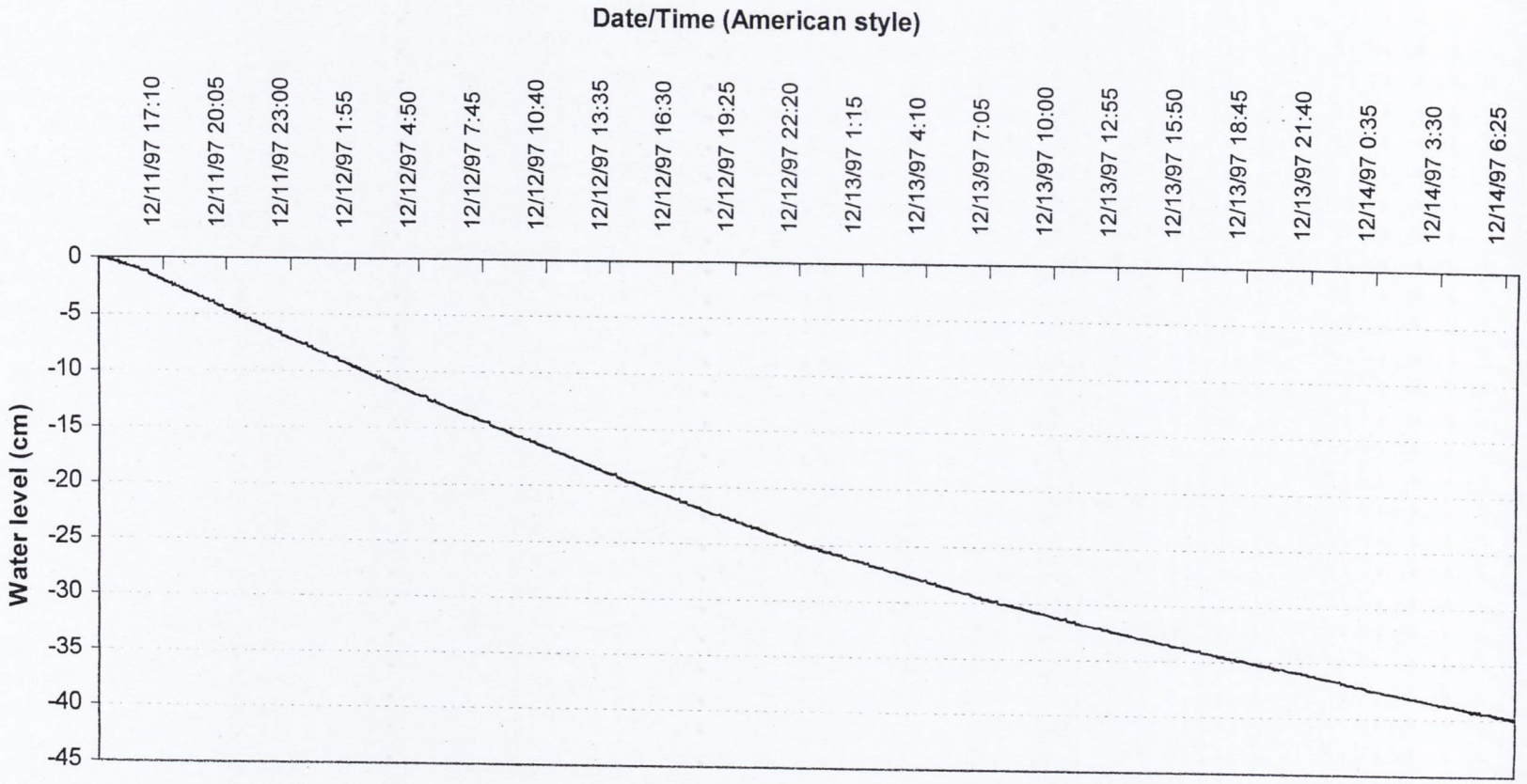


Figure 7.7: Water level in the tank below the weir crest at the end of event 18.4 at the Warren 2.

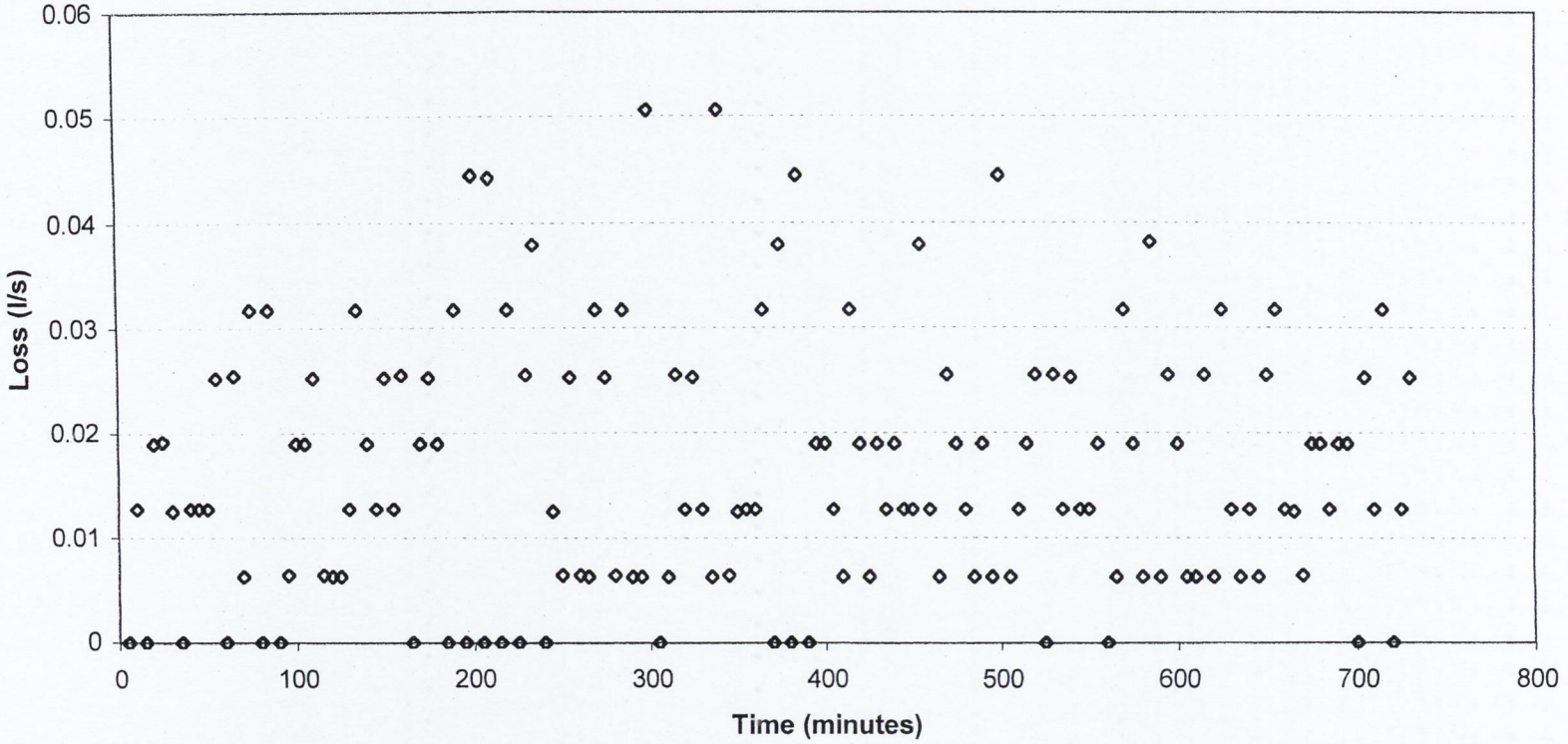


Figure 7.8: Rate of loss (l/s) at the end of event 18.4 in the weir tank at the Warren 2 plotted against time (minutes).

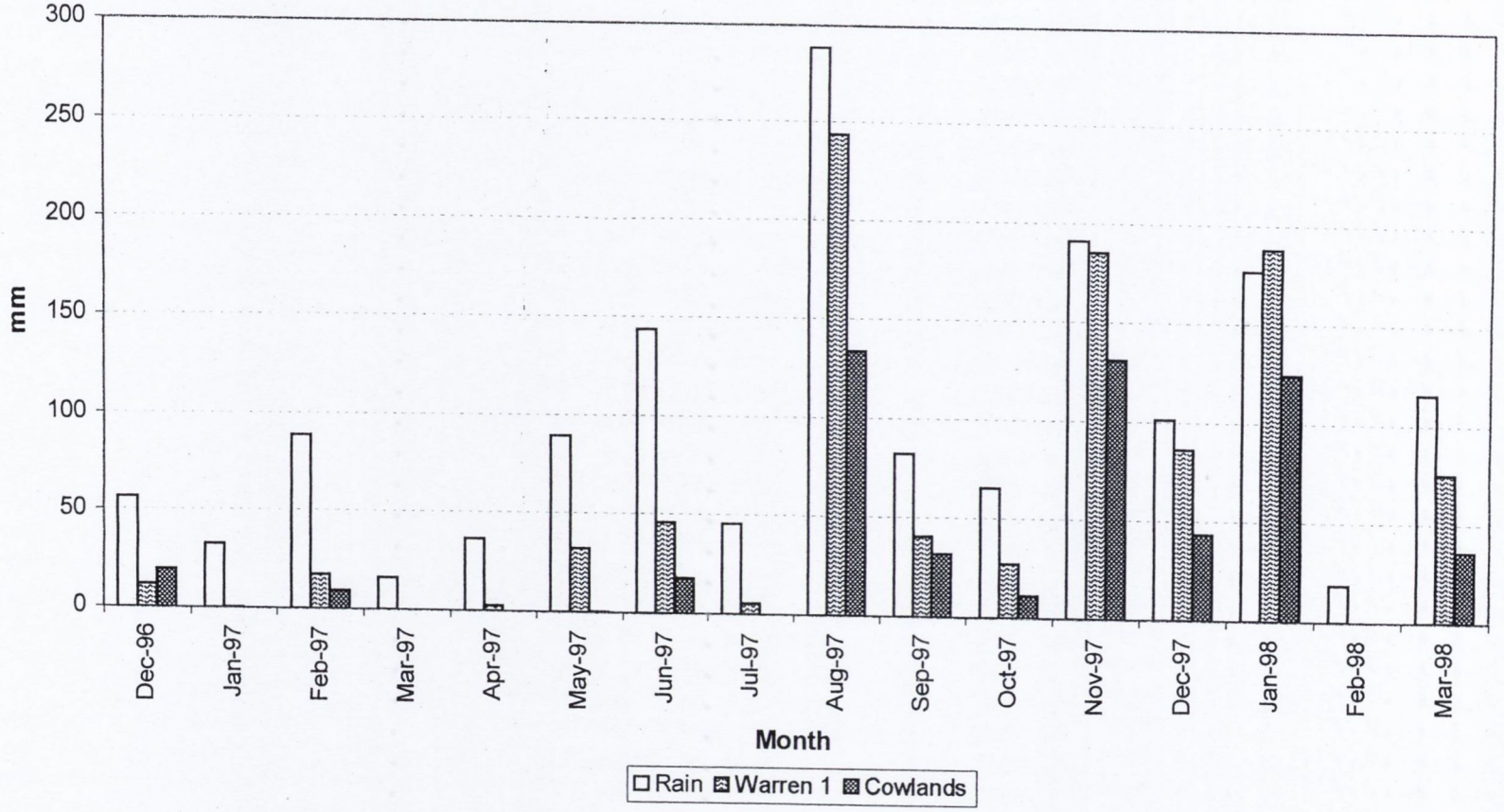


Figure 7.9: Monthly rainfall and monthly overland flow (mm) at the Warren 1 and the Cowlands.

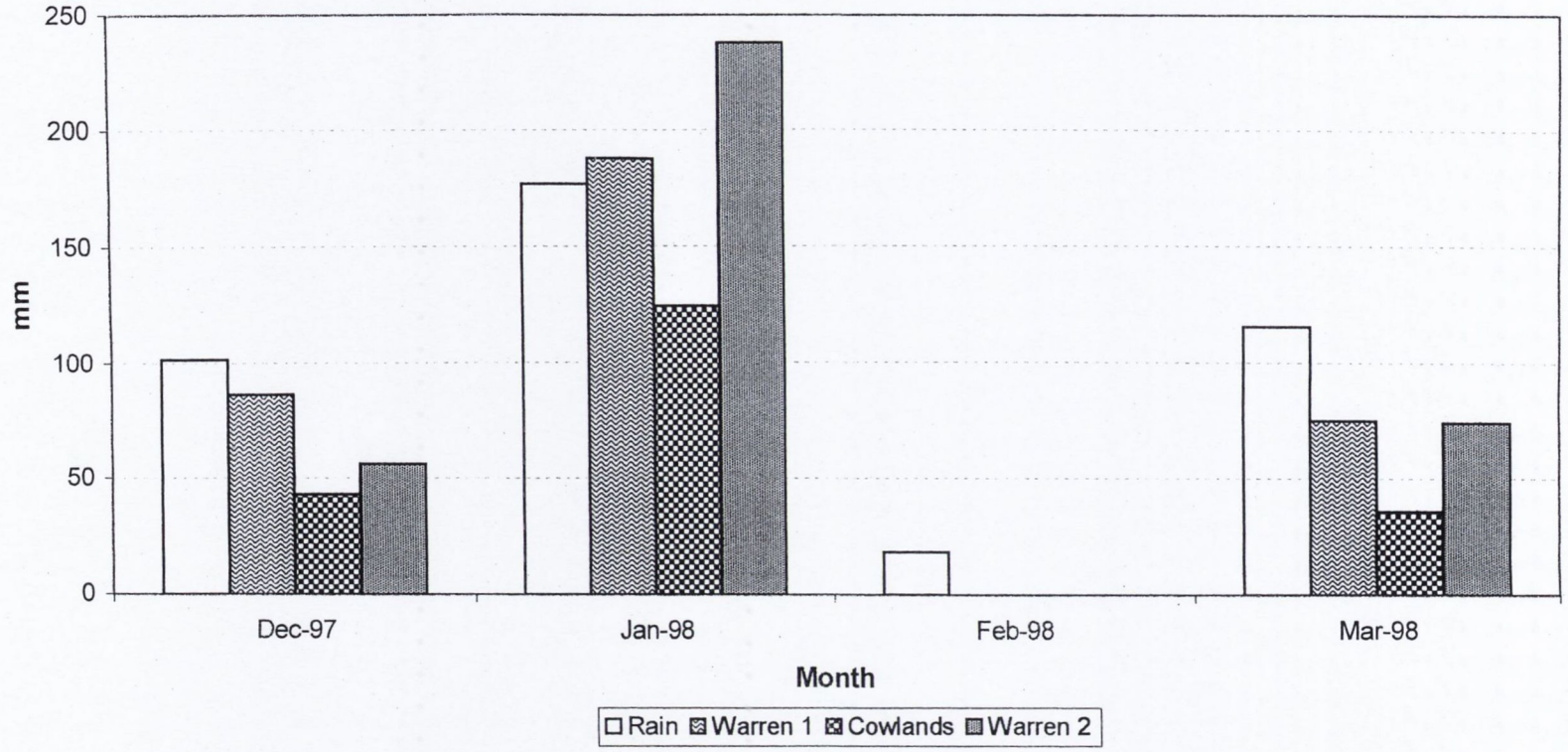


Figure 7.10: Monthly rainfall and monthly overland flow at the Warren 1, the Cowlands and the Warren 2.

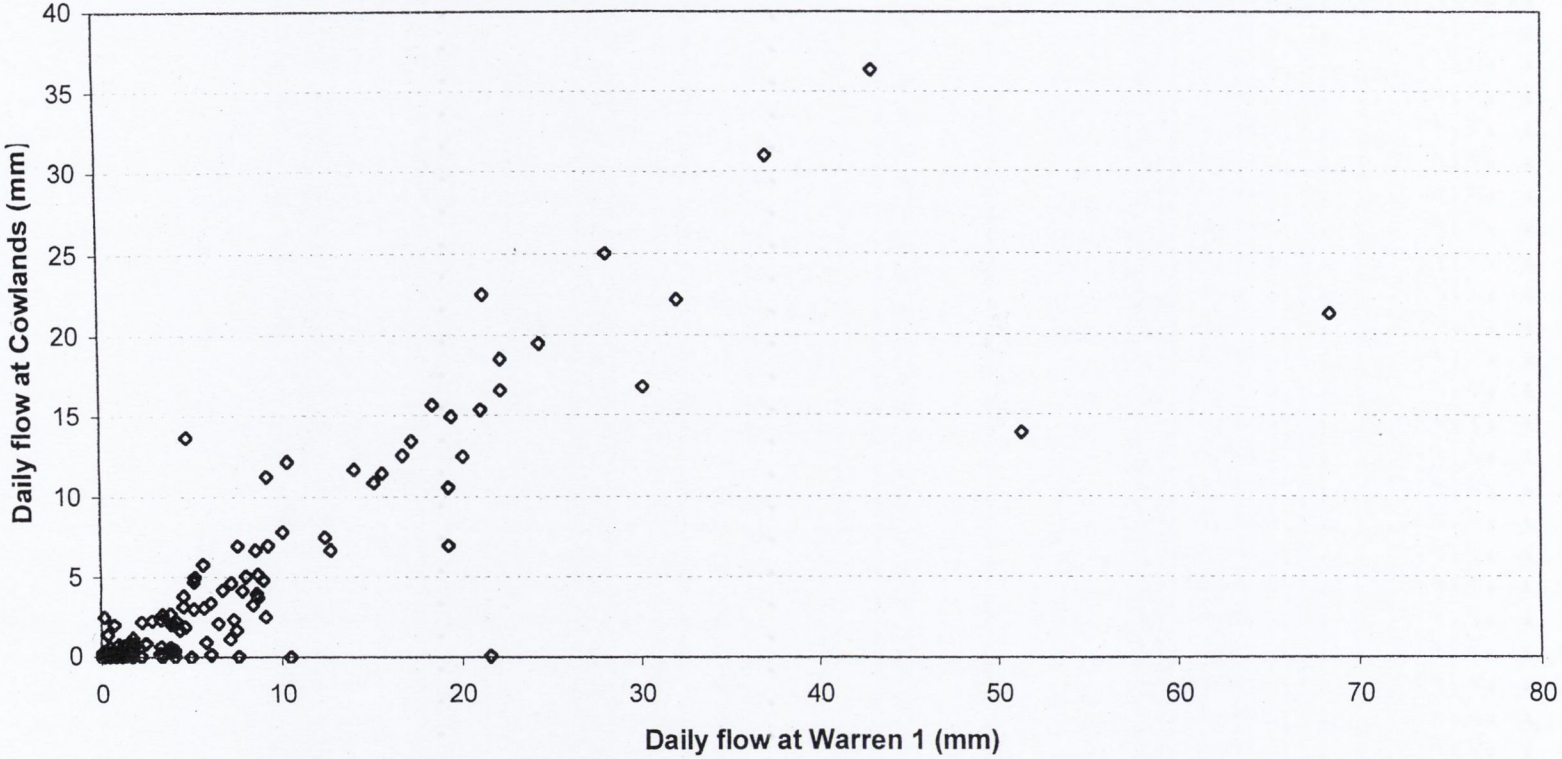


Figure 7.11: Daily overland flow at the Cowlands (mm) plotted against the daily overland flow at the Warren 1 (mm).

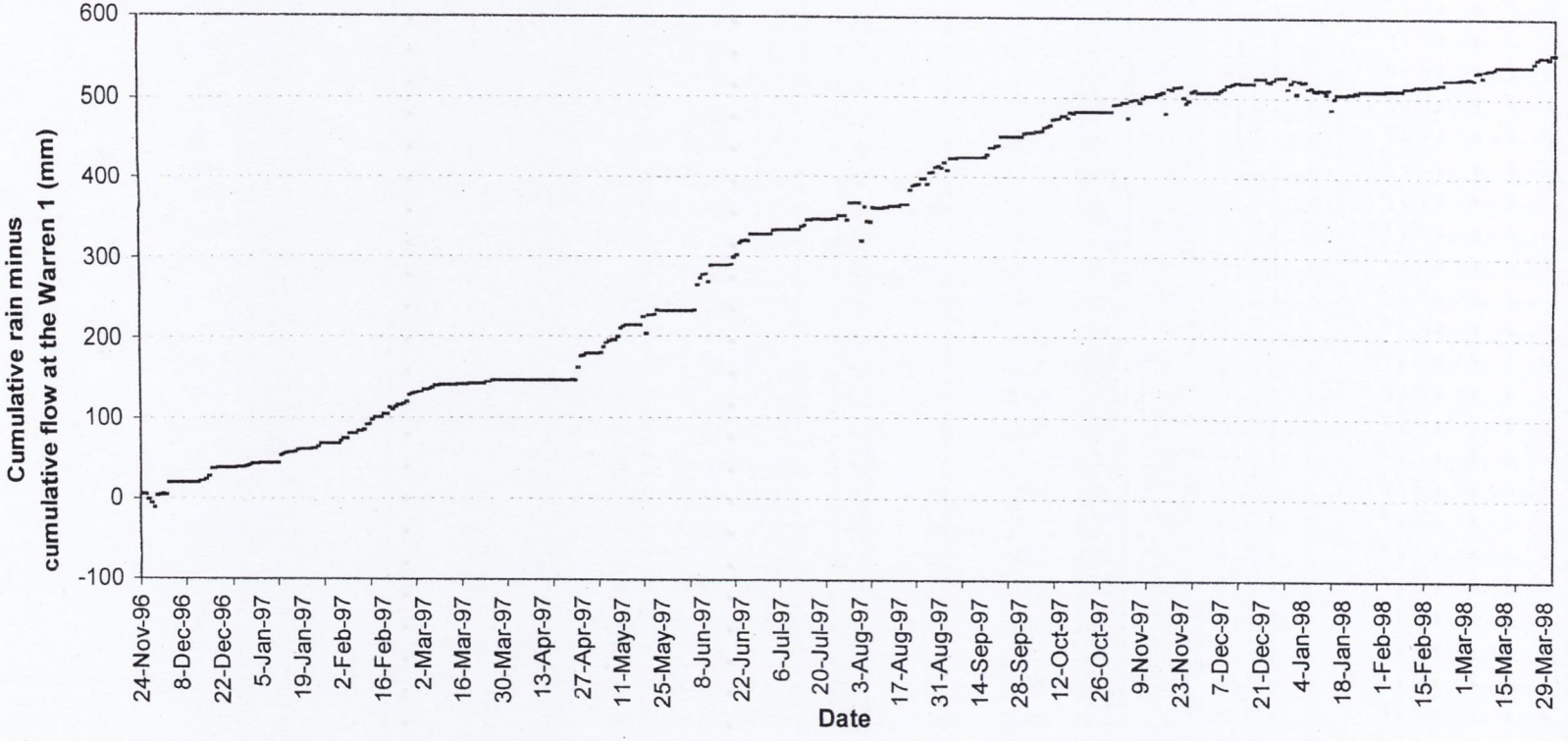


Figure 7.12: Cumulative differences between cumulative rainfall and cumulative flow (mm) at the Warren 1.

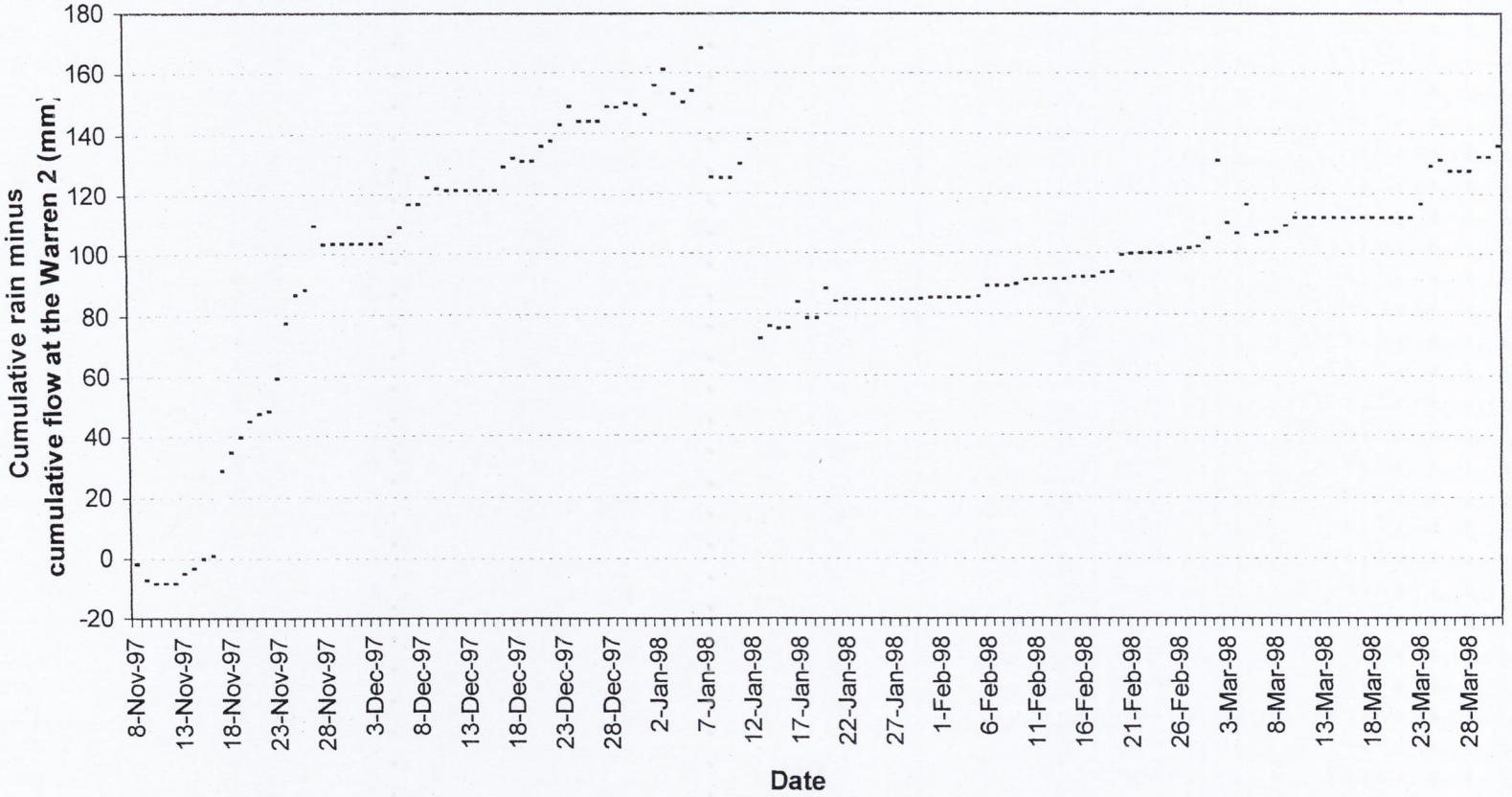


Figure 7.13: Cumulative differences between cumulative rainfall and cumulative flow (mm) at the Warren 2.

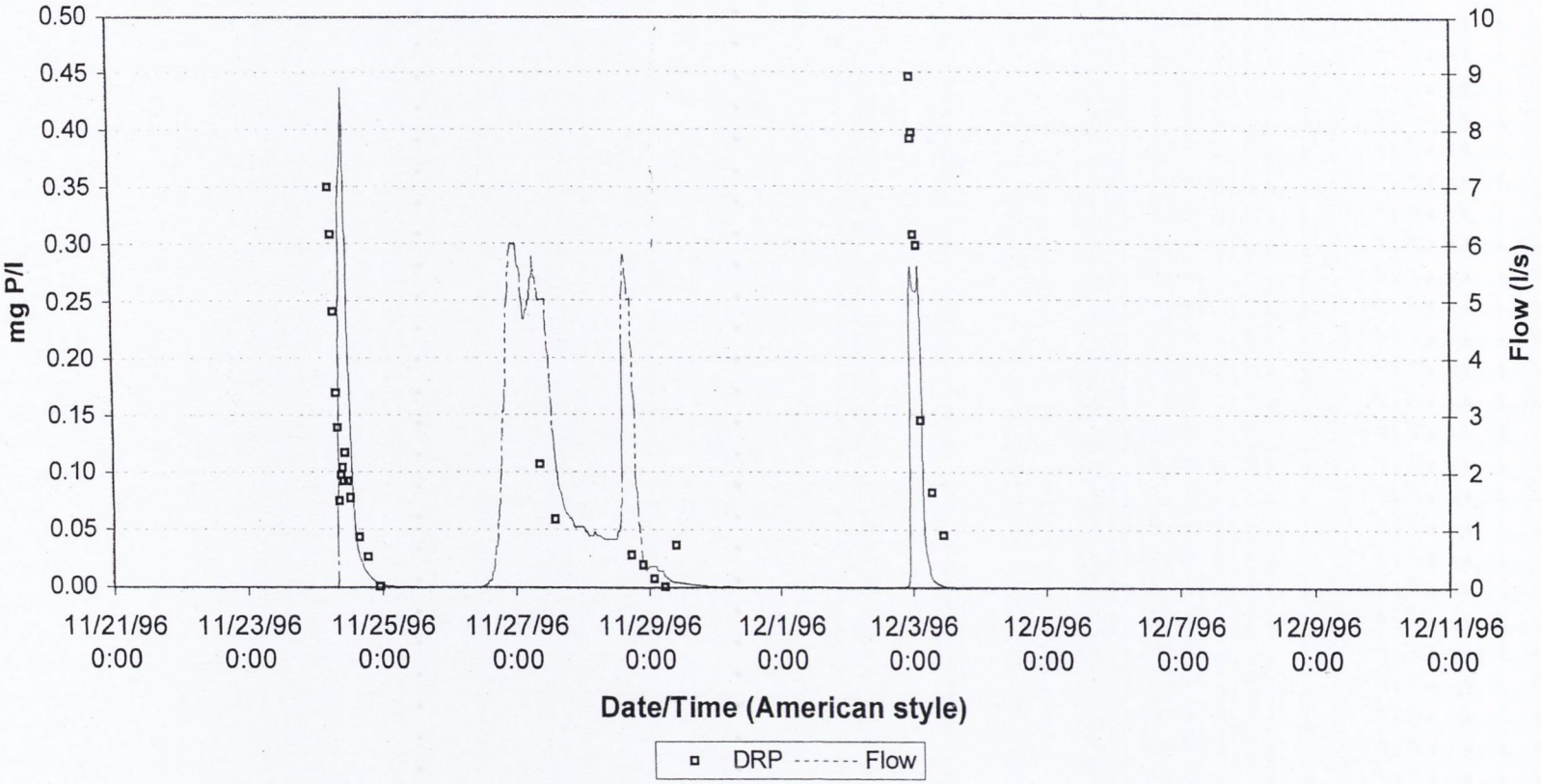


Figure 7.14: Overland flow (l/s) and DRP (mg P/l) concentrations for event 1 at the Warren 1.

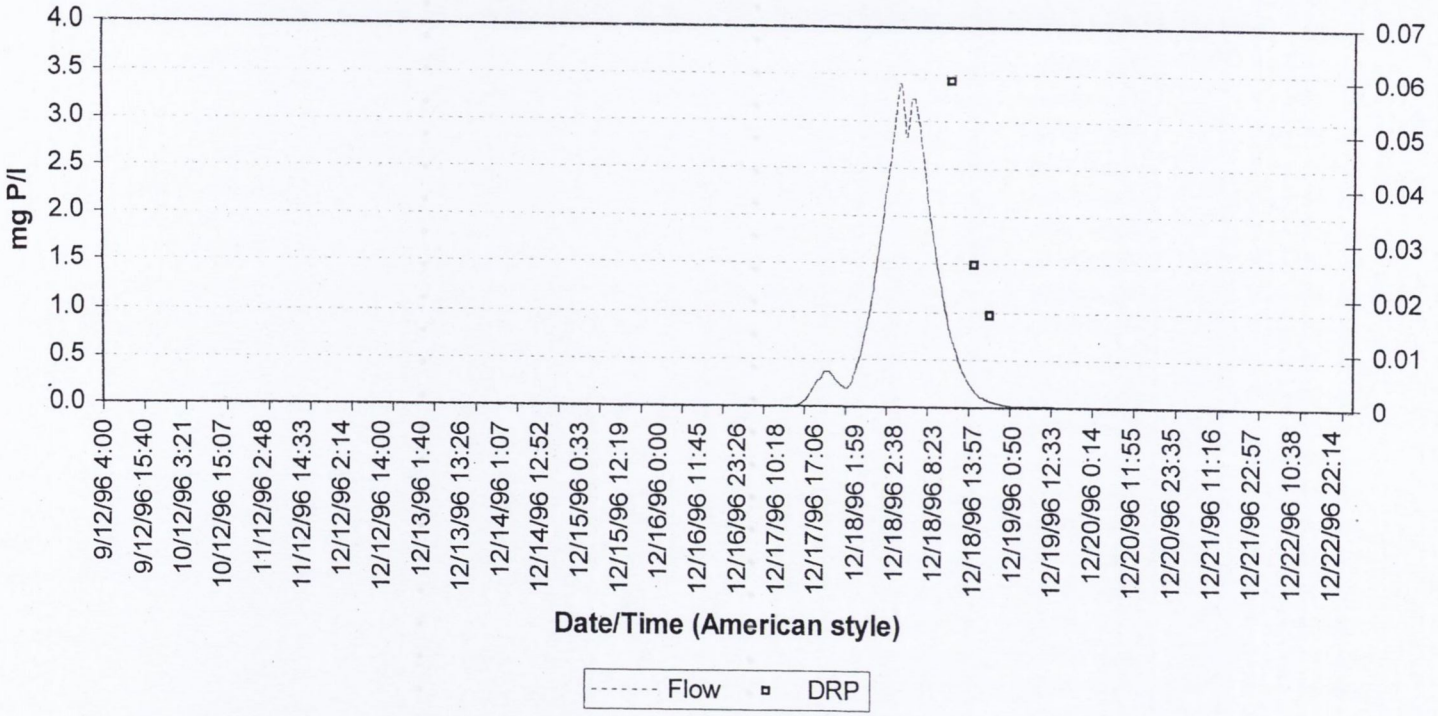


Figure 7.15: Overland flow (l/s) and DRP (mg P/l) concentrations for event 2 at the Warren 1.

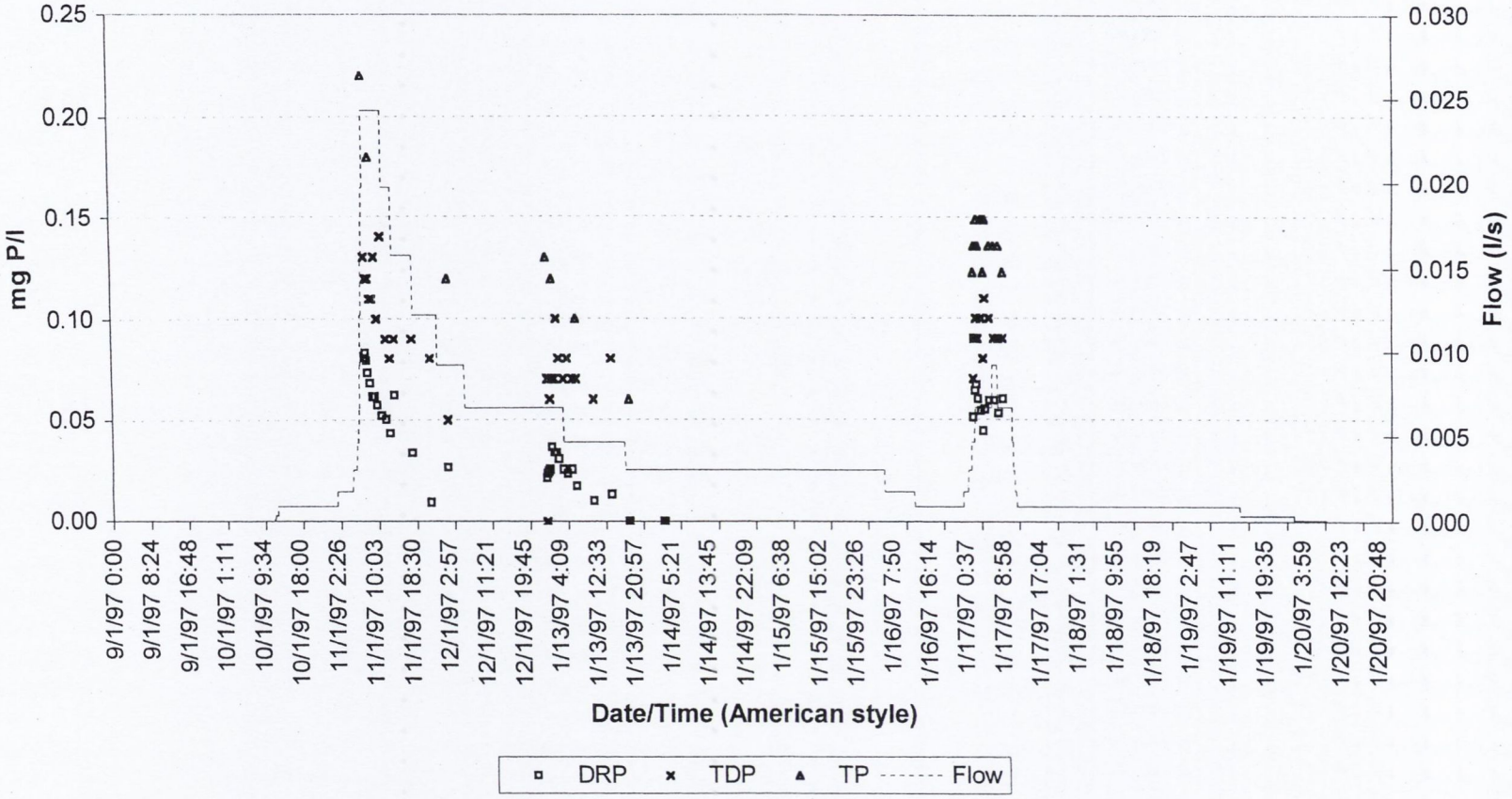


Figure 7.16: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 3 at the Warren 1.

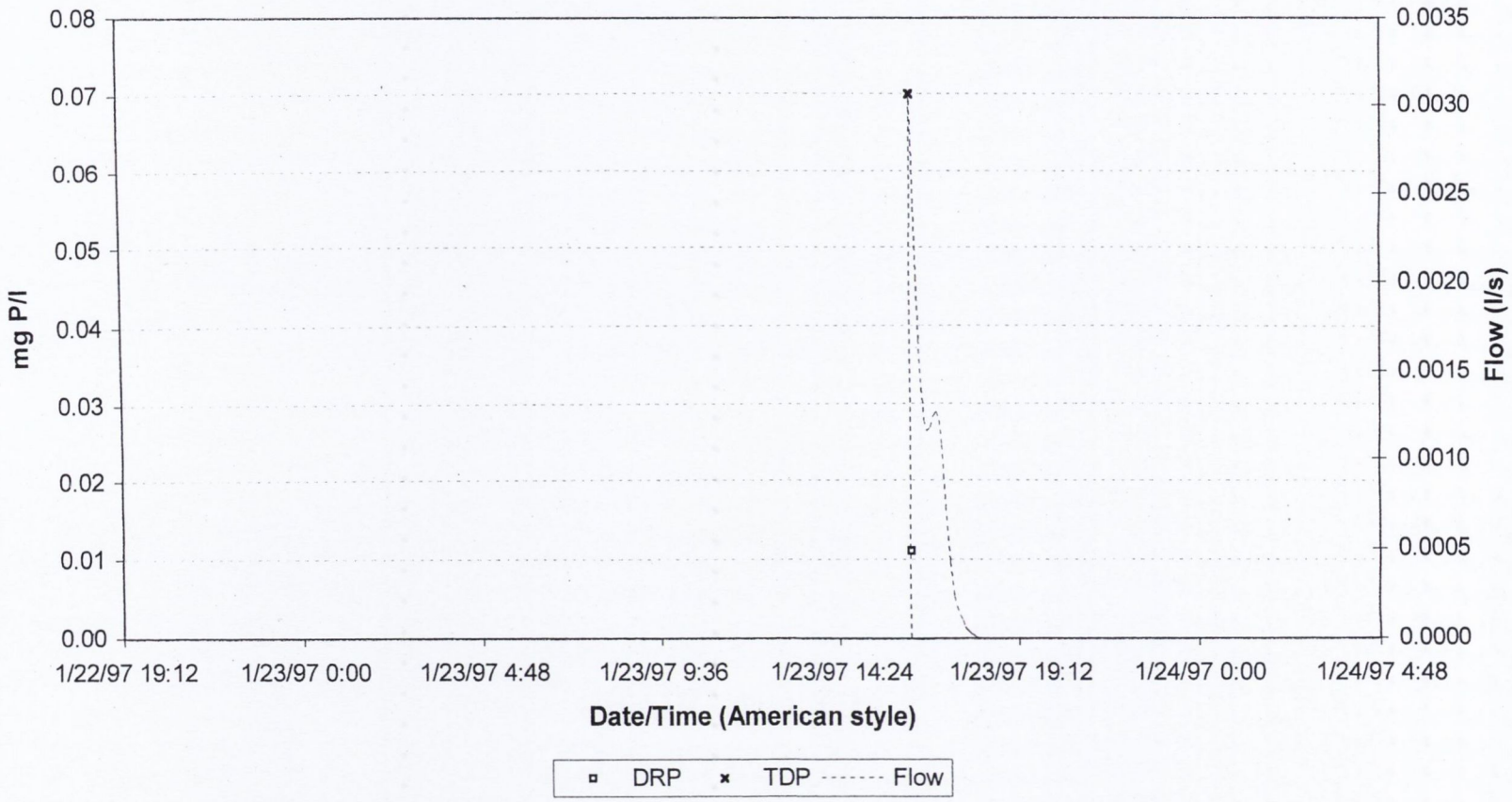


Figure 7.17: Overland flow (l/s) and DRP (mg P/l) and TDP (mg P/l) concentrations for event 4 at the Warren 1.

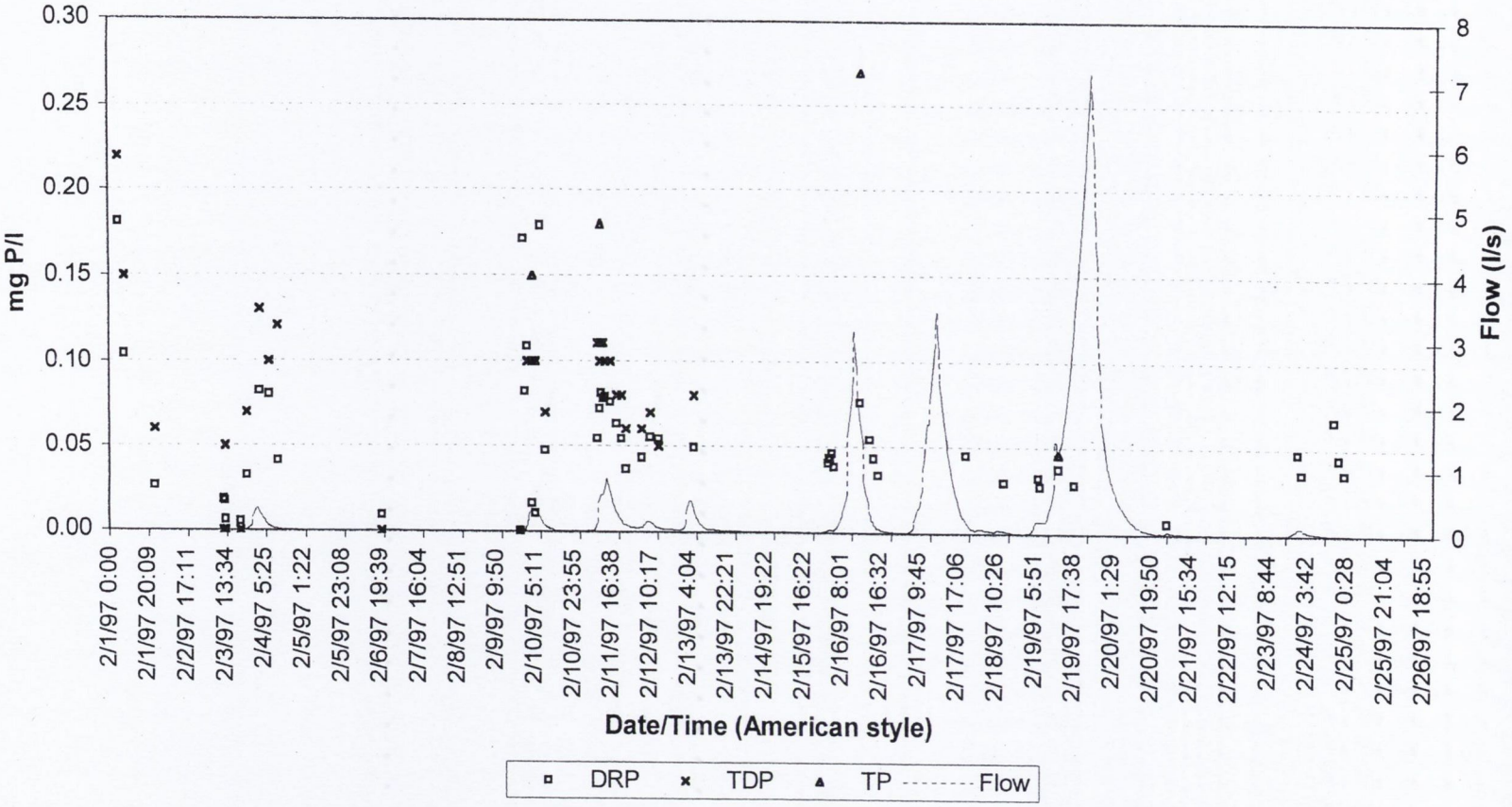


Figure 7.18: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 5 at the Warren 1.

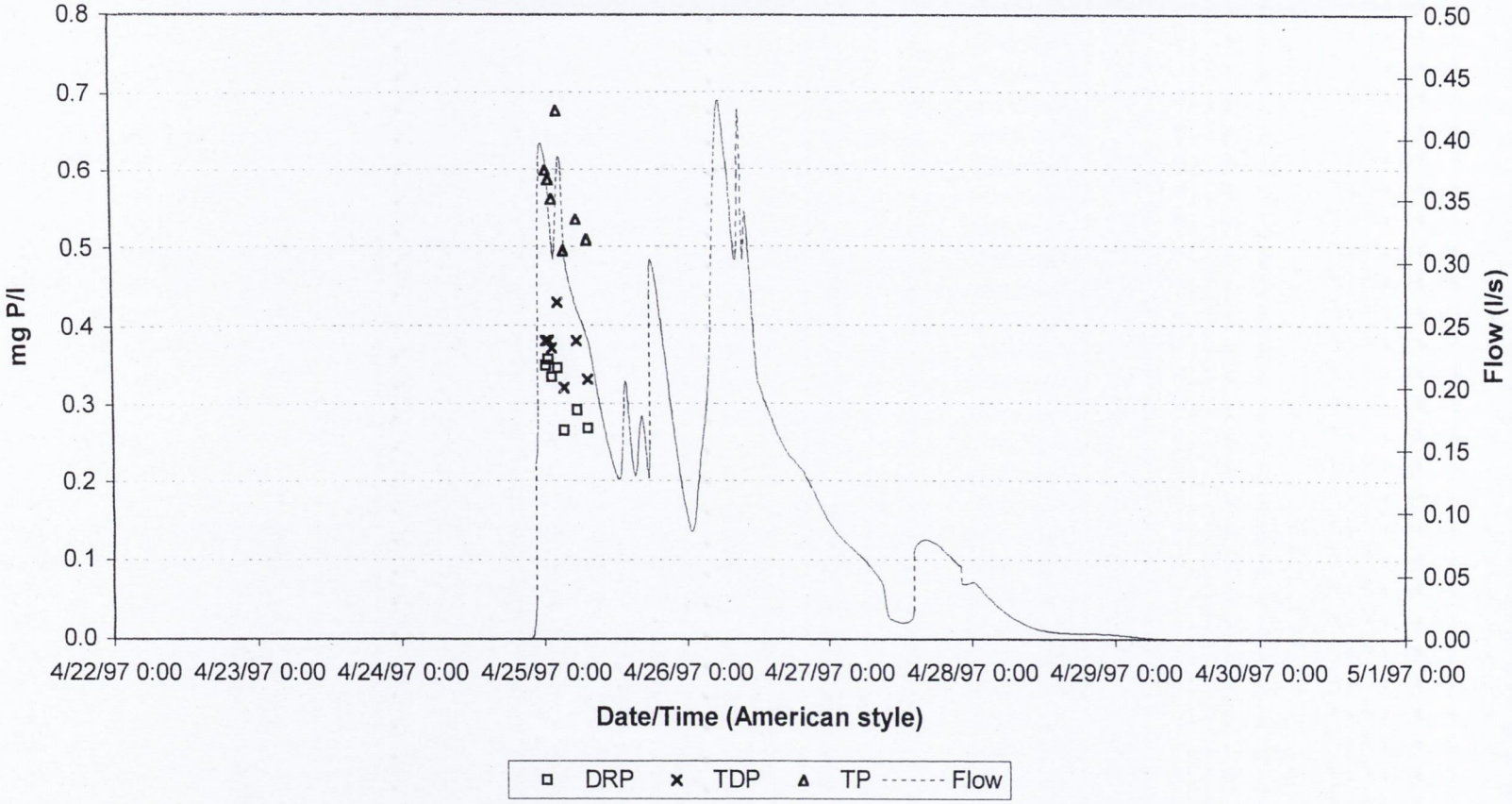


Figure 7.19: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 6 at the Warren 1.

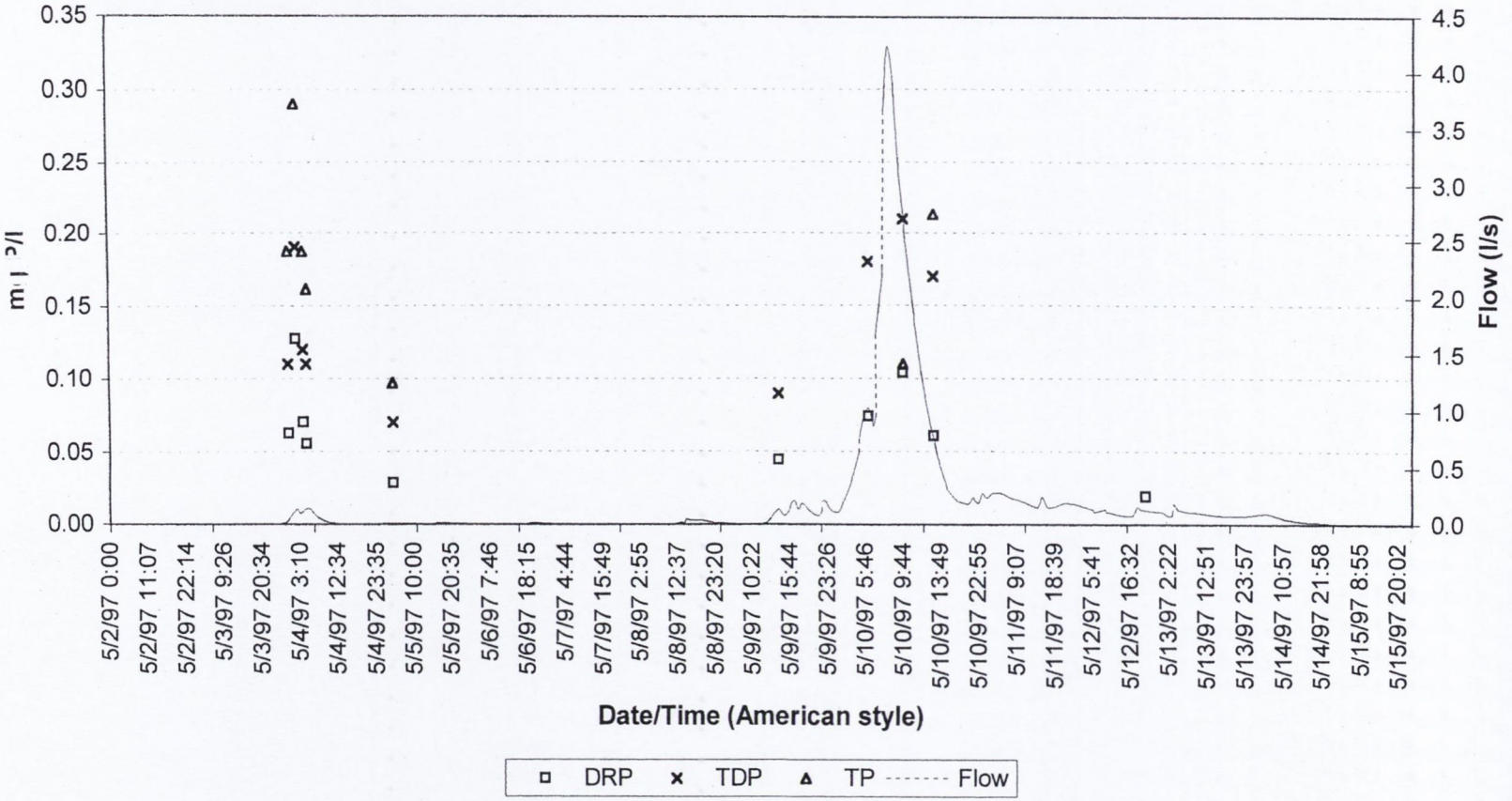


Figure 7.20: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 7 at the Warren 1.

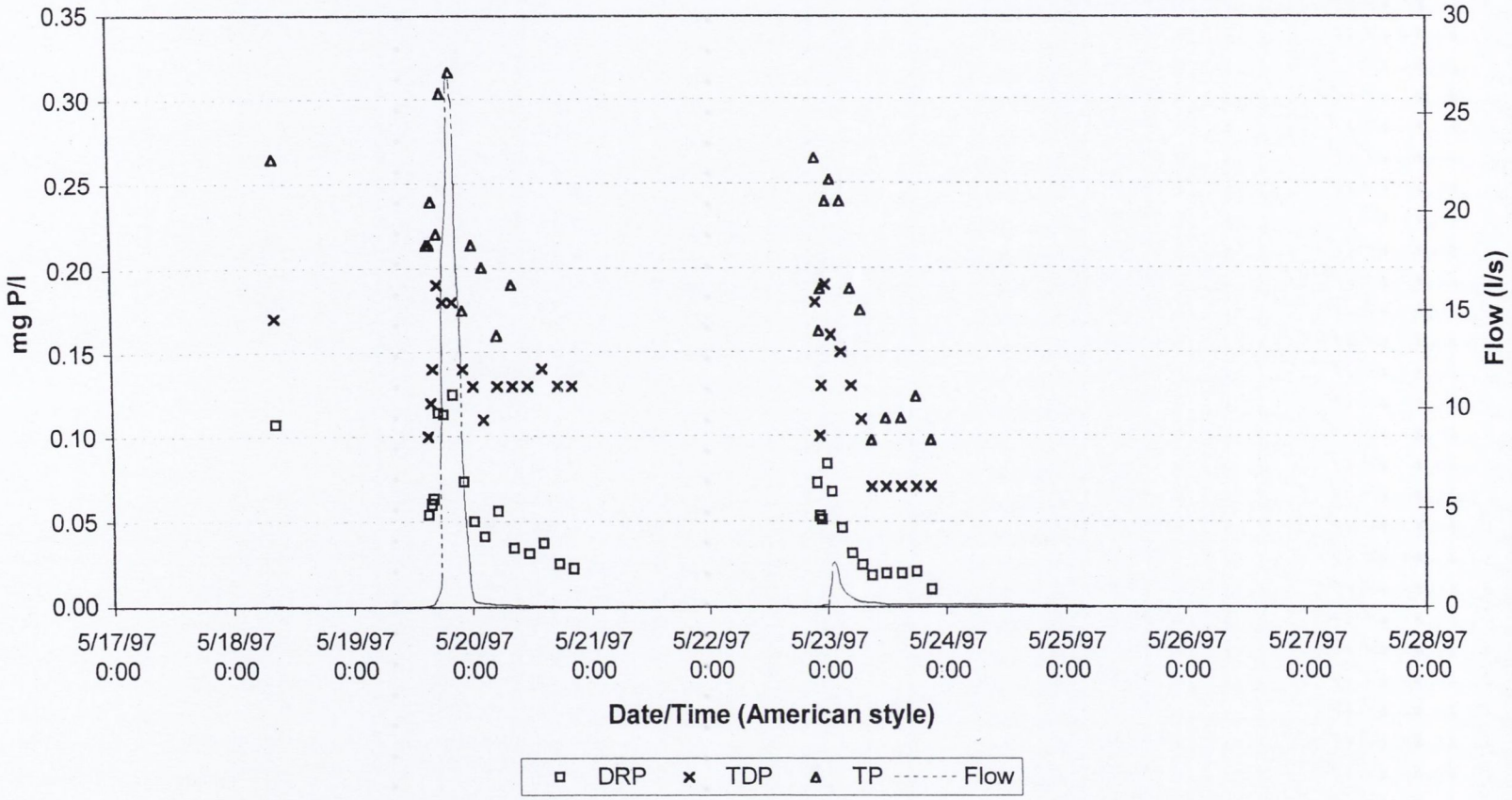


Figure 7.21: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 8 at the Warren 1.

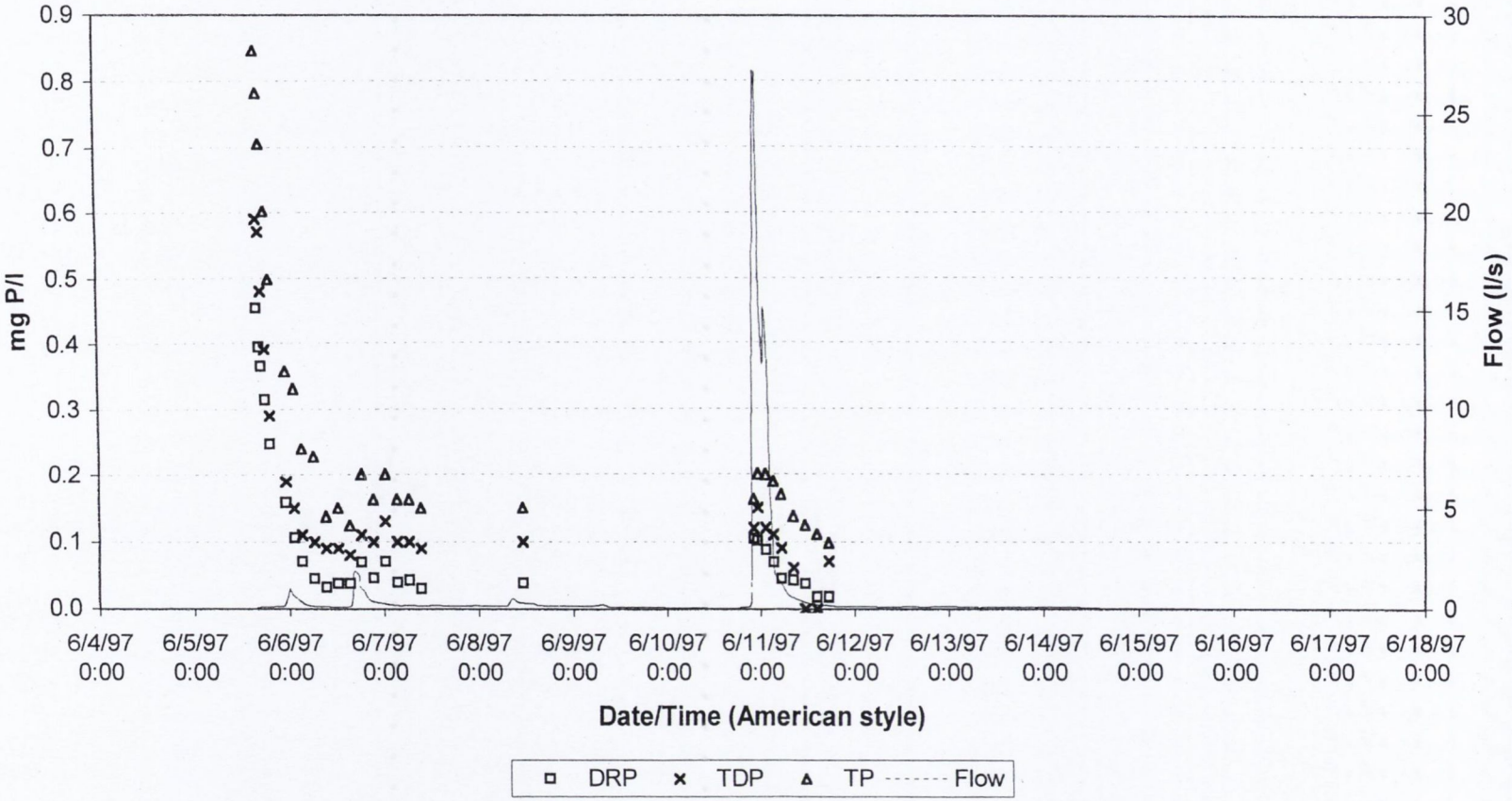


Figure 7.22: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 9 at the Warren 1.

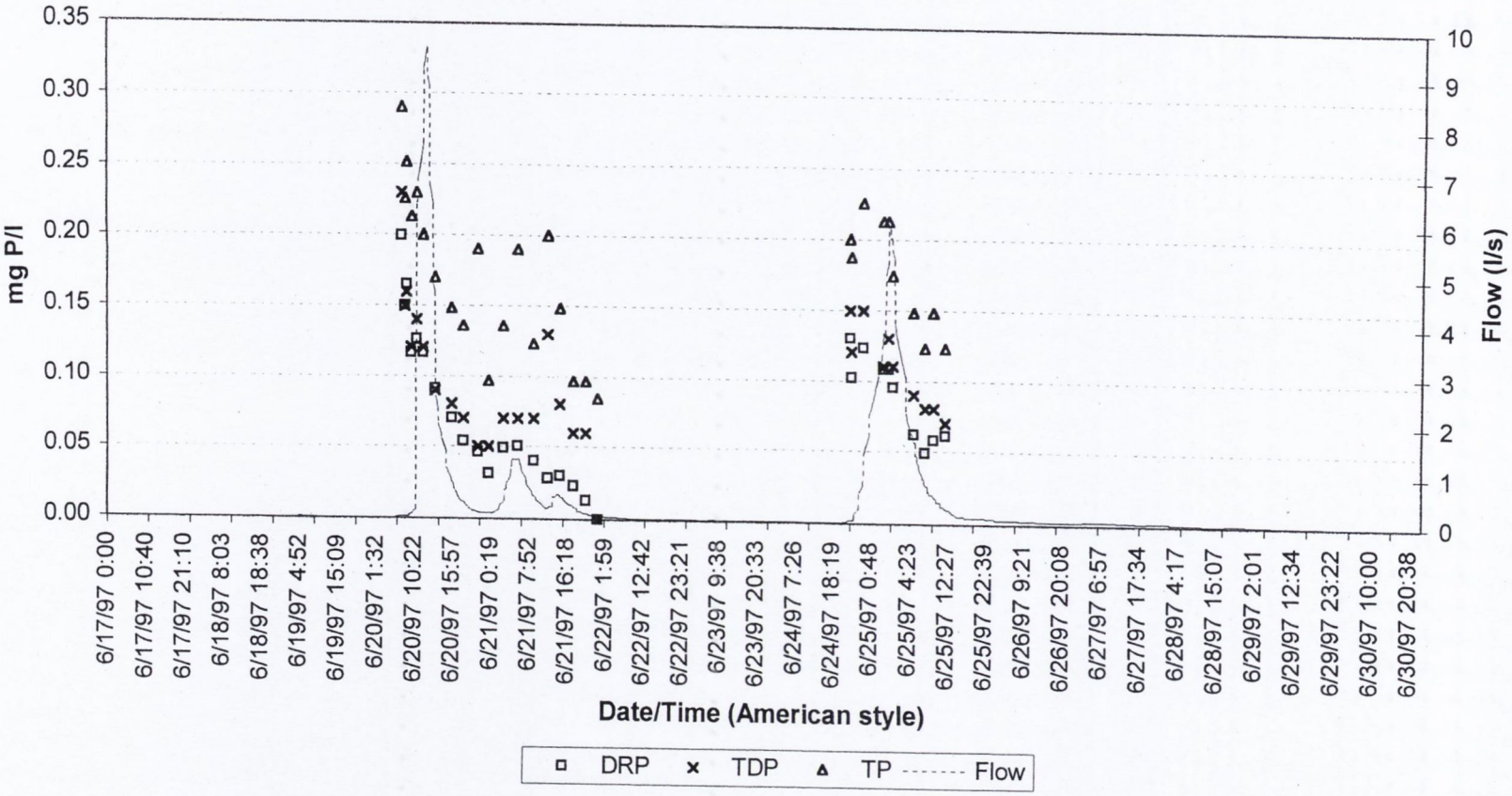


Figure 7.23: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 10 at the Warren 1.

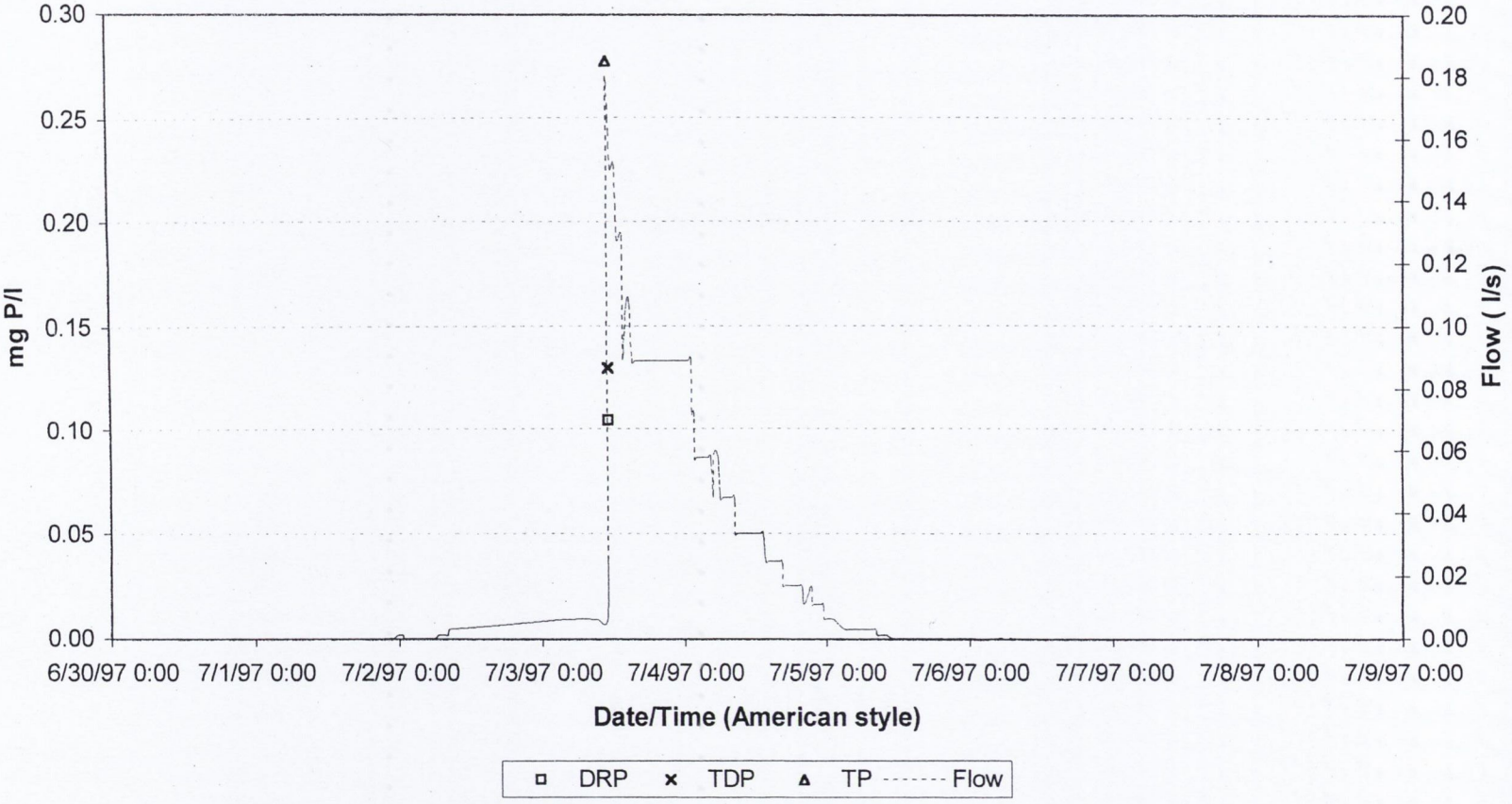


Figure 7.24: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 11 at the Warren 1.

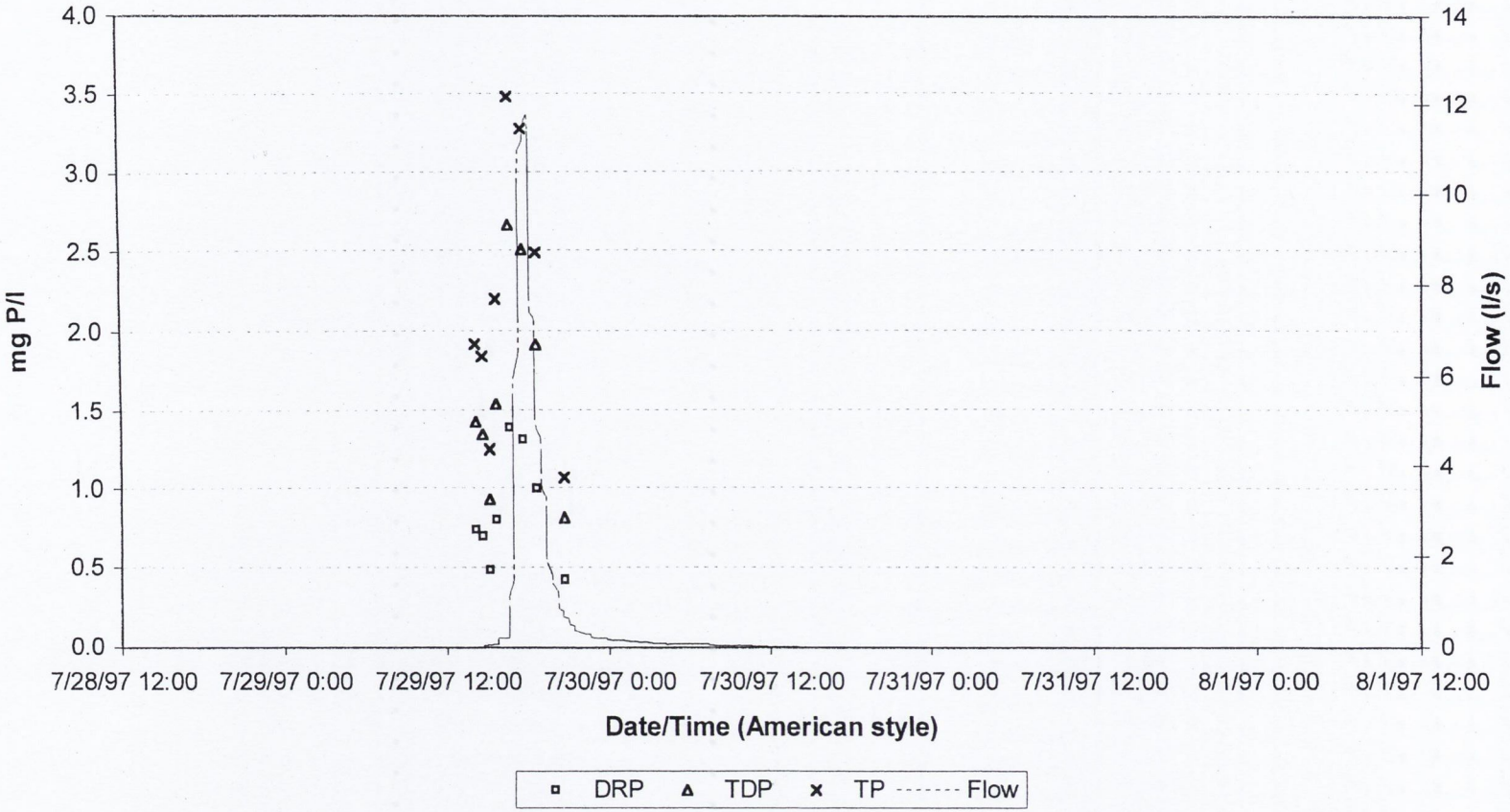


Figure 7.25: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 12 at the Warren 1.

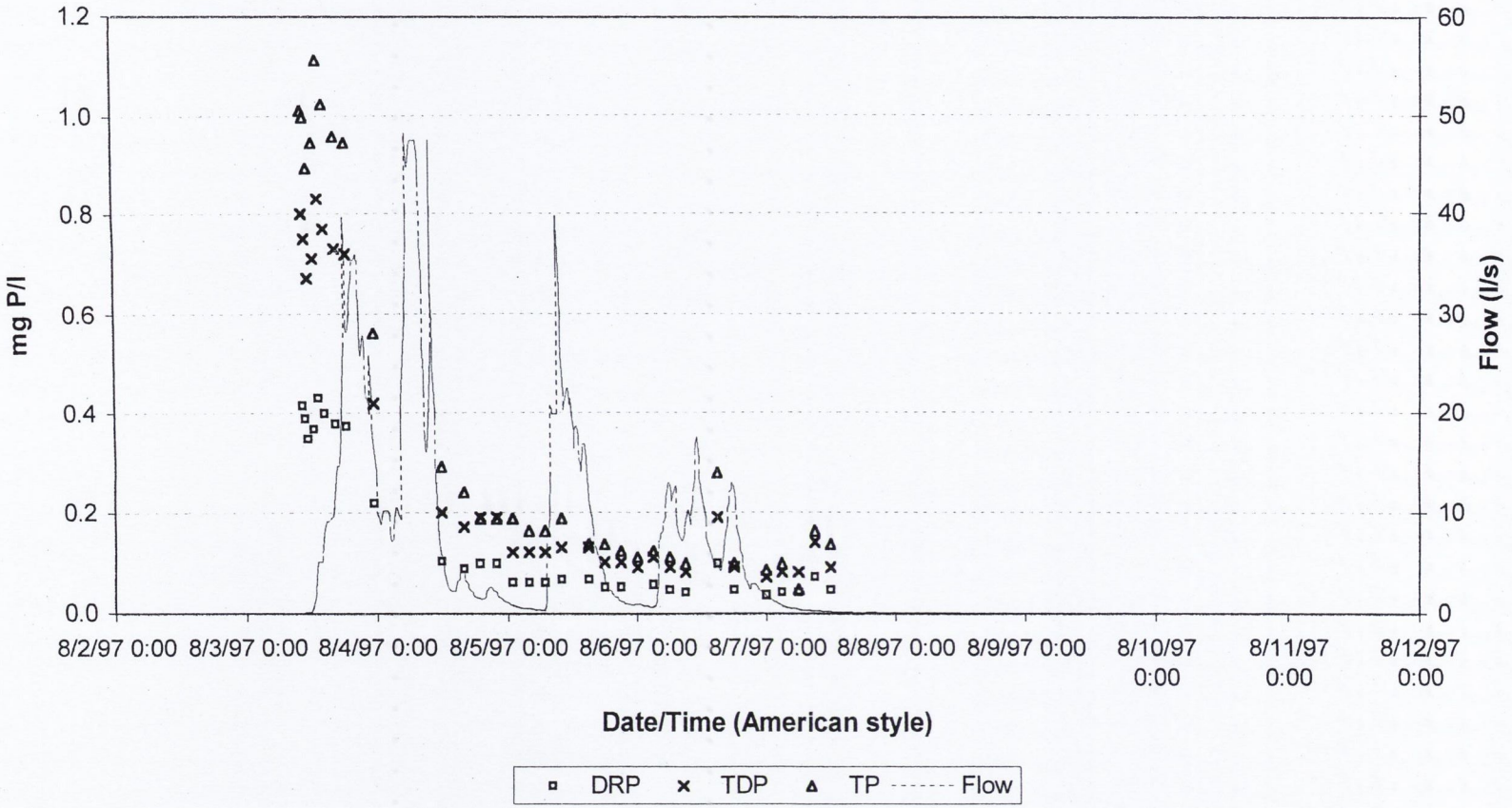


Figure 7.26: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 13 at the Warren 1.

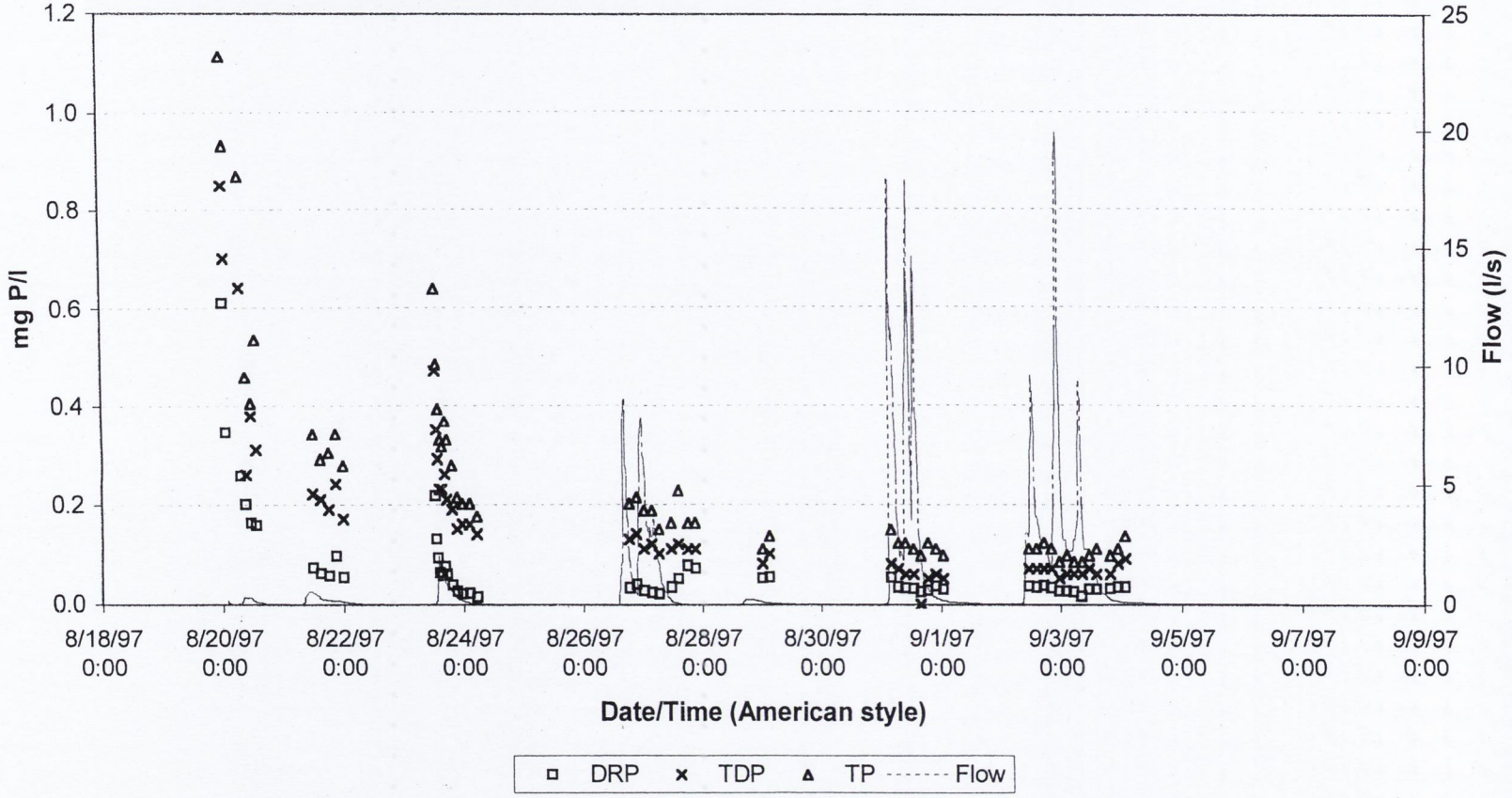


Figure 7.27: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 14 at the Warren 1.

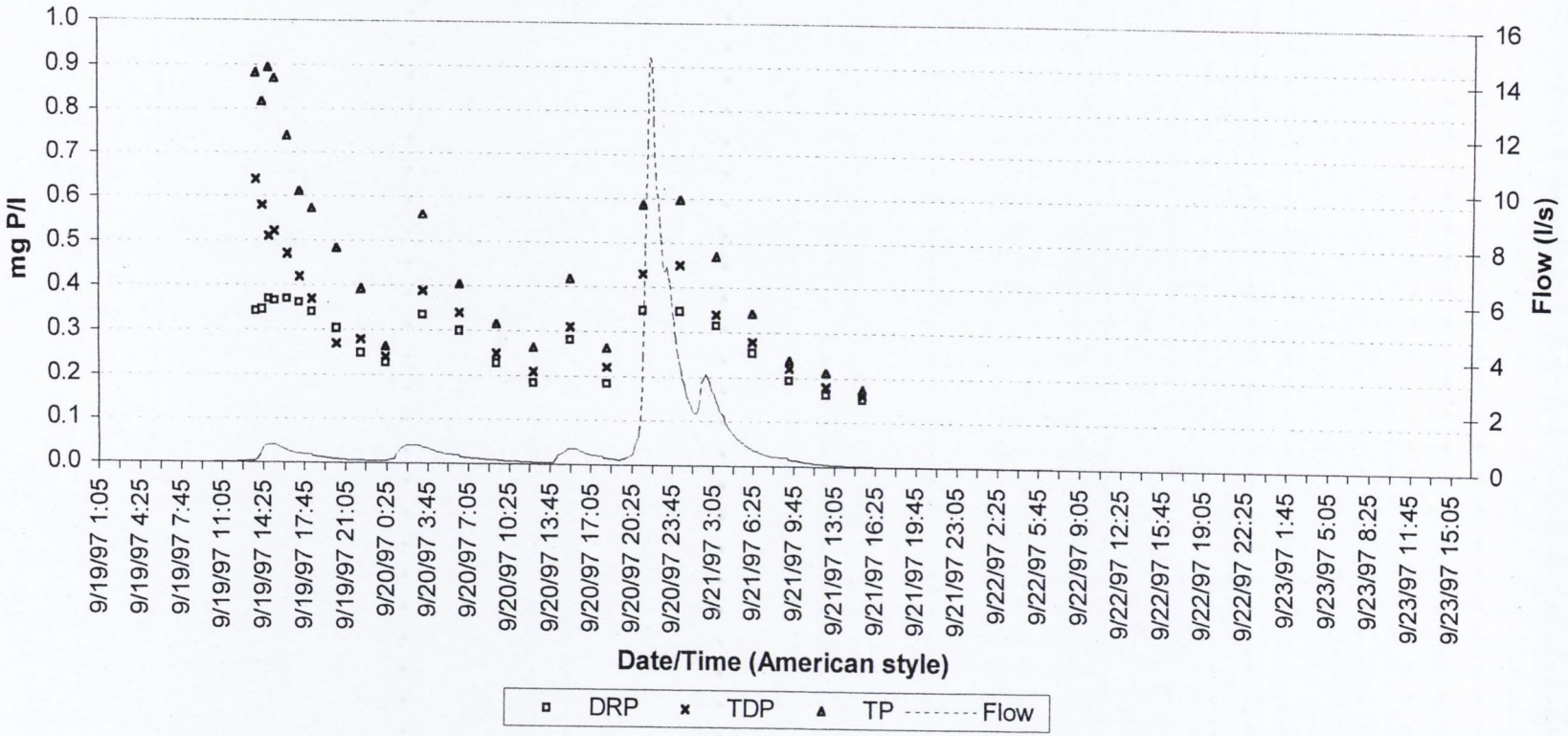


Figure 7.28: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 15 at the Warren 1.

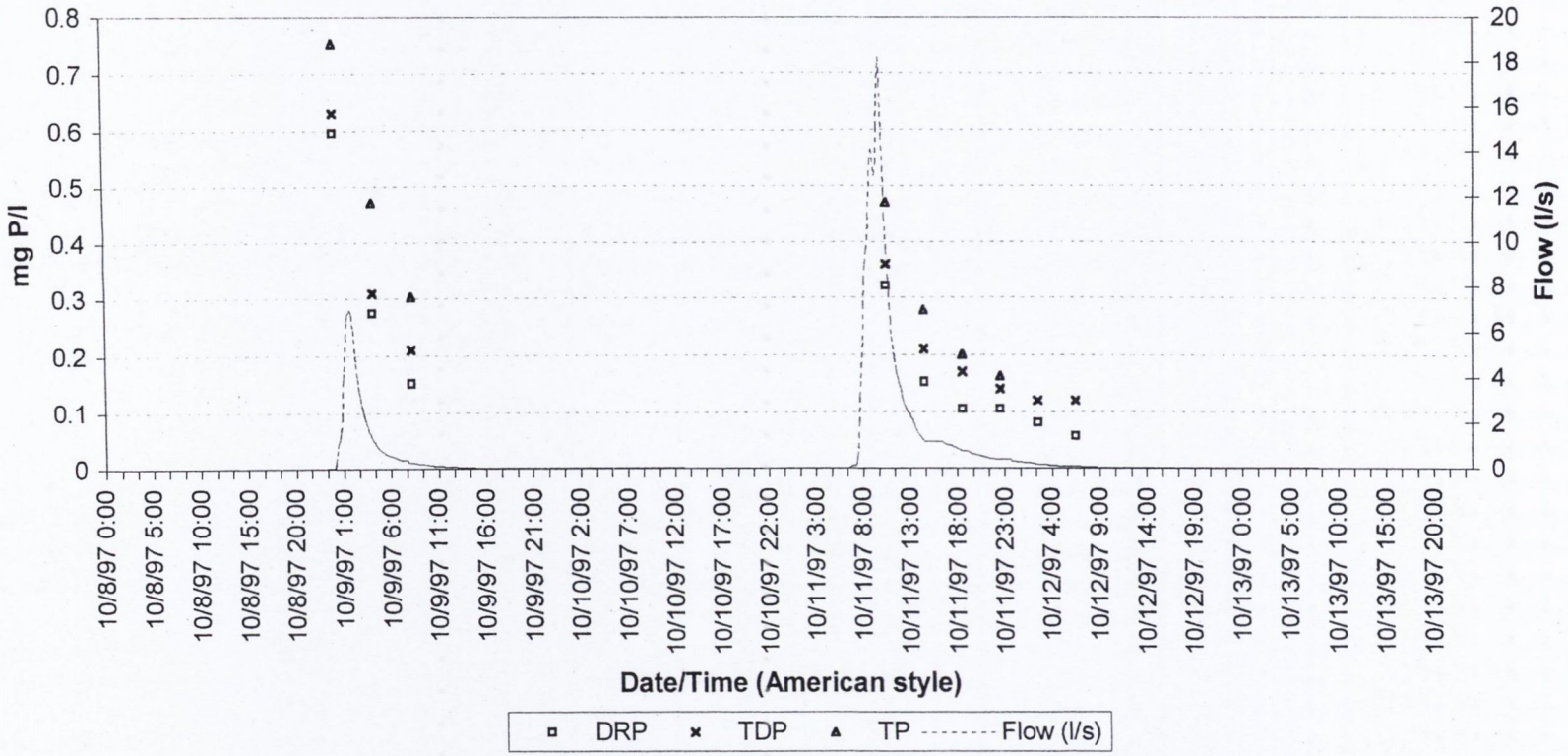


Figure 7.29: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 16 at the Warren 1.

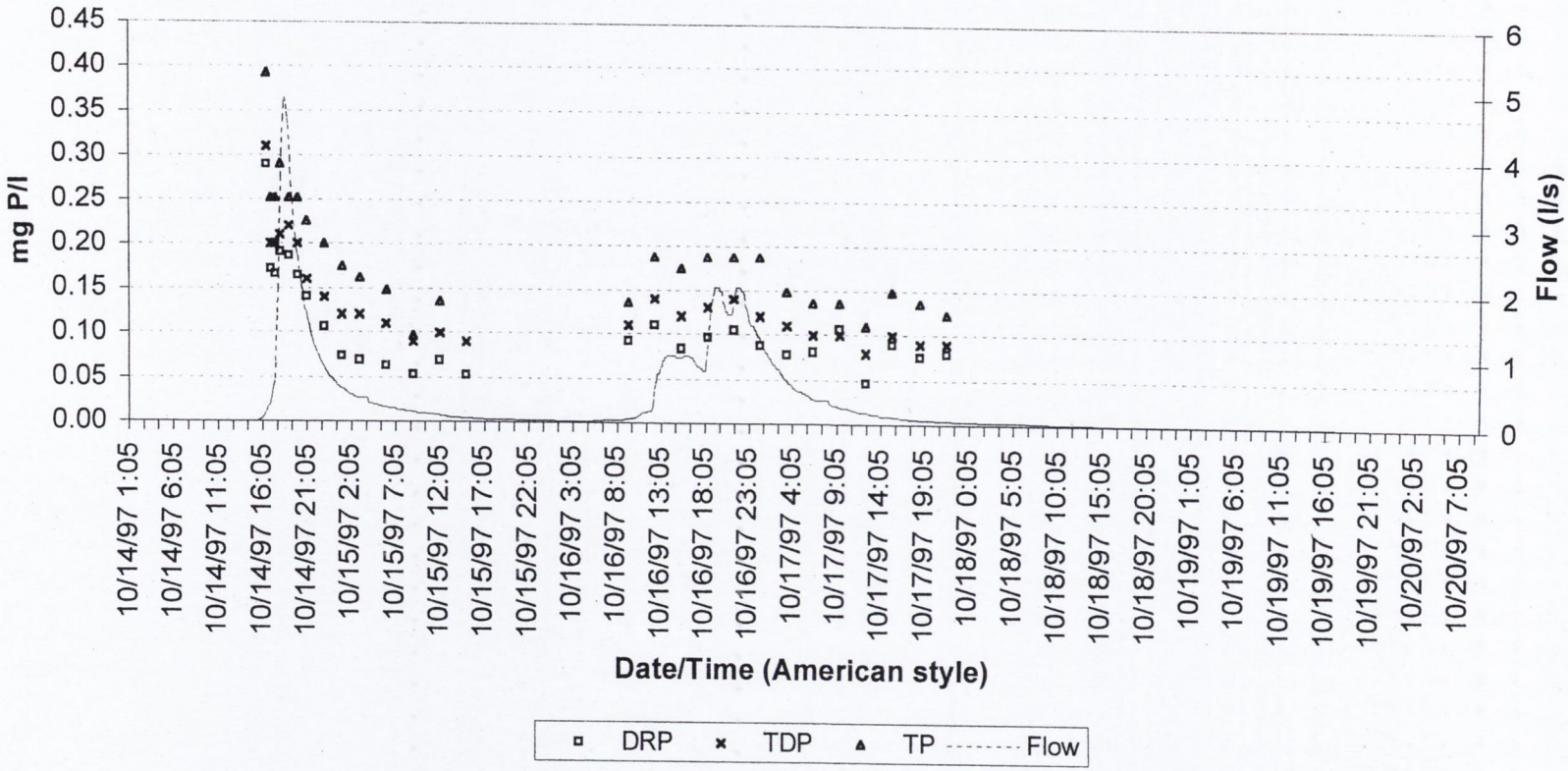


Figure 7.30: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 17 at the Warren 1.

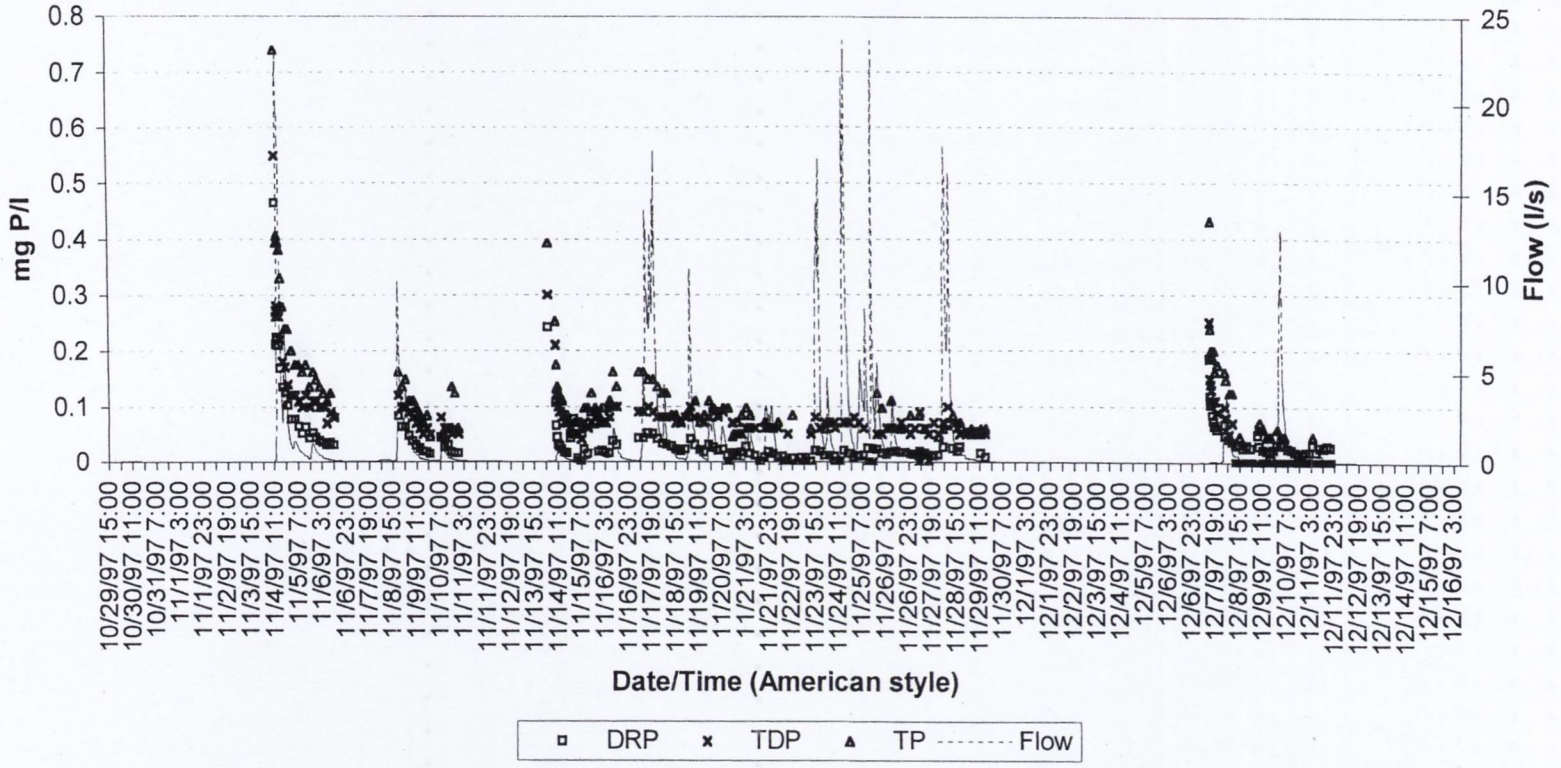


Figure 7.31: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 18 at the Warren 1. (Excessively high P concentrations at beginning of event omitted. See table 7.2.)

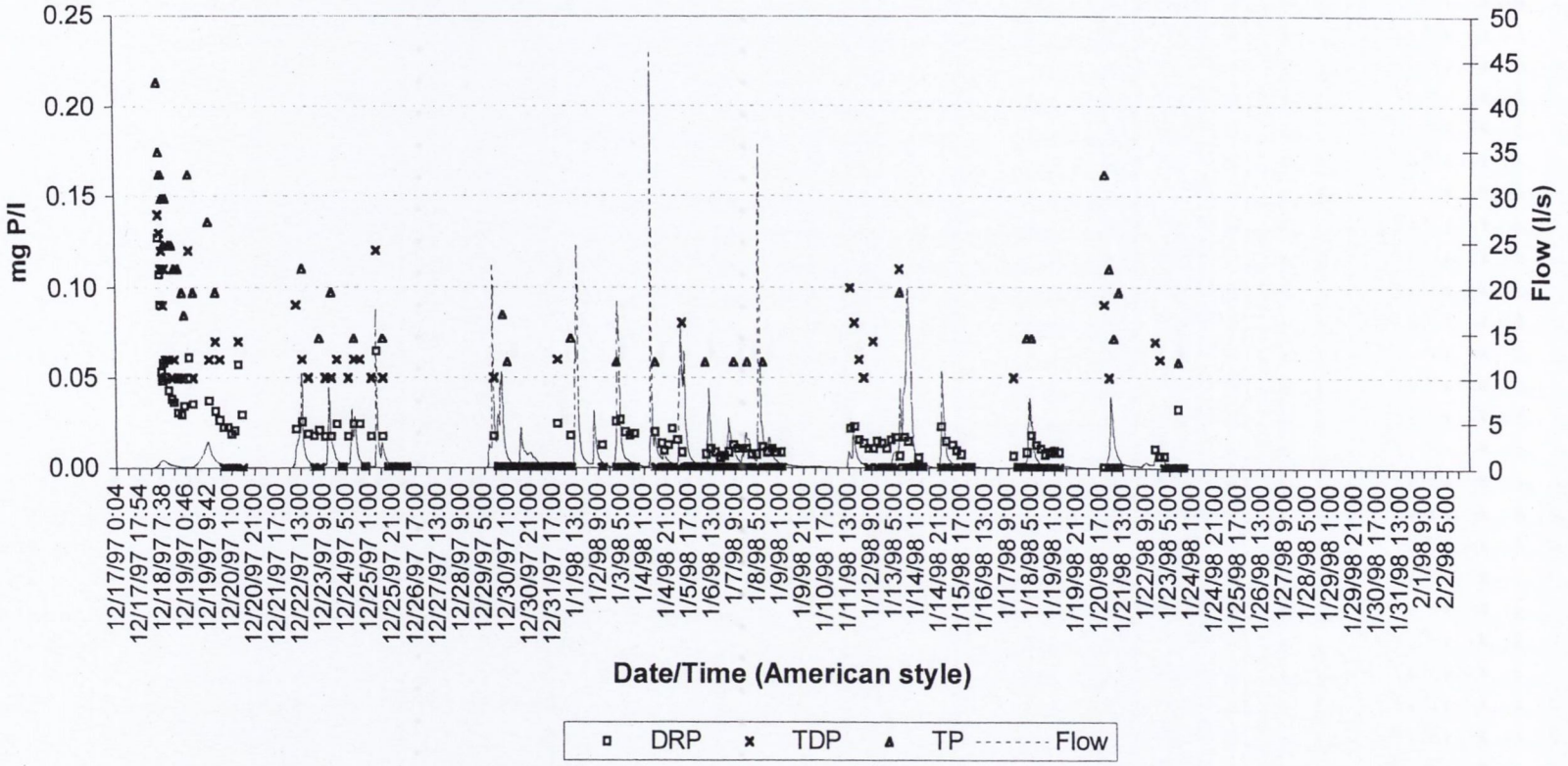


Figure 7.32: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 19 at the Warren 1.

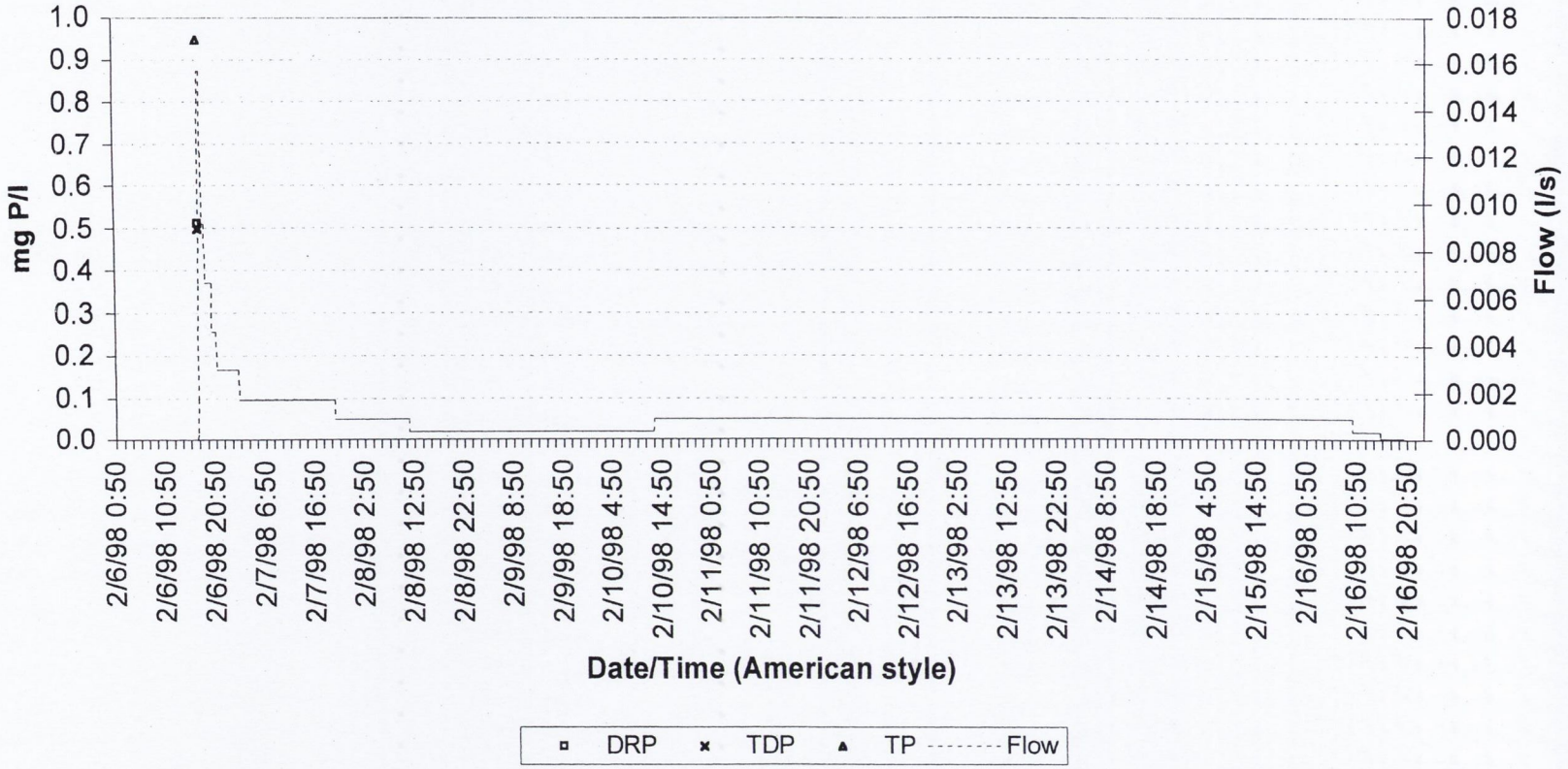


Figure 7.33: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 20 at the Warren 1.

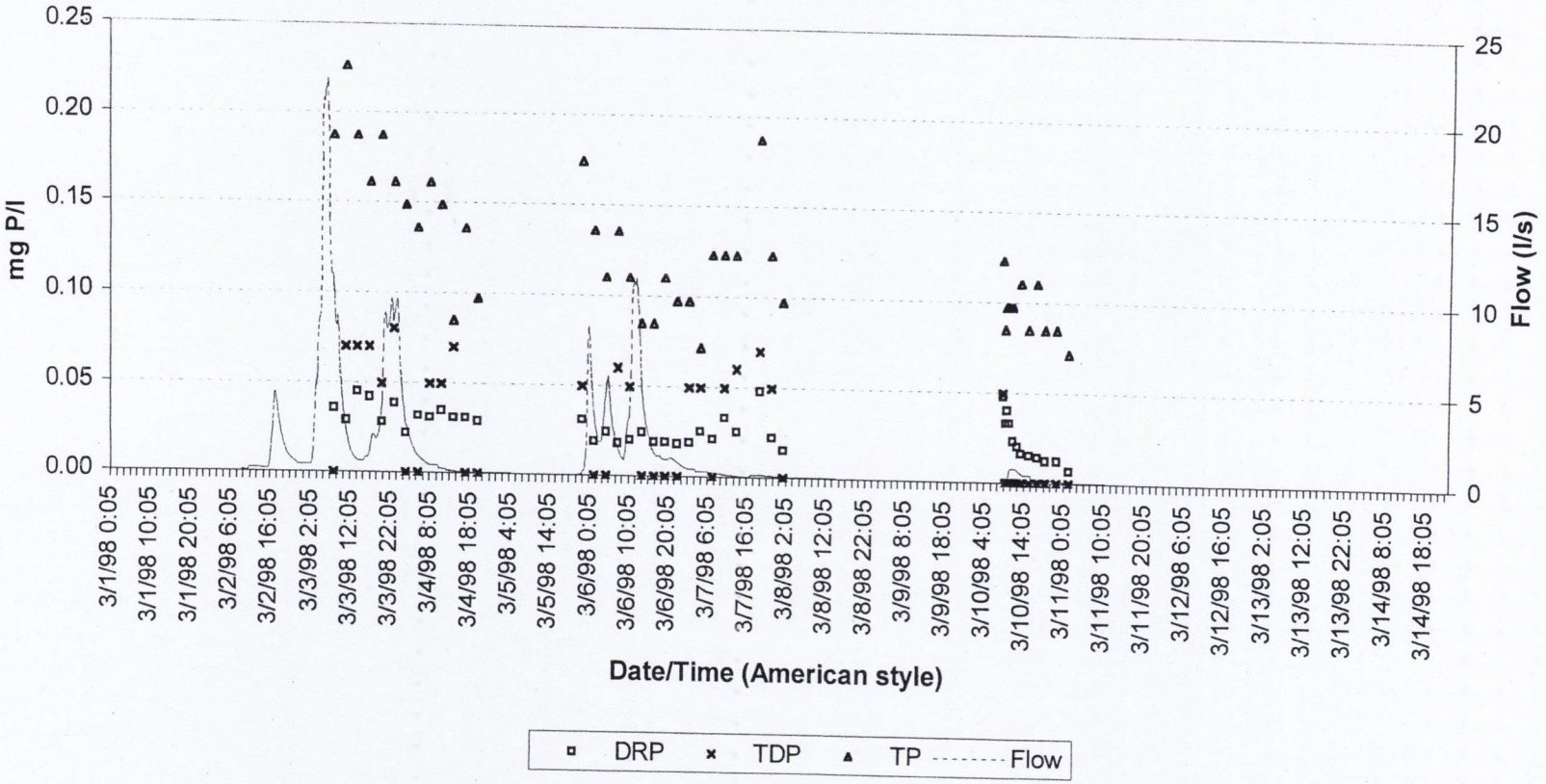


Figure 7.34: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 21 at the Warren 1.

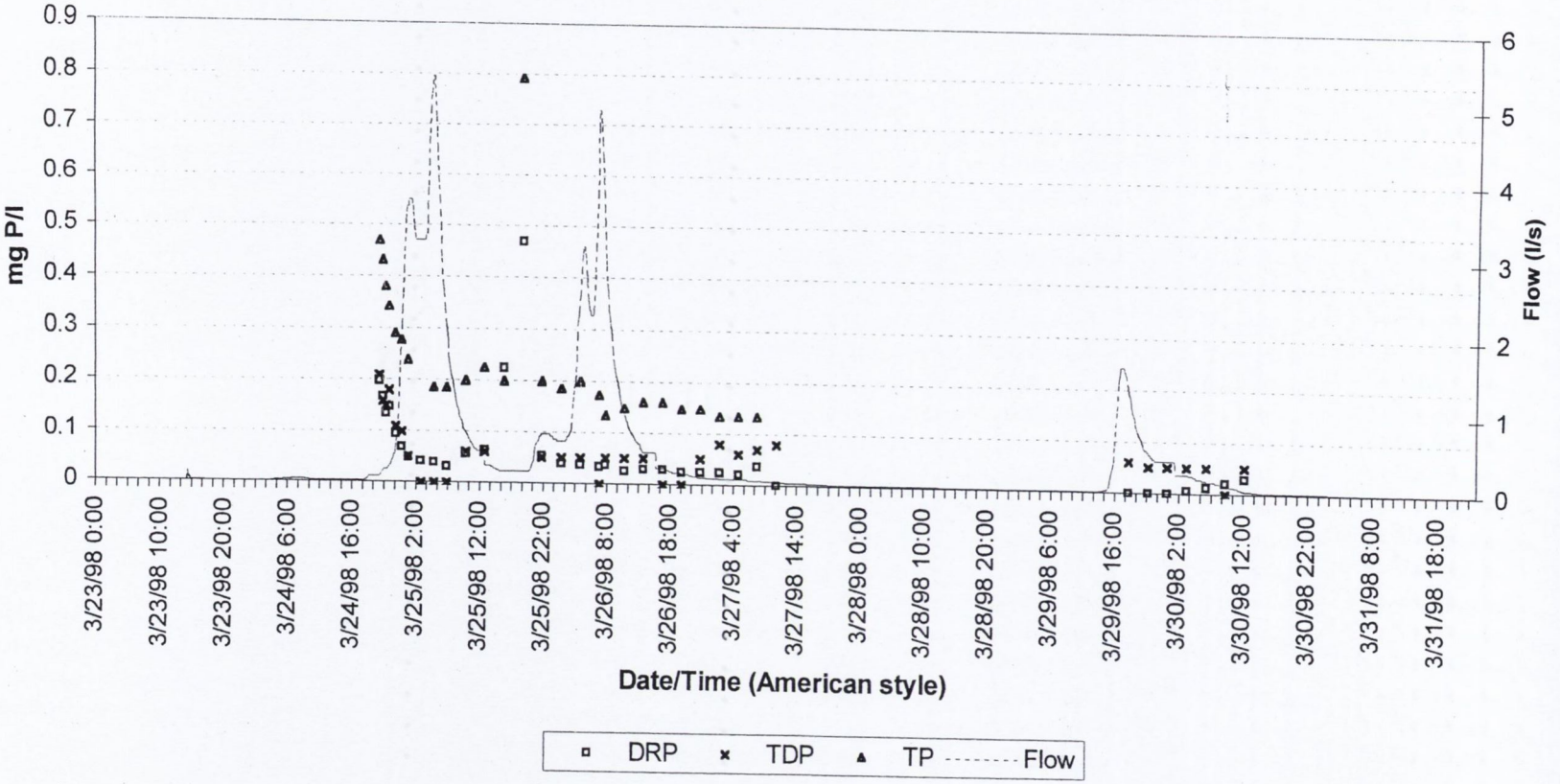


Figure 7.35: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 22 at the Warren 1.

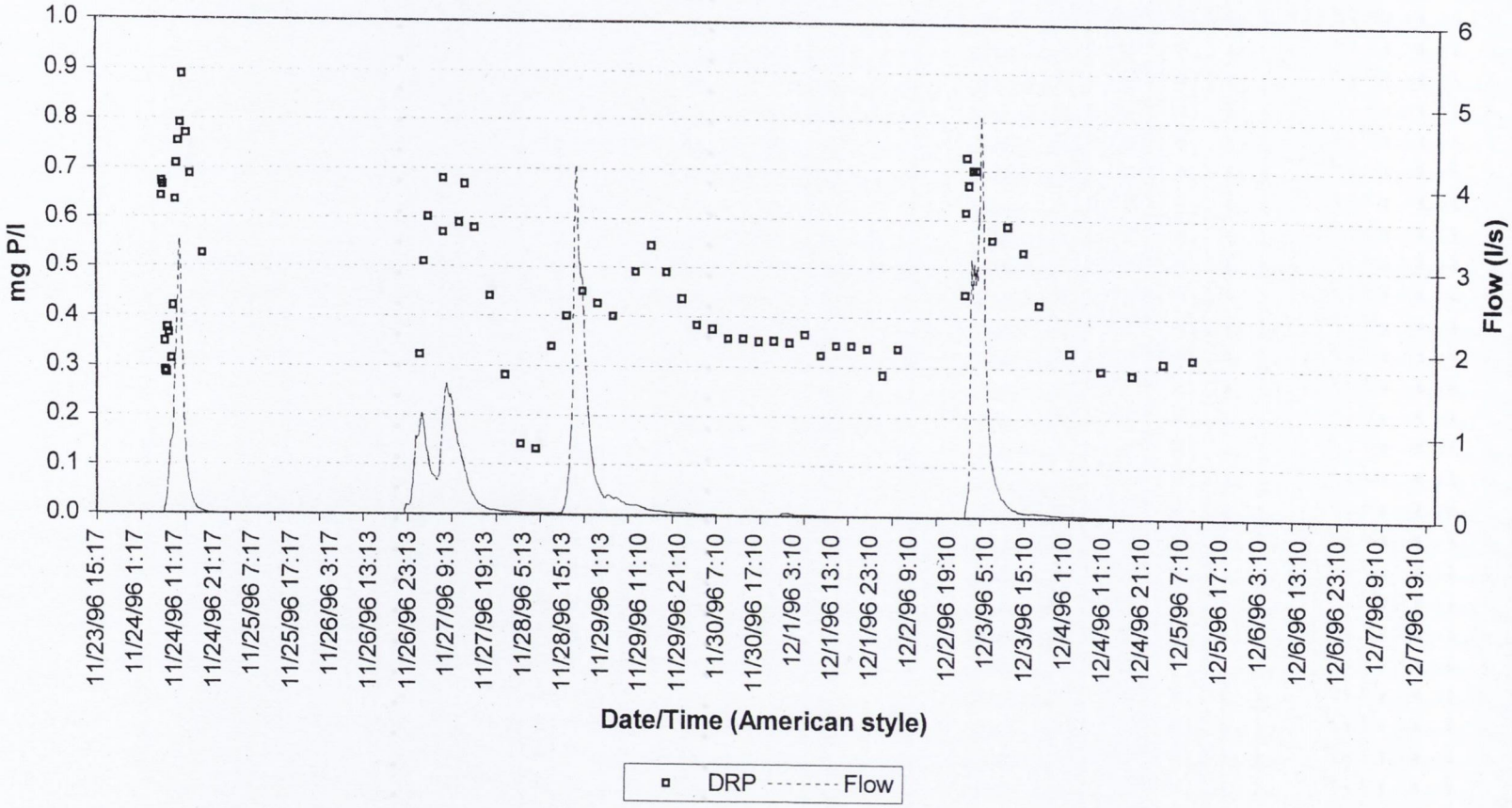


Figure 7.36: Overland flow (l/s) and DRP (mg P/l) concentrations for event 1 at the Cowlands.

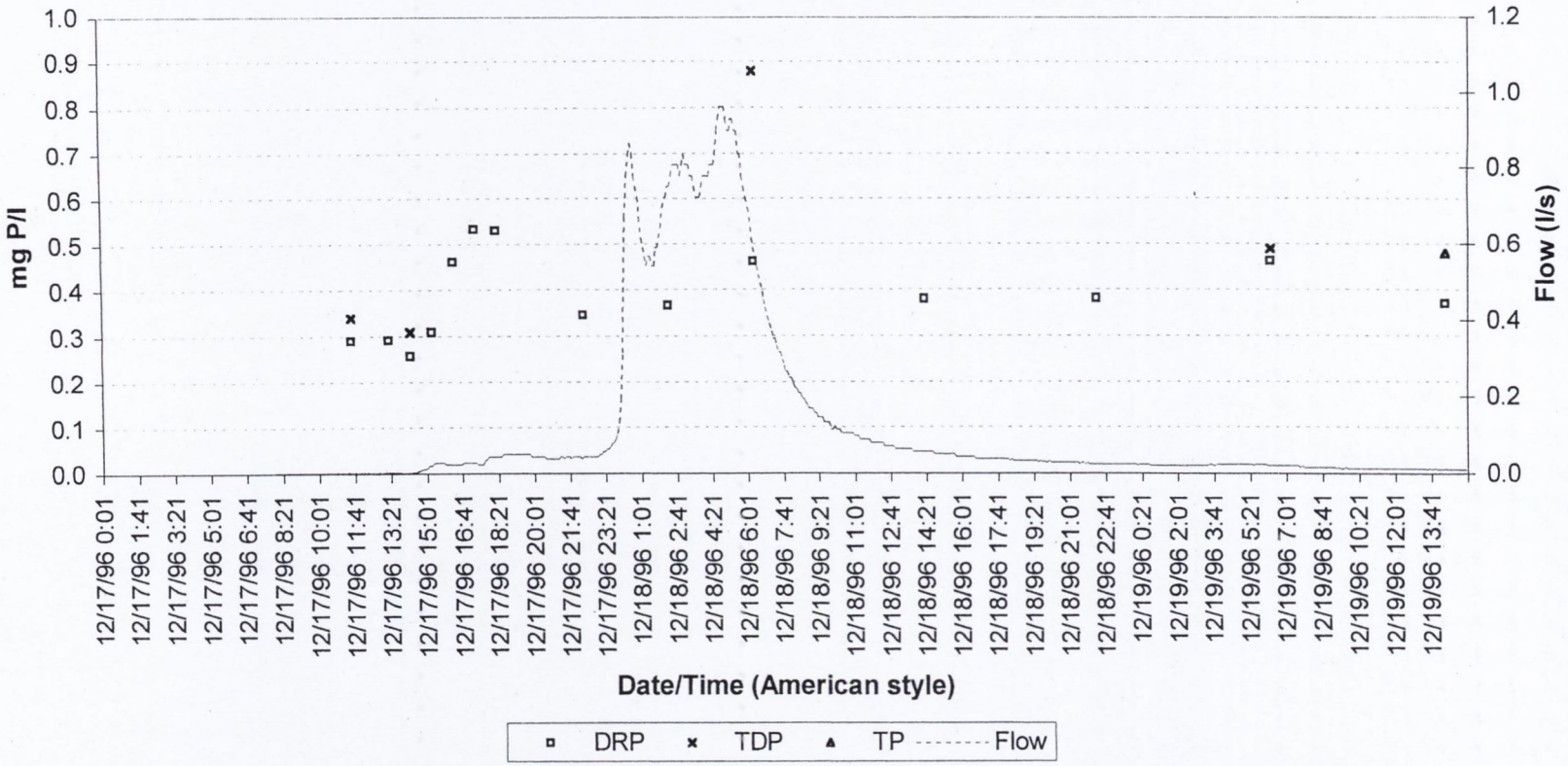


Figure 7.37: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 2 at the Cowlands.

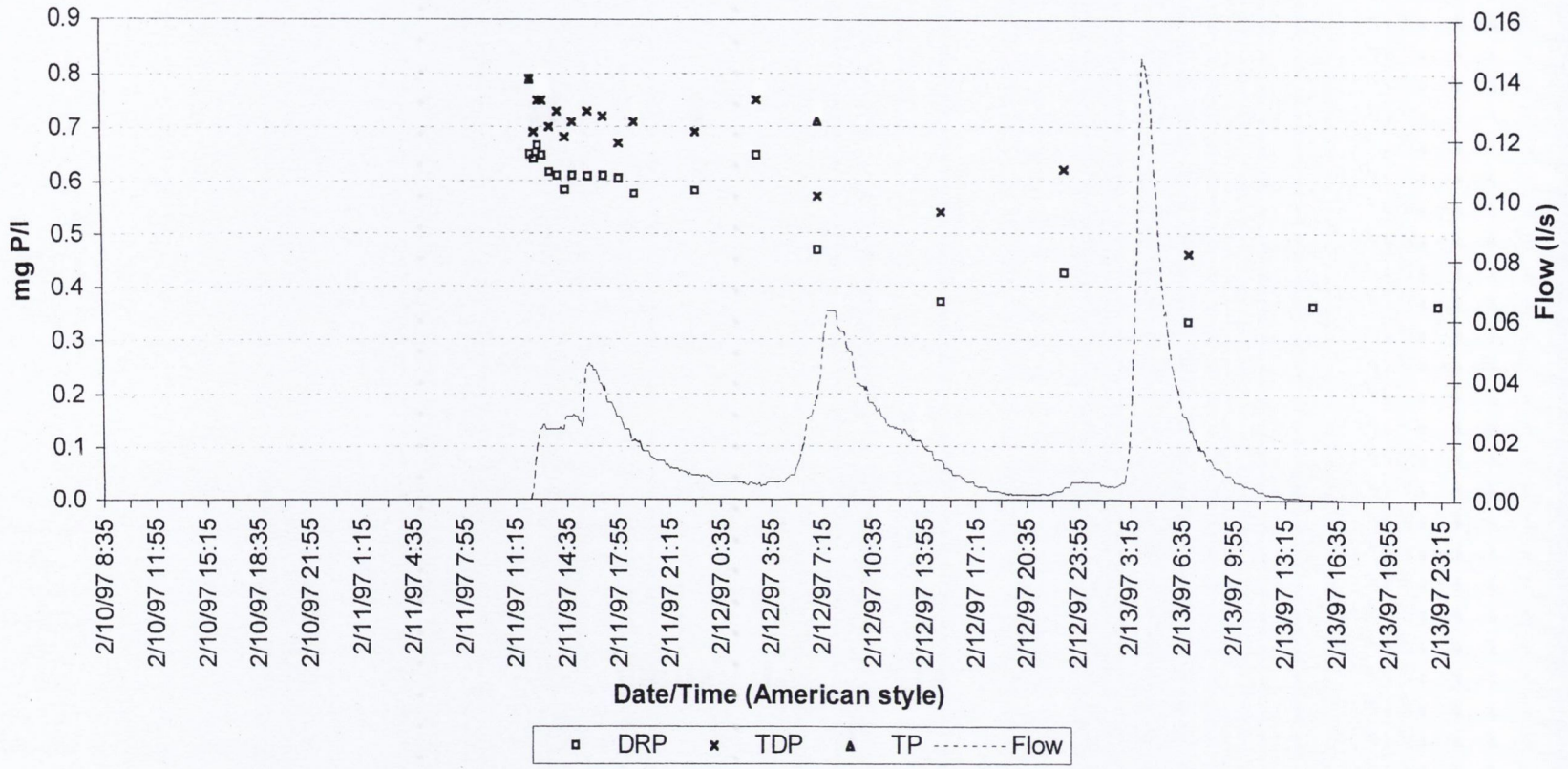


Figure 7.38: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 5.1 at the Cowlands.

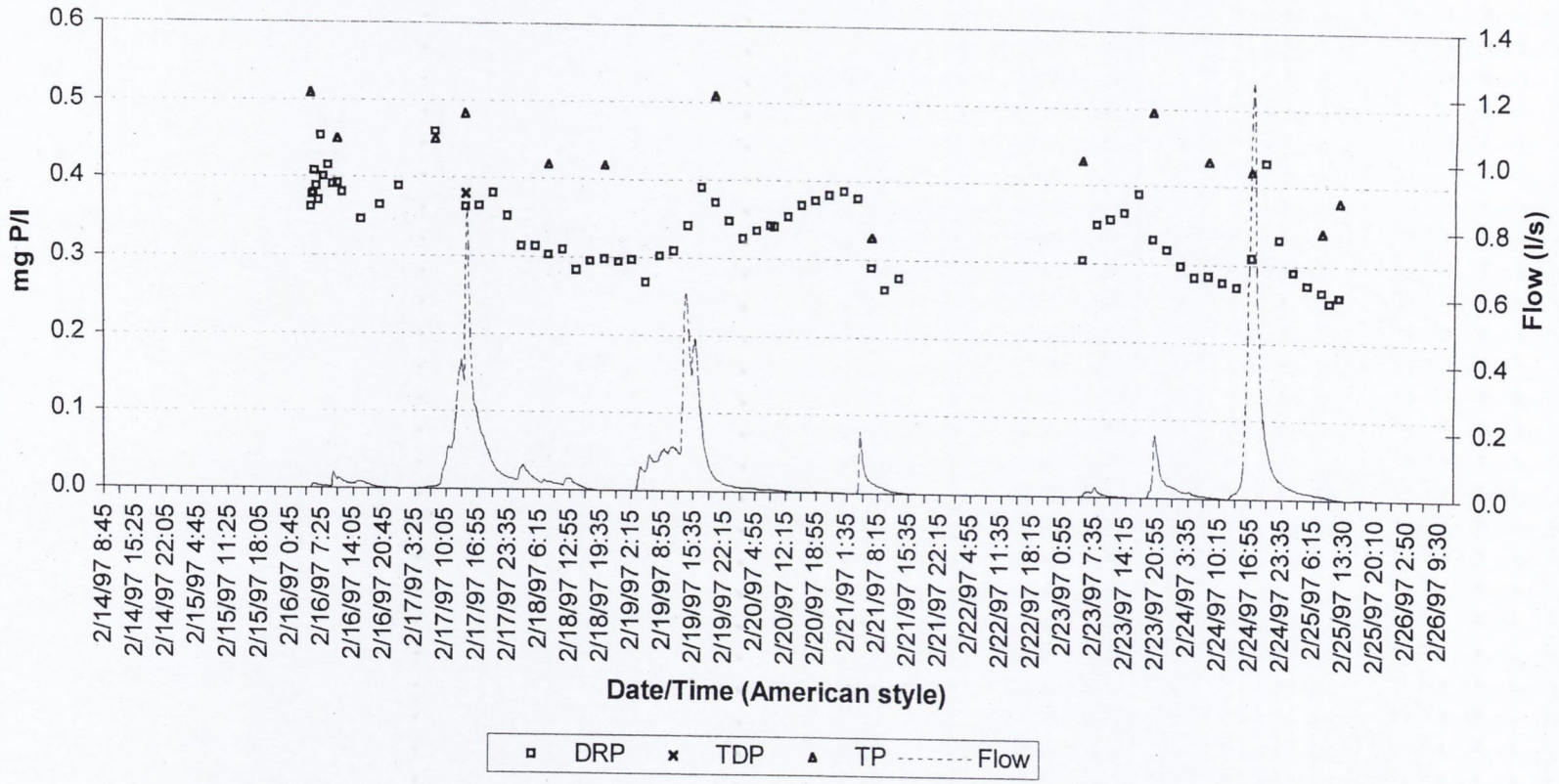


Figure 7.39: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 5.2 at the Cowlands.

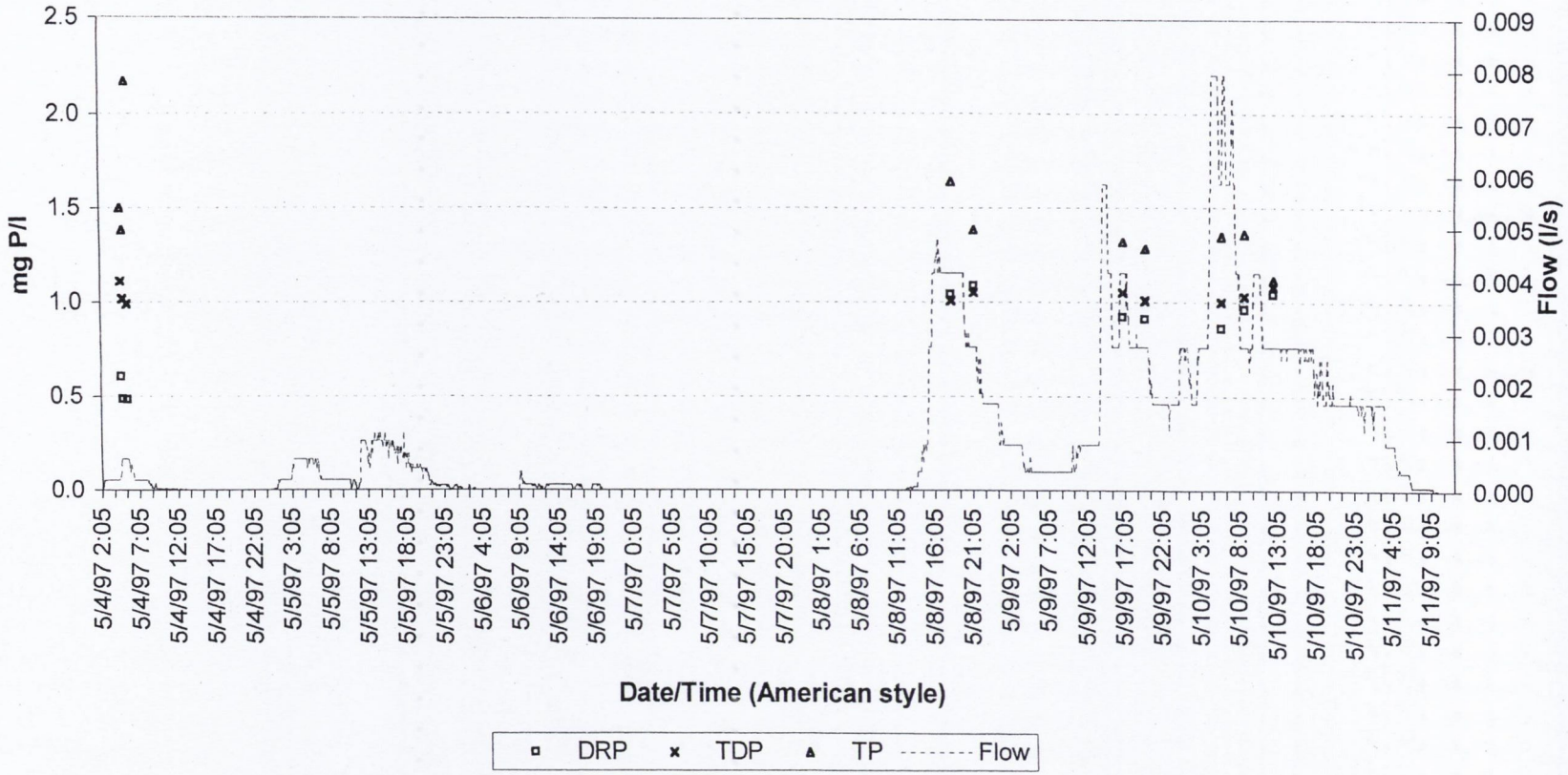


Figure 7.40: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 7 at the Cowlands.

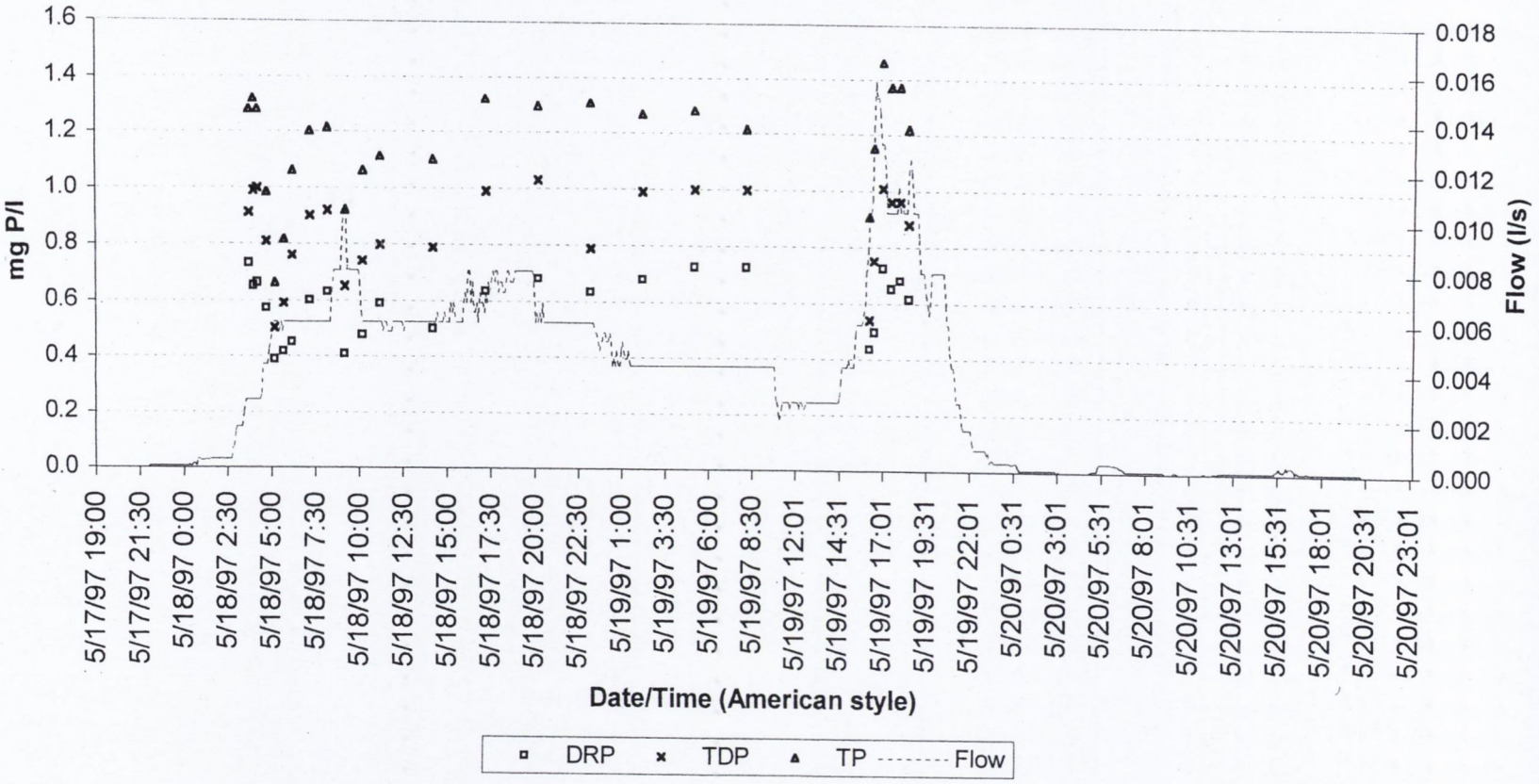


Figure 7.41: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 8 at the Cowlands.

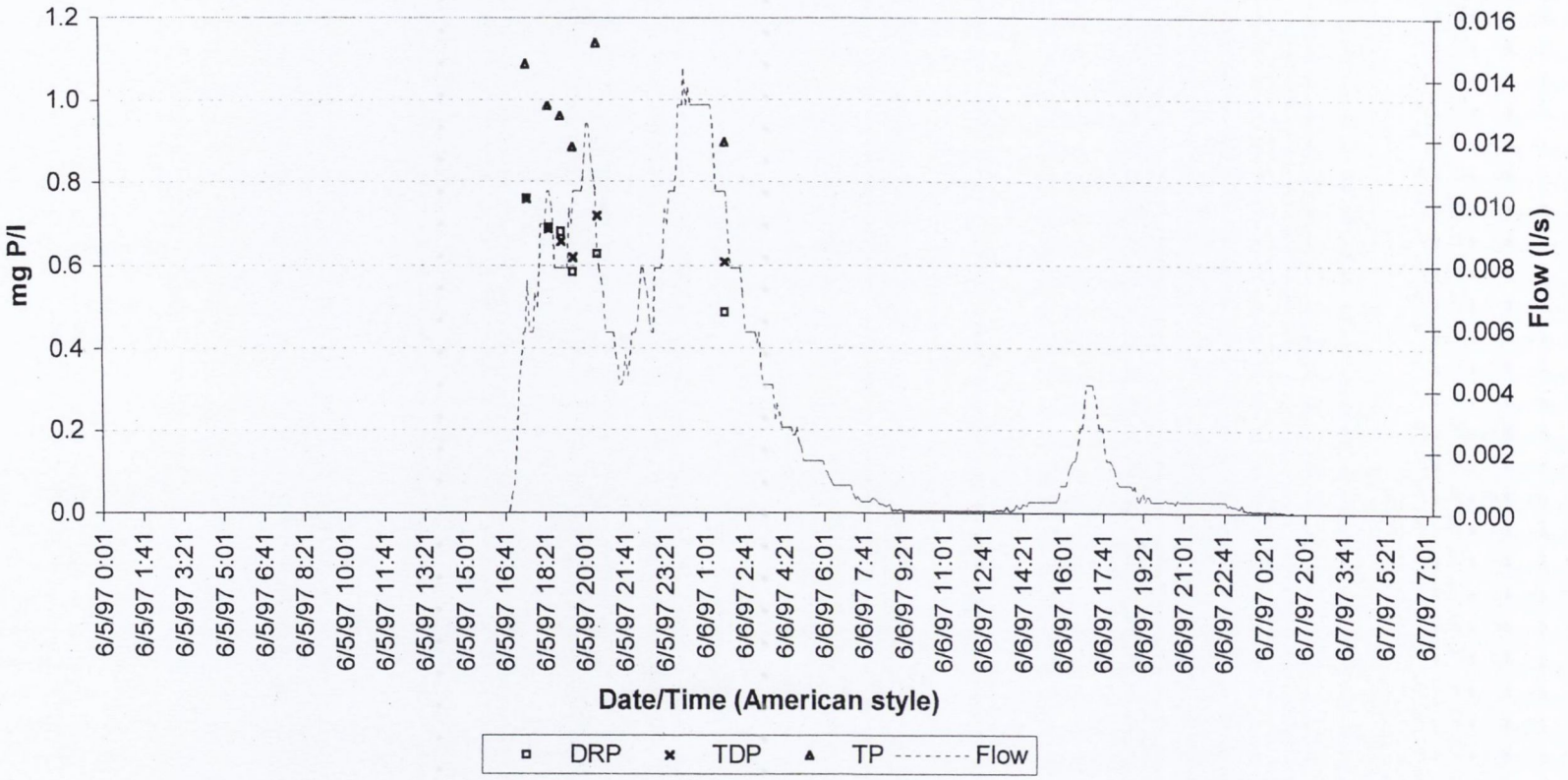


Figure 7.42: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 9.1 at the Cowlands.

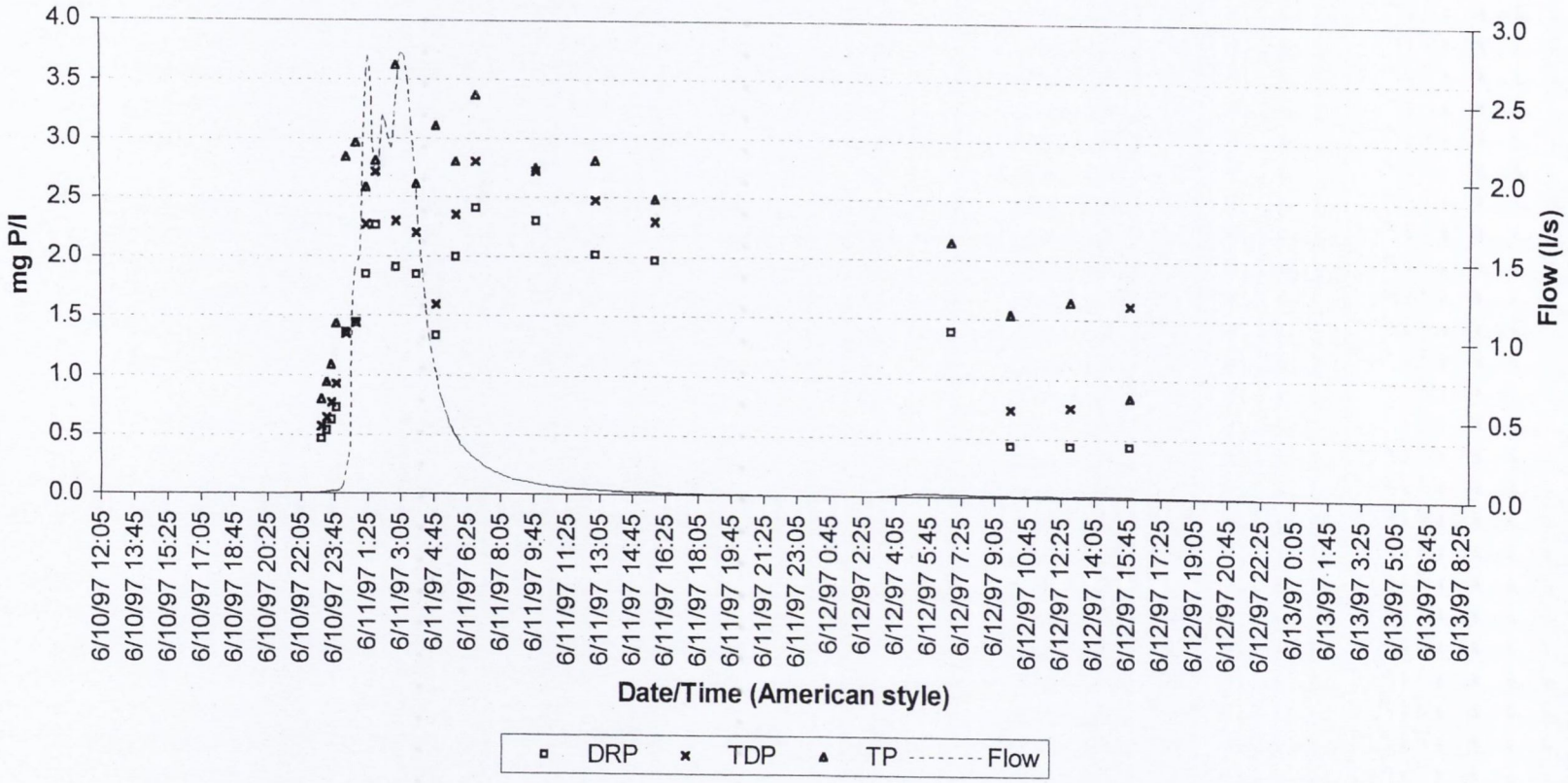


Figure 7.43: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 9.2 at the Cowlands.

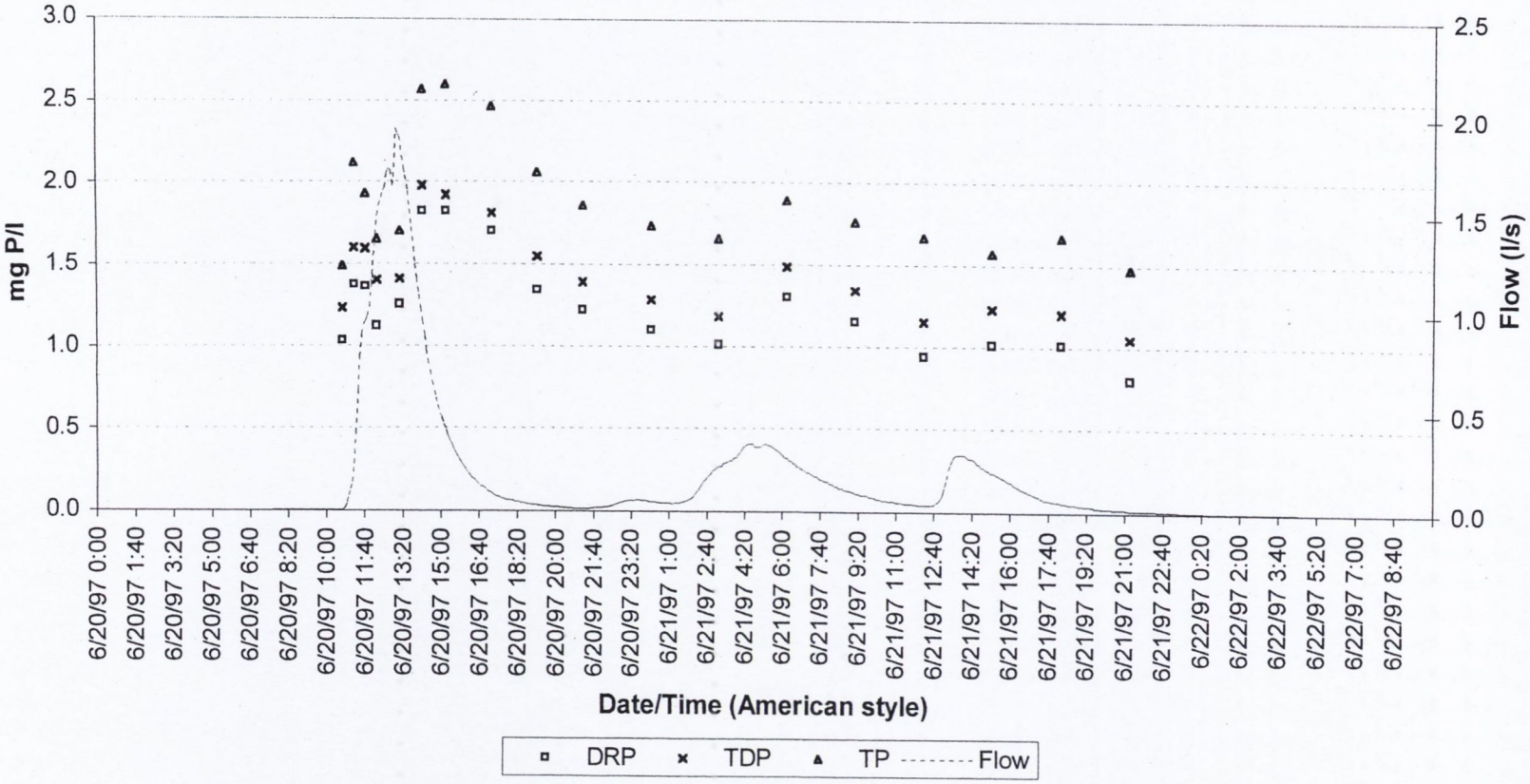


Figure 7.44: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 10.1 at the Cowlands.

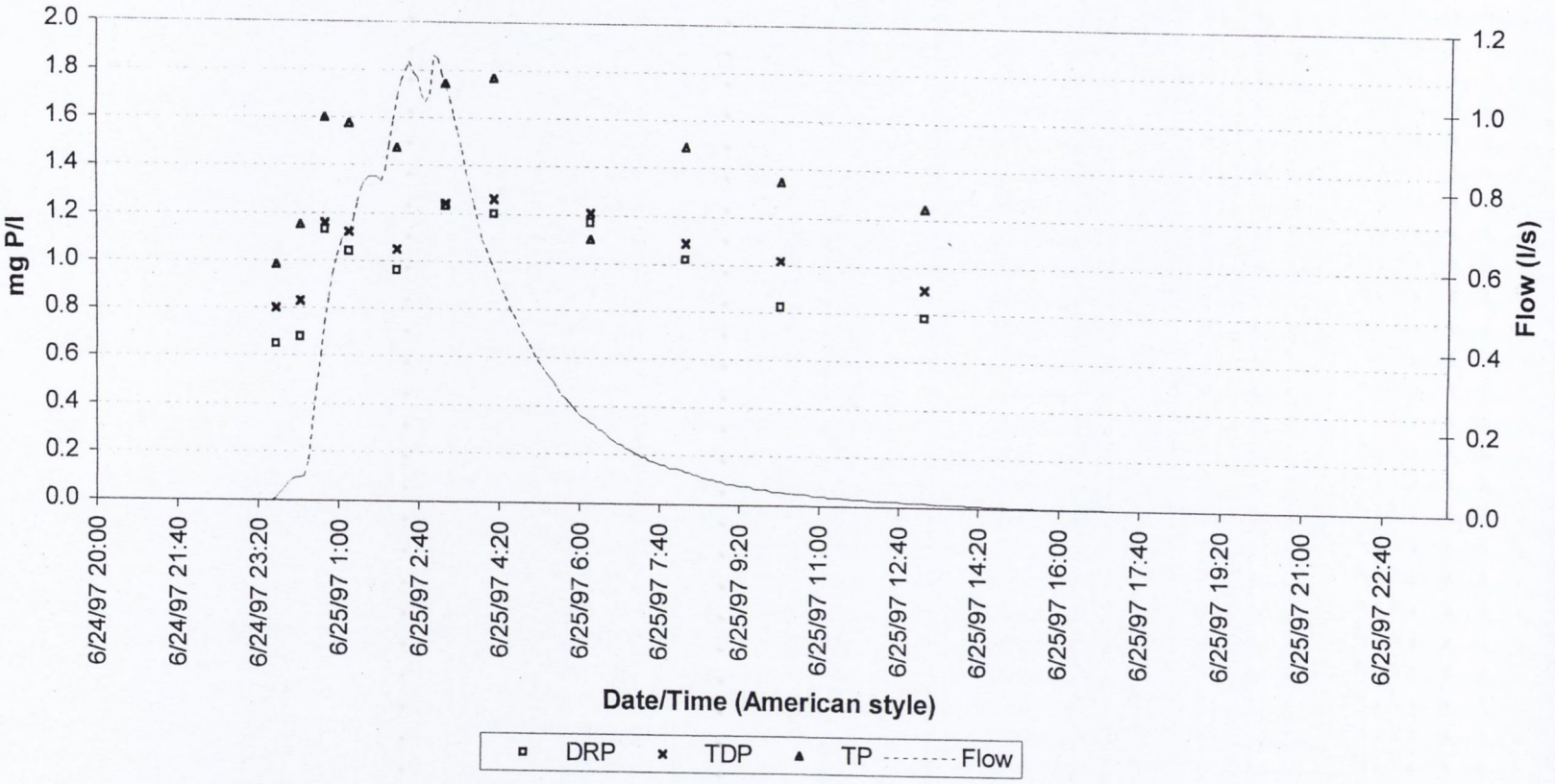


Figure 7.45: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 10.2 at the Cowlands.

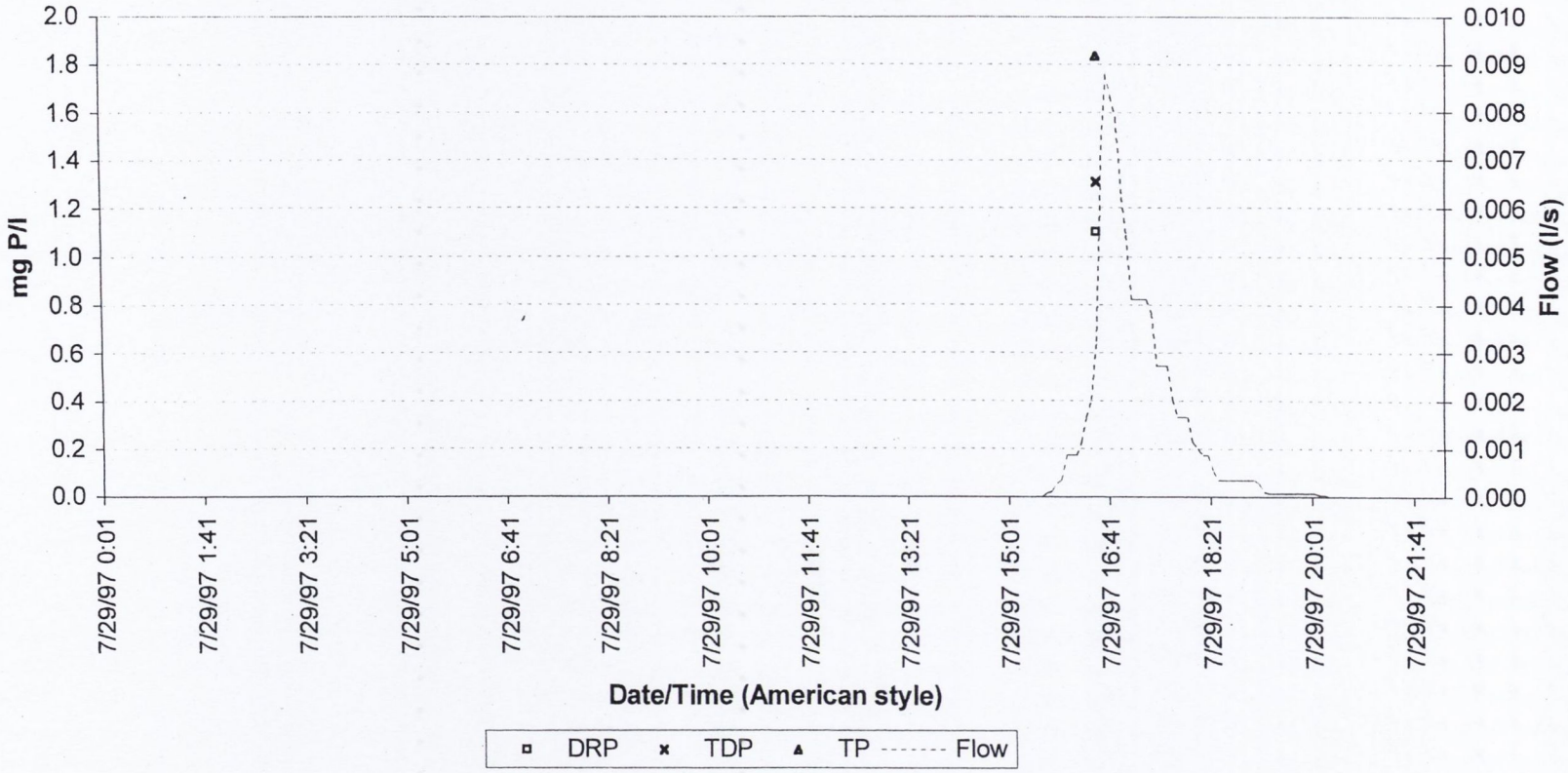


Figure 7.46: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 12 at the Cowlands.

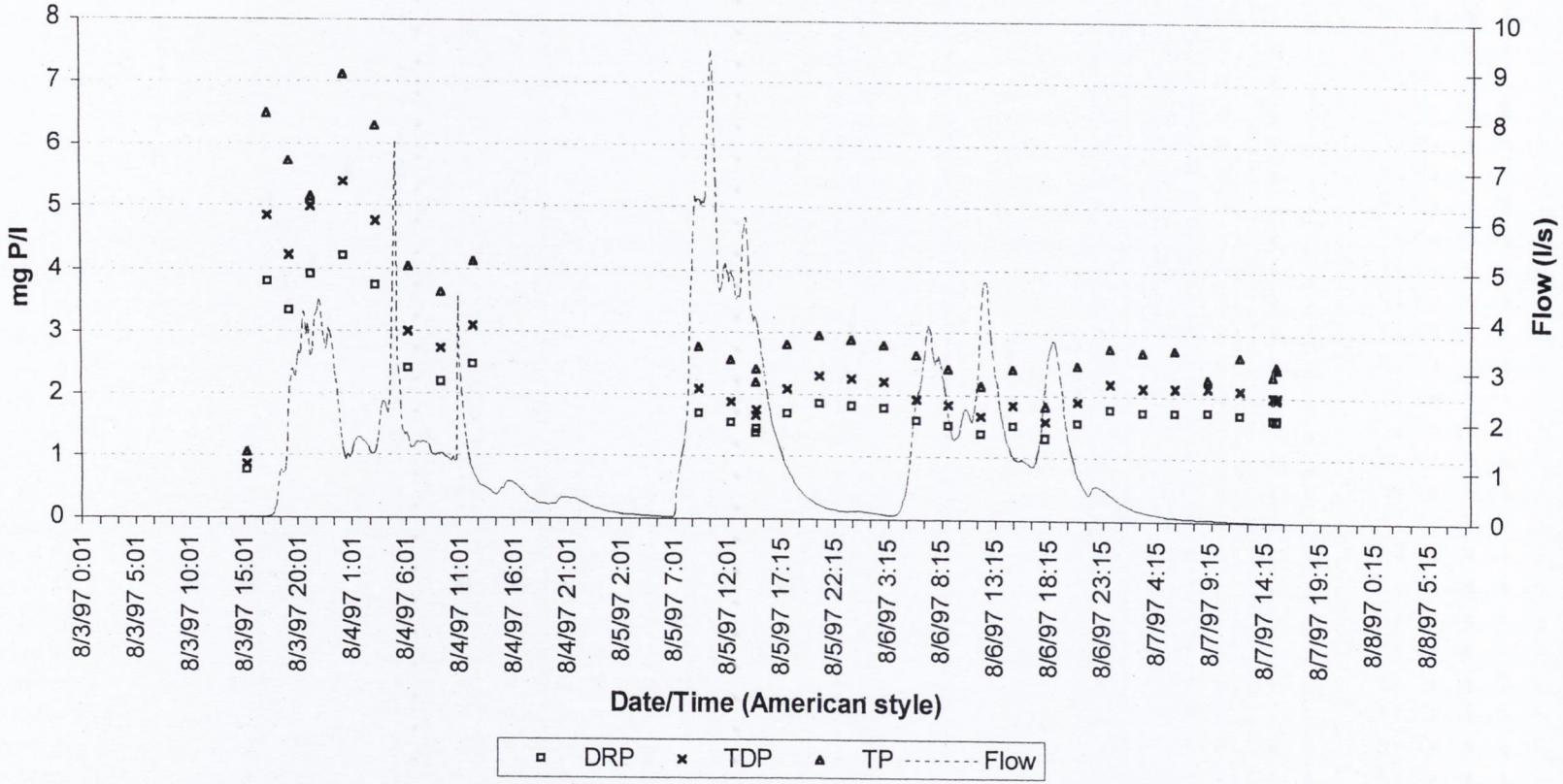


Figure 7.47: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 13 at the Cowlands.

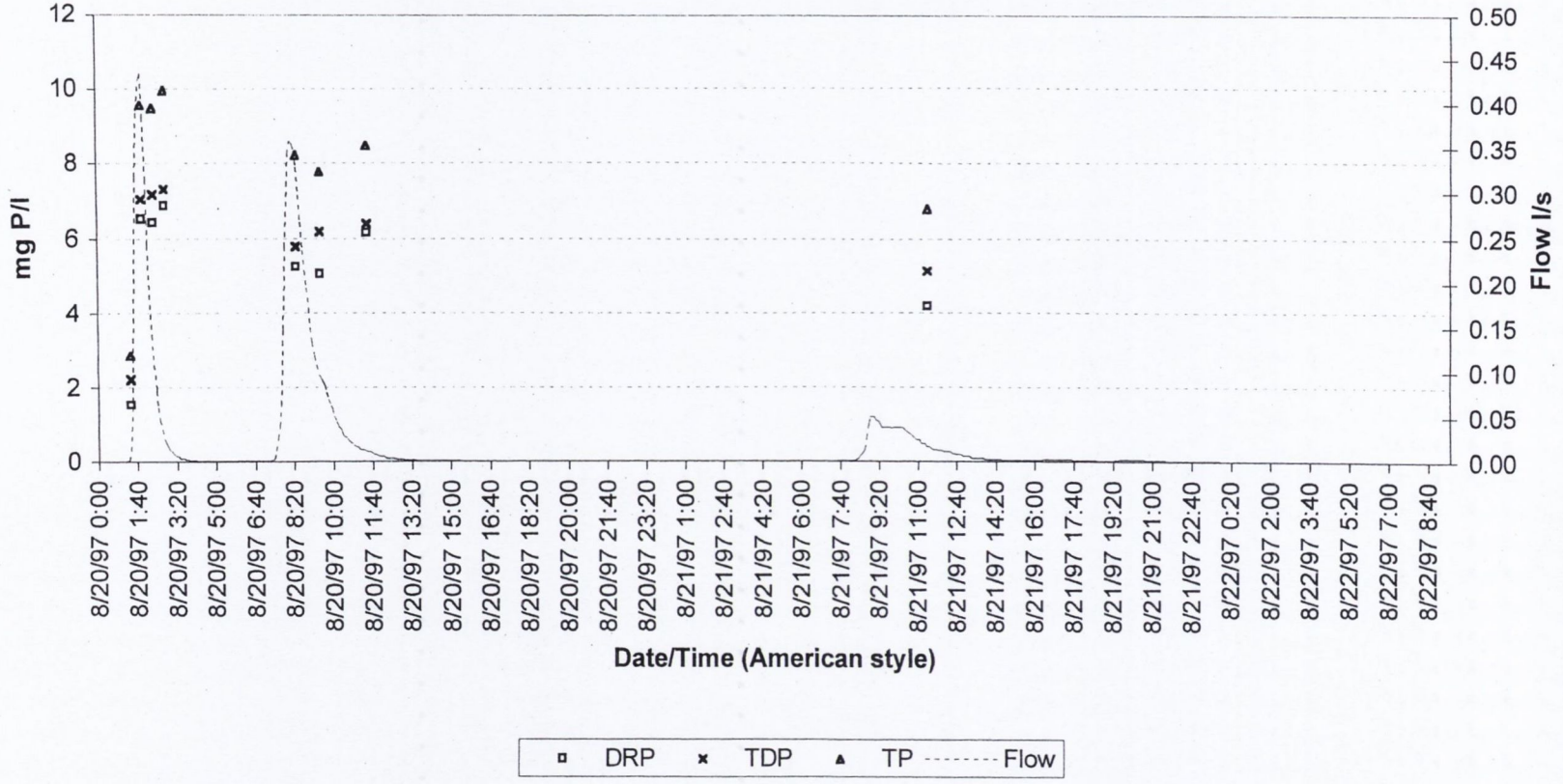


Figure 7.48: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 14.1 at the Cowlands.

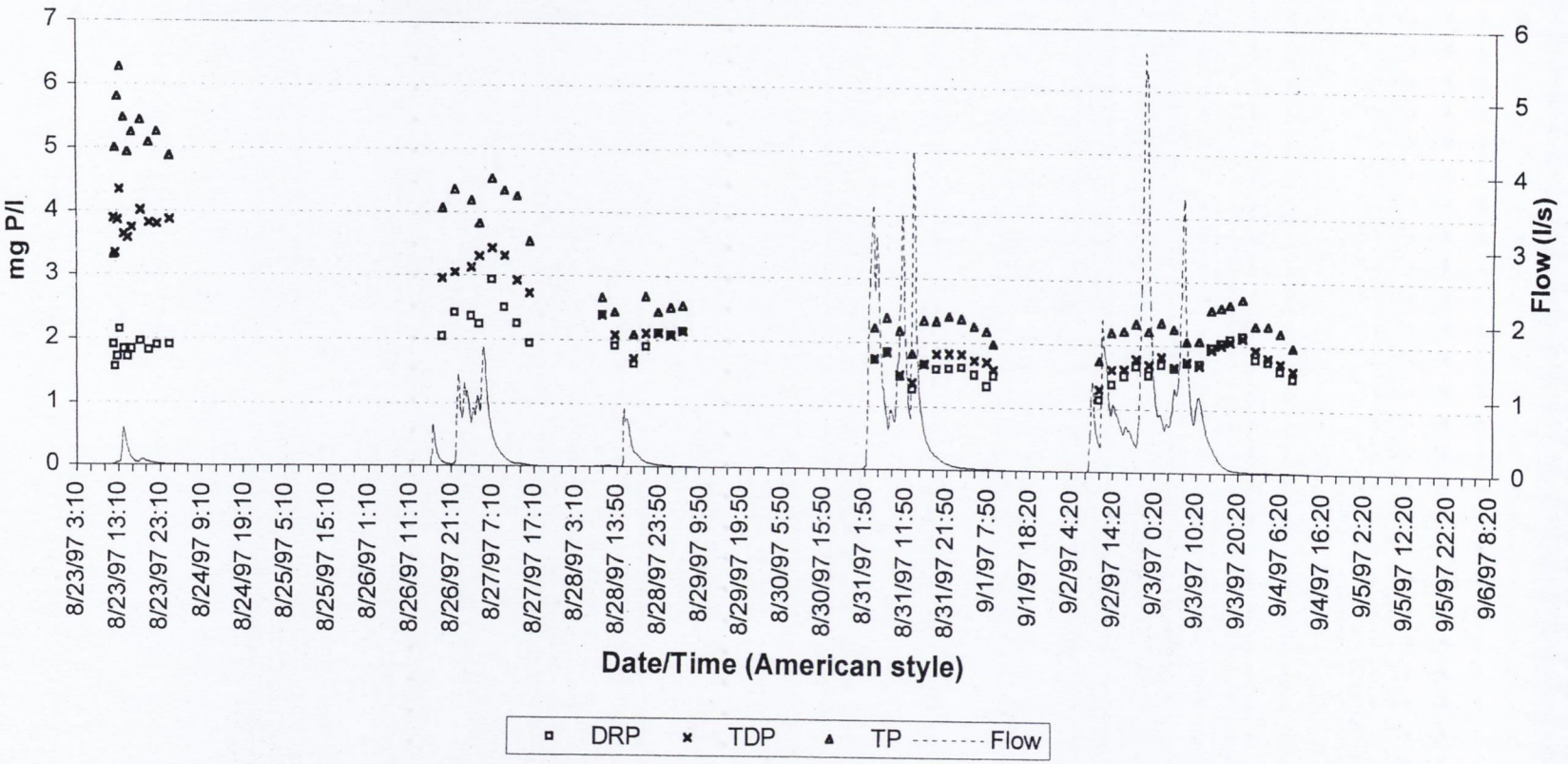


Figure 7.49: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 14.2 at the Cowlands.

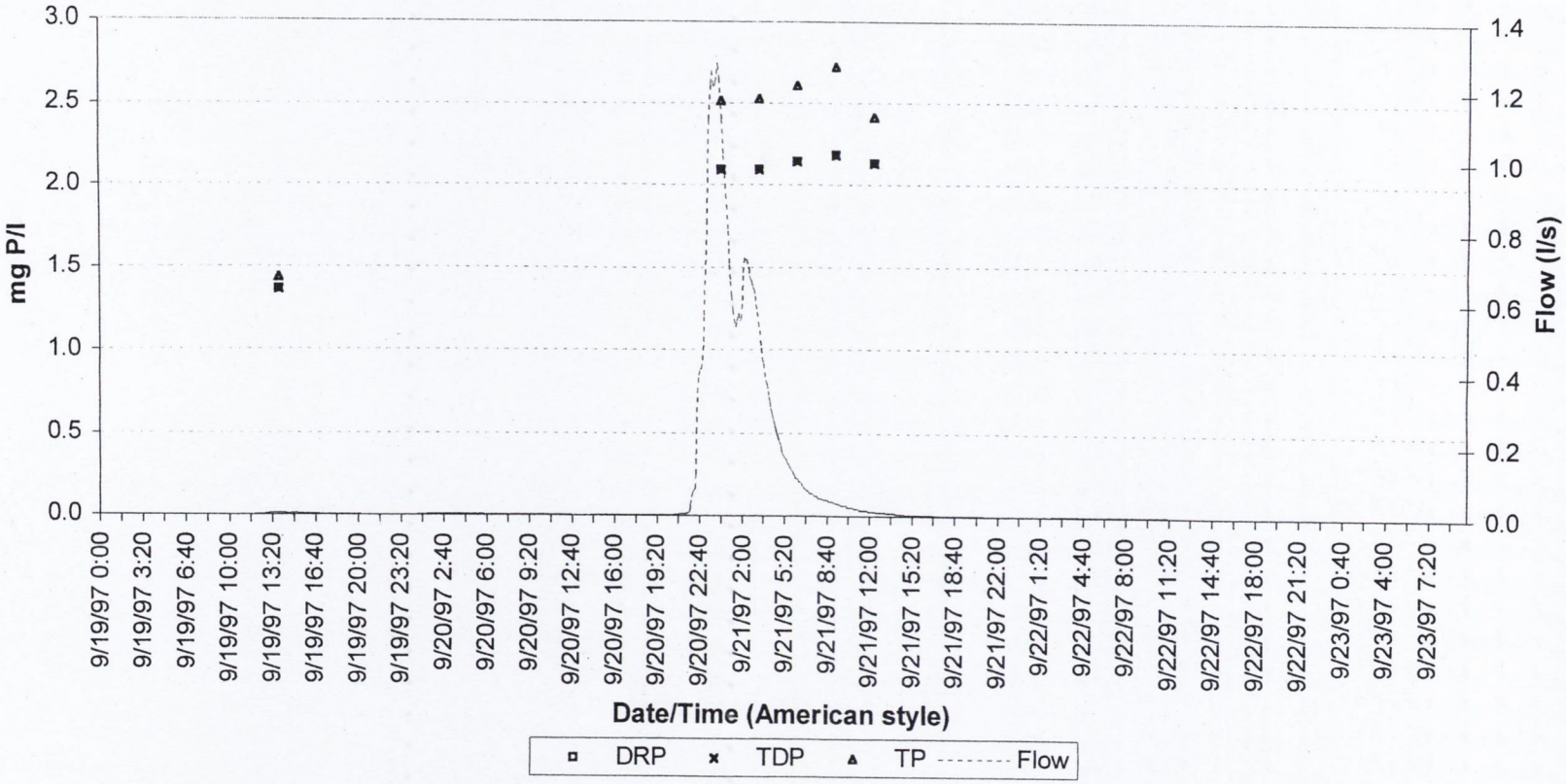


Figure 7.50: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 15 at the Cowlands.

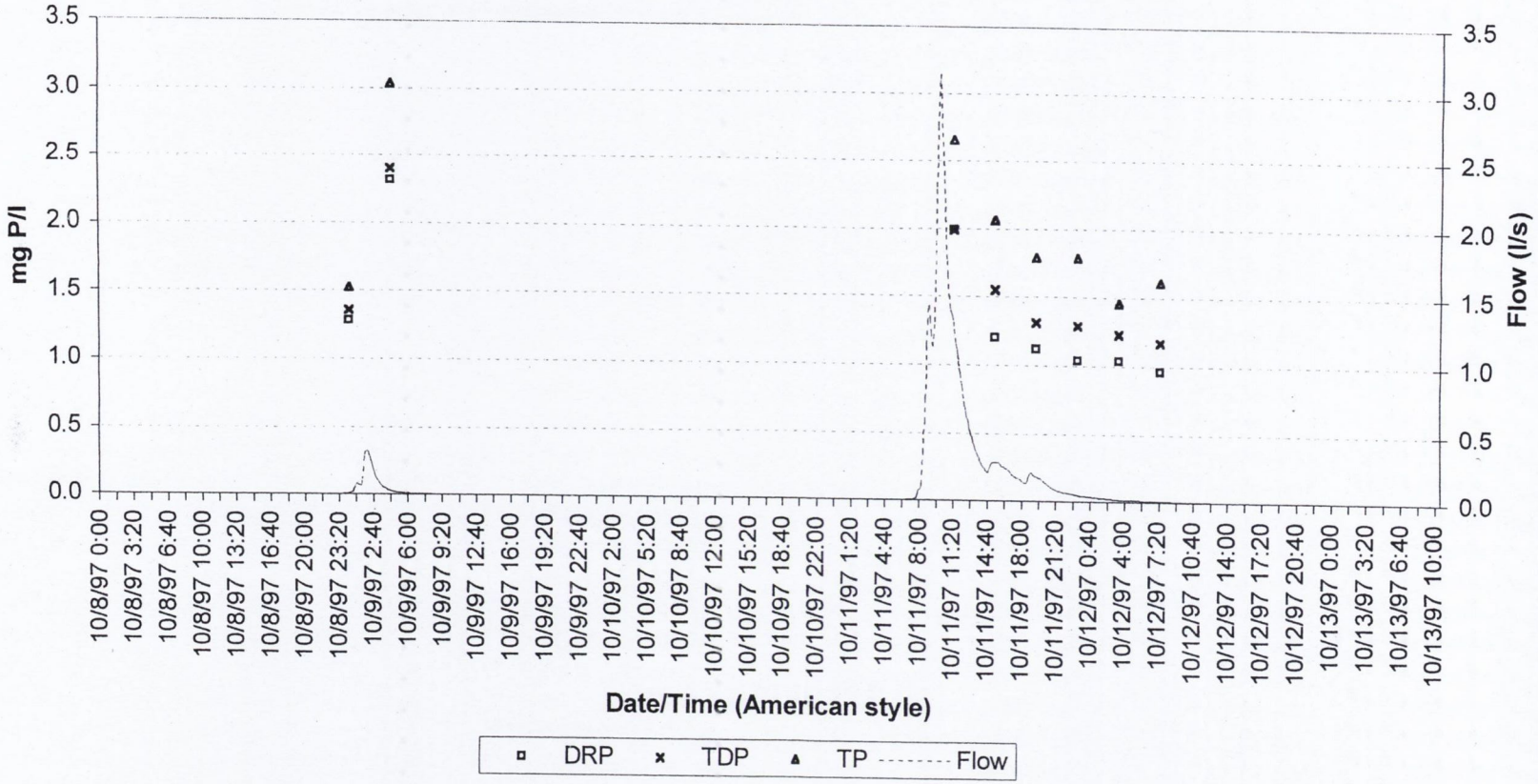


Figure 7.51: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 16 at the Cowlands.

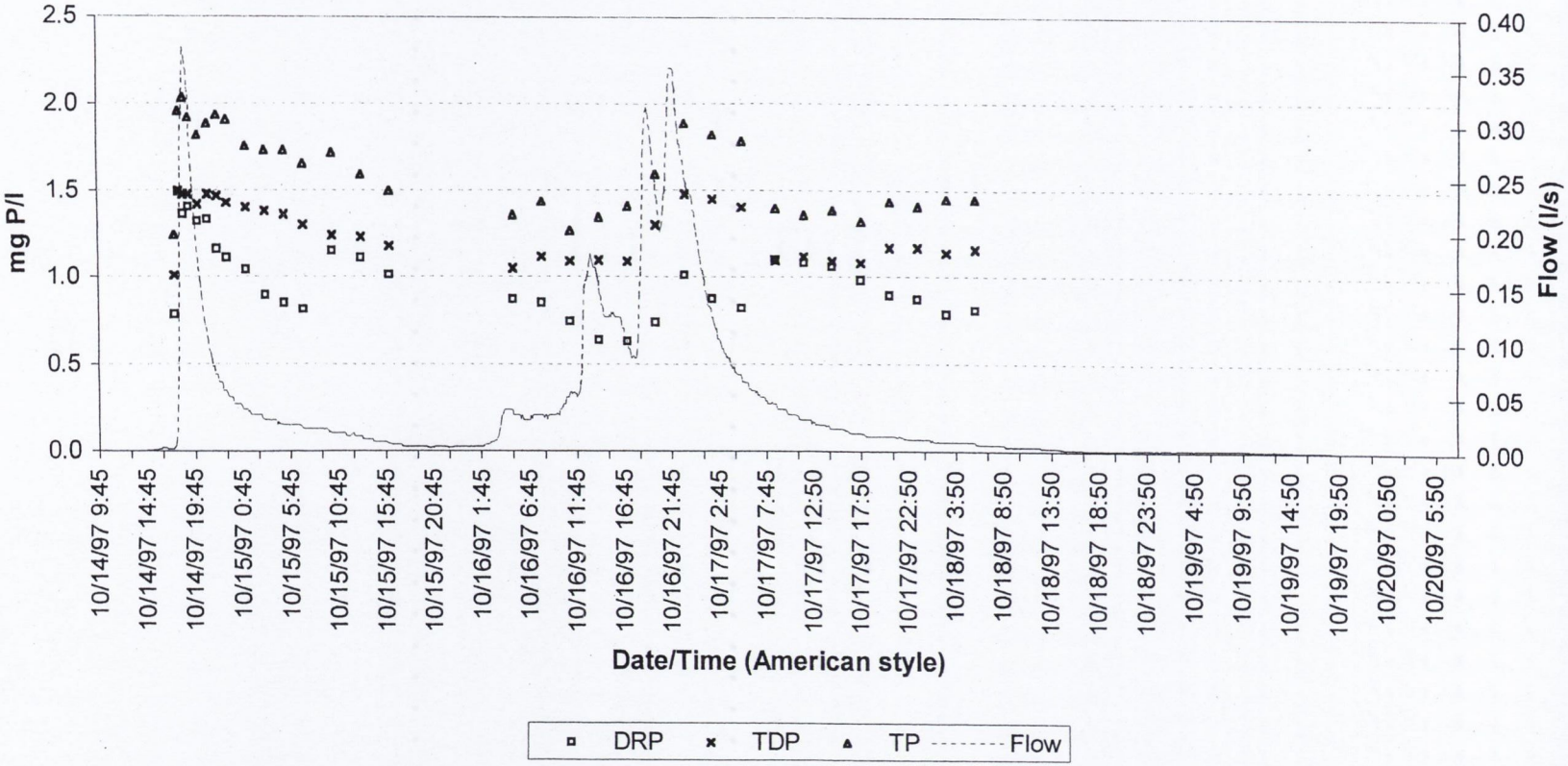


Figure 7.52: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 17 at the Cowlands.

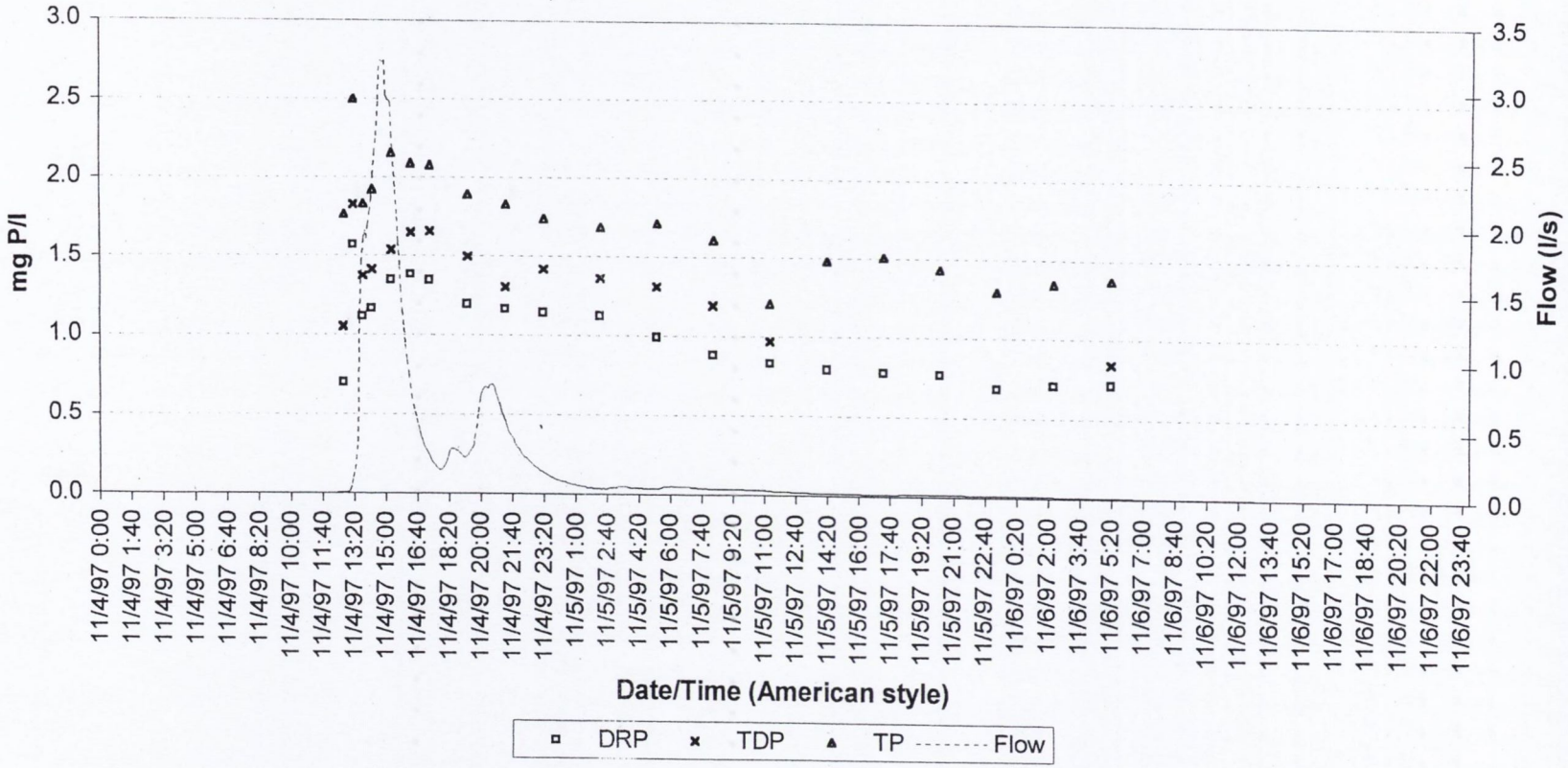


Figure 7.53: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 18.1 at the Cowlands.

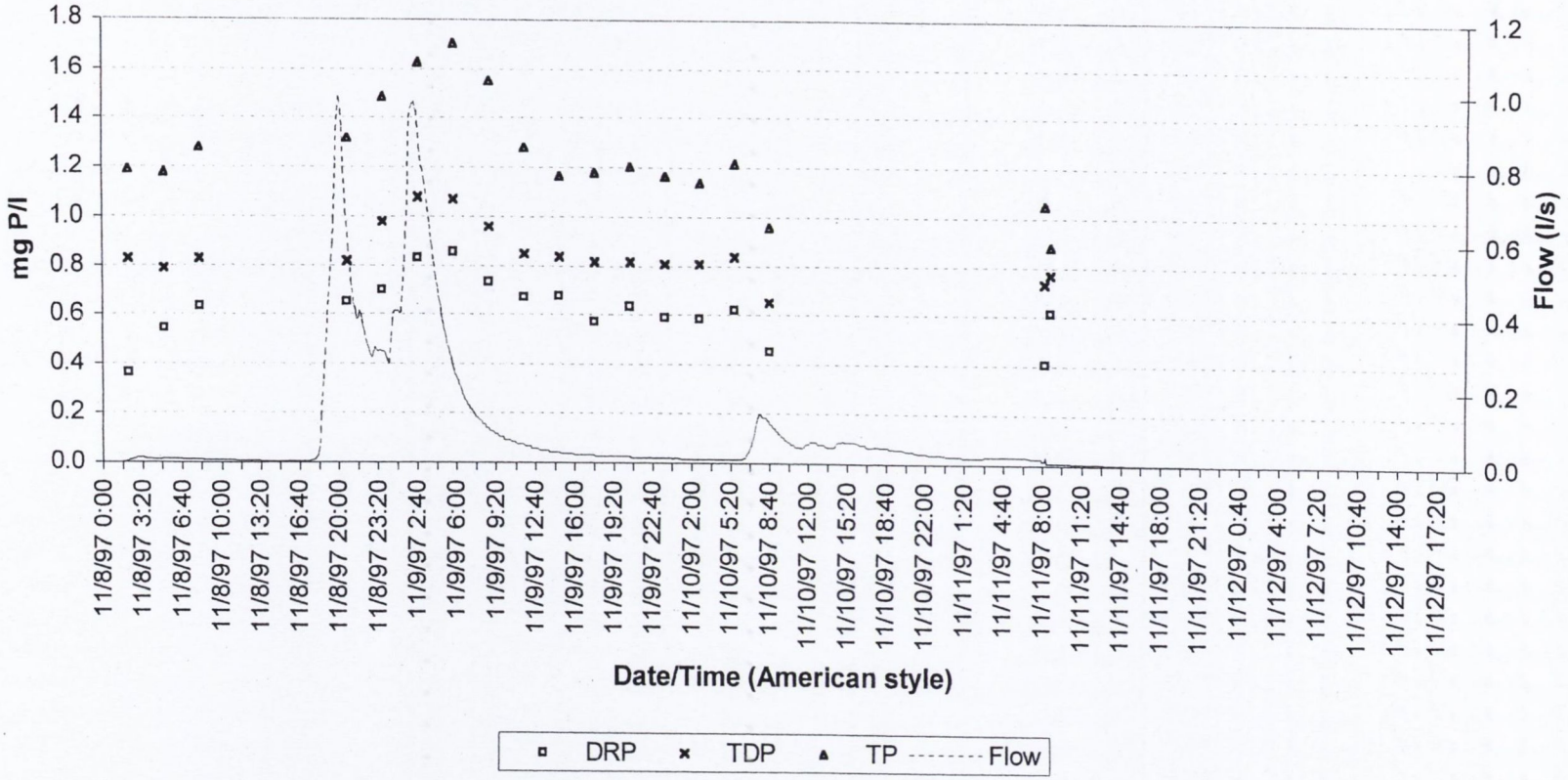


Figure 7.54: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 18.2 at the Cowlands.

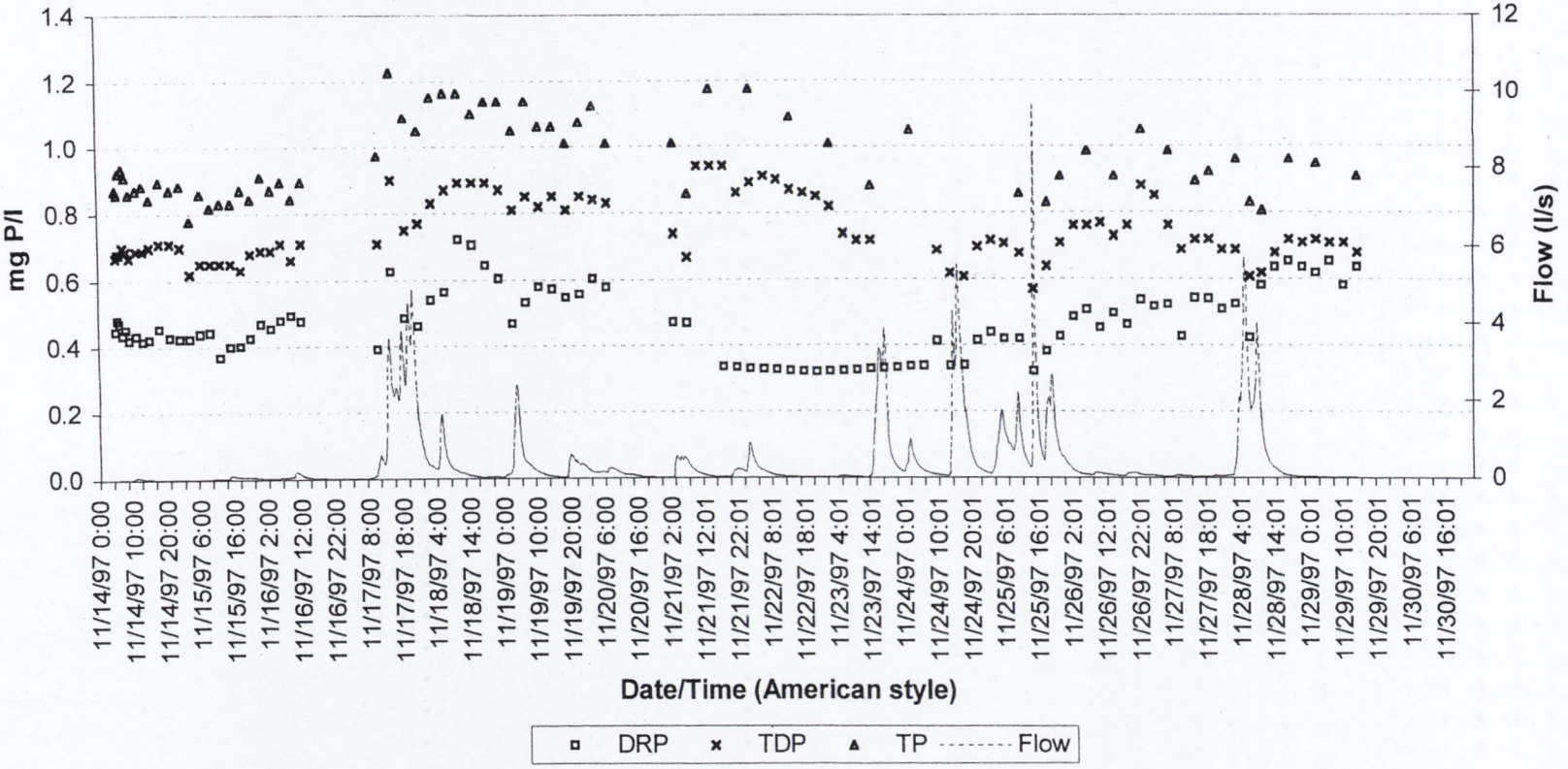


Figure 7.55: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 18.3 at the Cowlands.

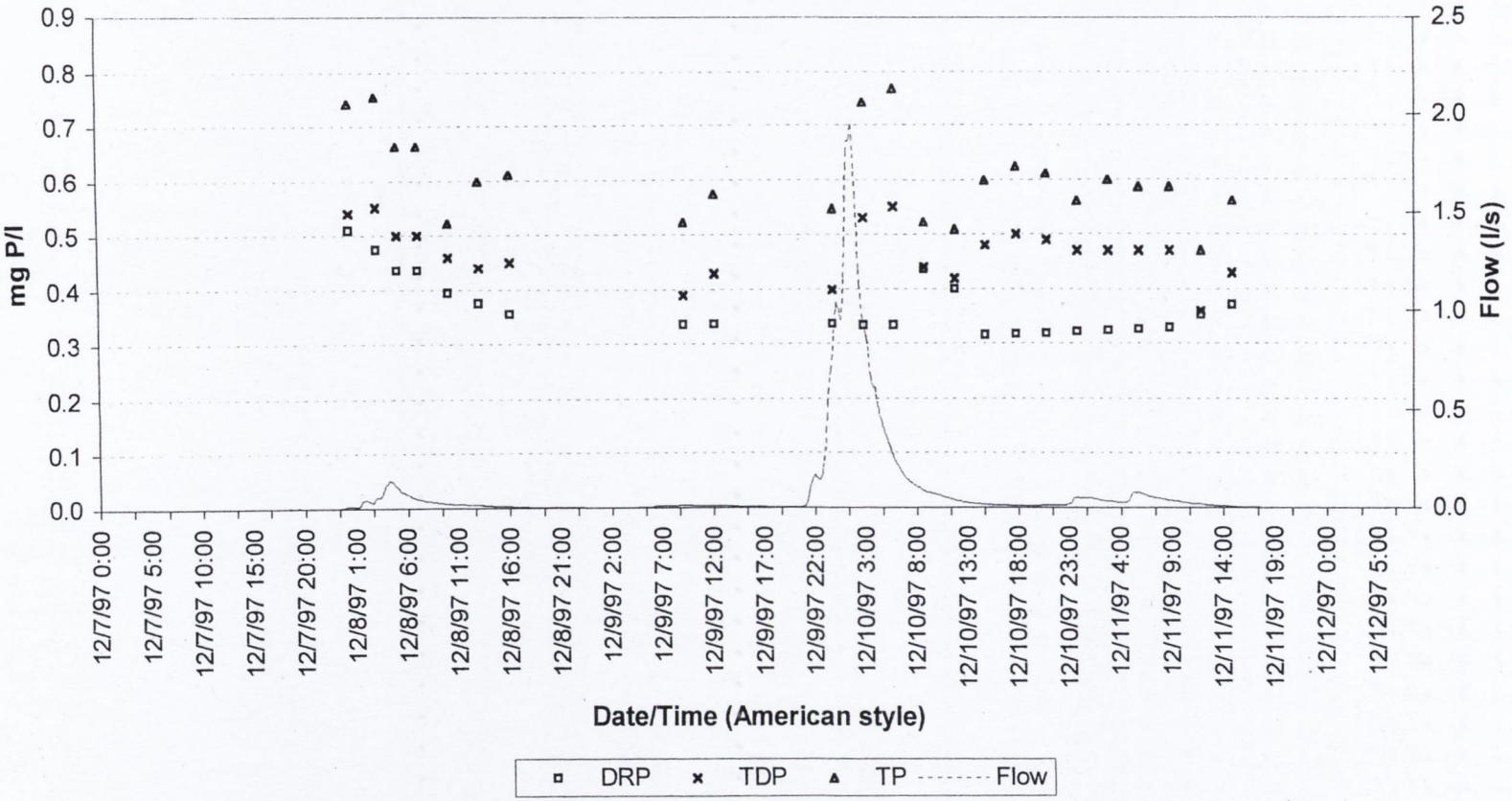


Figure 7.56: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 18.4 at the Cowlands.

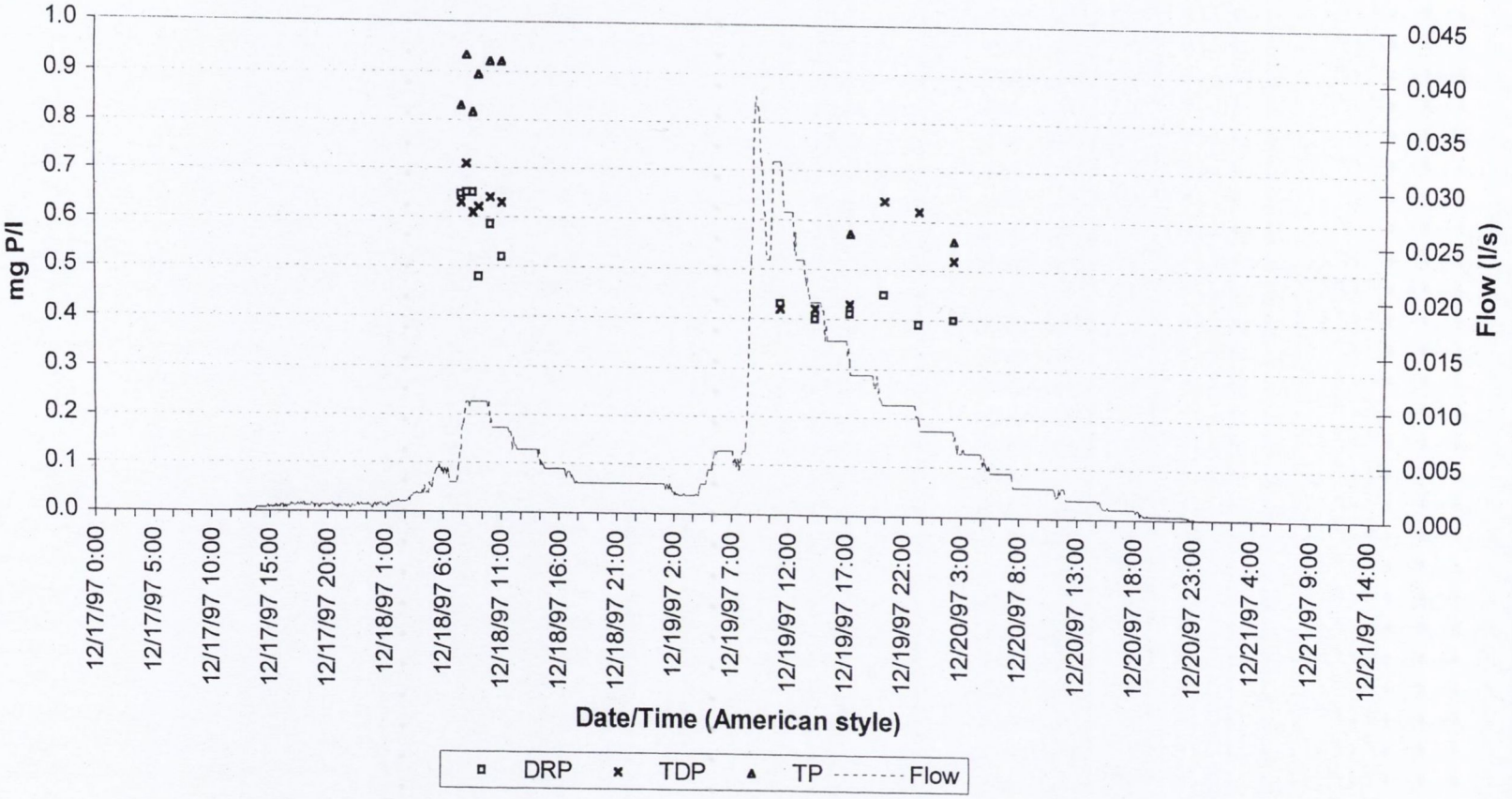


Figure 7.57: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 19.1 at the Cowlands.

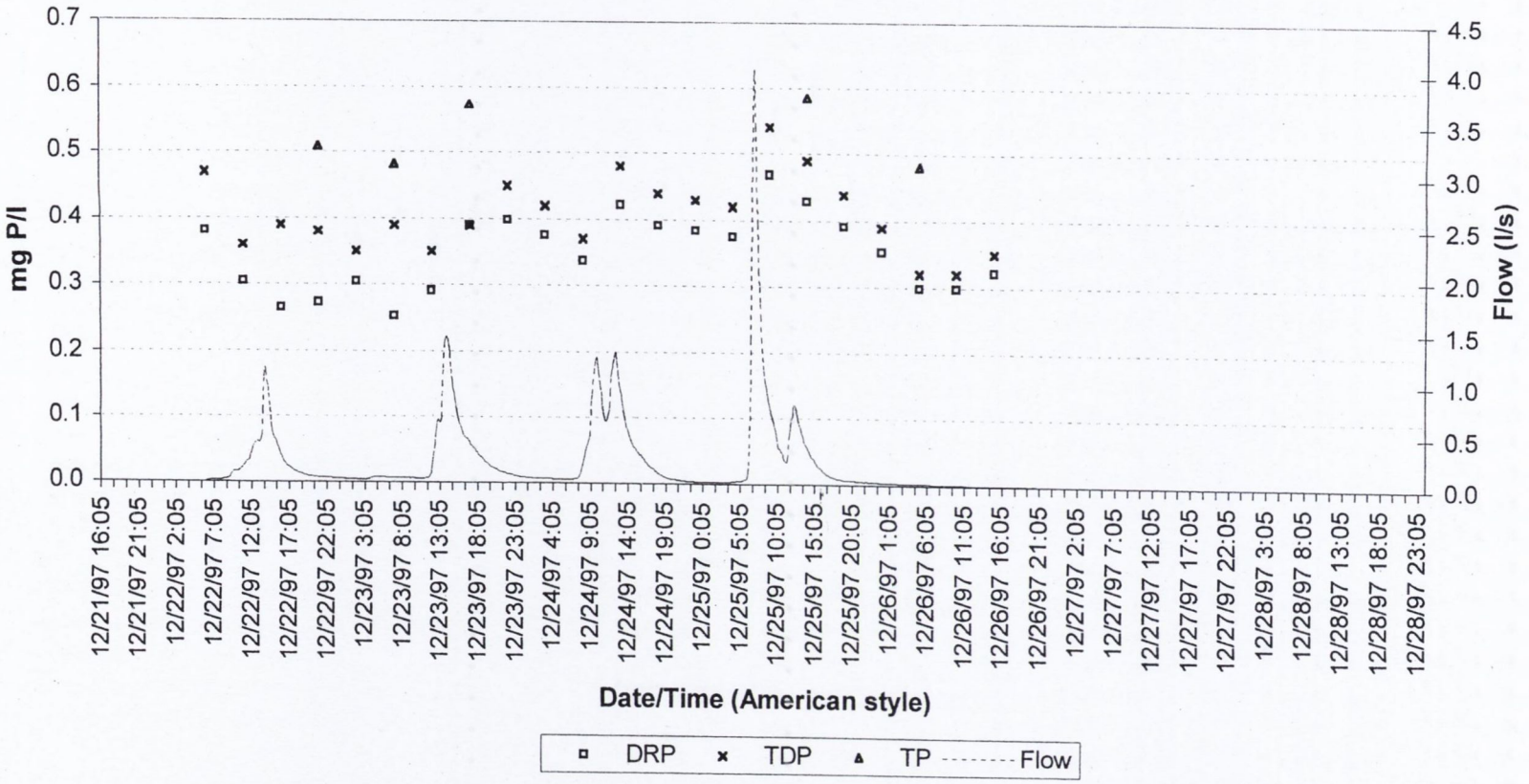


Figure 7.58: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 19.2 at the Cowlands.

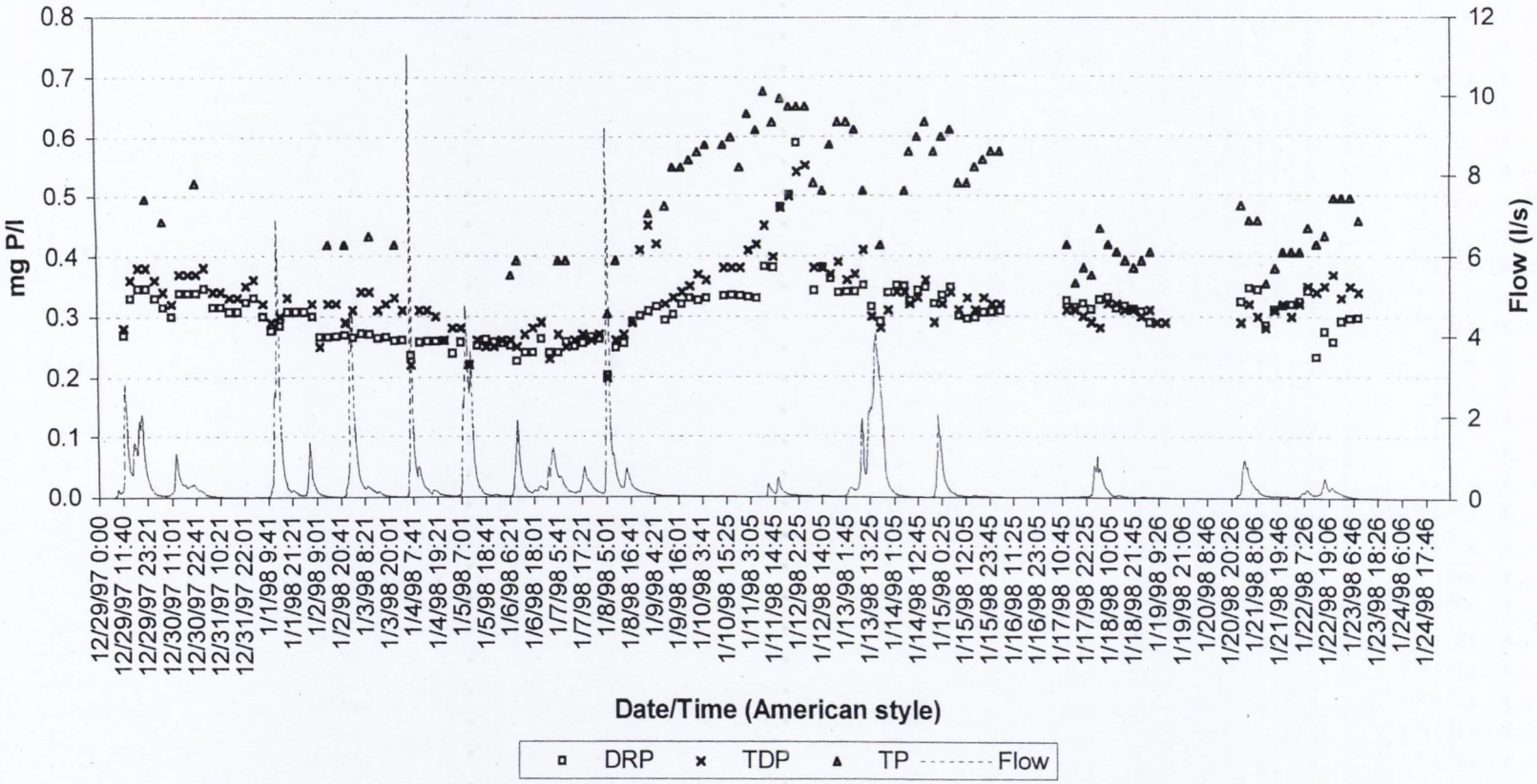


Figure 7.59: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 19.3 at the Cowlands.

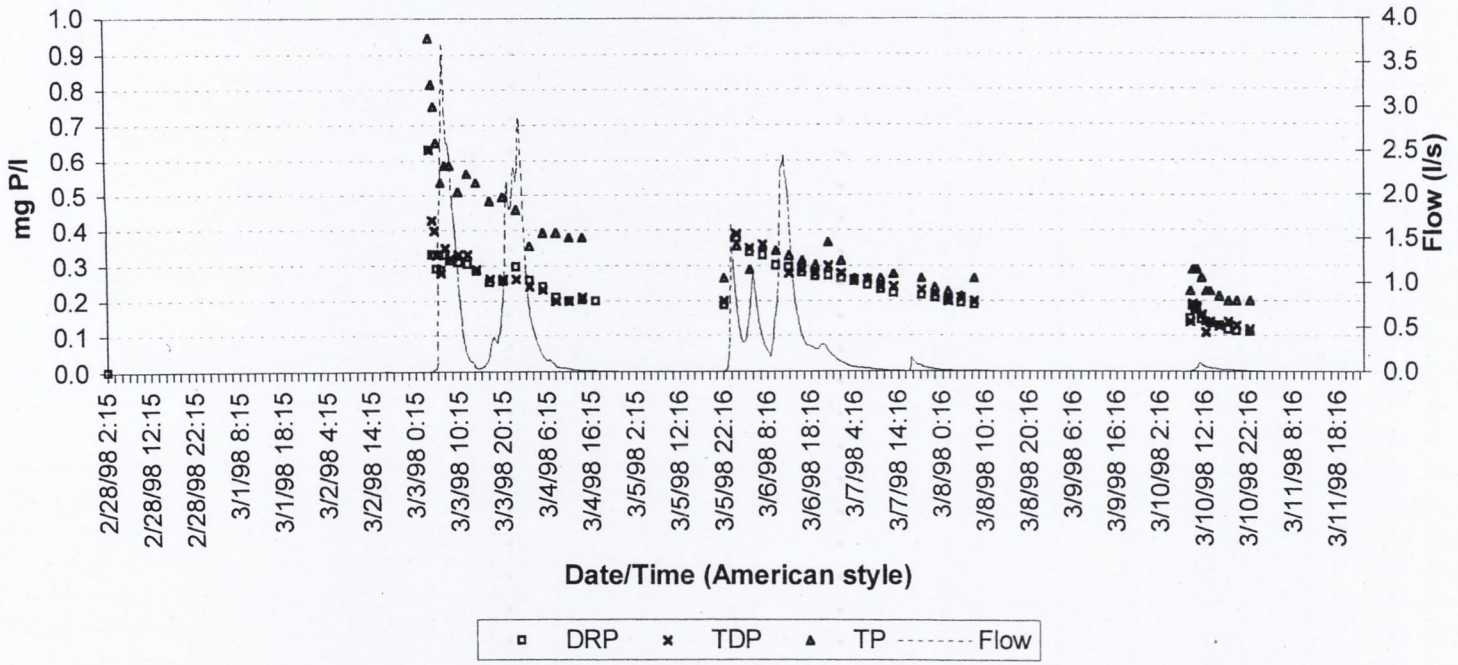


Figure 7.60: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 21 at the Cowlands.

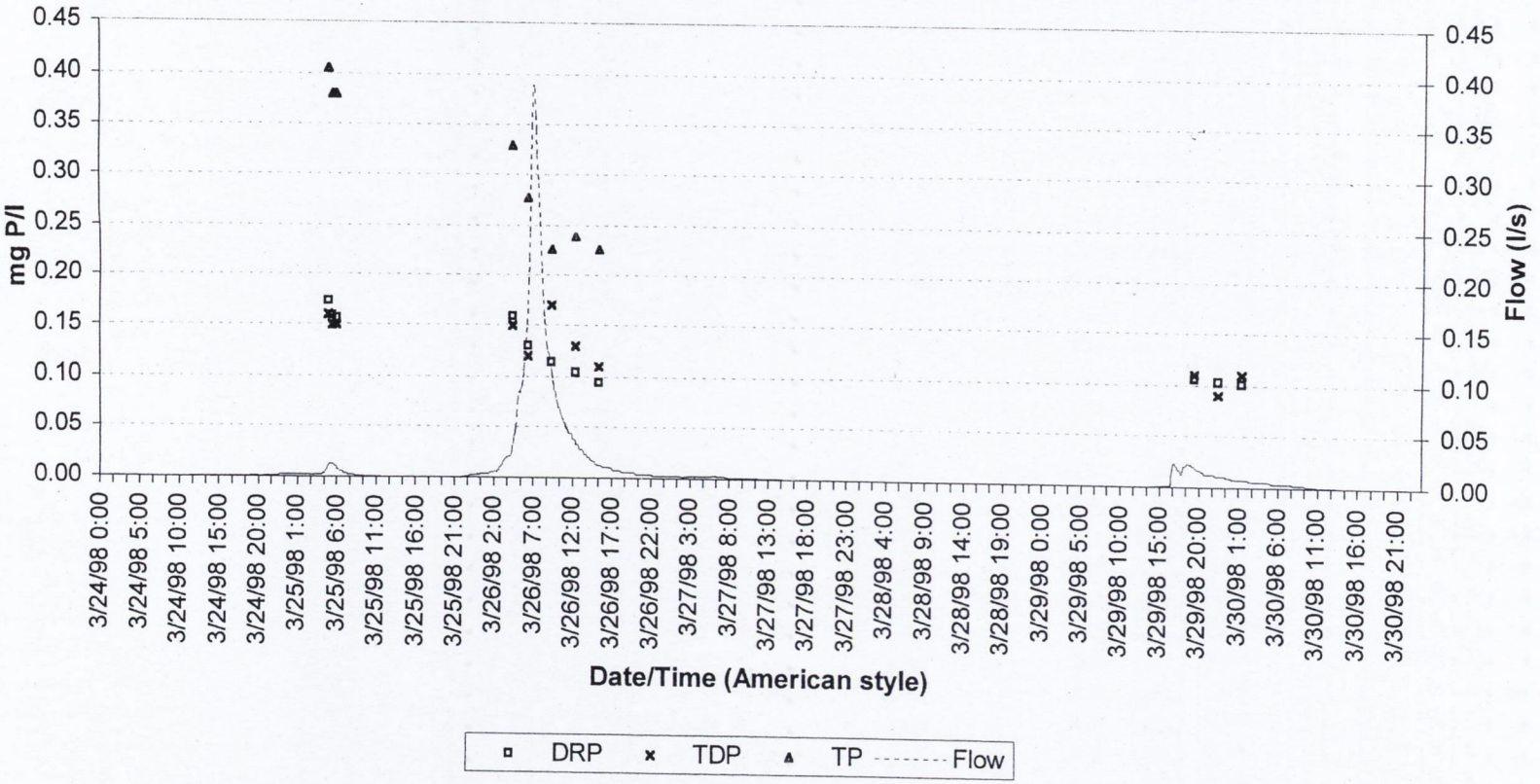


Figure 7.61: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 22 at the Cowlands.

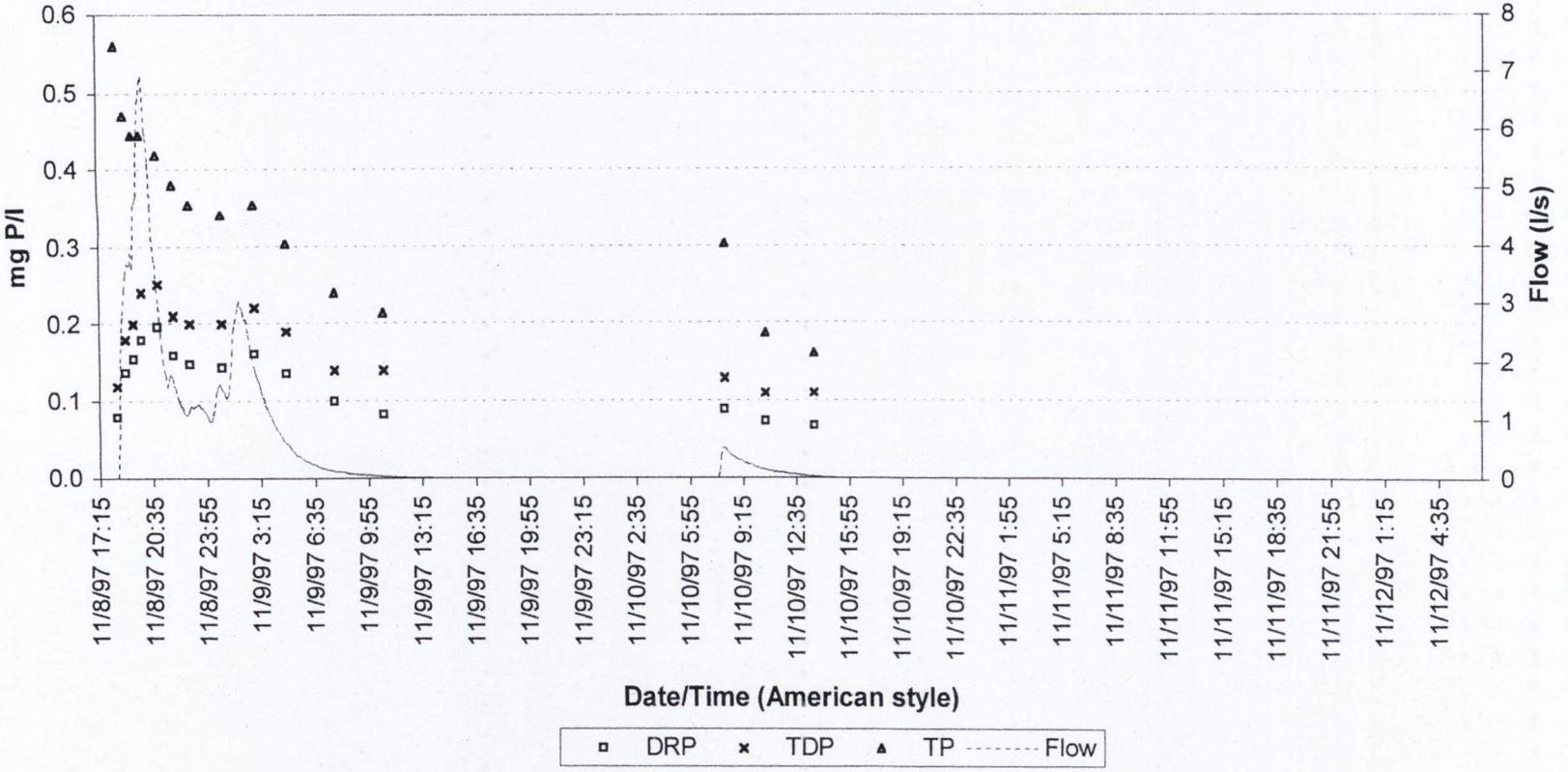


Figure 7.62: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 18.2 at the Warren 2.

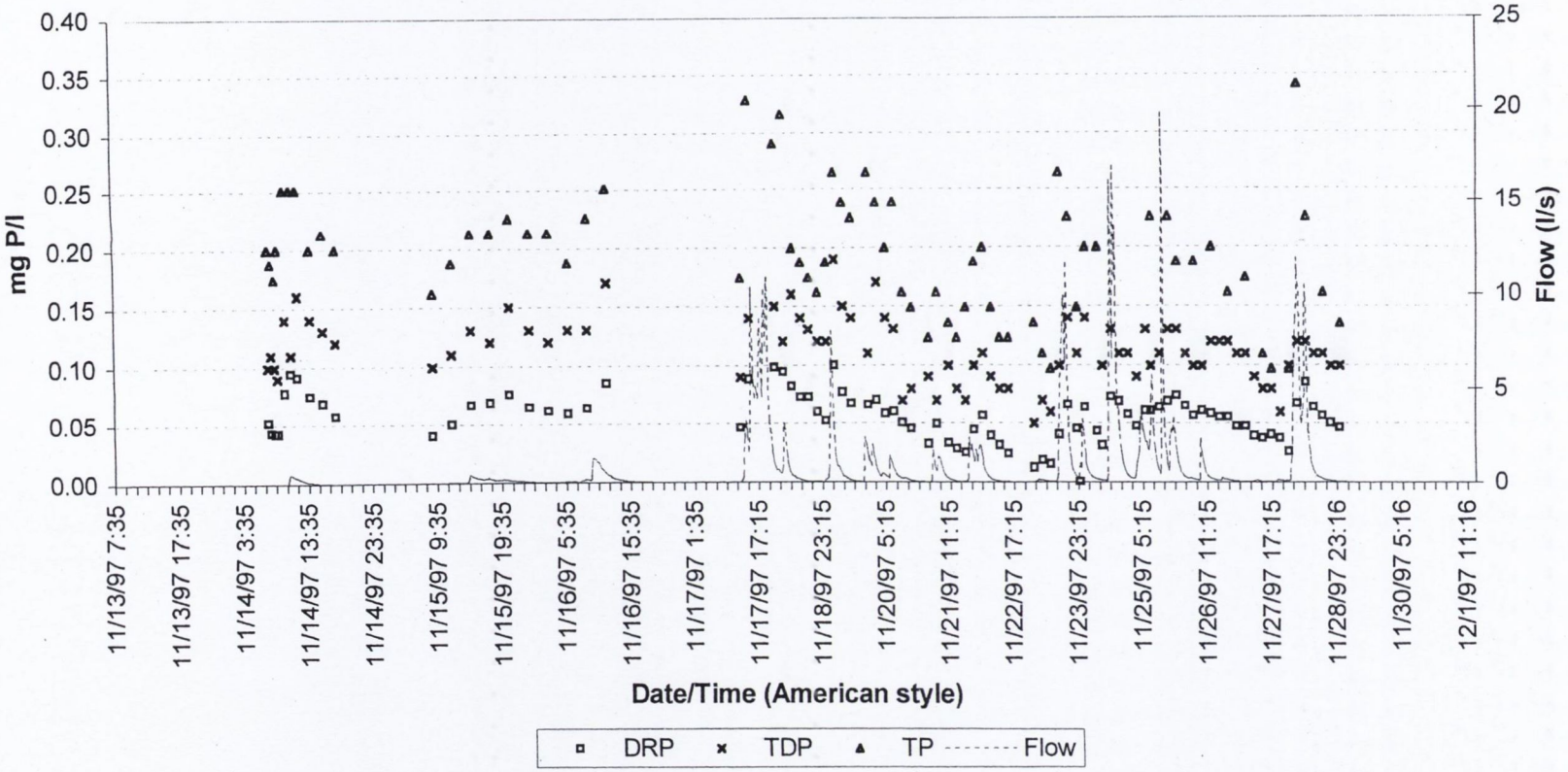


Figure 7.63: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 18.3 at the Warren 2.

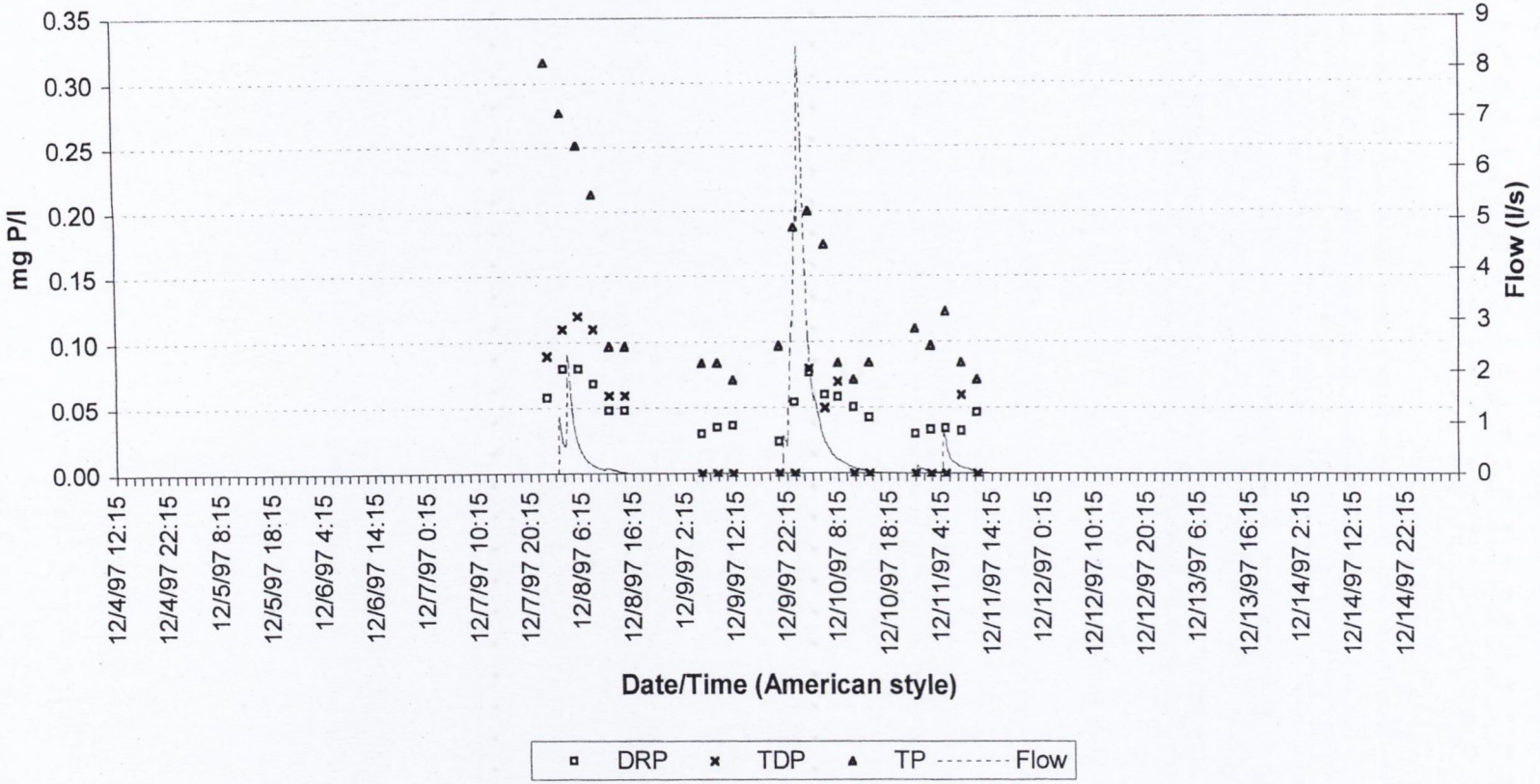


Figure 7.64: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 18.4 at the Warren 2.

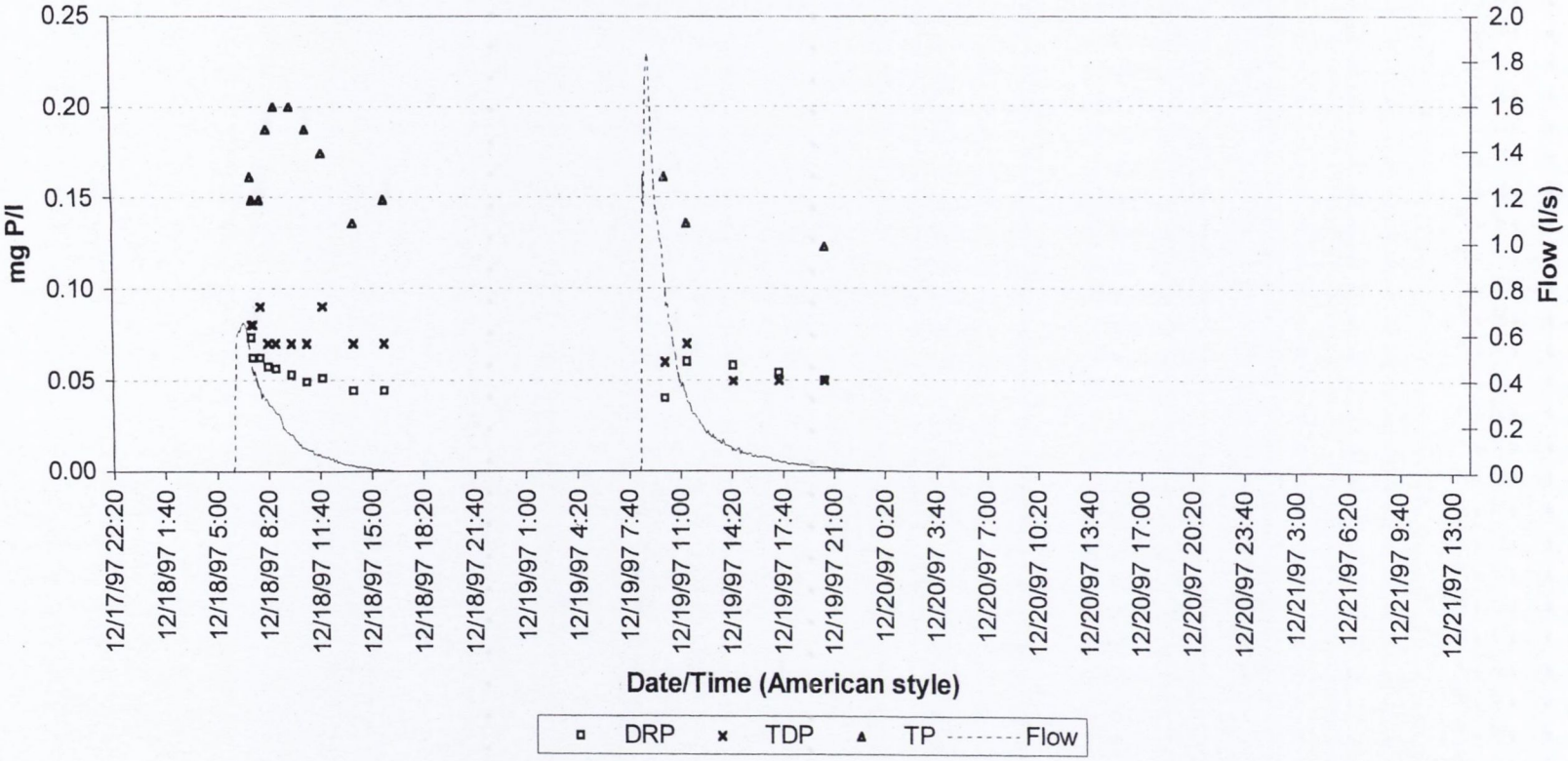


Figure 7.65: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 19.1 at the Warren 2.

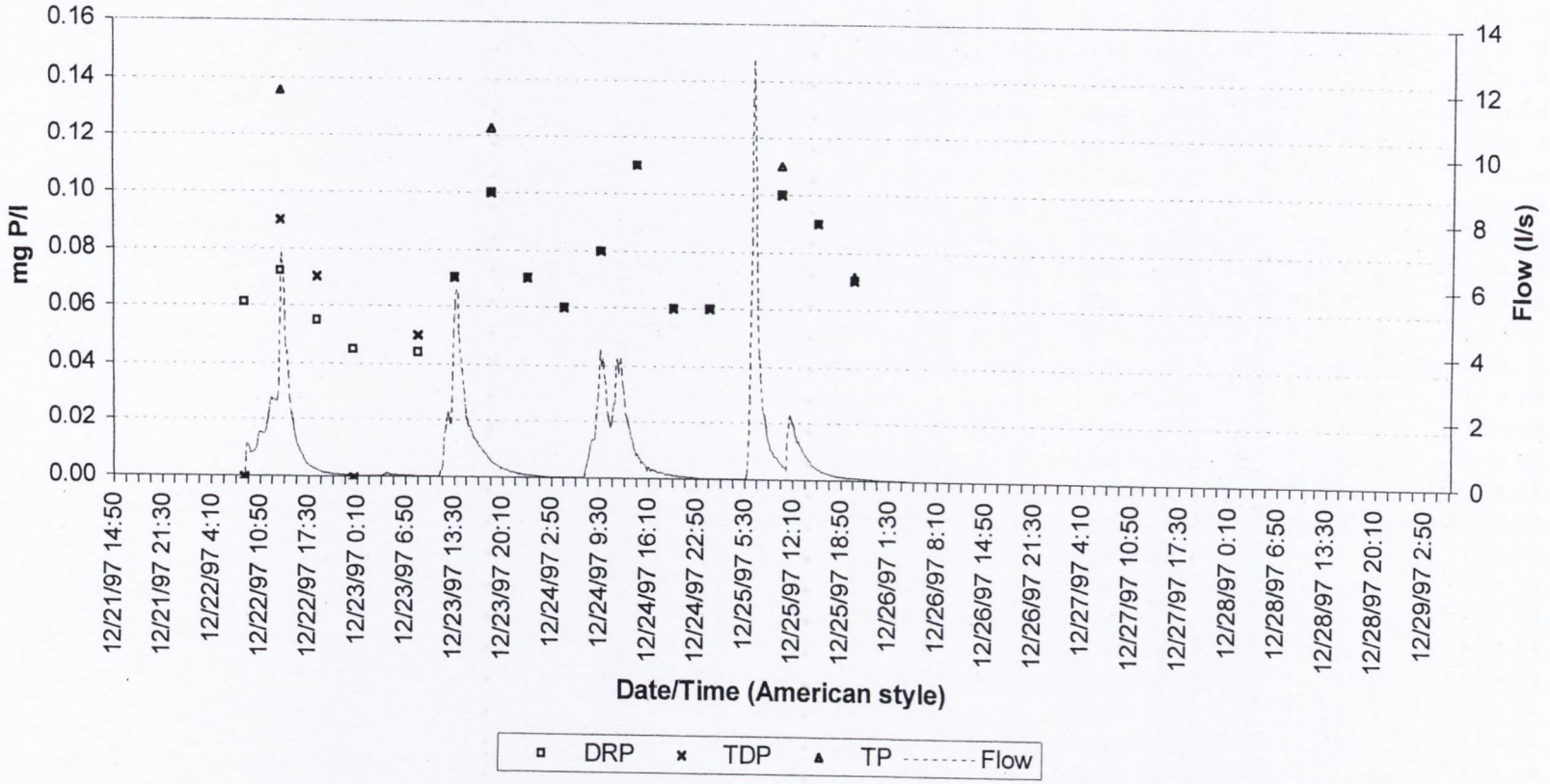


Figure 7.66: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 19.2 at the Warren 2.

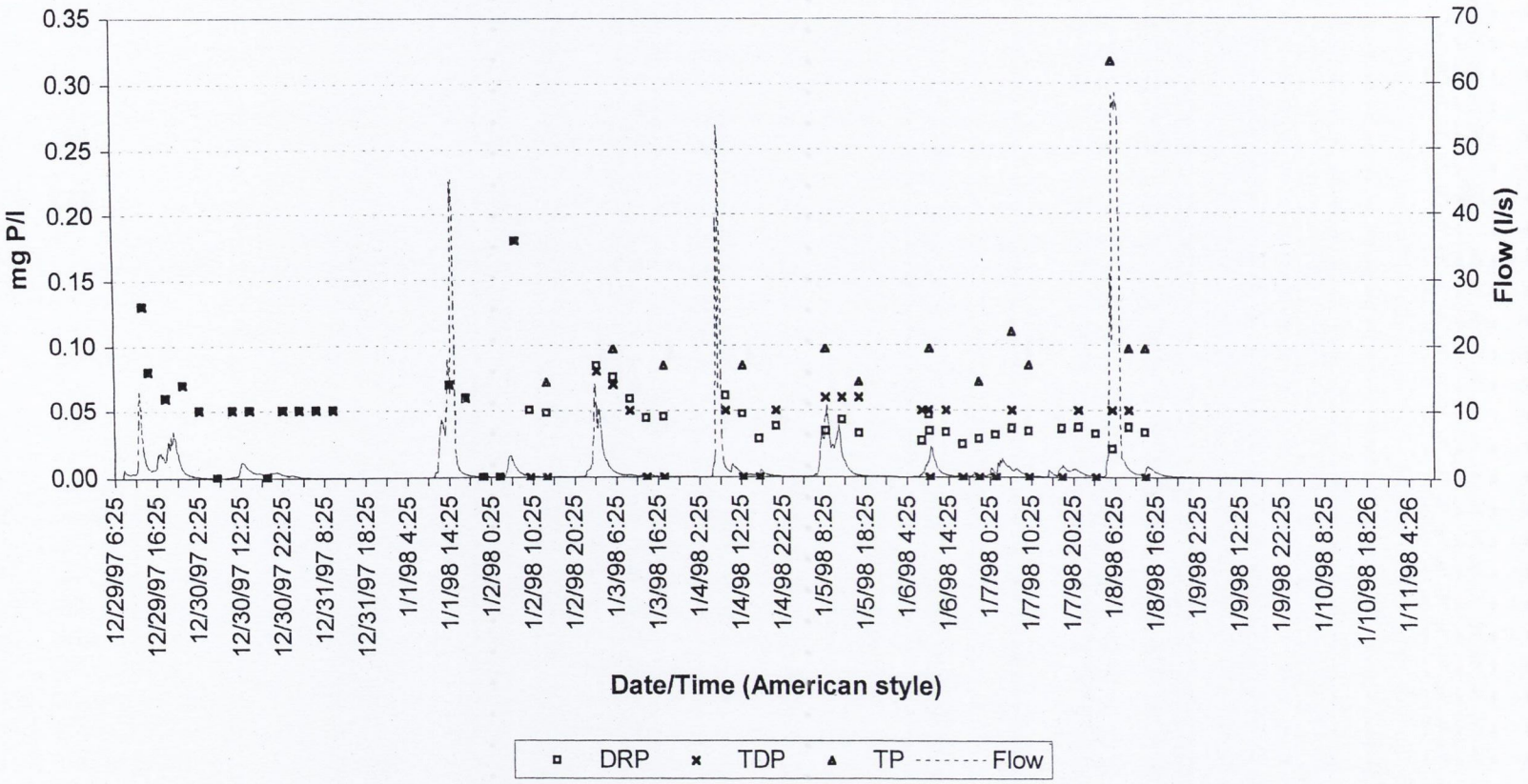


Figure 7.67: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 19.3.1 at the Warren 2.

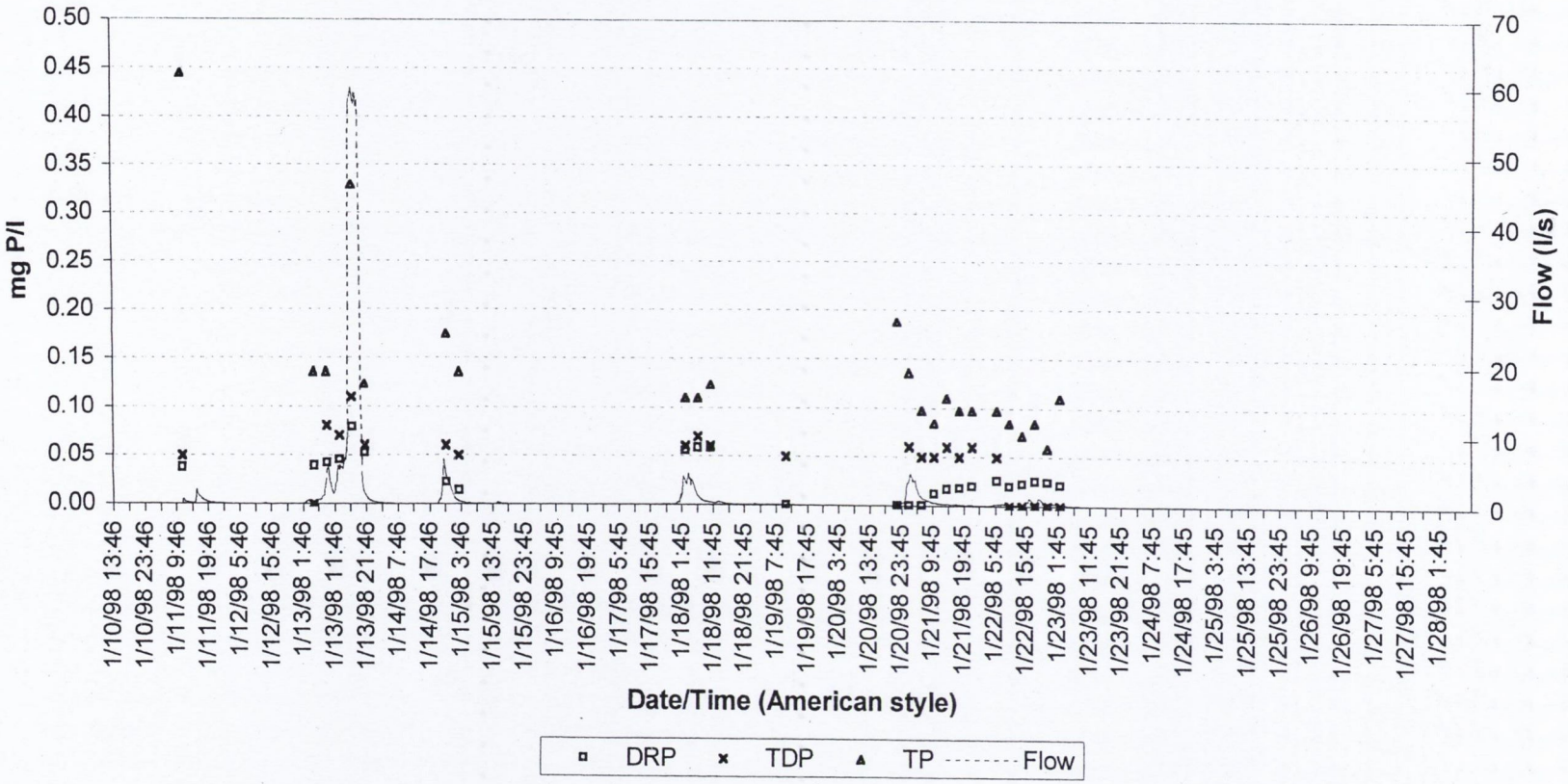


Figure 7.68: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 19.3.2 at the Warren 2.

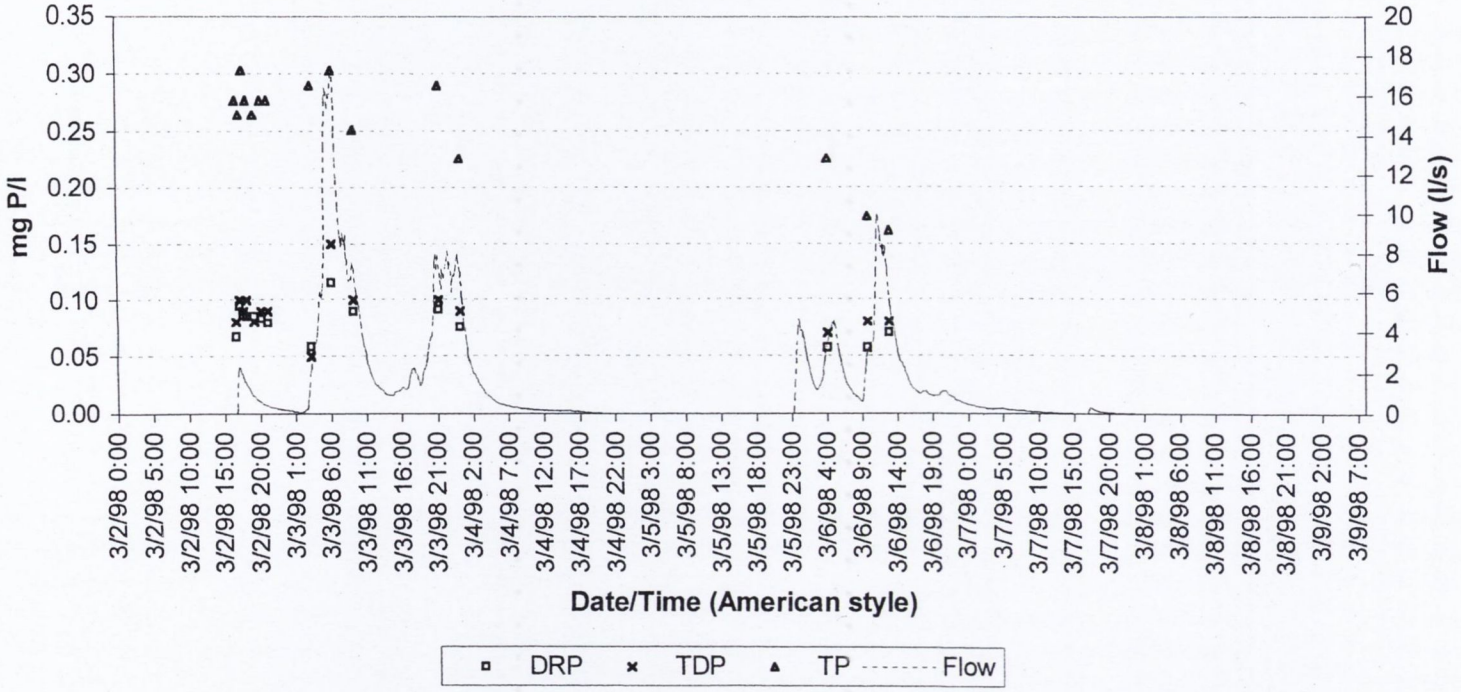


Figure 7.69: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 21 at the Warren 2.

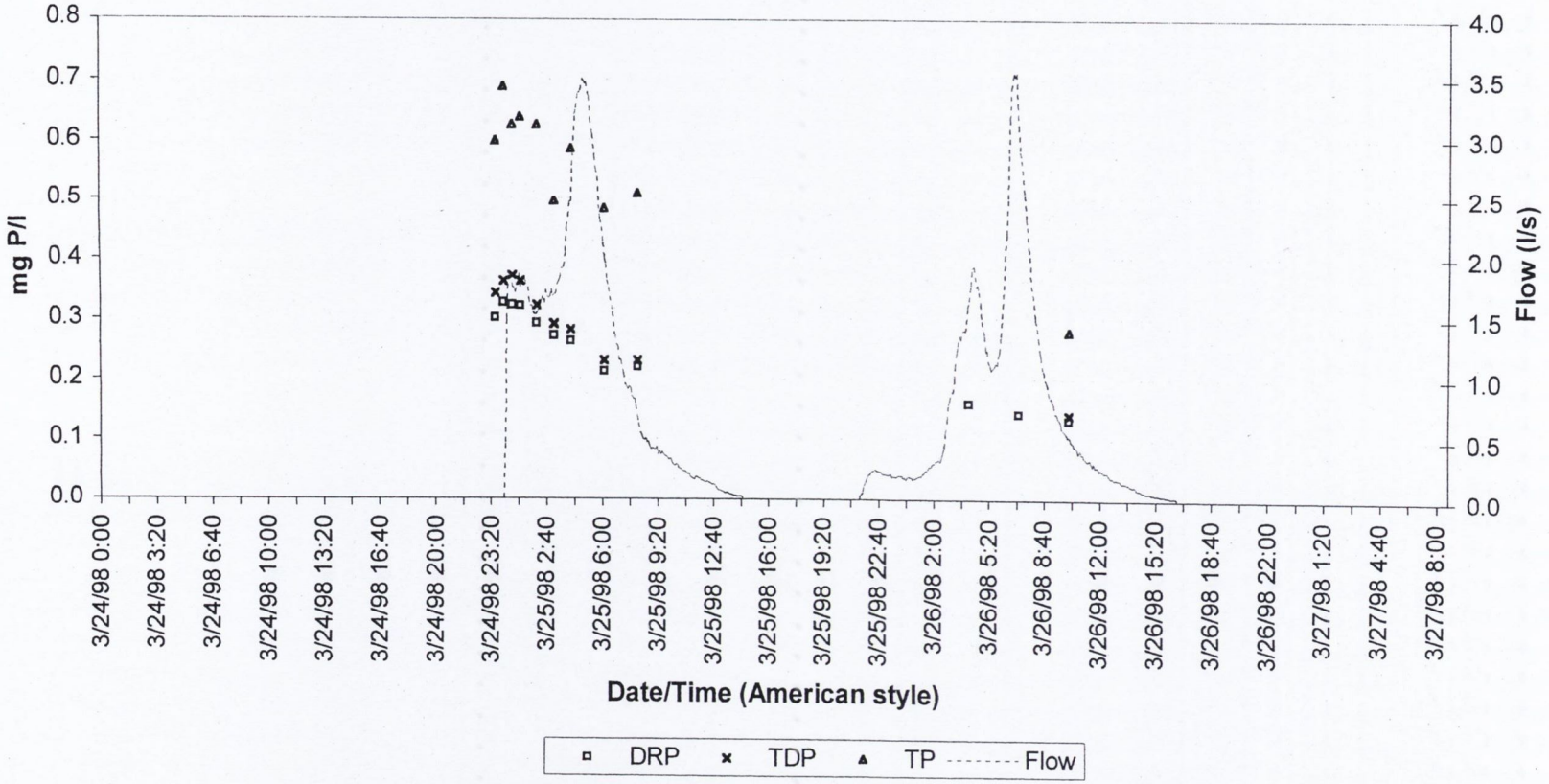


Figure 7.70: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 22.1 at the Warren 2.

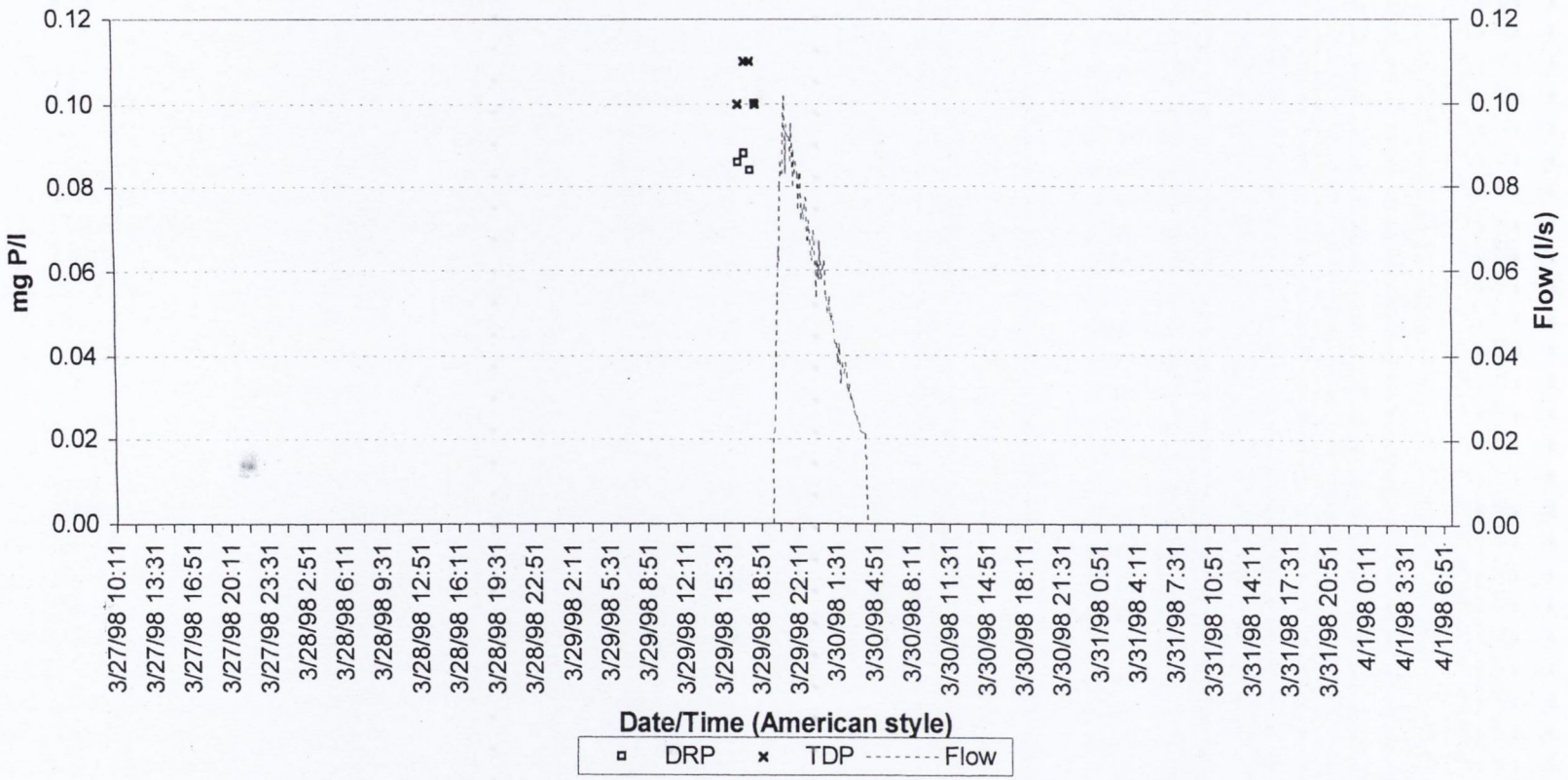


Figure 7.71: Overland flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event 22.2 at the Warren 2.

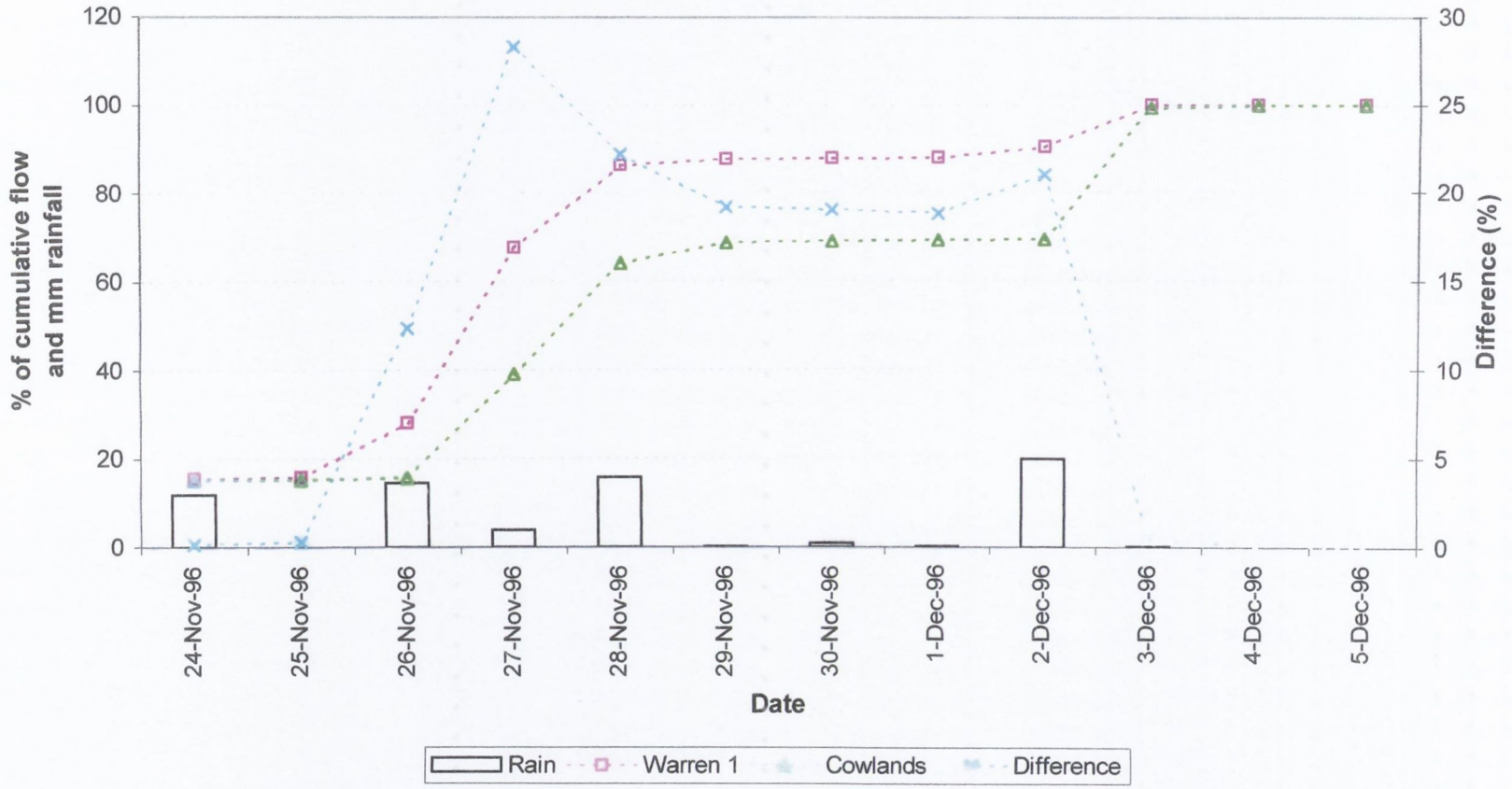


Figure 7.72: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 1, and curve of the difference between the percentages of cumulative flow at the two sites.

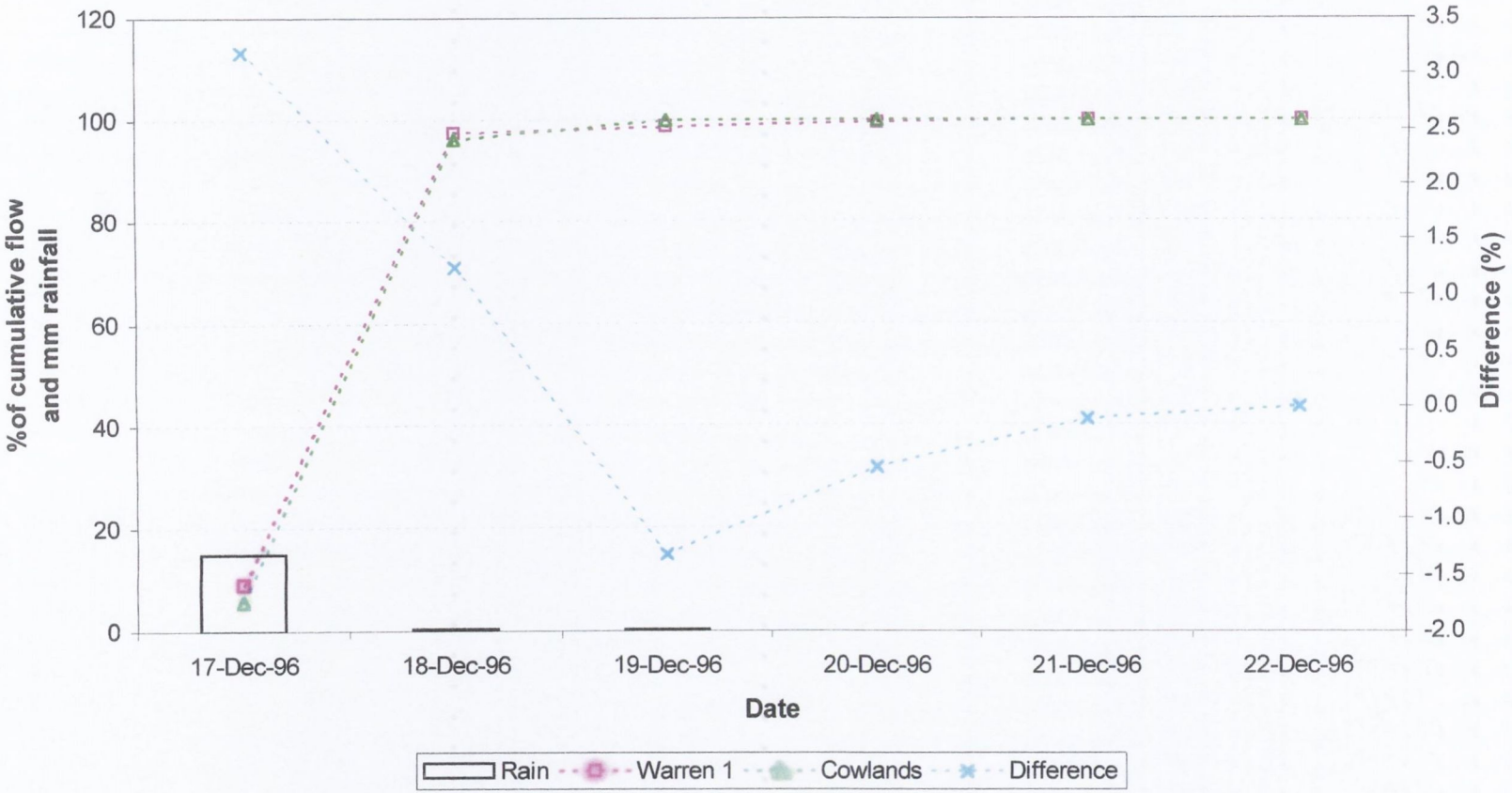


Figure 7.73: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 2, and curve of the difference between the percentages of cumulative flow at the two sites.

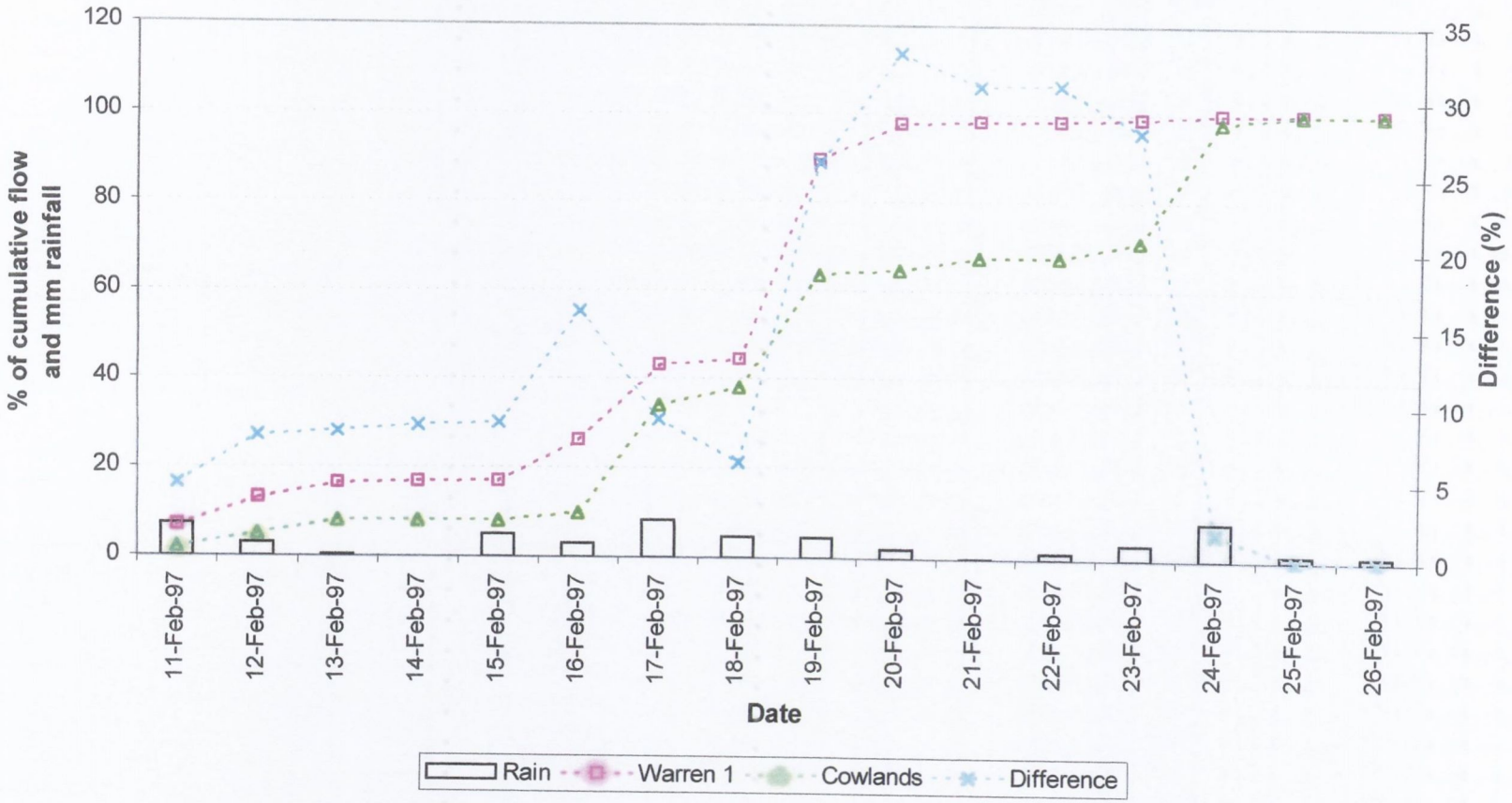


Figure 7.74: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 5, and curve of the difference between the percentages of cumulative flow at the two sites.

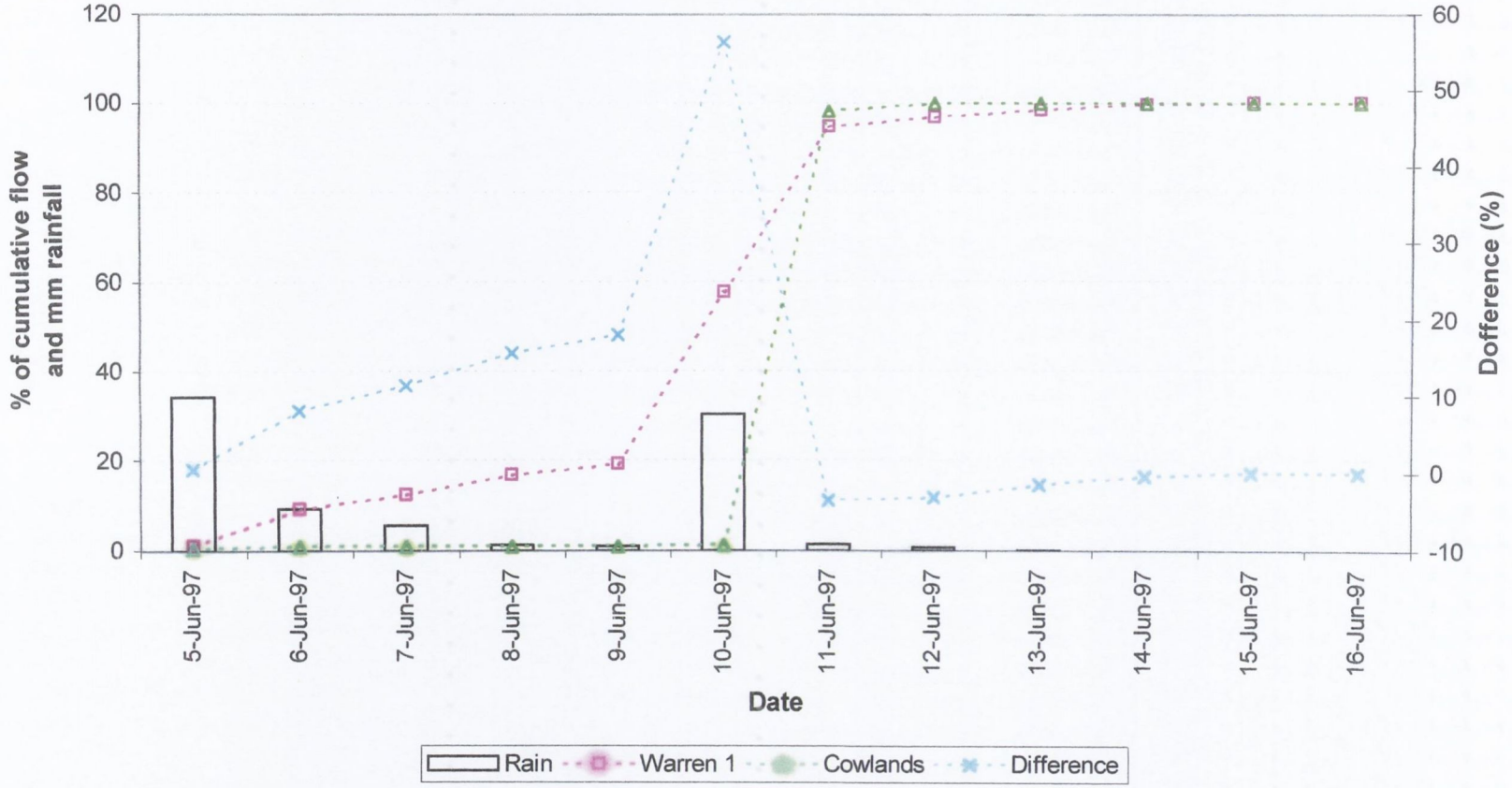


Figure 7.75: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 9, and curve of the difference between the percentages of cumulative flow at the two sites.

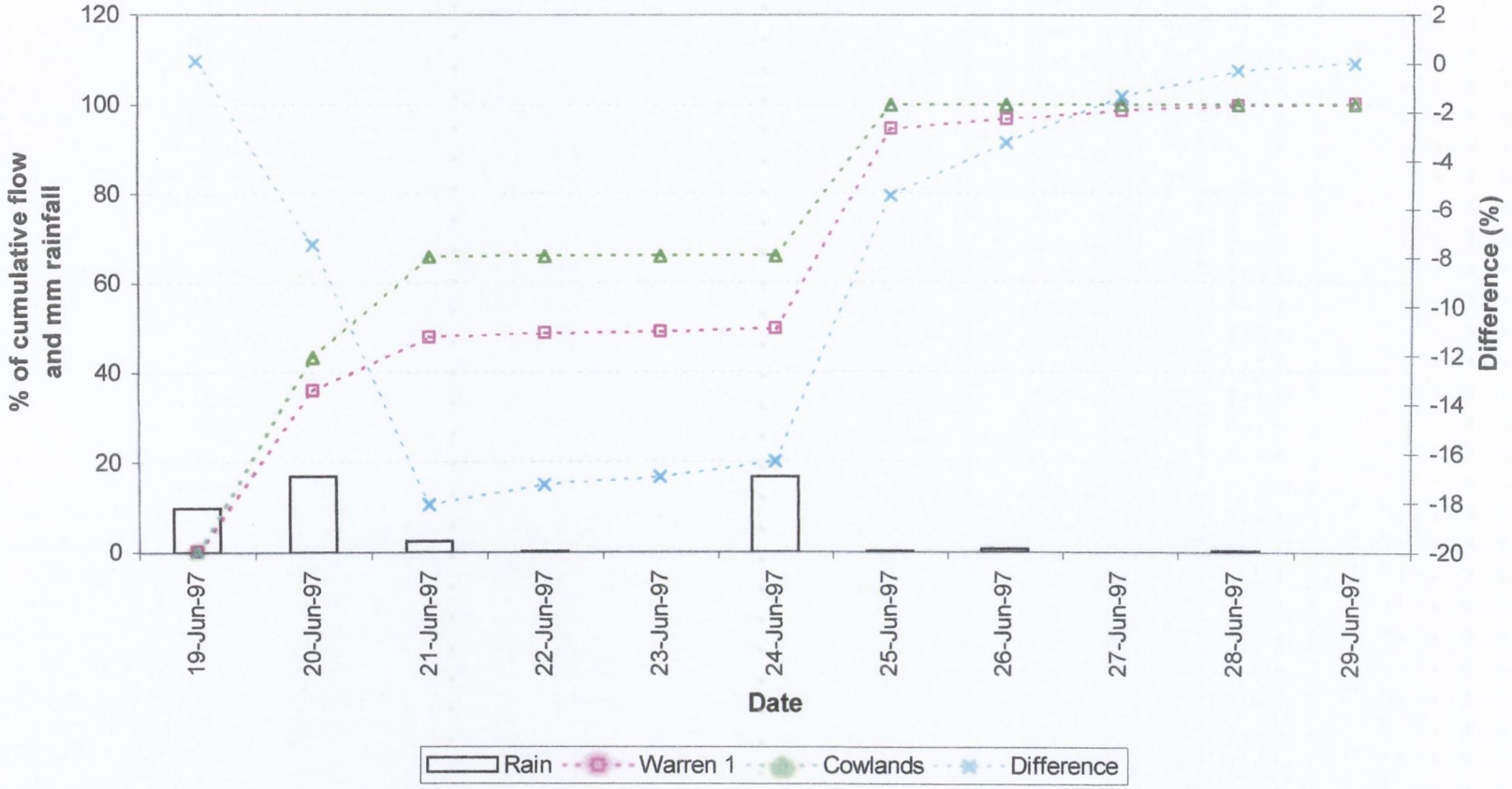


Figure 7.76: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 10, and curve of the difference between the percentages of cumulative flow at the two sites.

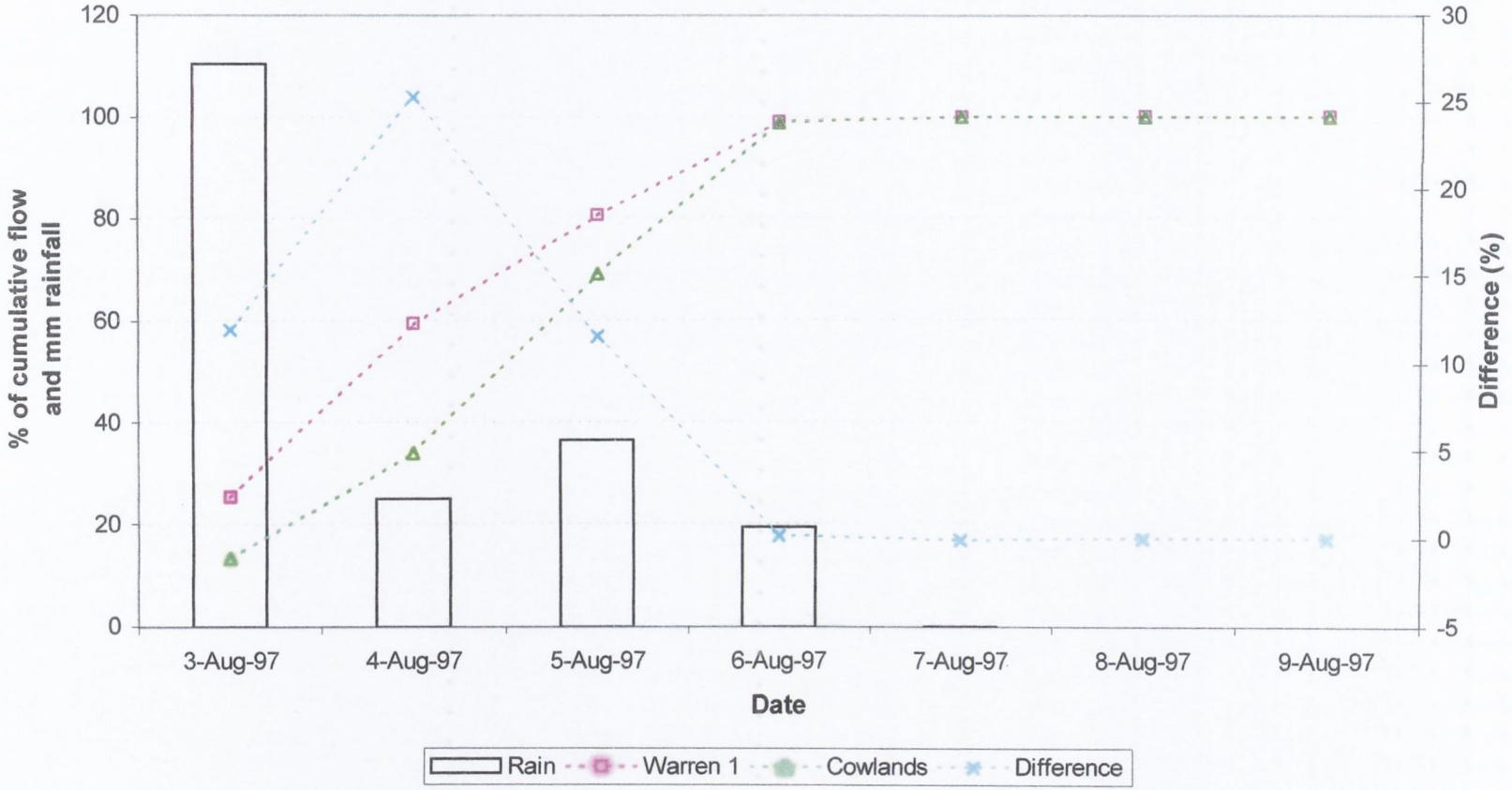


Figure 7.77: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 13, and curve of the difference between the percentages of cumulative flow at the two sites.

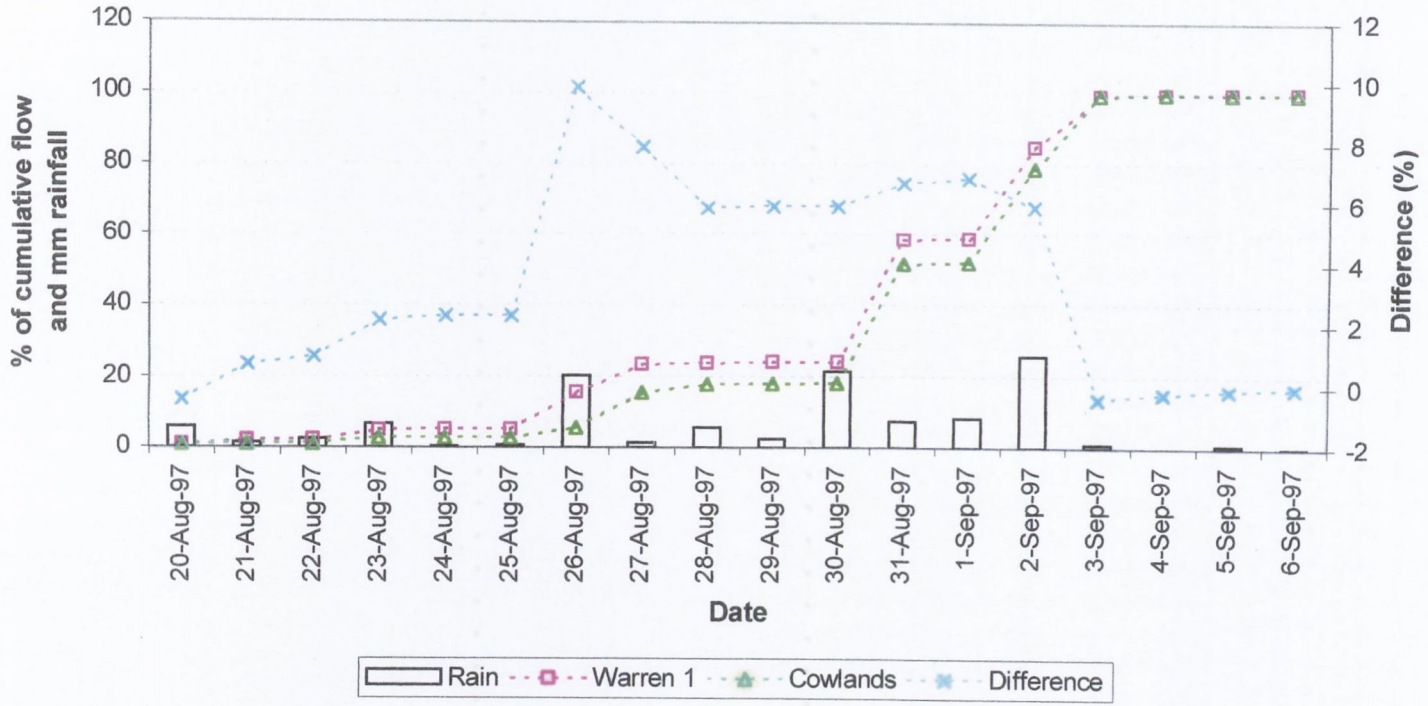


Figure 7.78: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 14, and curve of the difference between the percentages of cumulative flow at the two sites.

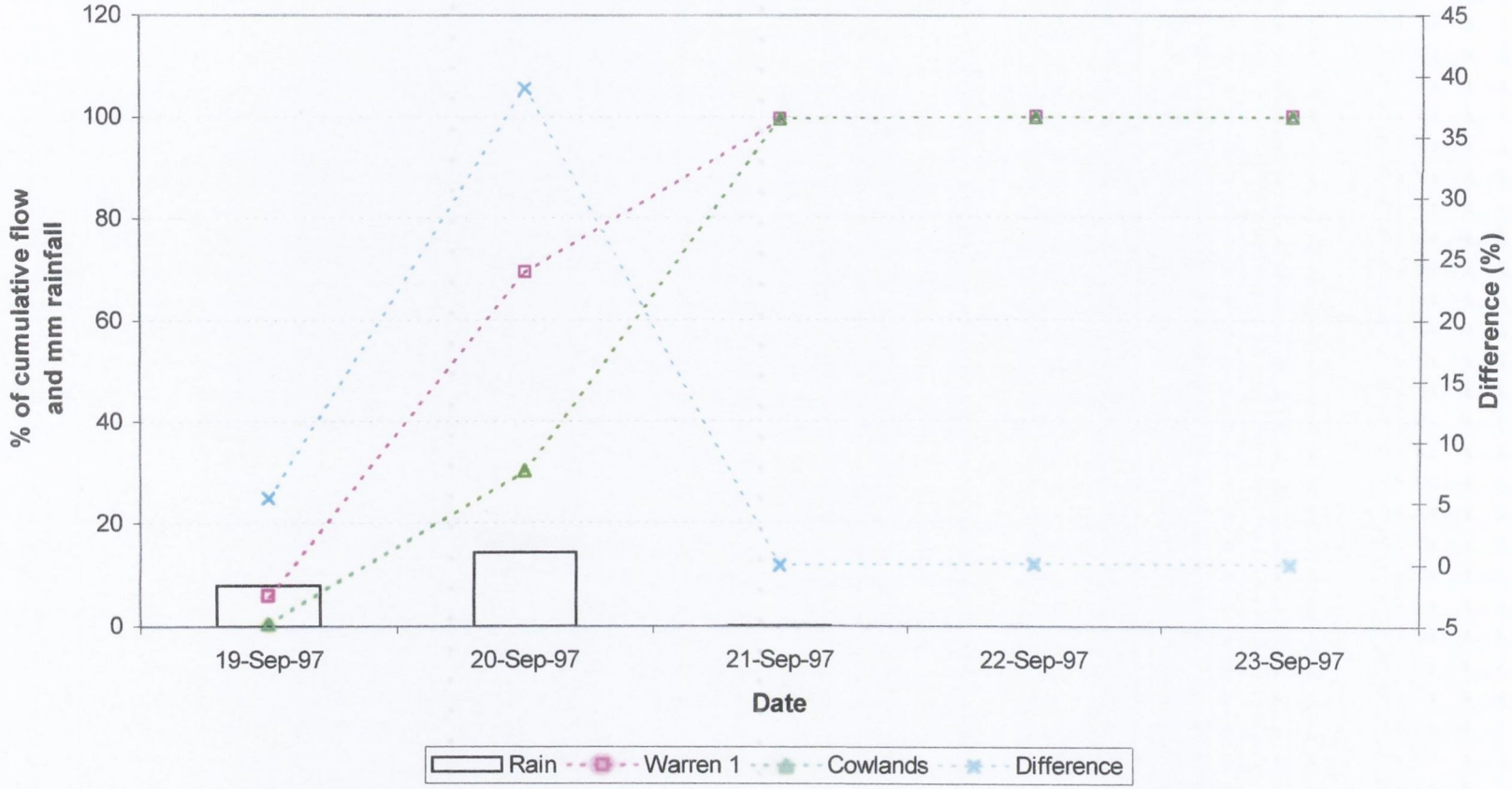


Figure 7.79: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 15, and curve of the difference between the percentages of cumulative flow at the two sites.

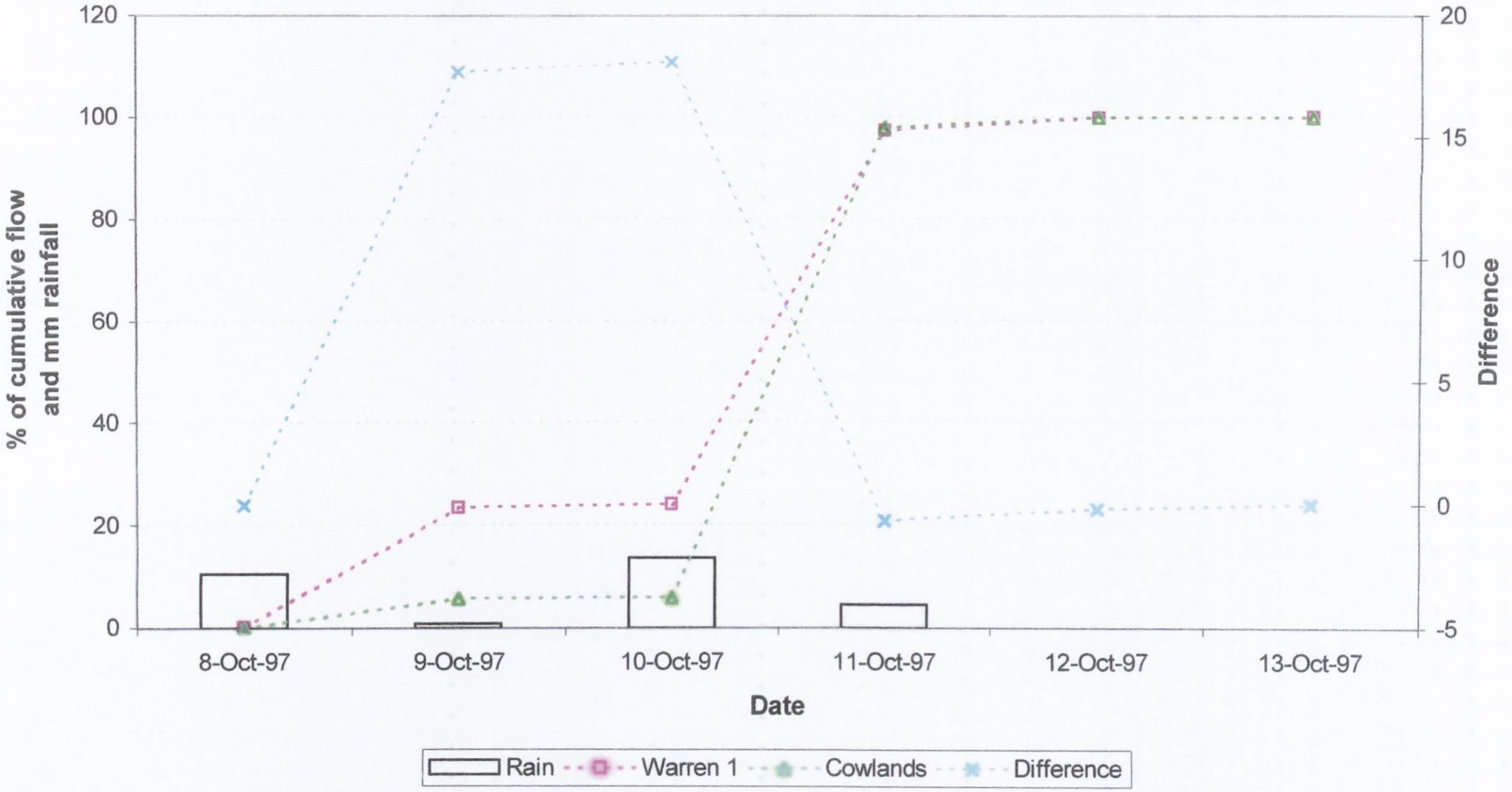


Figure 7.80: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 16, and curve of the difference between the percentages of cumulative flow at the two sites.

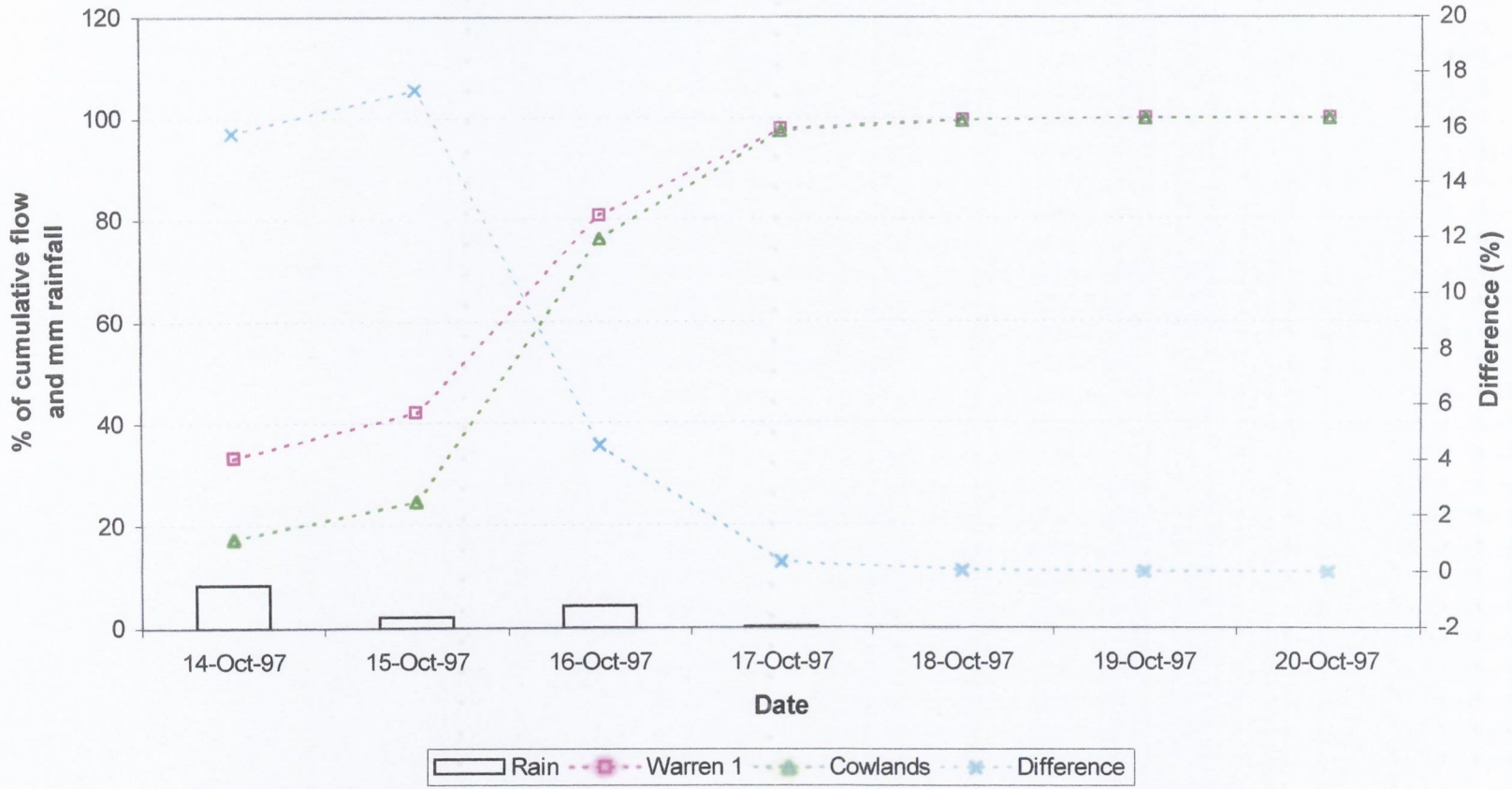


Figure 7.81: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 17, and curve of the difference between the percentages of cumulative flow at the two sites.

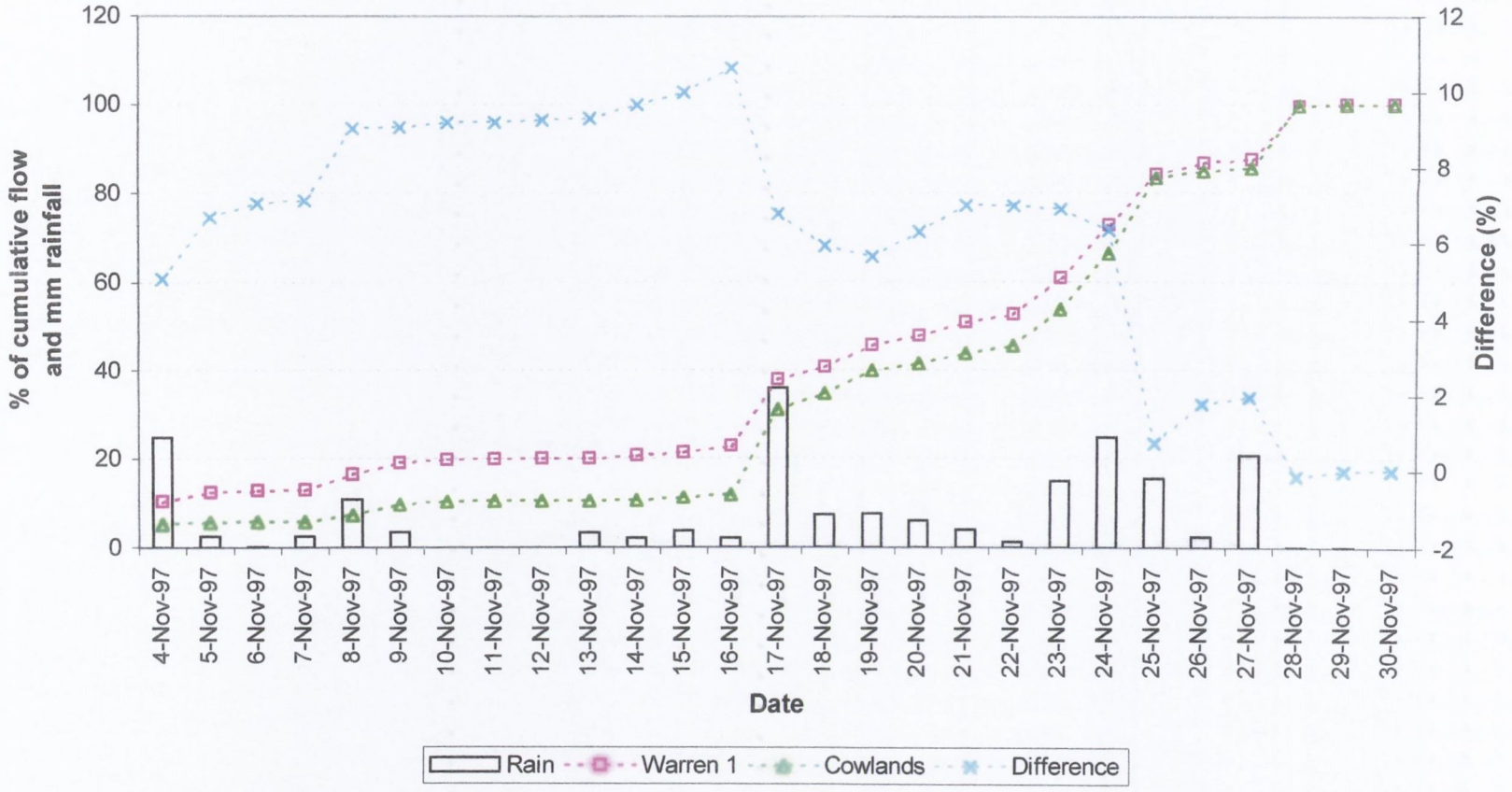


Figure 7.82: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 18.1-18.3, and curve of the difference between the percentages of cumulative flow at the two sites.

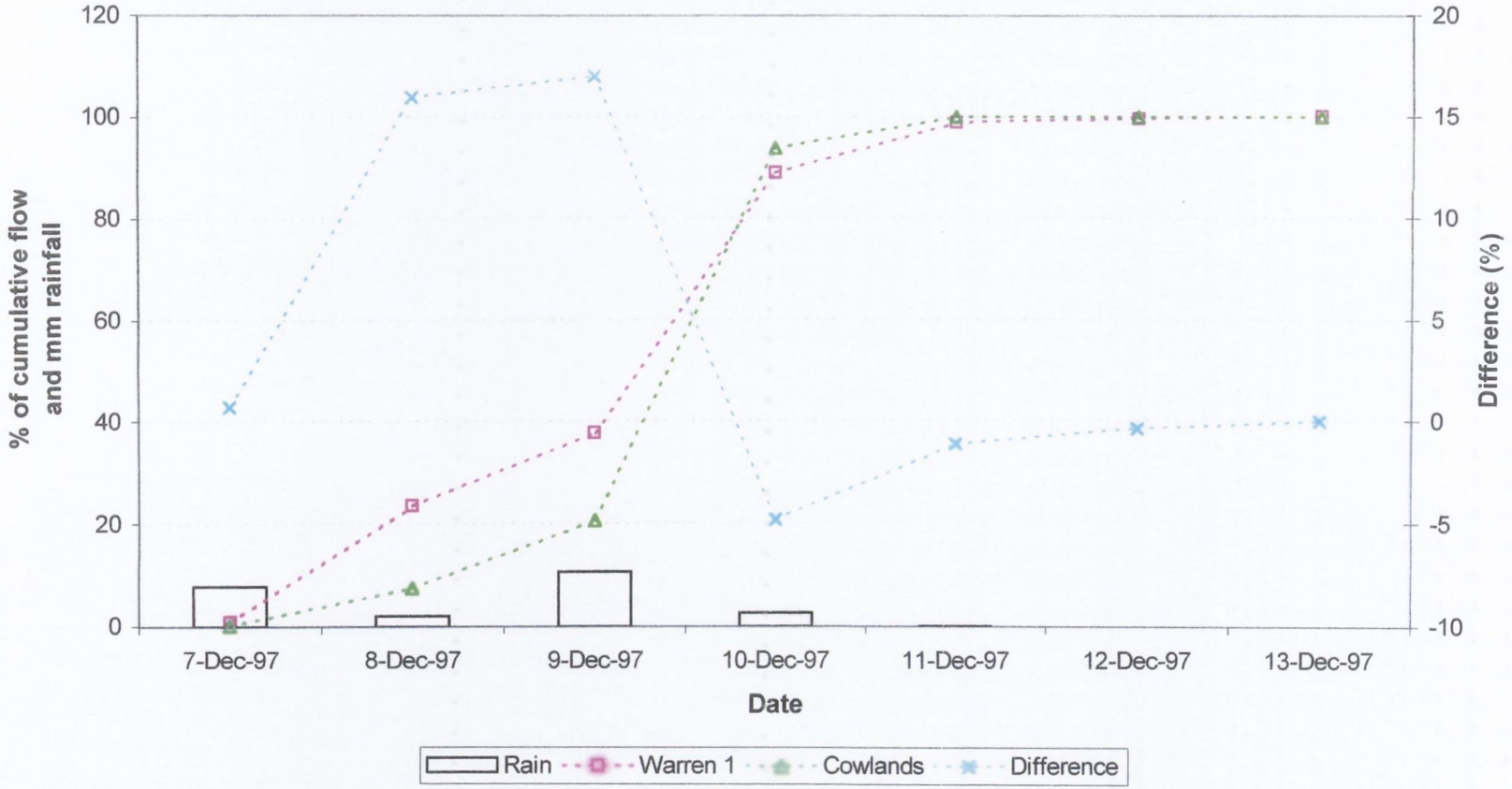


Figure 7.83: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 18.4, and curve of the difference between the percentages of cumulative flow at the two sites.

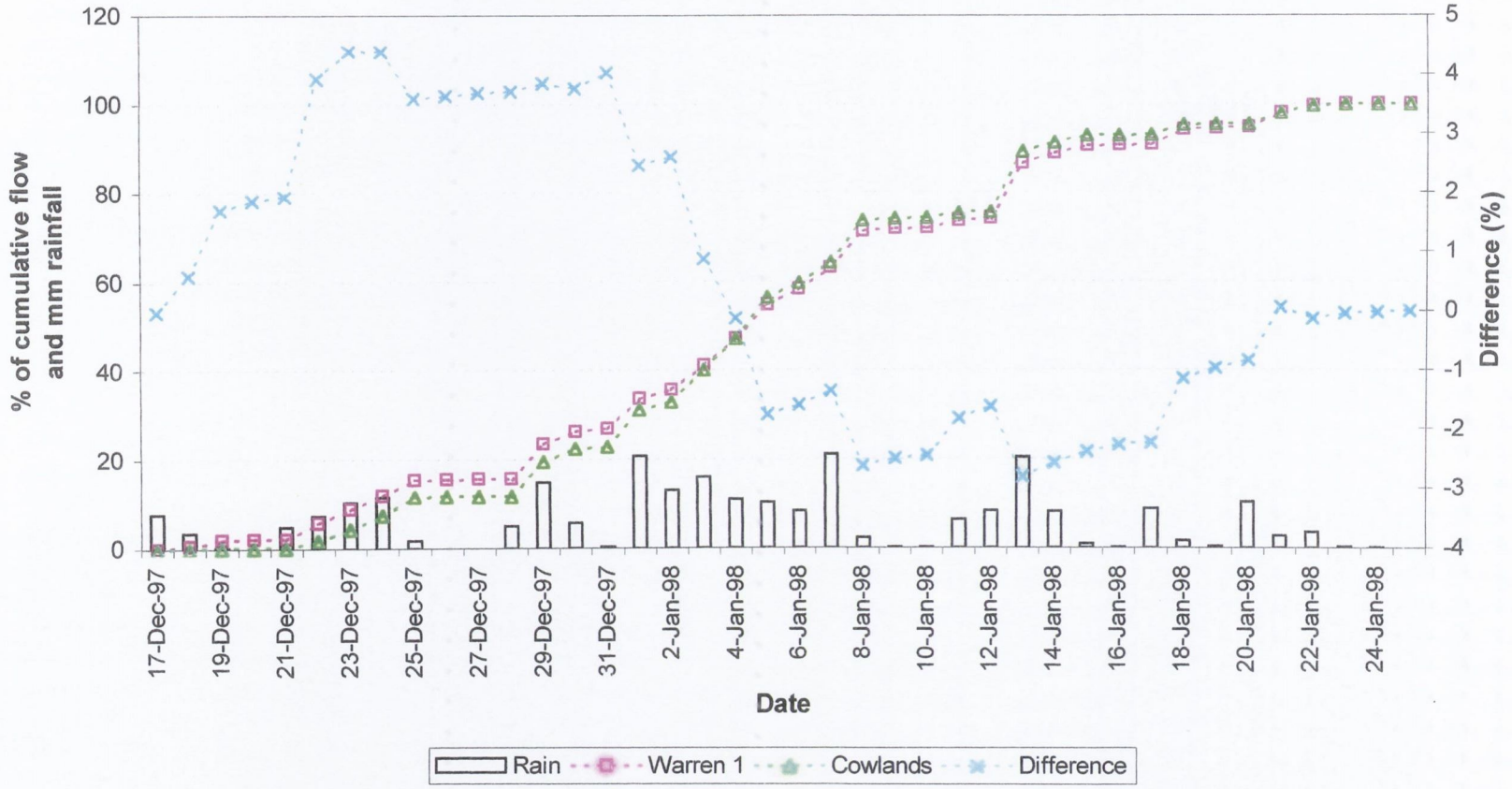


Figure 7.84: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 19, and curve of the difference between the percentages of cumulative flow at the two sites.

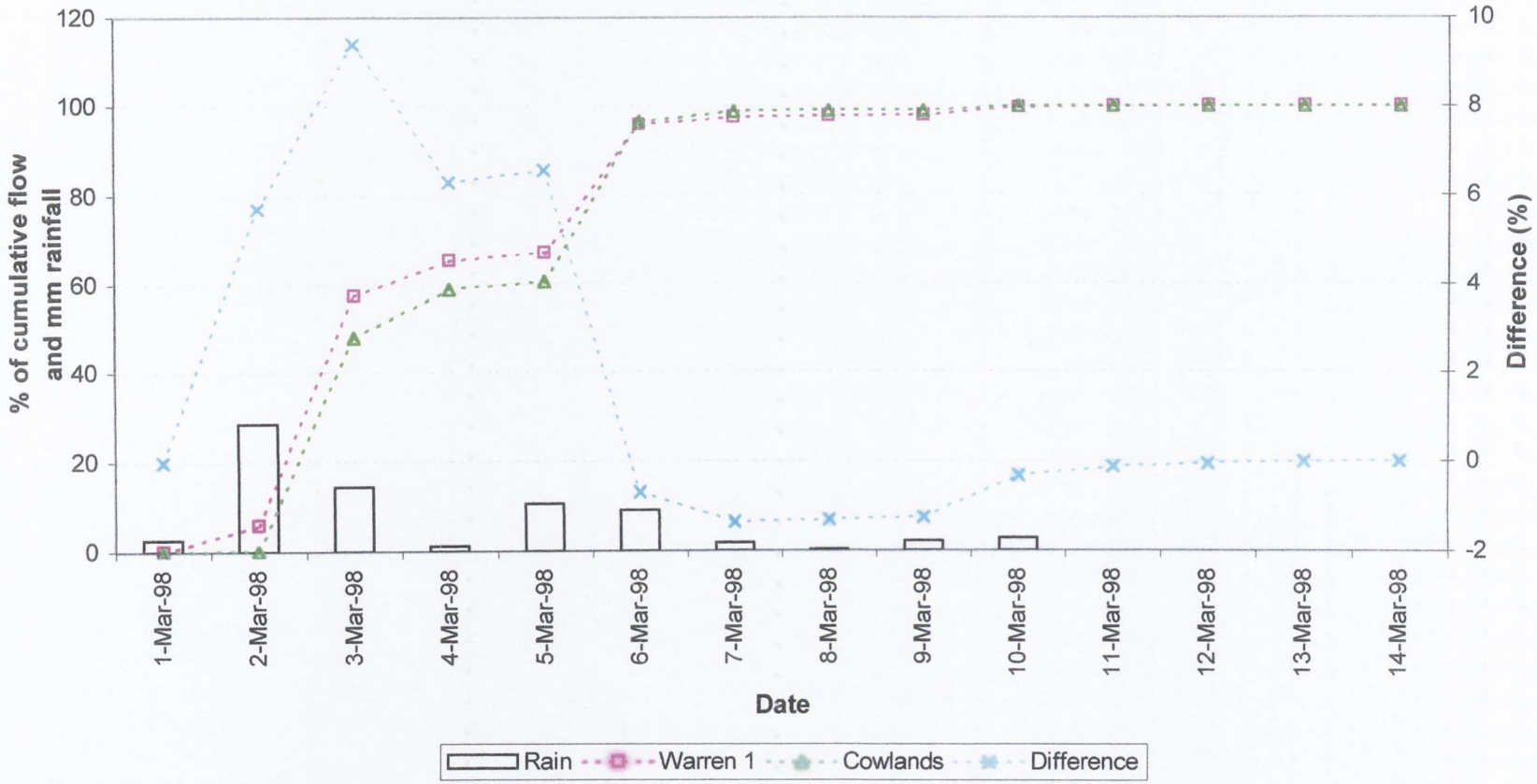


Figure 7.85: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 21, and curve of the difference between the percentages of cumulative flow at the two sites.

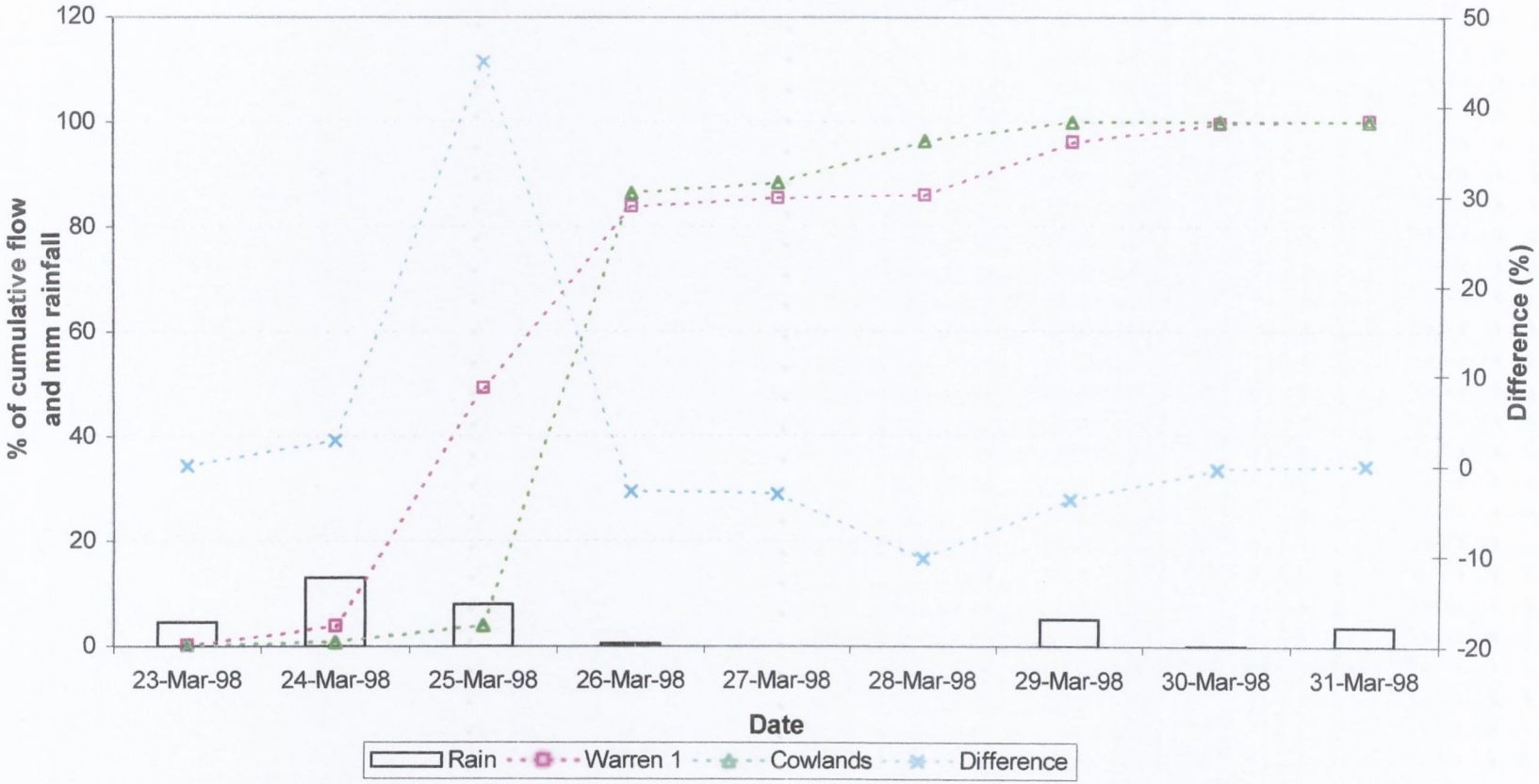


Figure 7.86: Rainfall (mm), percentage of cumulative flow at the Warren 1 and the Cowlands during event 22, and curve of the difference between the percentages of cumulative flow at the two sites.

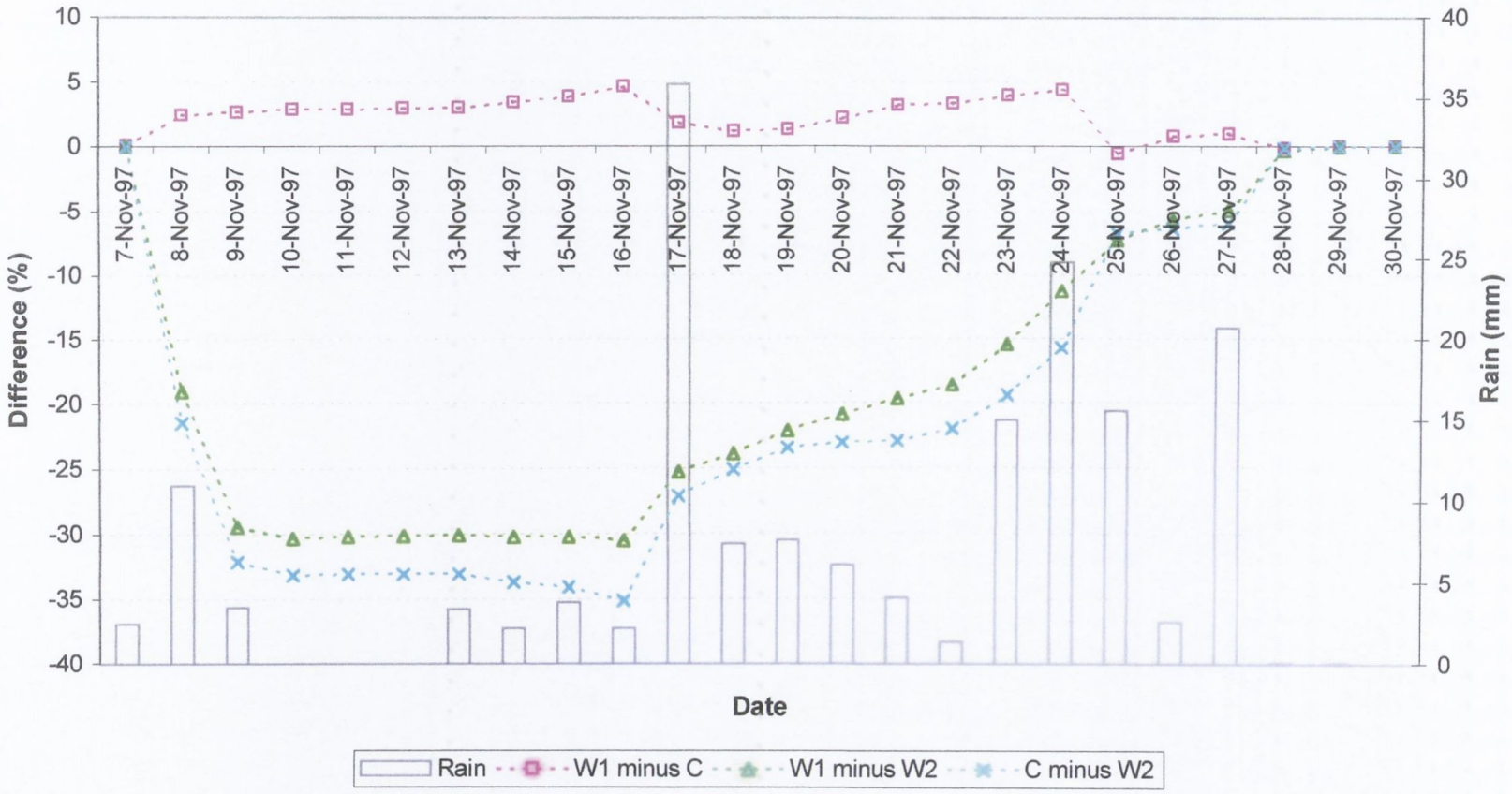


Figure 7.87: Rainfall (mm) and curves of the differences between the percentages of cumulative flow at the overland flow sites for event 18.2-18.3: Percentage cumulative flow Warren 1 minus percentage cumulative flow Warren 2, percentage cumulative flow Warren 1 minus percentage cumulative flow Cowlands, percentage cumulative flow Cowlands minus percentage cumulative flow Warren 2.

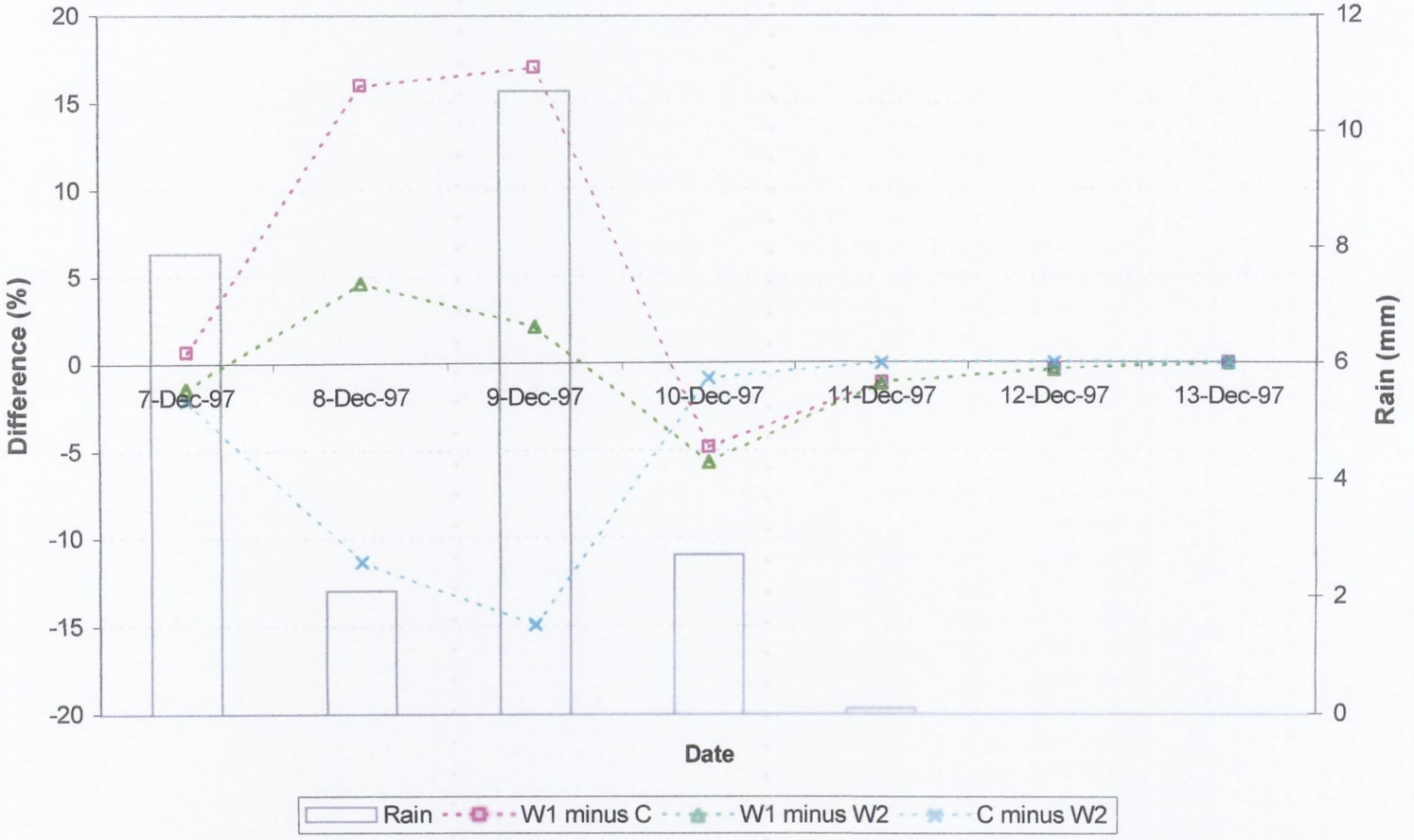


Figure 7.88: Rainfall (mm) and curves of the differences between the percentages of cumulative flow at the overland flow sites for event 18.4: Percentage cumulative flow Warren 1 minus percentage cumulative flow Warren 2, percentage cumulative flow Warren 1 minus percentage cumulative flow Cowlands, percentage cumulative flow Cowlands minus percentage cumulative flow Warren 2.

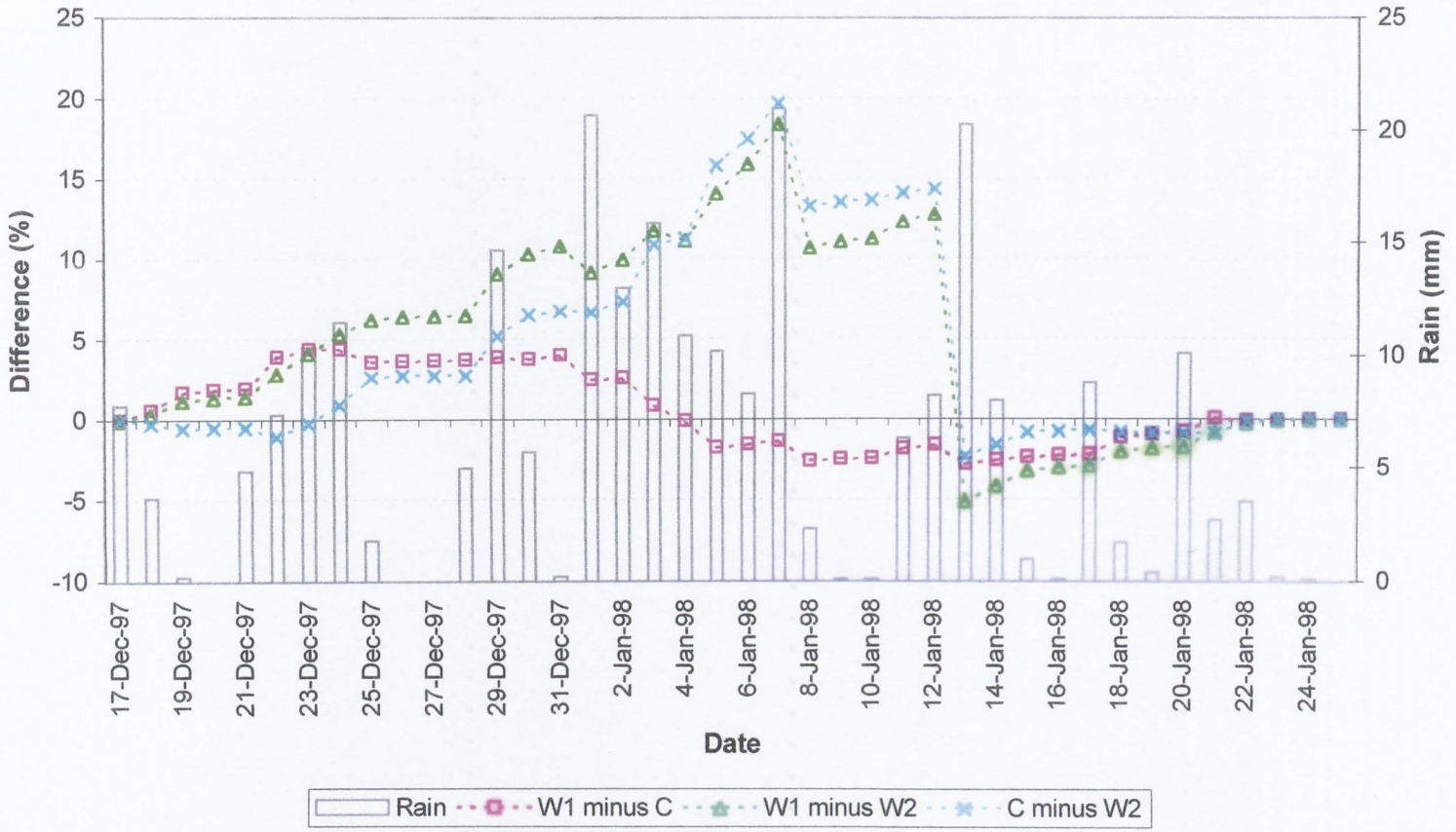


Figure 7.89: Rainfall (mm) and curves of the differences between the percentages of cumulative flow at the overland flow sites for event 19: Percentage cumulative flow Warren 1 minus percentage cumulative flow Warren 2, percentage cumulative flow Warren 1 minus percentage cumulative flow Cowlands, percentage cumulative flow Cowlands minus percentage cumulative flow Warren 2.

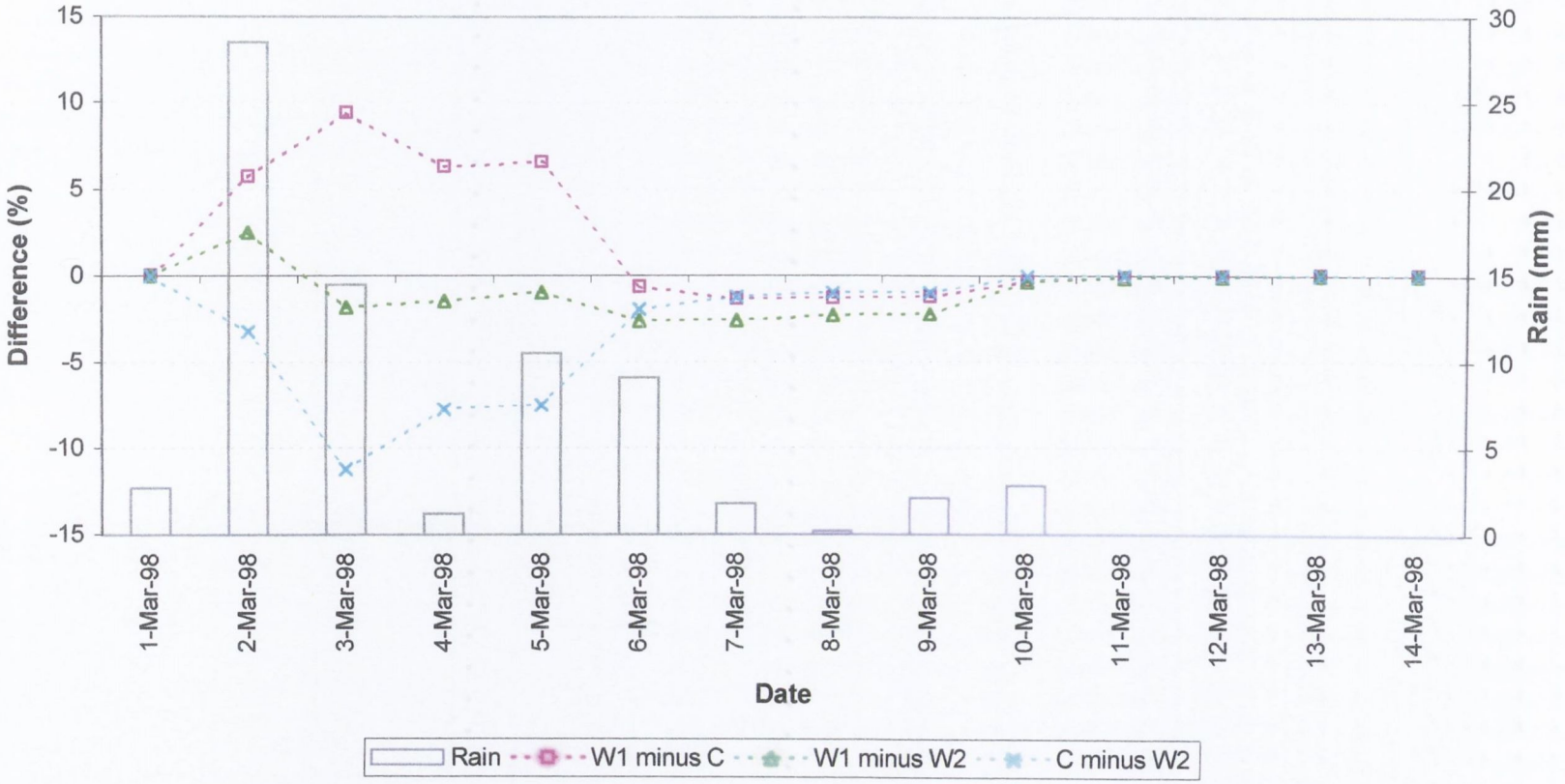


Figure 7.90: Rainfall (mm) and curves of the differences between the percentages of cumulative flow at the overland flow sites for event 21: Percentage cumulative flow Warren 1 minus percentage cumulative flow Warren 2, percentage cumulative flow Warren 1 minus percentage cumulative flow Cowlands, percentage cumulative flow Cowlands minus percentage cumulative flow Warren 2.

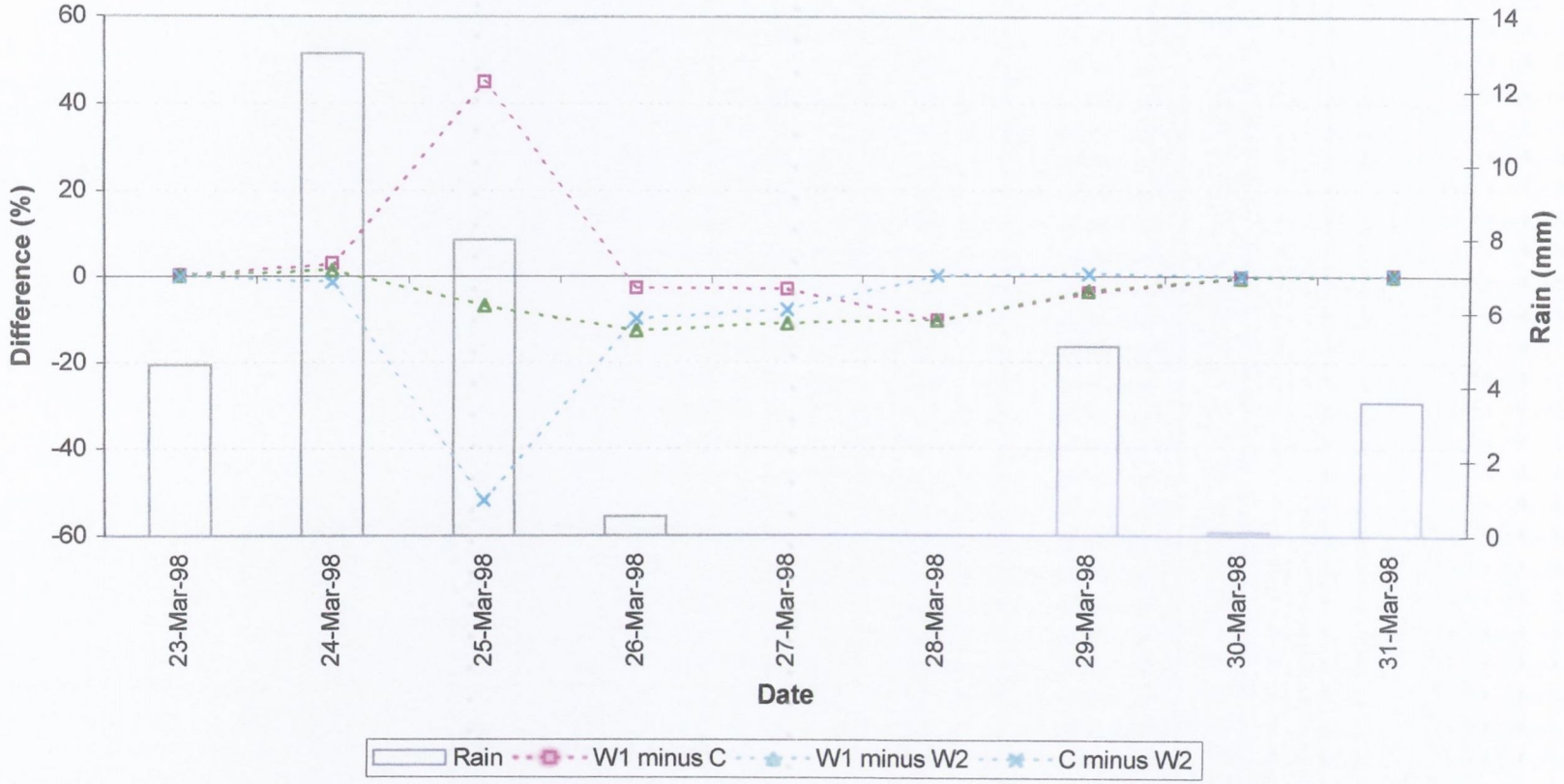


Figure 7.91: Rainfall (mm) and curves of the differences between the percentages of cumulative flow at the overland flow sites for event 22: Percentage cumulative flow Warren 1 minus percentage cumulative flow Warren 2, percentage cumulative flow Warren 1 minus percentage cumulative flow Cowlands, percentage cumulative flow Cowlands minus percentage cumulative flow Warren 2.

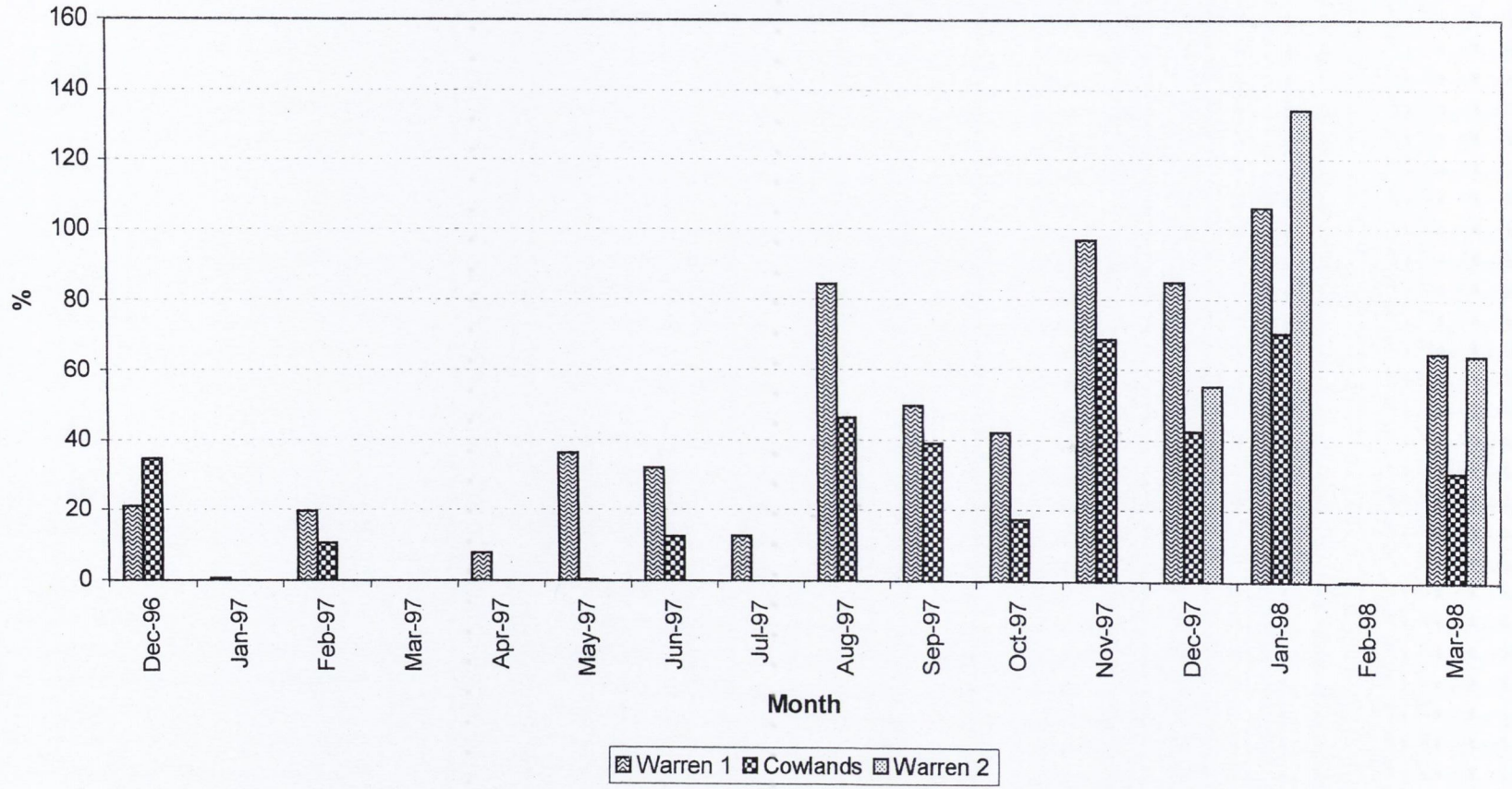


Figure 7.92: Monthly overland flow totals at the Warren 1, the Cowlands and the Warren 2 expressed as a percentage of monthly rainfall.

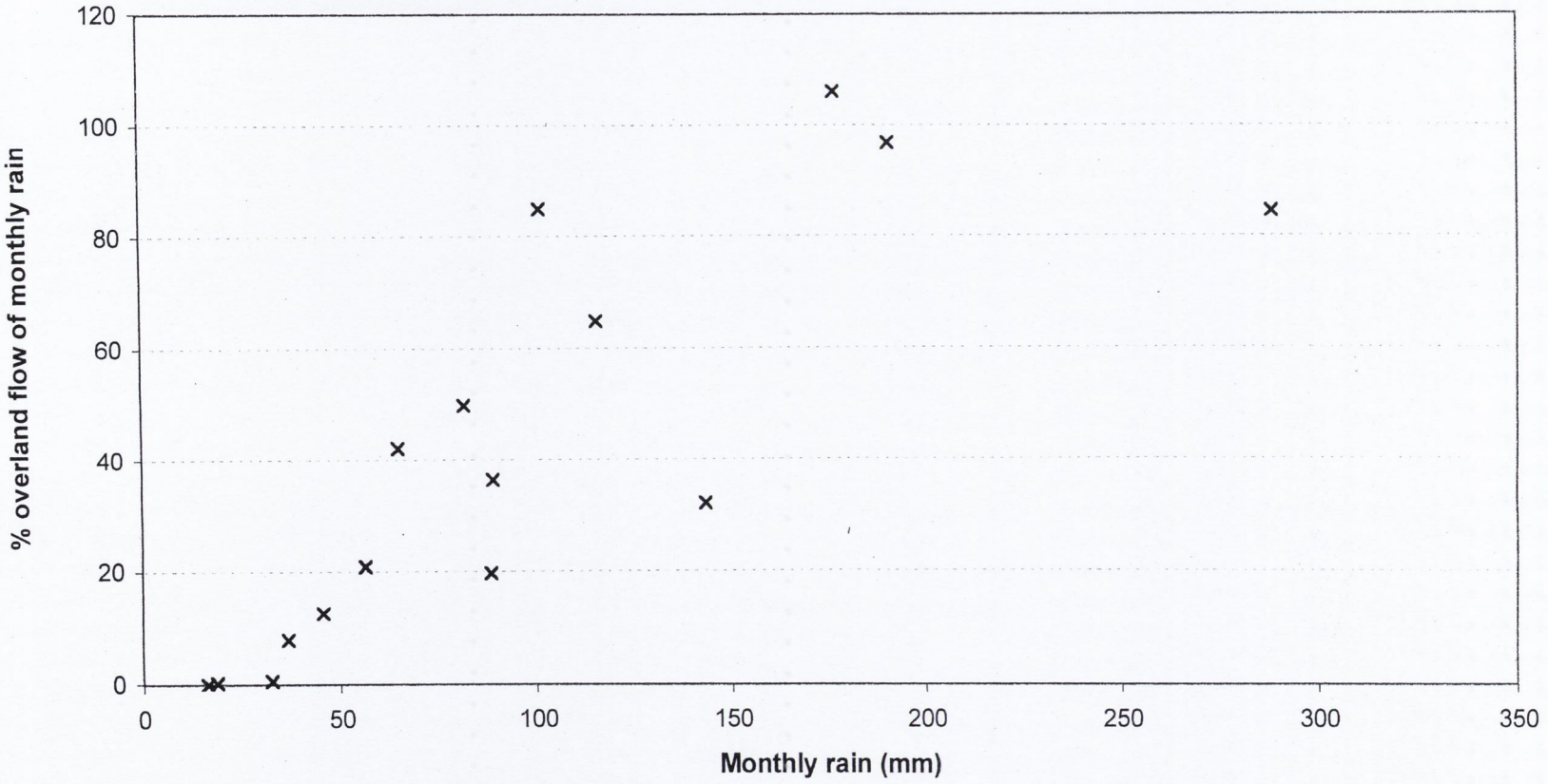


Figure 7.93: Monthly overland flow totals at the Warren 1 expressed as a percentage of monthly rainfall plotted against monthly rainfall (mm).

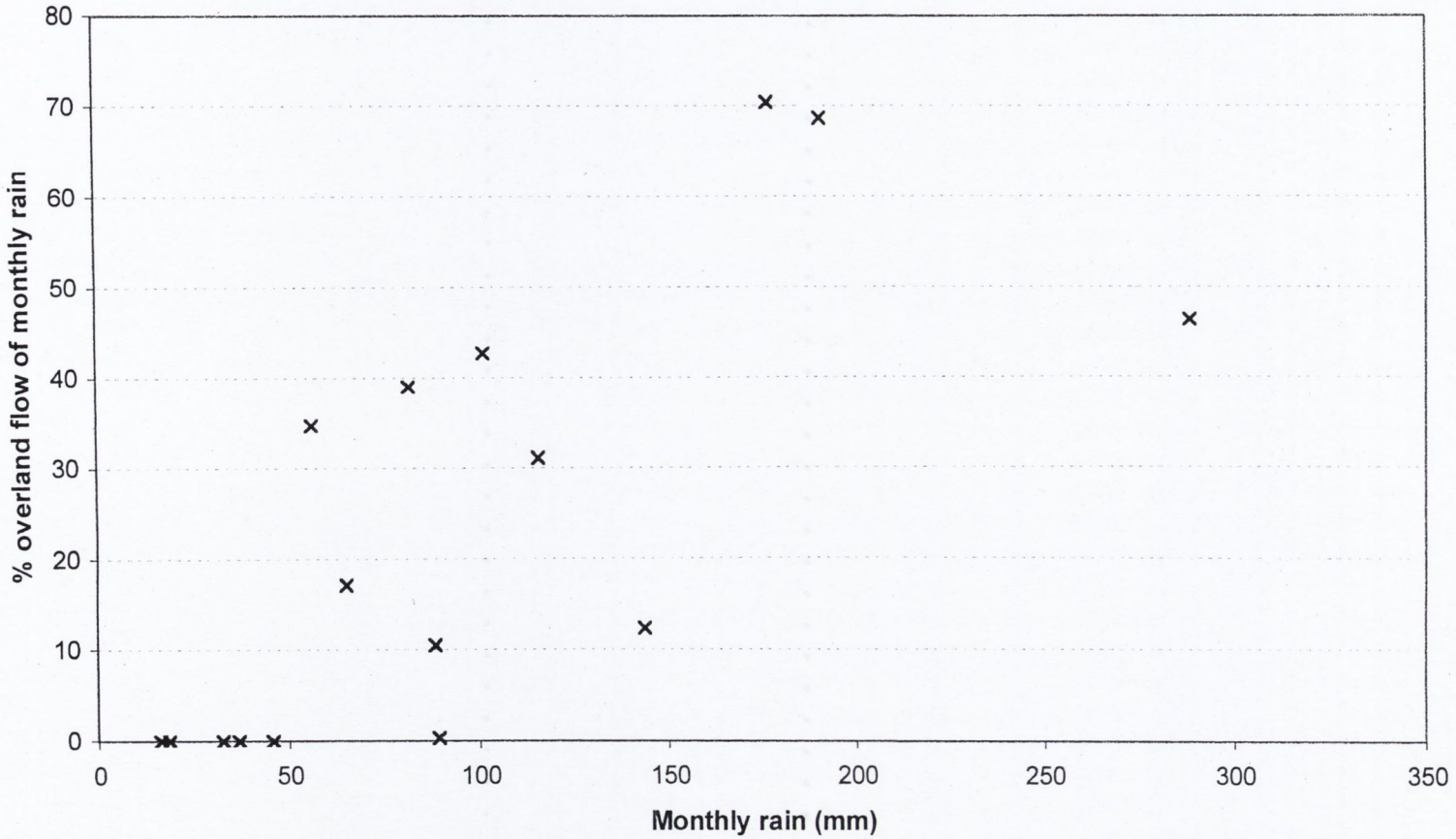


Figure 7.94: Monthly overland flow totals at the Cowlands expressed as a percentage of monthly rainfall plotted against monthly rainfall (mm).

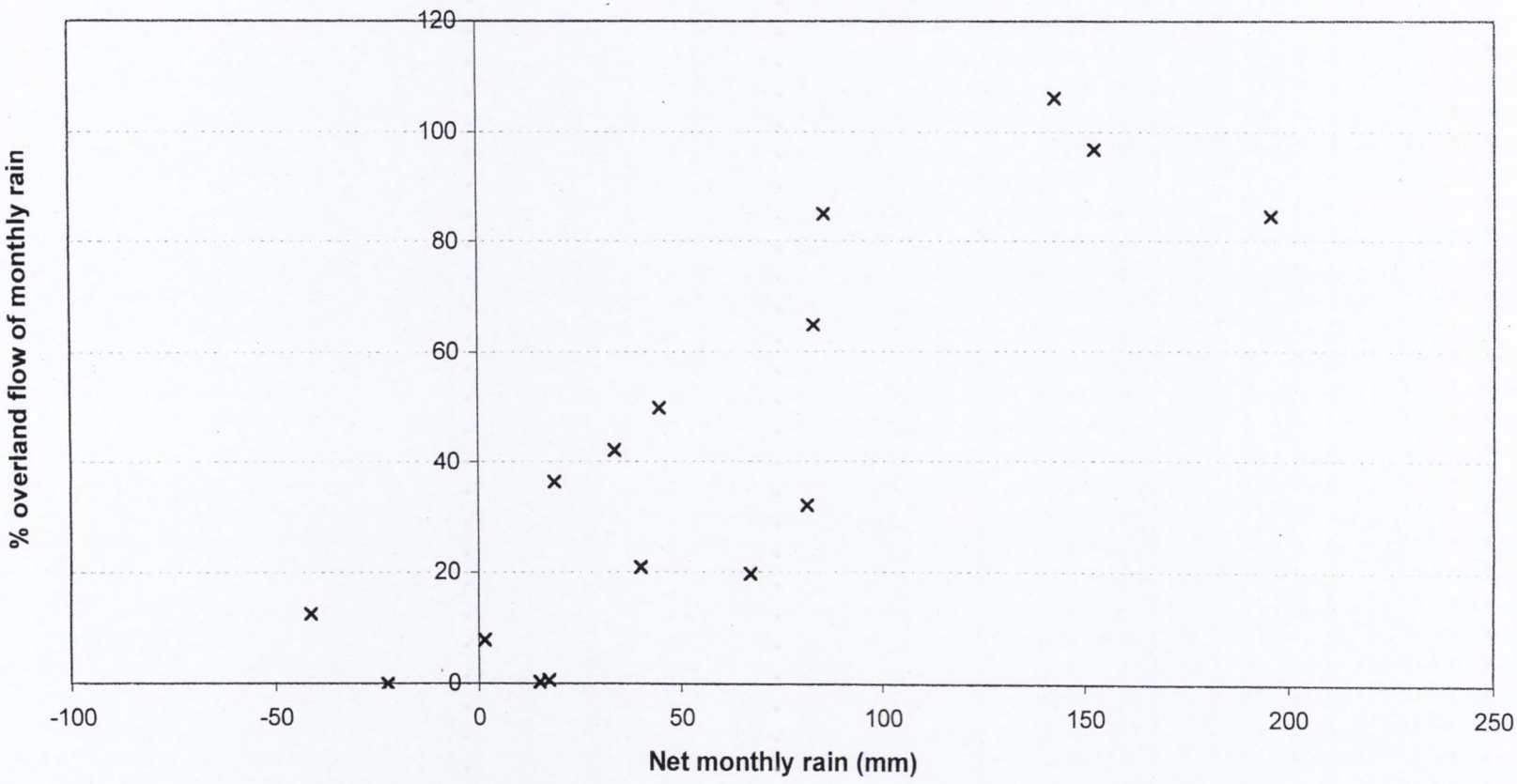


Figure 7.95: Monthly overland flow totals at the Warren 1 expressed as a percentage of monthly rainfall plotted against net monthly rainfall (i.e. monthly rainfall minus monthly potential evapotranspiration) (mm).

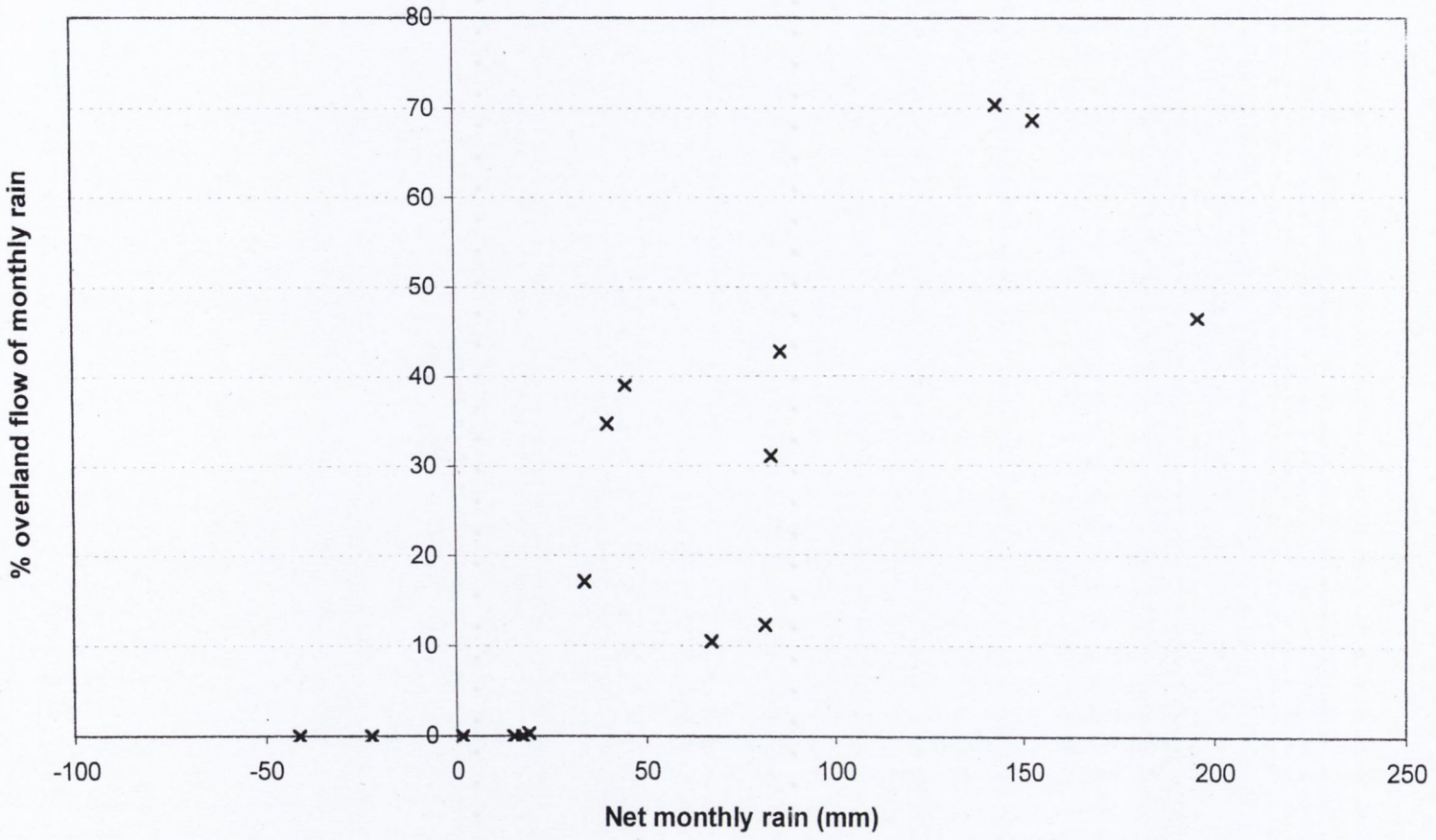


Figure 7.96: Monthly overland flow totals at the Cowlands expressed as a percentage of monthly rainfall plotted against net monthly rainfall (i.e. monthly rainfall minus monthly potential evapotranspiration) (mm).

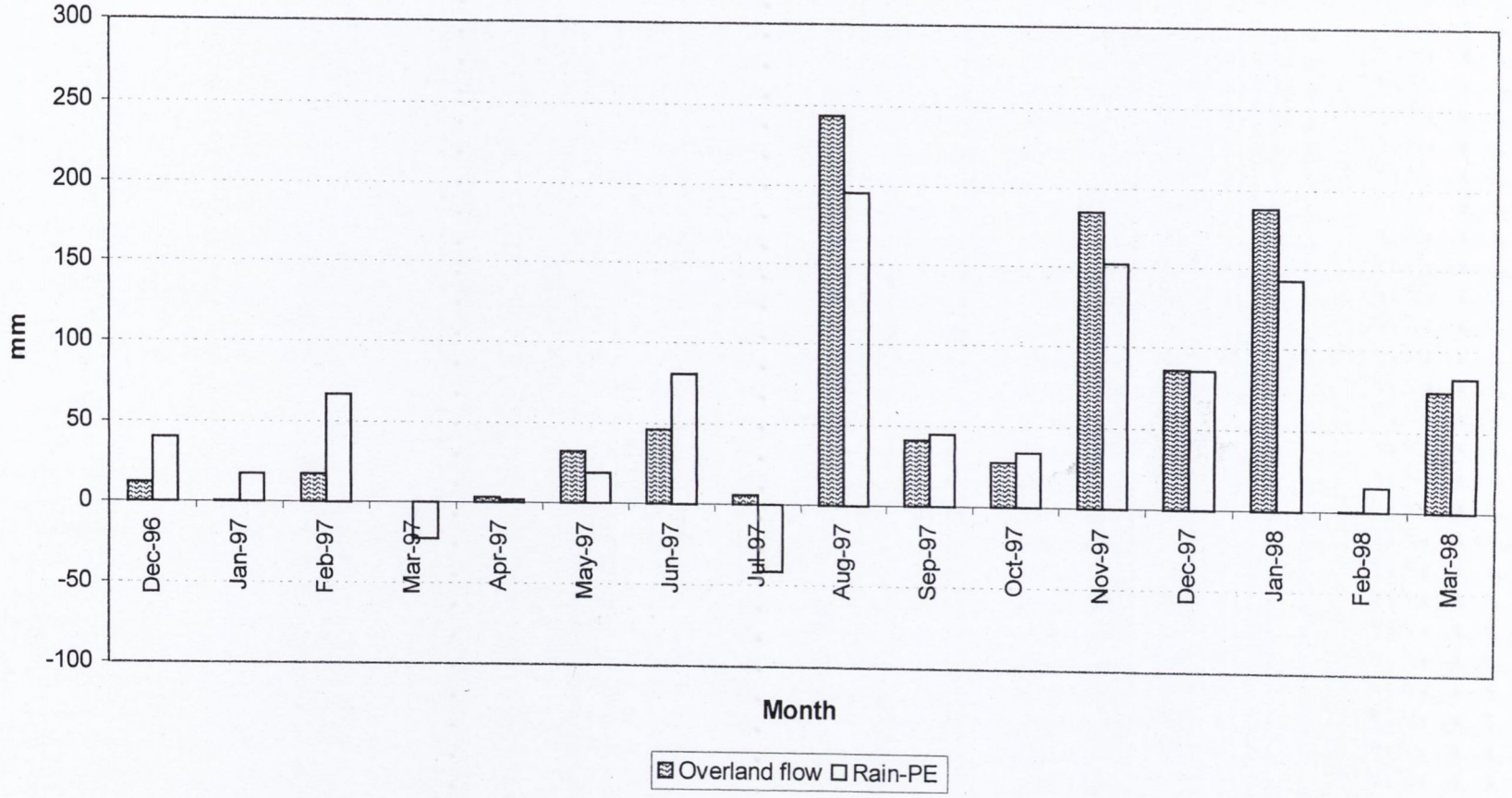


Figure 7.97: Overland flow (mm) at the Warren 1 and net monthly rainfall (i.e. monthly rainfall minus monthly potential evapotranspiration (PE)) (mm).

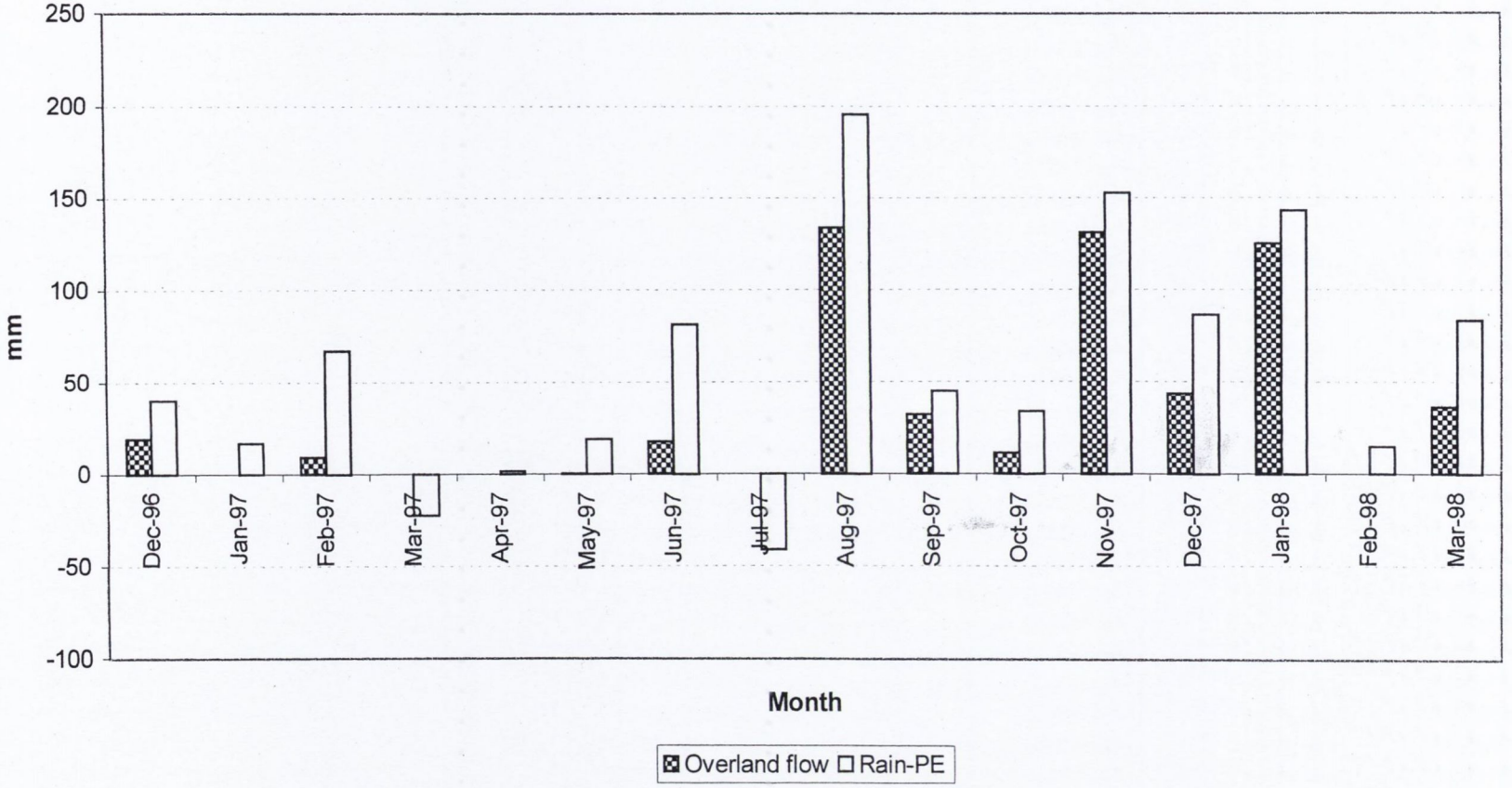


Figure 7.98: Overland flow (mm) at the Cowlands and net monthly rainfall (i.e. monthly rainfall minus monthly potential evapotranspiration (PE)) (mm).

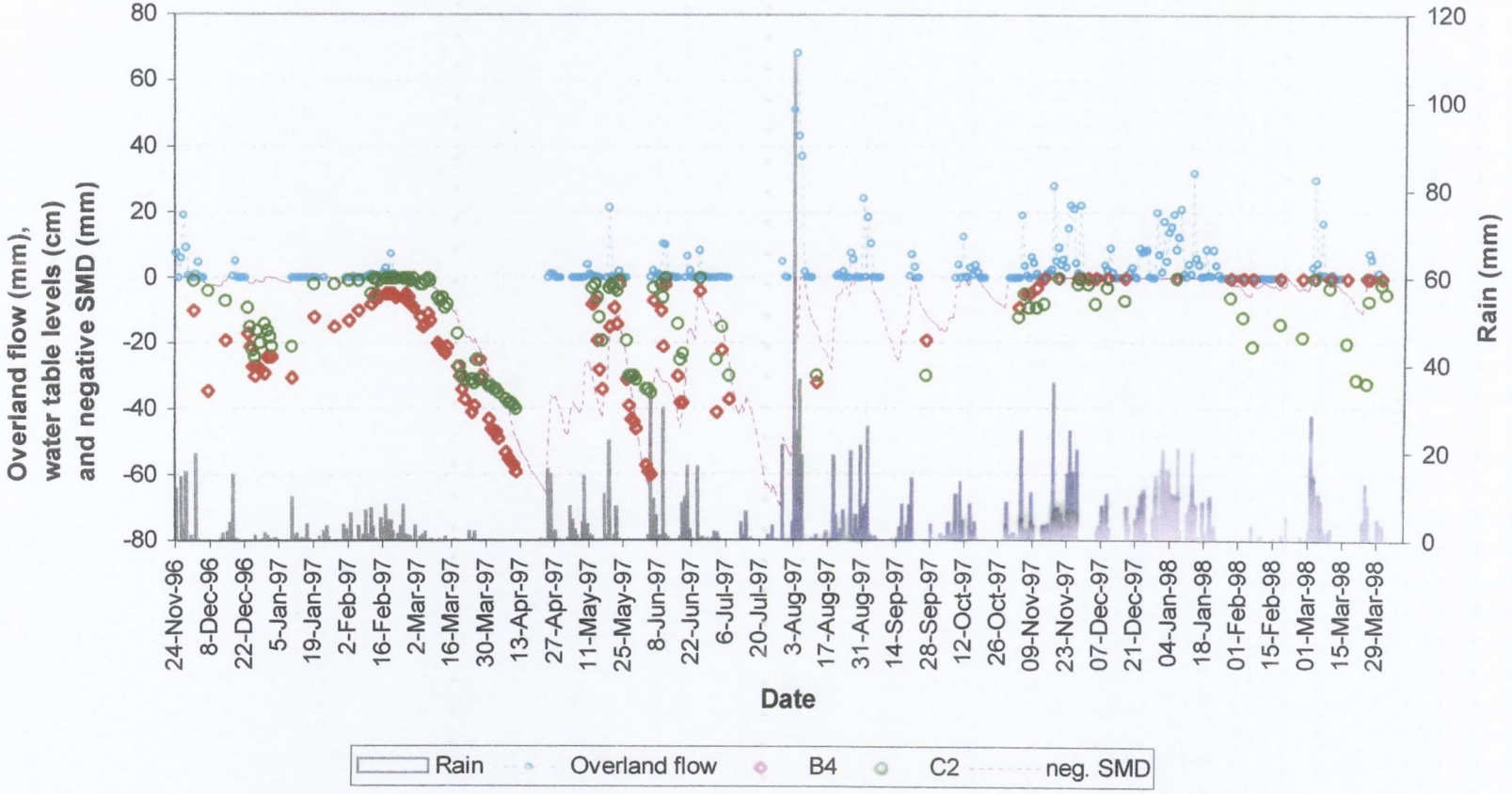


Figure 7.99: Daily rainfall (mm), daily overland flow (mm), water table levels (cm) in tubes B4 and C2 at the Warren 1, and negative daily soil moisture deficit (SMD) values (mm).

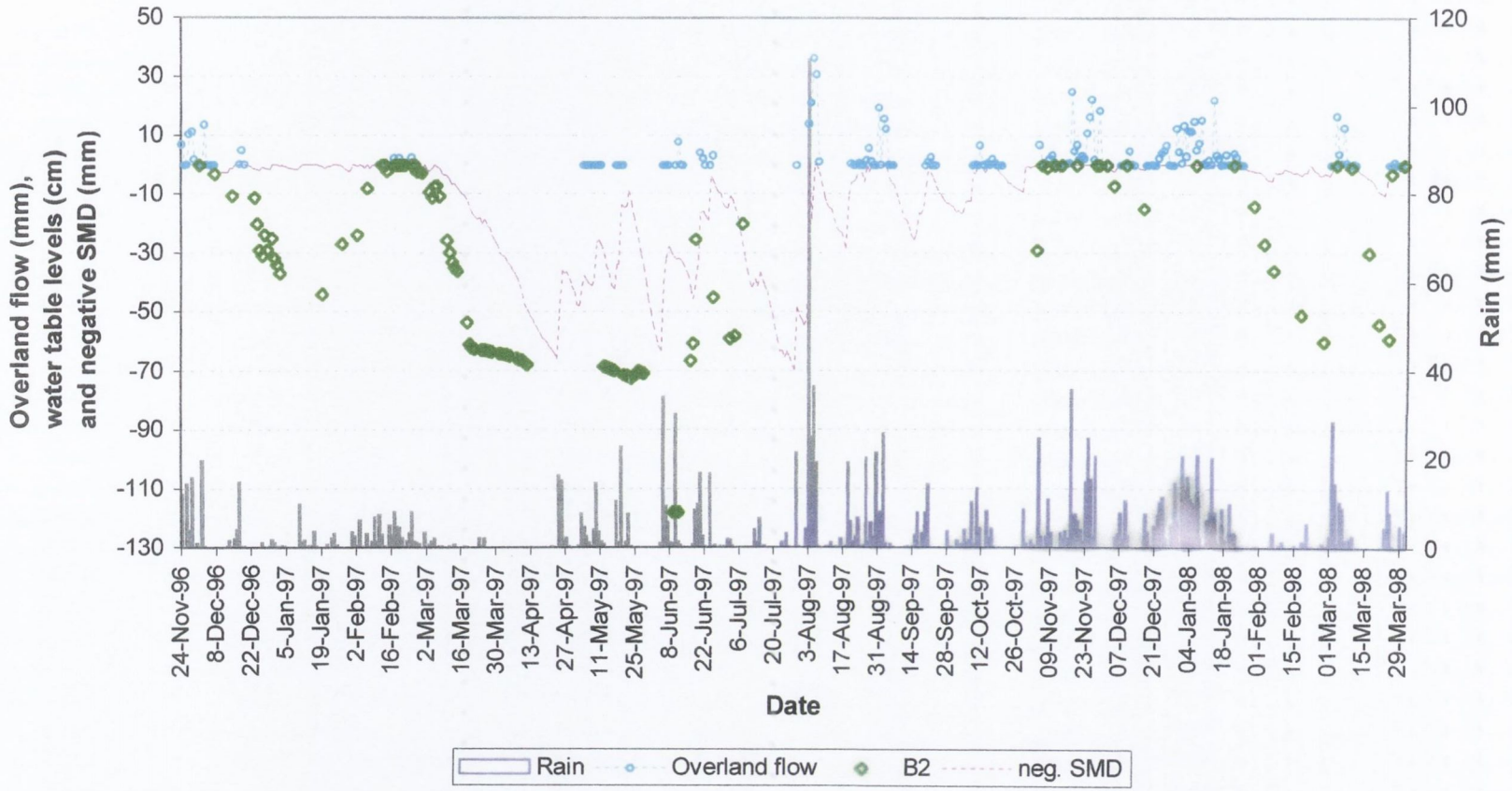


Figure 7.100: Daily rainfall (mm), daily overland flow (mm), water table levels (cm) in tube B2 at the Cowlands, and negative daily soil moisture deficit (SMD) values (mm).

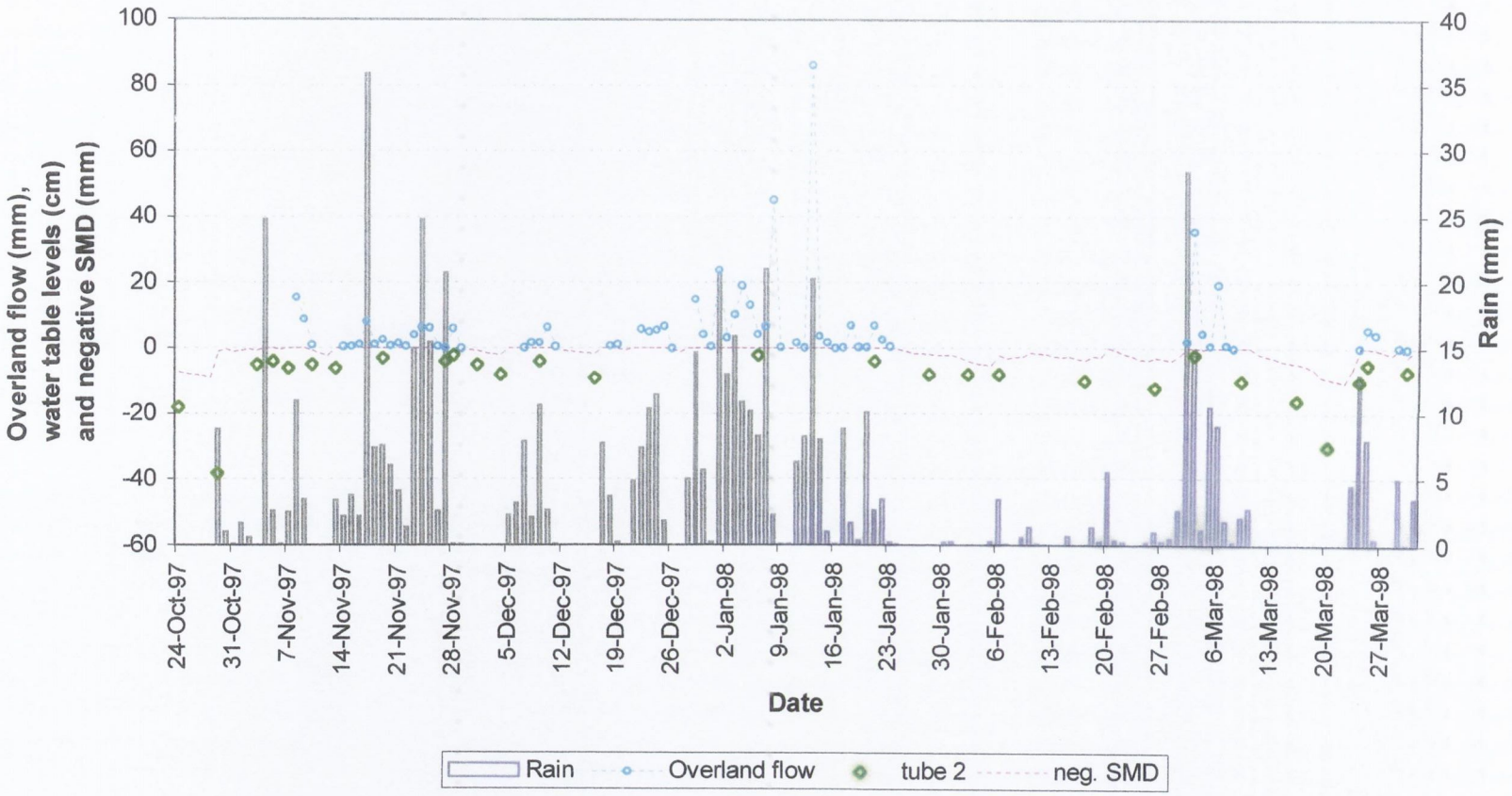


Figure 7.101: Daily rainfall (mm), daily overland flow (mm), water table levels (cm) in tube 2 at the Warren 2, and negative daily soil moisture deficit (SMD) values (mm).

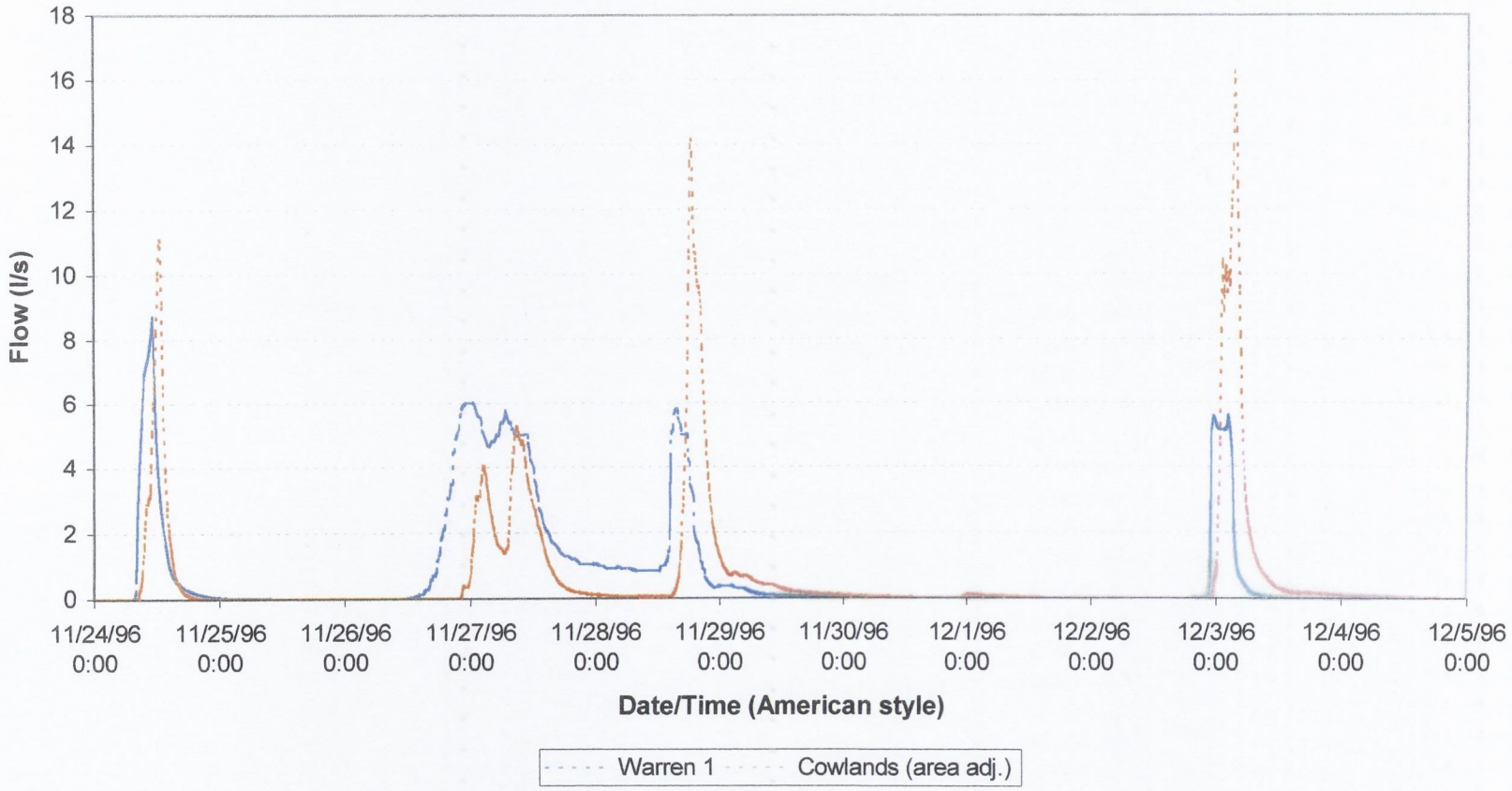


Figure 7.102: Overland flow (l/s) for event 1 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

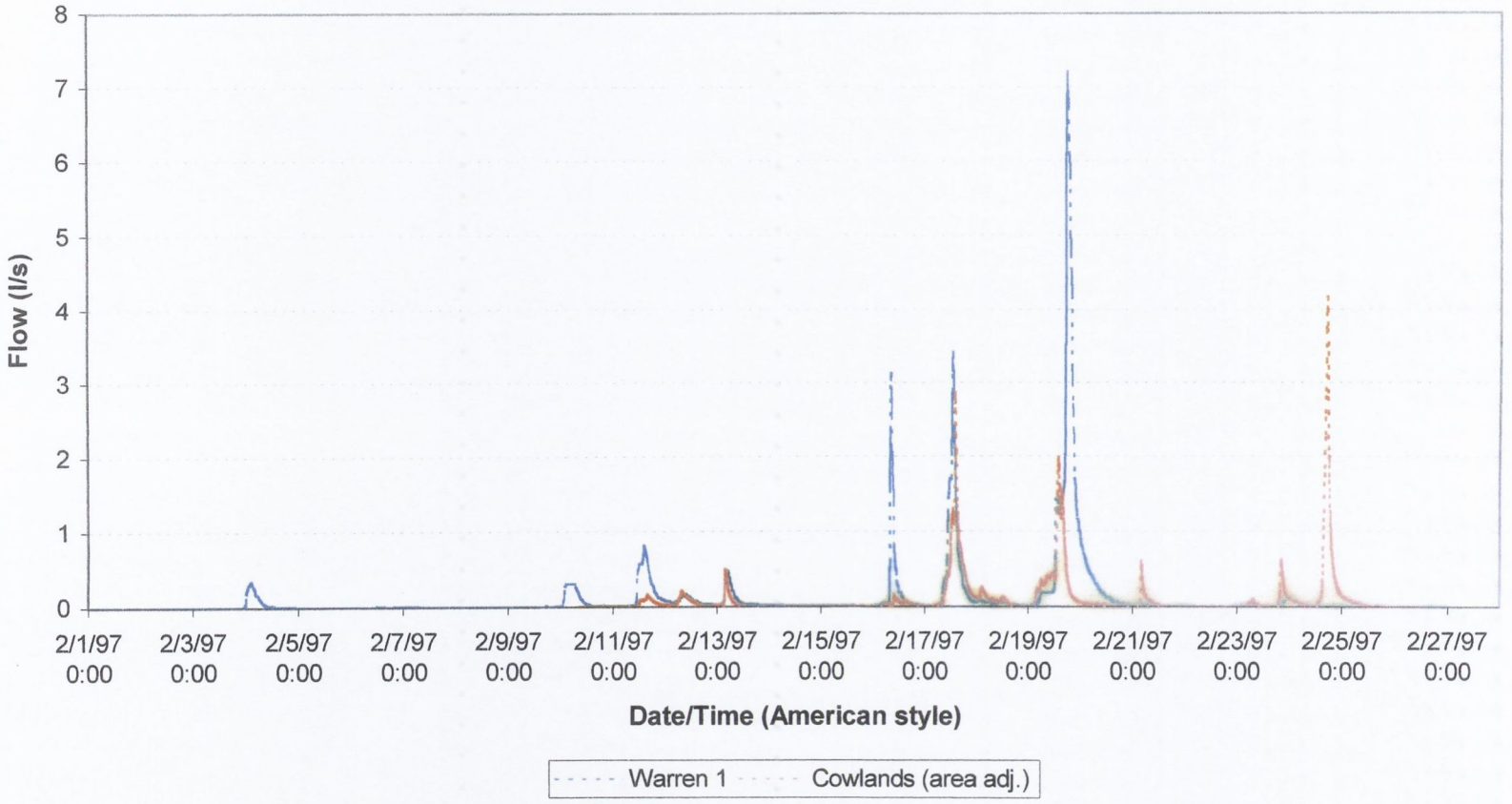


Figure 7.103: Overland flow (l/s) for event 5 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

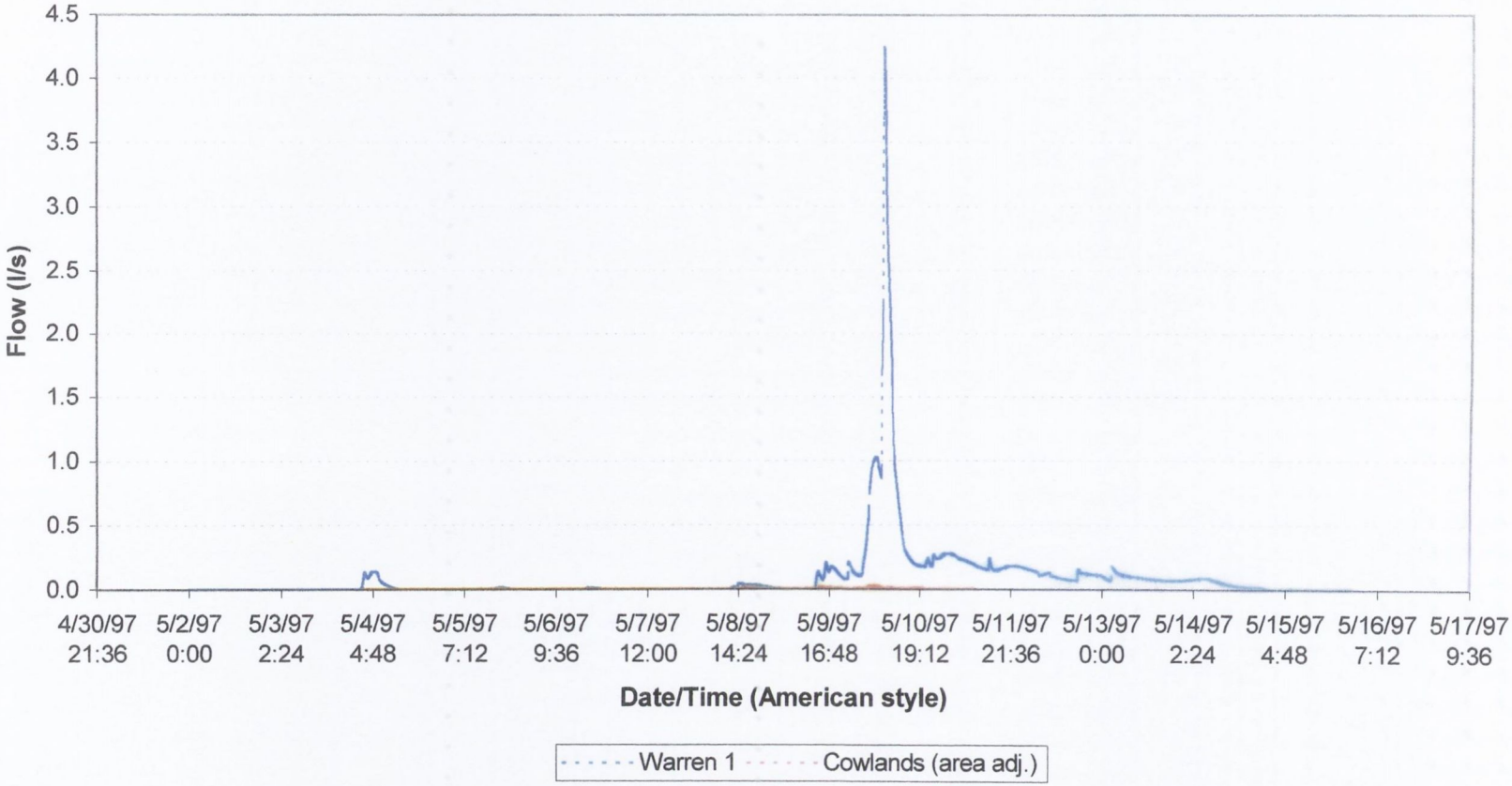


Figure 7.104: Overland flow (l/s) for event 7 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

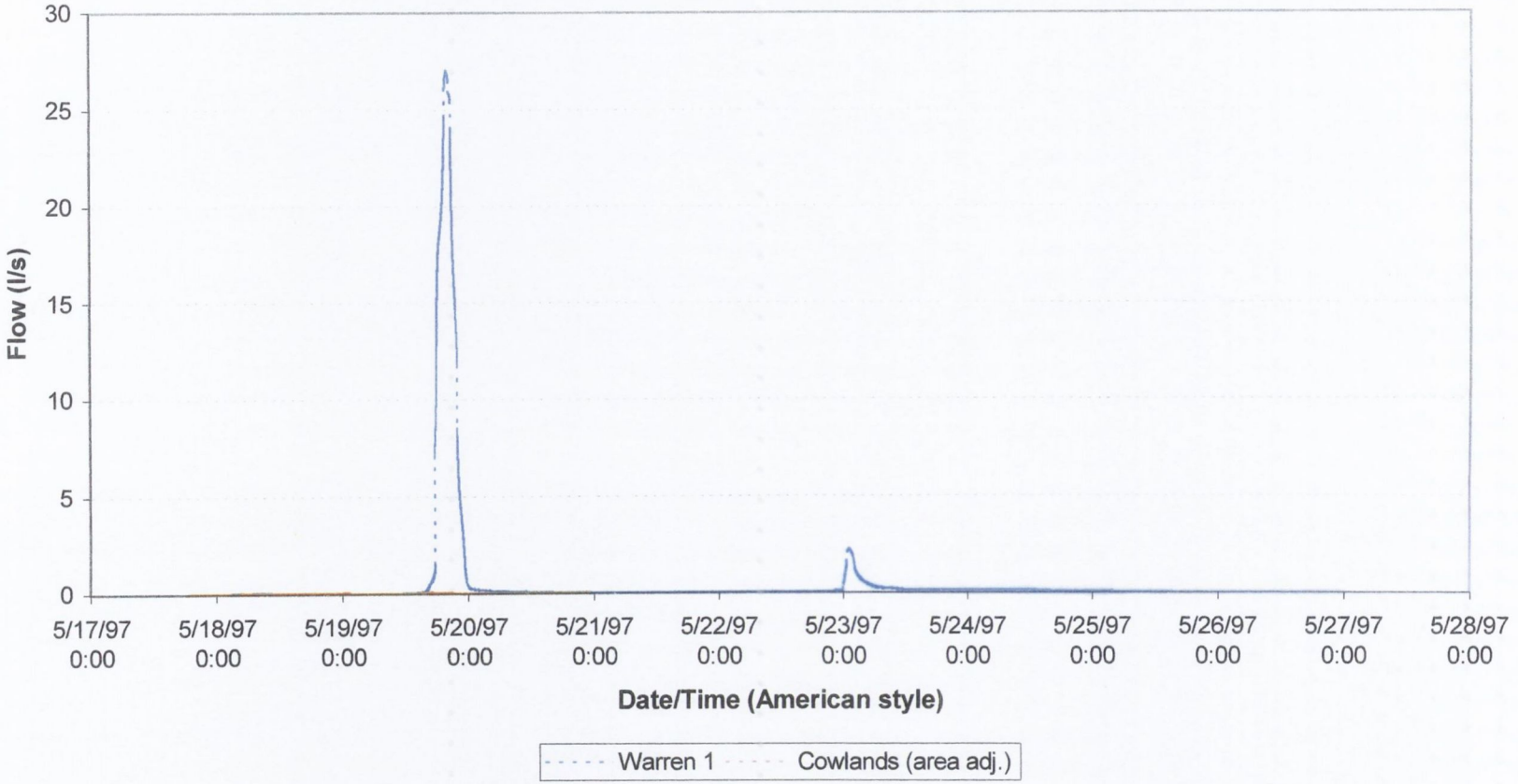


Figure 7.105: Overland flow (l/s) for event 8 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

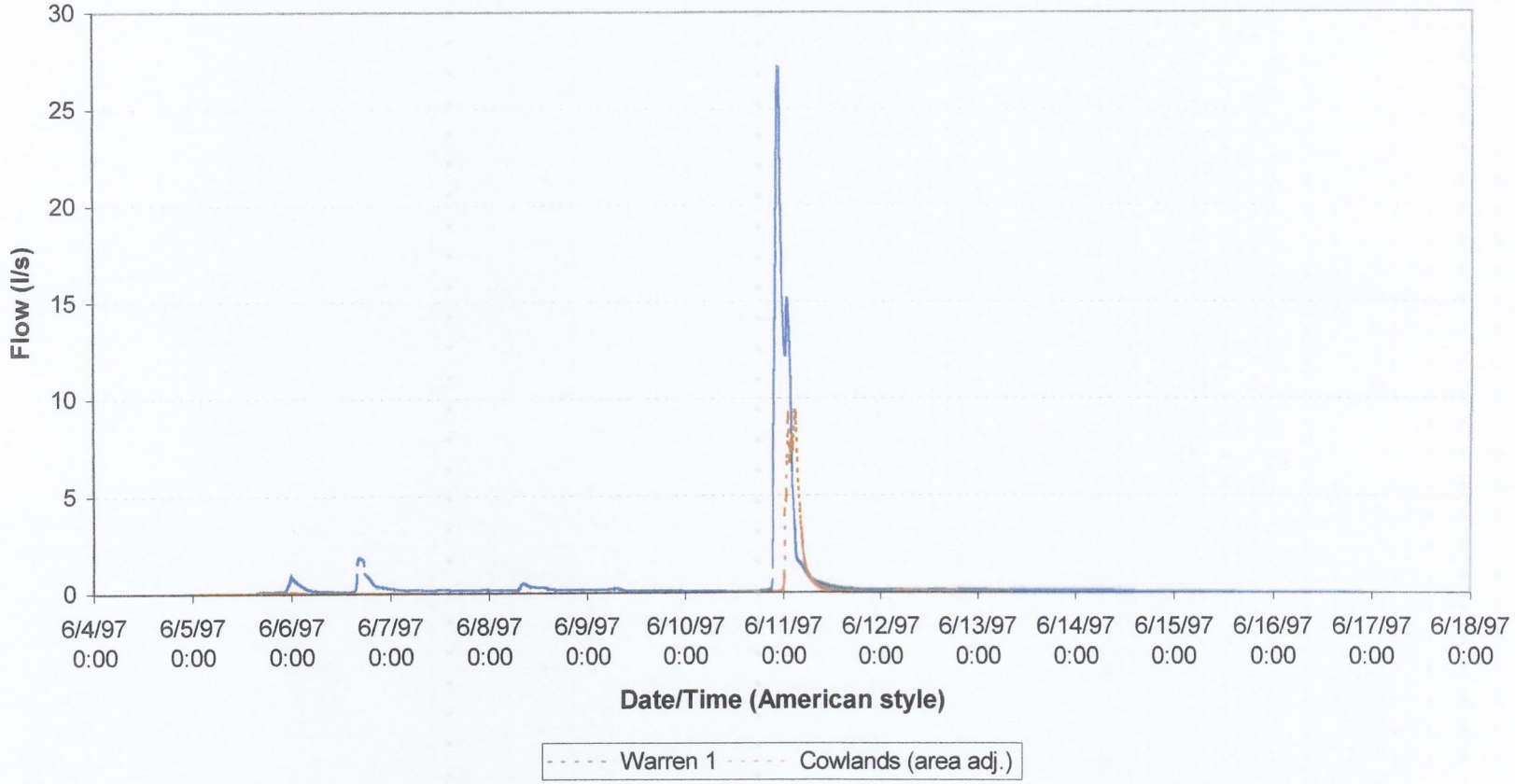


Figure 7.106: Overland flow (l/s) for event 9 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

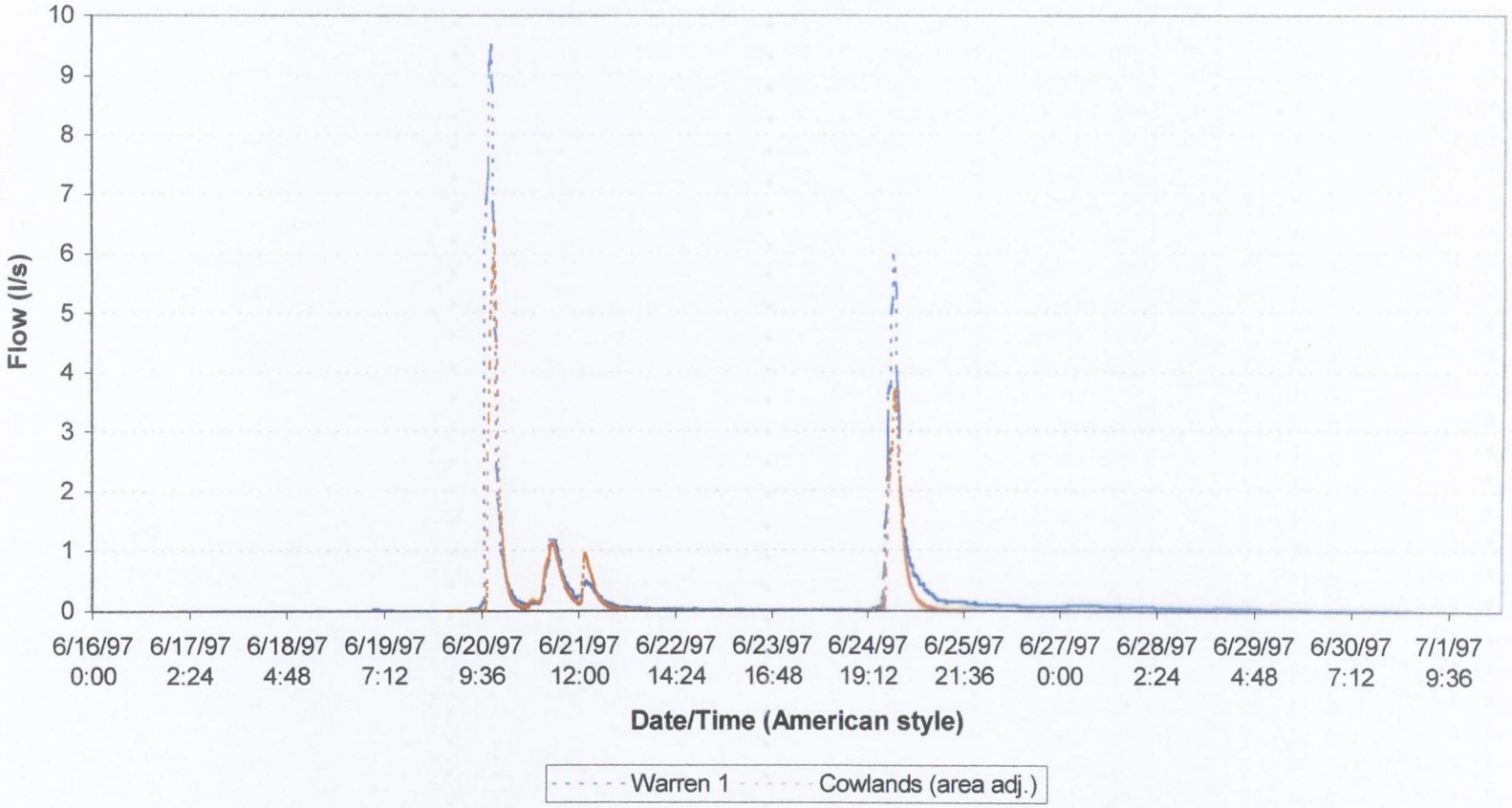


Figure 7.107: Overland flow (l/s) for event 10 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

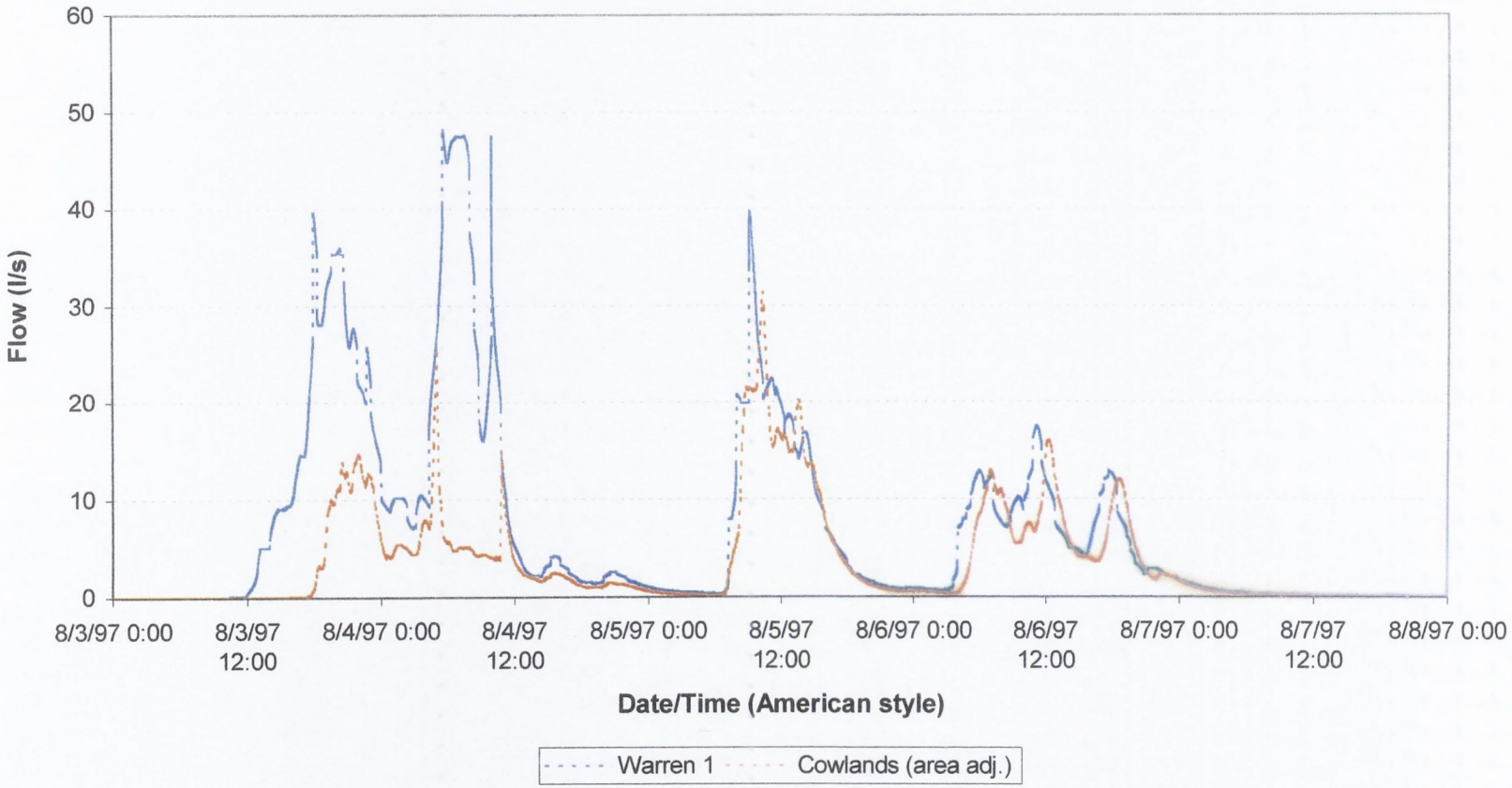


Figure 7.108: Overland flow (l/s) for event 13 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

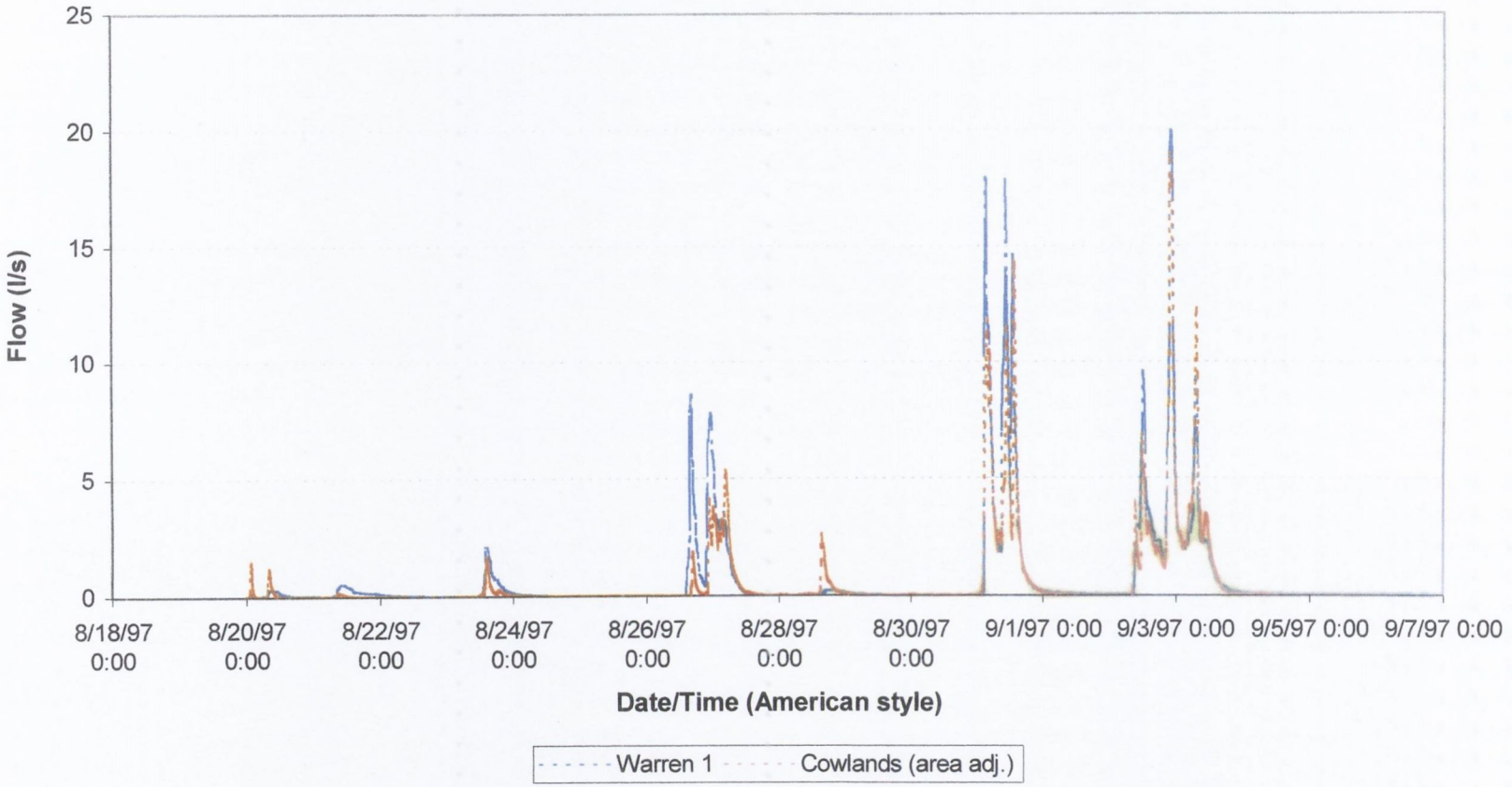


Figure 7.109: Overland flow (l/s) for event 14 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

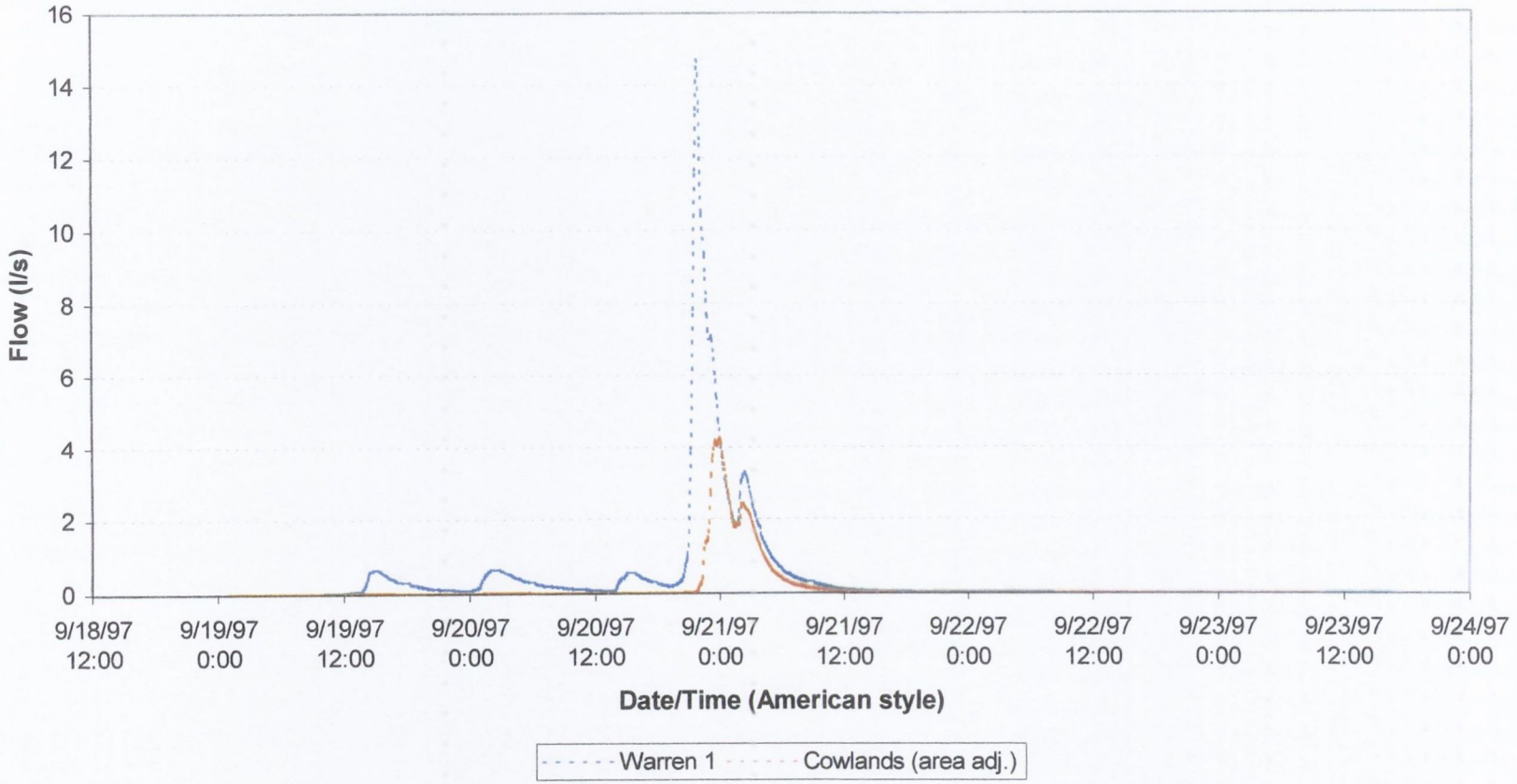


Figure 7.110: Overland flow (l/s) for event 15 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

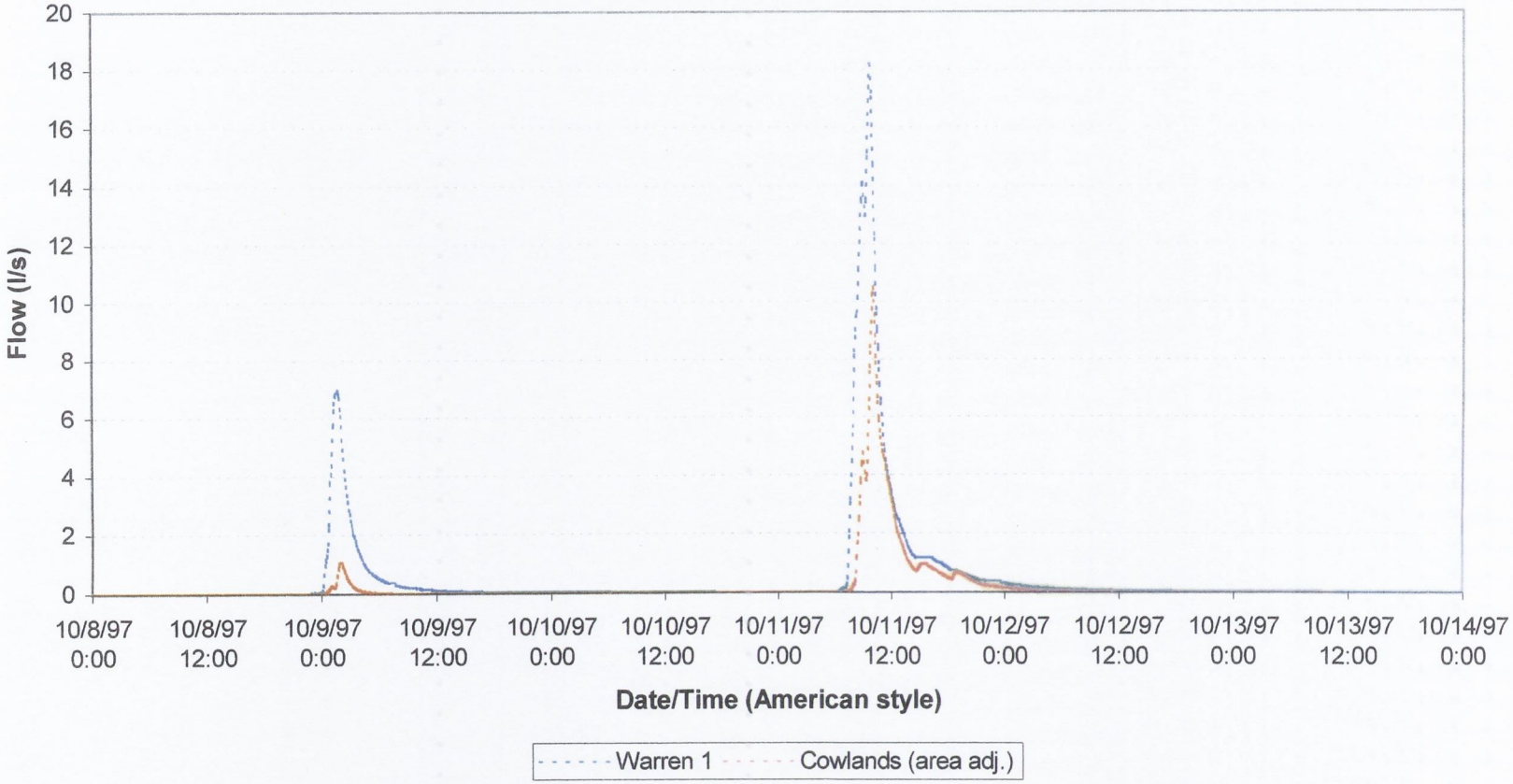


Figure 7.111: Overland flow (l/s) for event 16 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

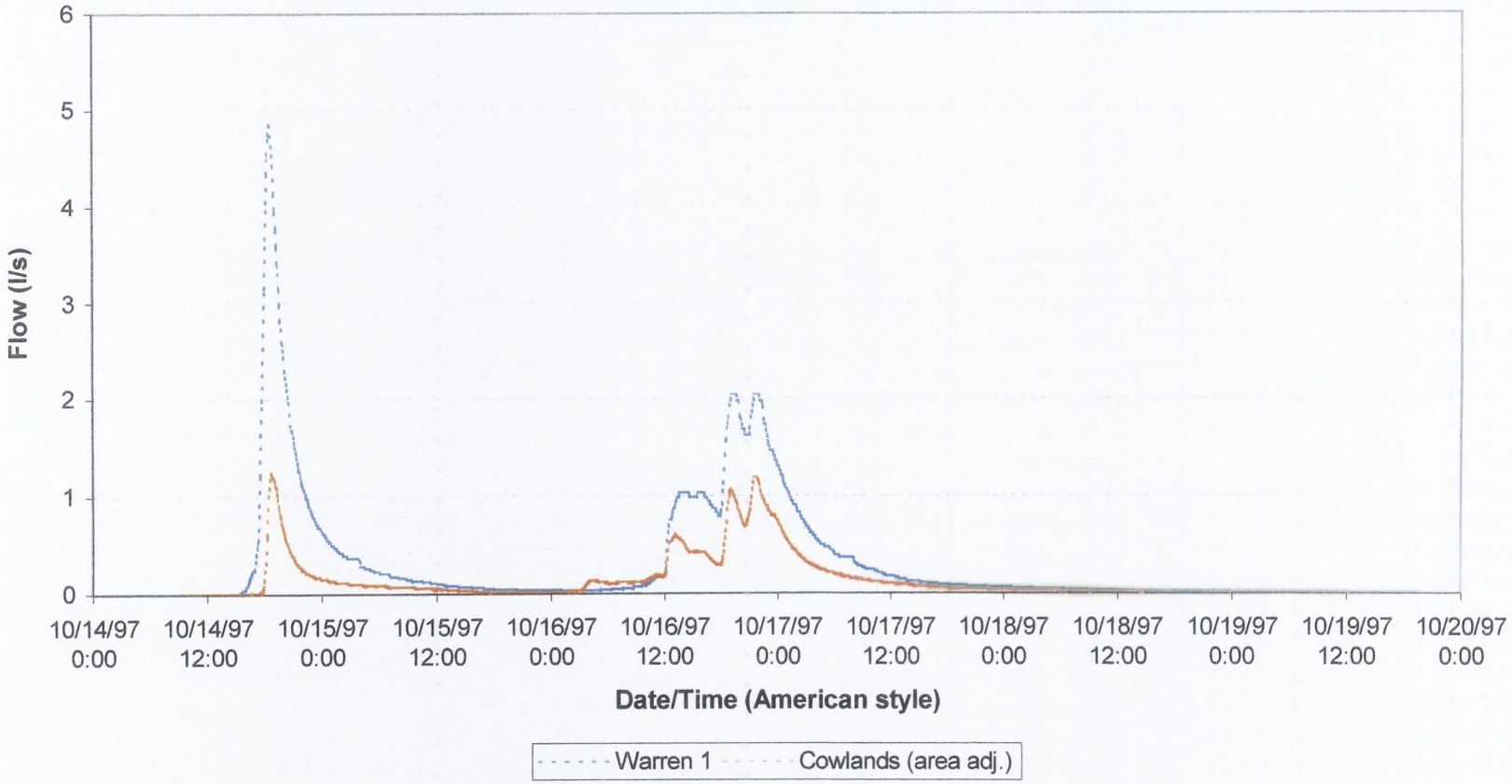


Figure 7.112: Overland flow (l/s) for event 17 at the Warren 1 and overland flow values at the Cowlands, which were adjusted to the area of the Warren 1.

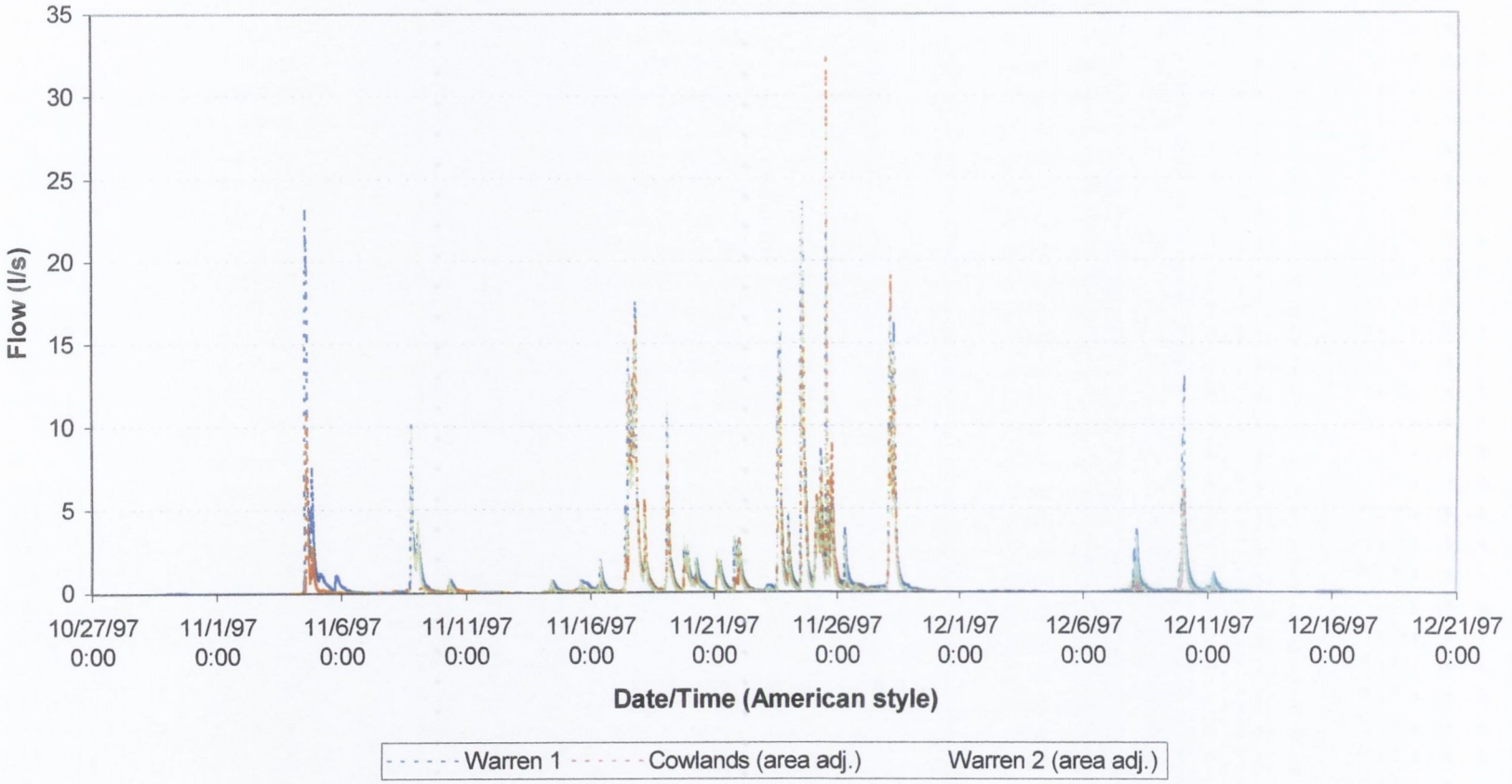


Figure 7.113: Overland flow (l/s) for event 18 at the Warren 1 and overland flow values at the Cowlands and the Warren 2, which were adjusted to the area of the Warren 1.

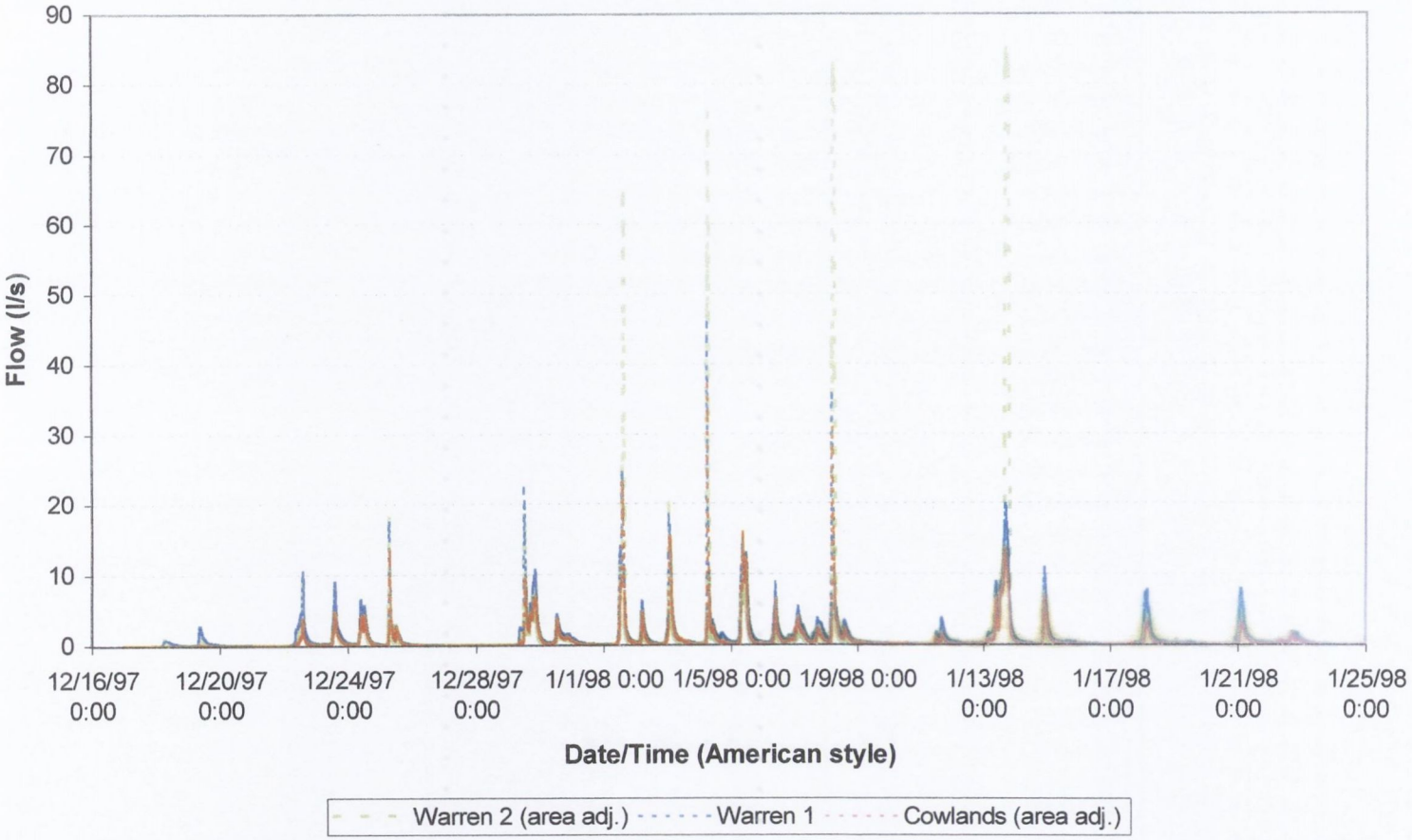


Figure 7.114: Overland flow (l/s) for event 19 at the Warren 1 and overland flow values at the Cowlands and the Warren 2, which were adjusted to the area of the Warren 1.

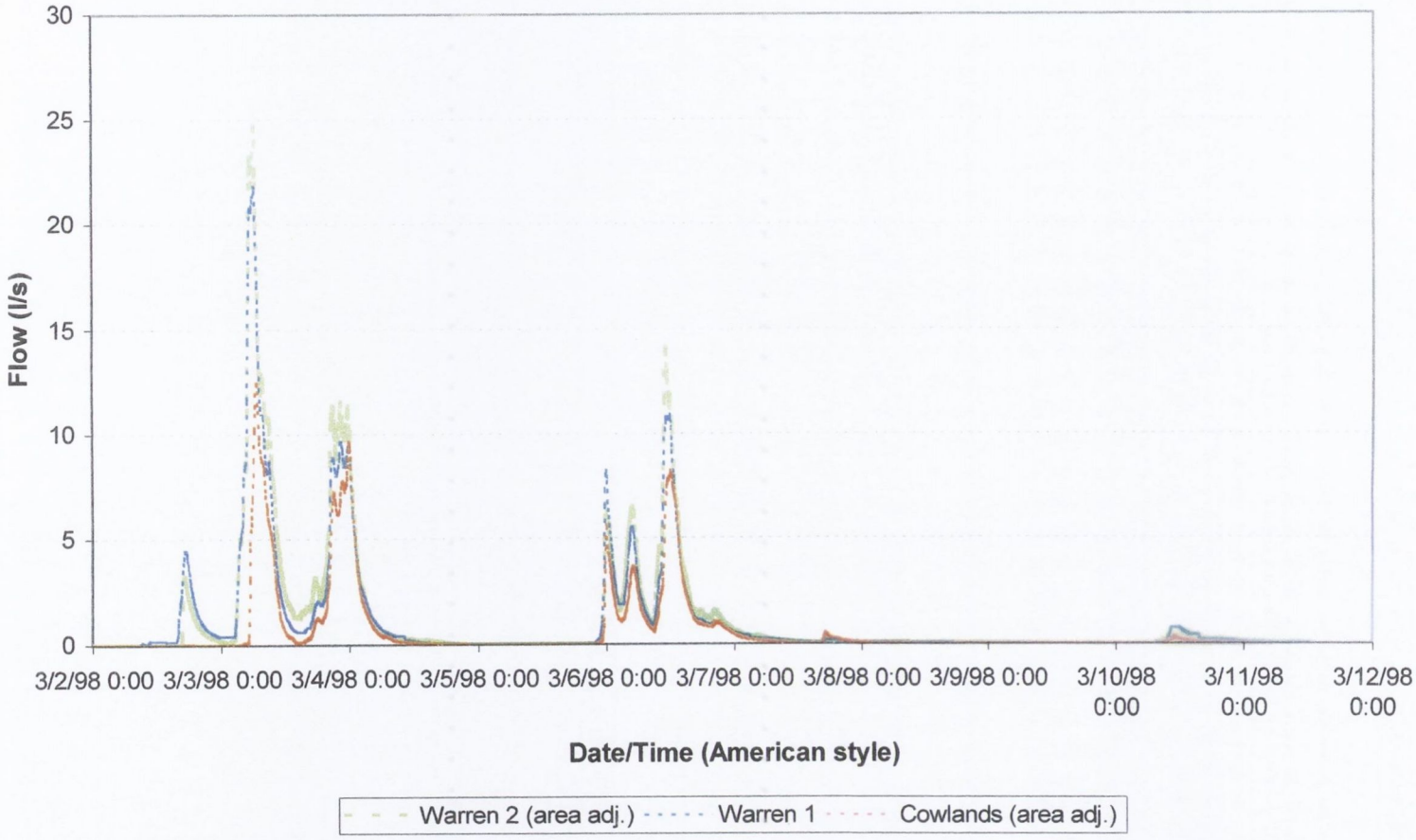


Figure 7.115: Overland flow (l/s) for event 21 at the Warren 1 and overland flow values at the Cowlands and the Warren 2, which were adjusted to the area of the Warren 1.

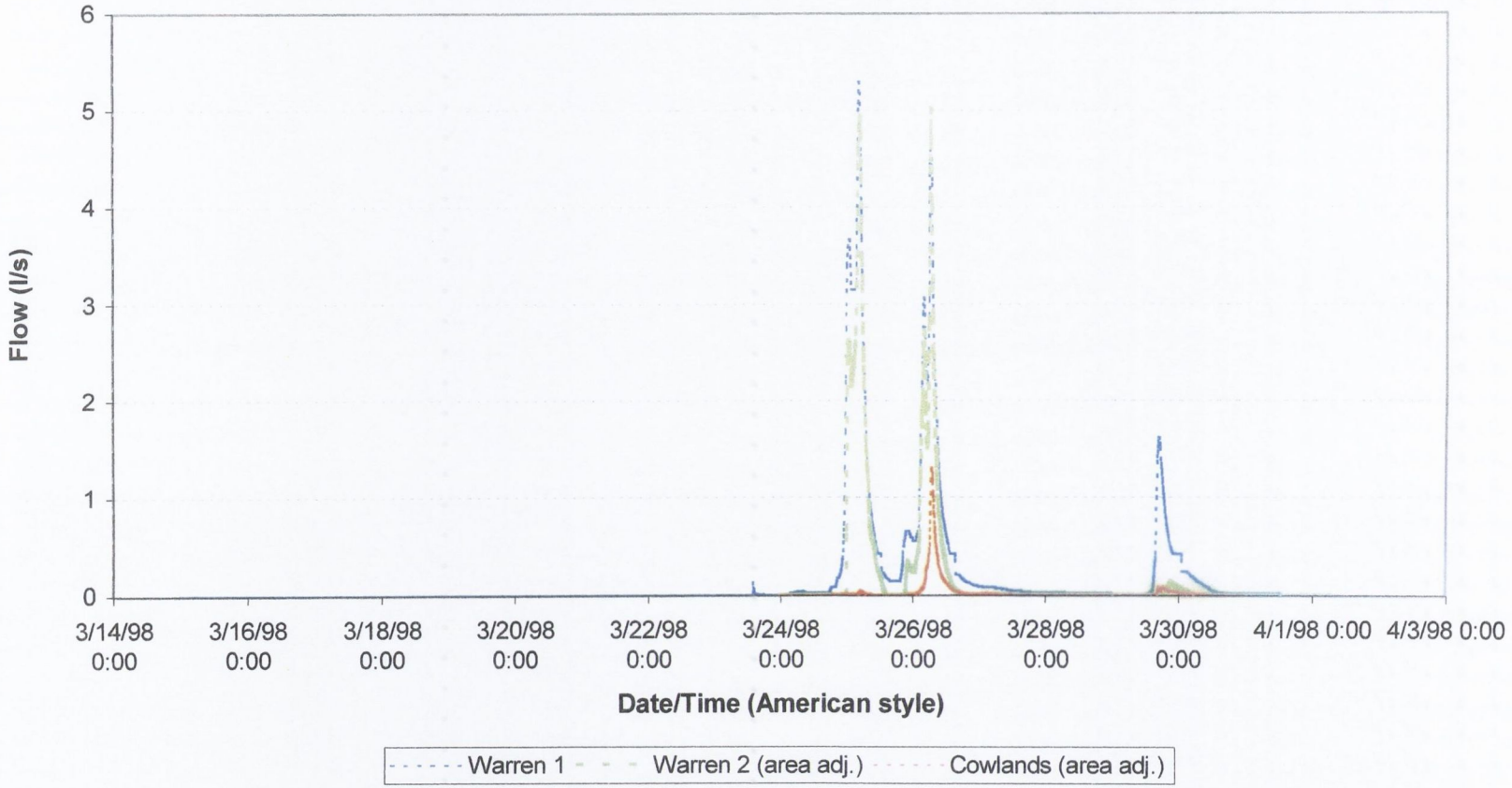


Figure 7.116: Overland flow (l/s) for event 22 at the Warren 1 and overland flow values at the Cowlands and the Warren 2, which were adjusted to the area of the Warren 1.

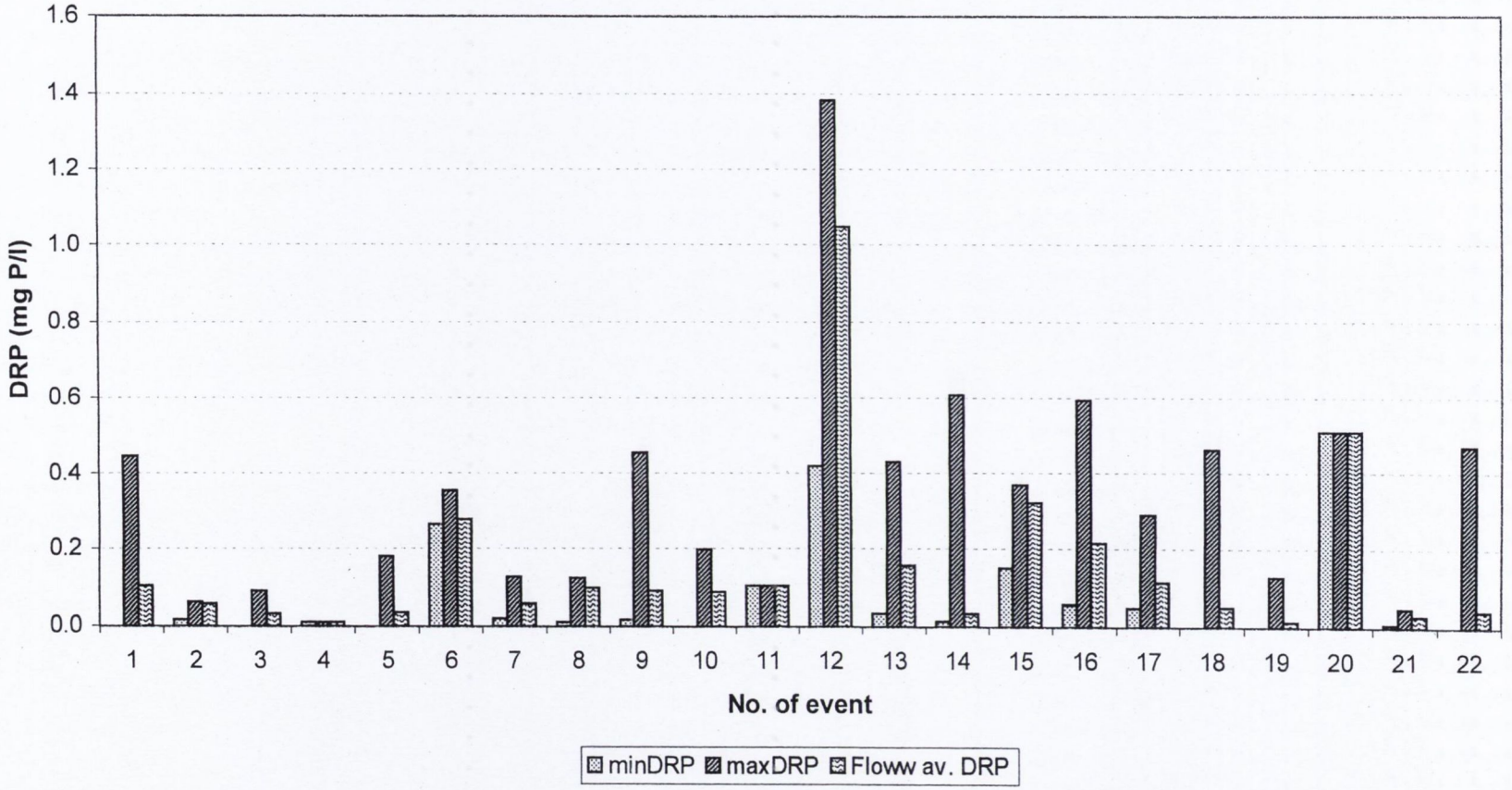


Figure 7.117: Minimum, maximum and flow weighted average DRP (mg P/l) concentrations at the Warren 1. (Excessively high P concentrations at beginning of event 18 not considered in working out maximum for that event. See Table 7.2 and Section 7.3.2.)

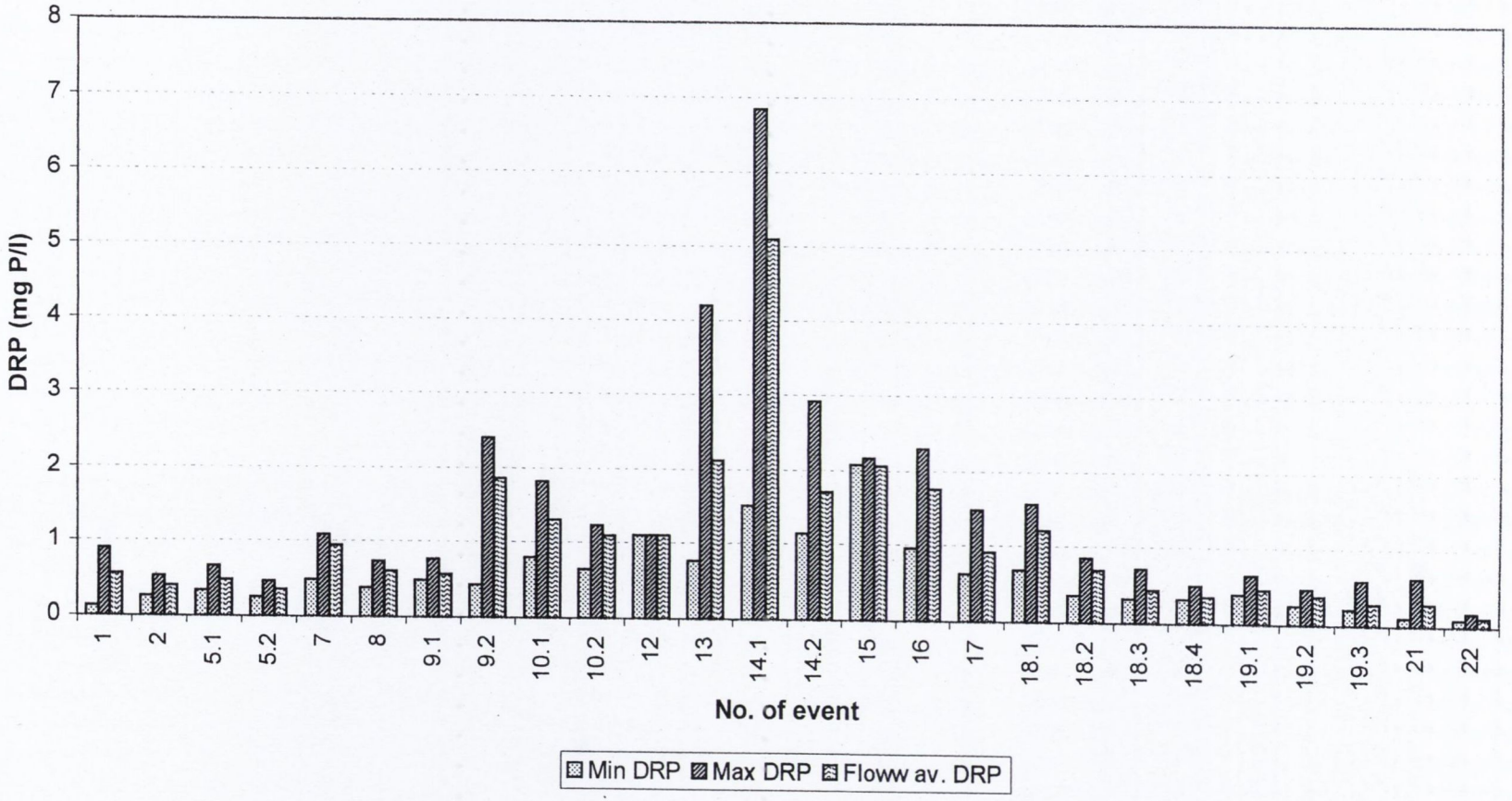


Figure 7.118: Minimum, maximum and flow weighted average DRP (mg P/l) concentrations at the Cowlands.

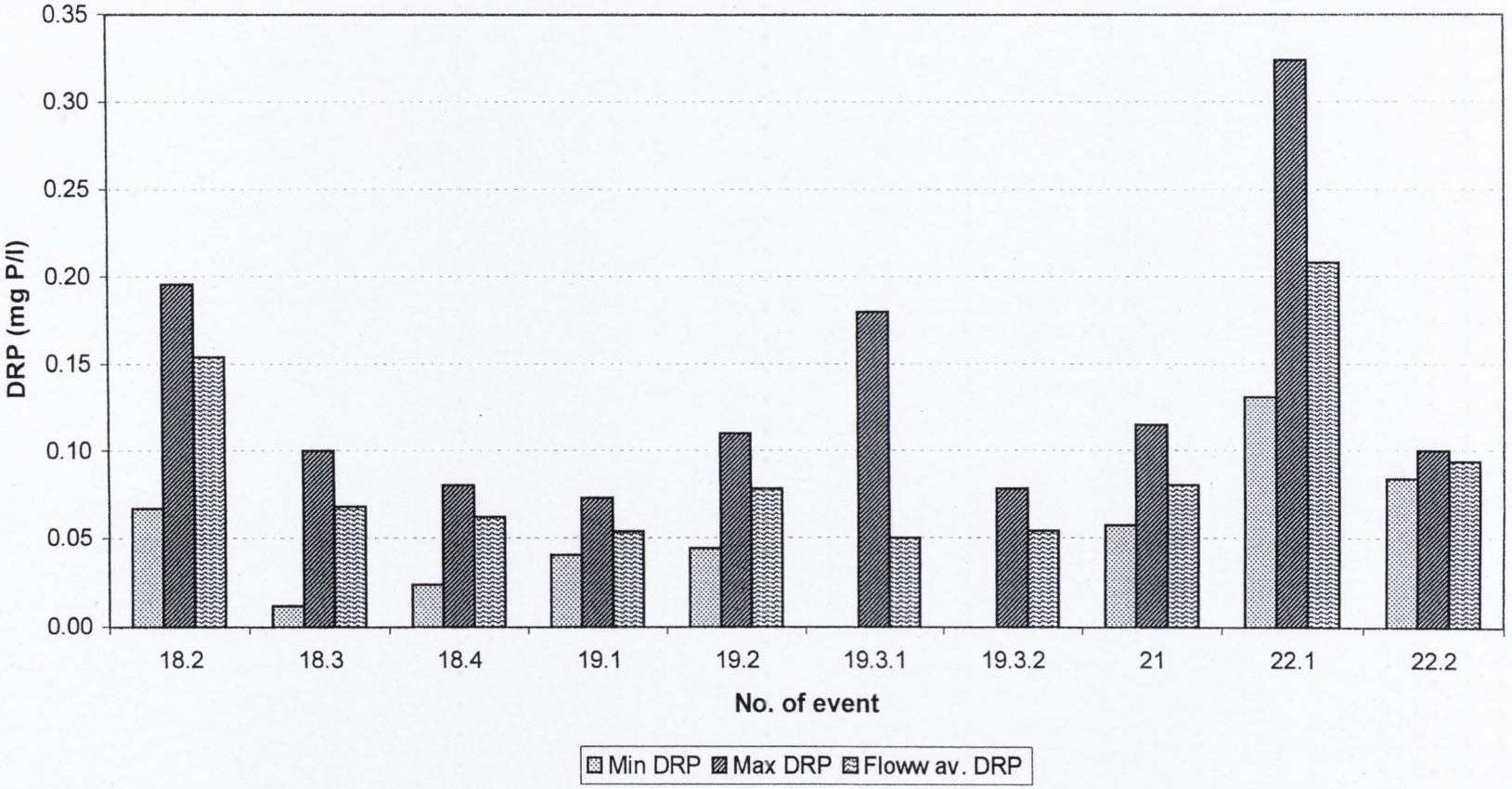


Figure 7.119: Minimum, maximum and flow weighted average DRP (mg P/l) concentrations at the Warren 2.

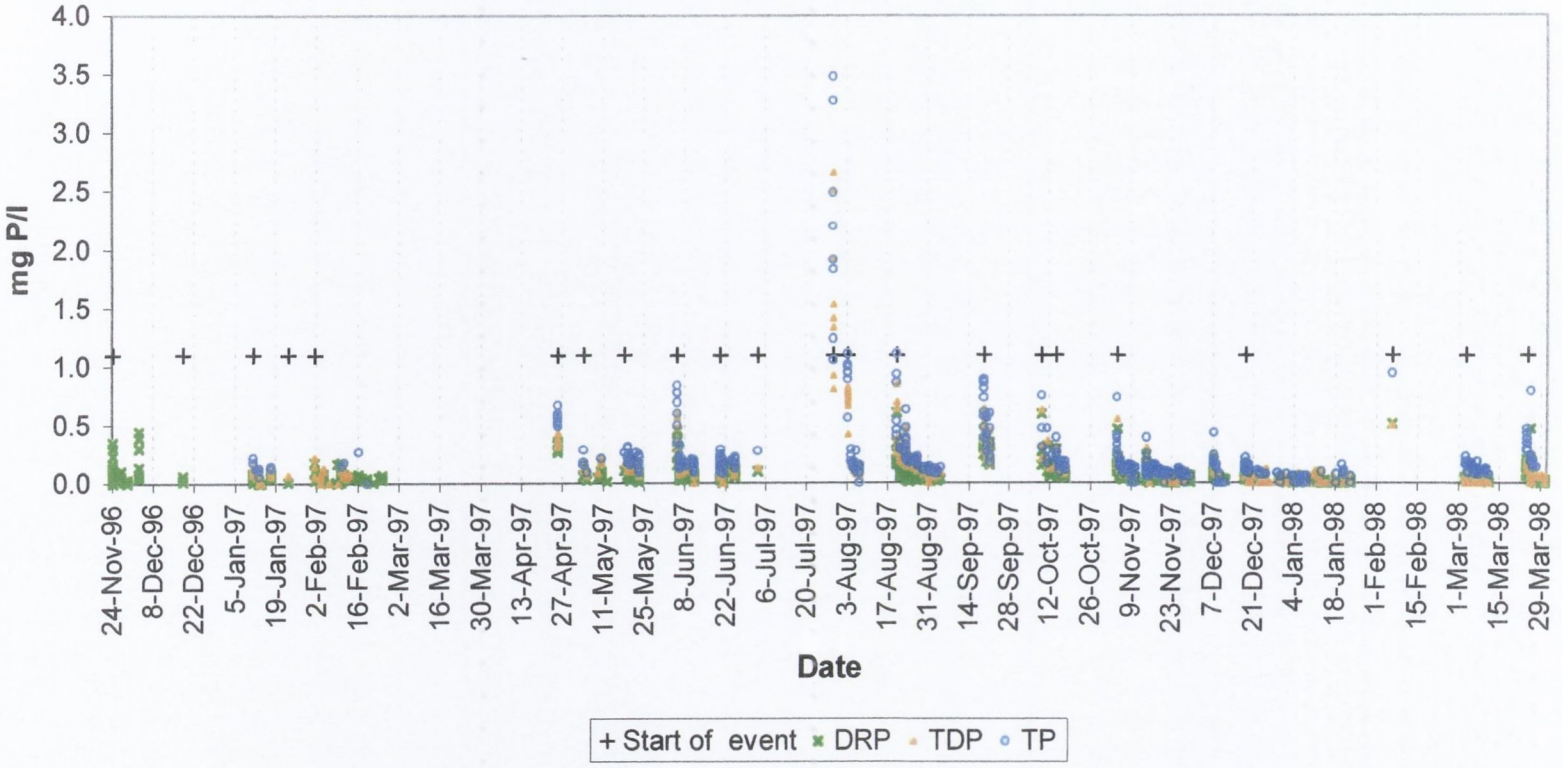


Figure 7.120: Marker for the start of events and DRP, TDP and TP concentrations (mg P/l) at the Warren 1. (DRP not measured for some samples taken July/August 1997 and in December/January 1997/98. See Section 5.2.3. Excessively high P concentrations at beginning of event 18 (30th October 1997) omitted. See table 7.2.)

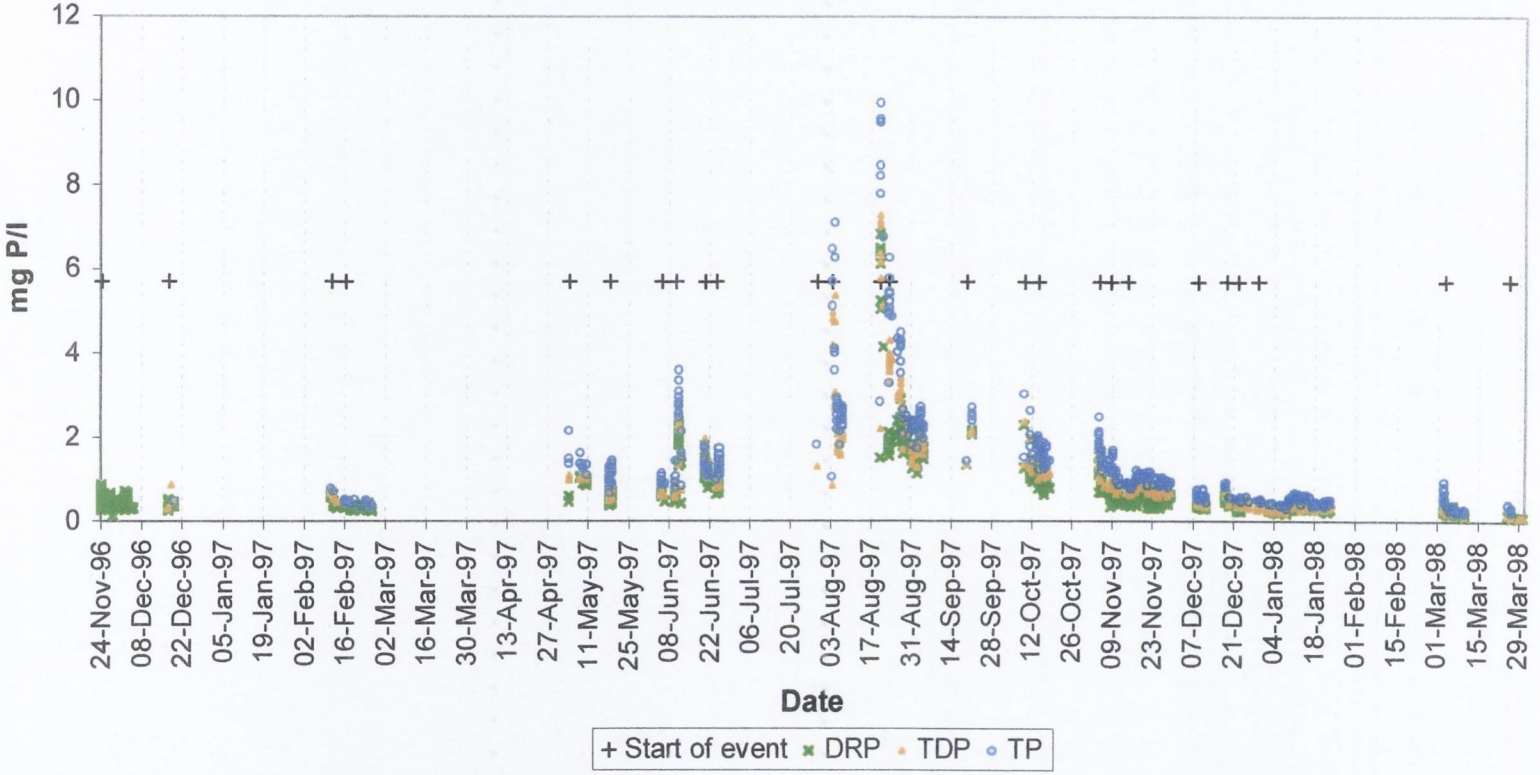


Figure 7.121: Marker for the start of events and DRP, TDP and TP concentrations (mg P/l) at the Cowlands. (DRP not measured for some samples taken July/August 1997 and in December/January 1997/98. See Section 5.2.3.)

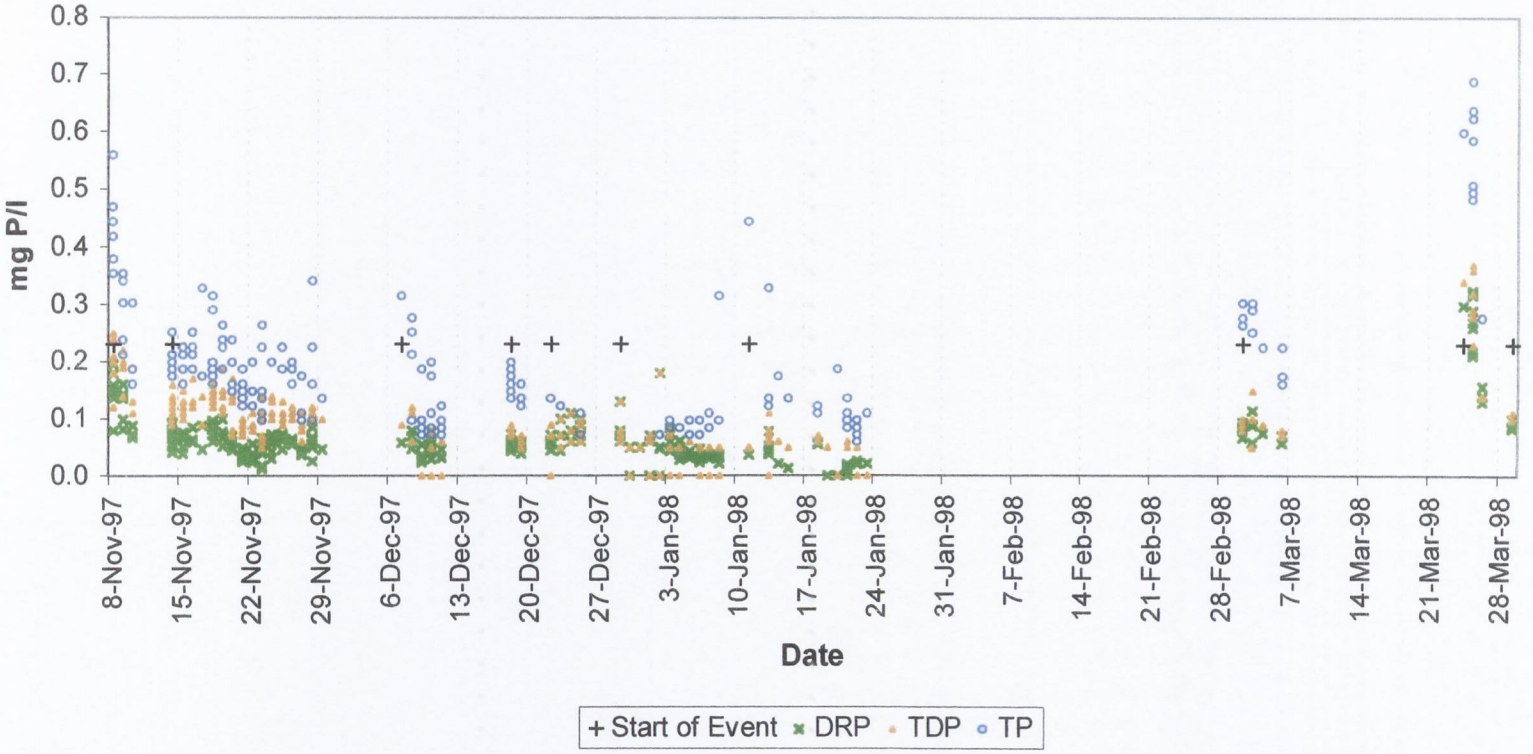


Figure 7.122: Marker for the start of events and DRP, TDP and TP concentrations (mg P/l) at the Warren 2. (DRP not measured for some samples taken in December/January 1997/98. See Section 5.2.3.)

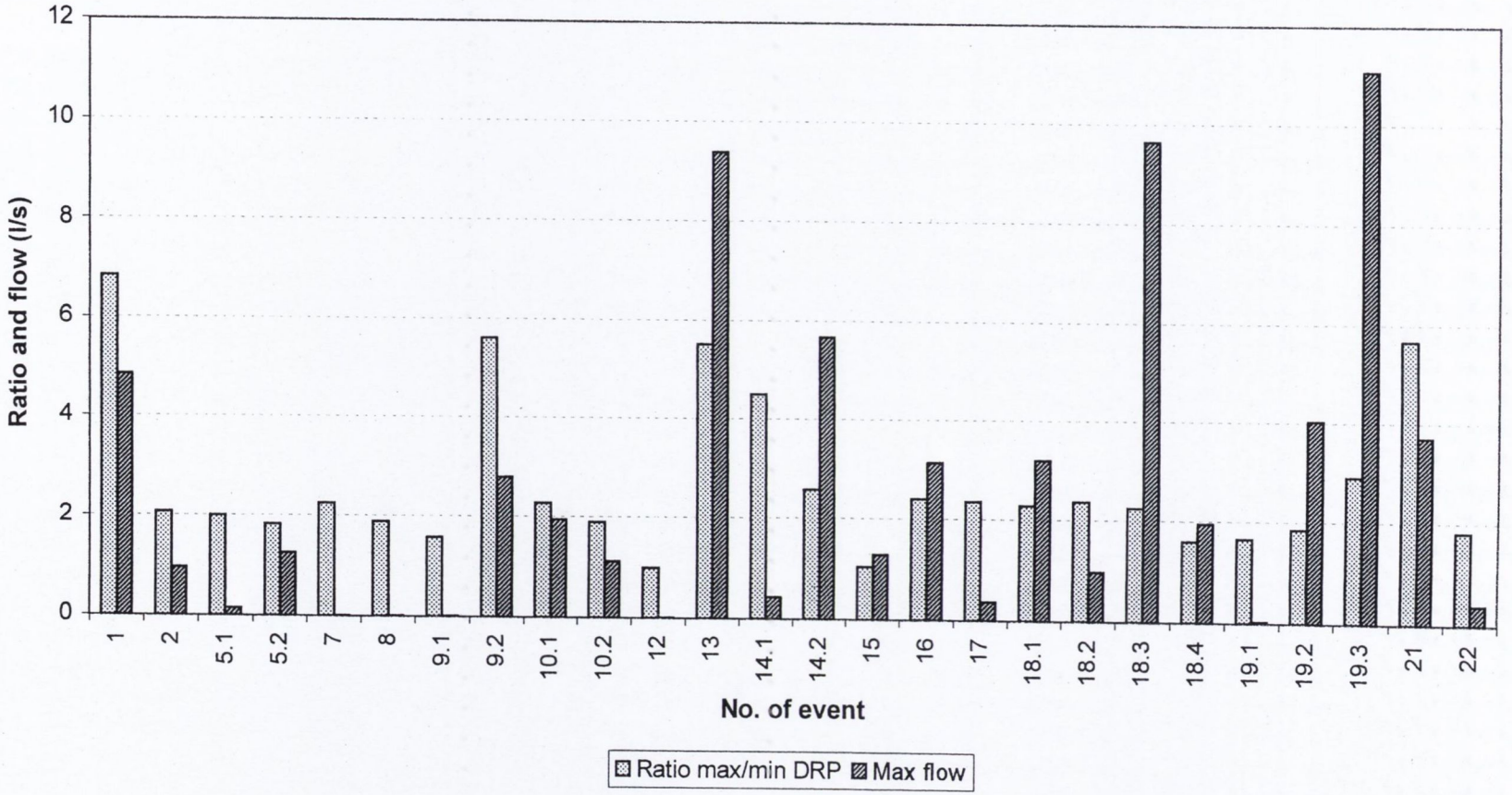


Figure 7.123: Ratios of maximum to minimum DRP concentrations per event and maximum rates of flow (l/s) per event at the Cowlands.

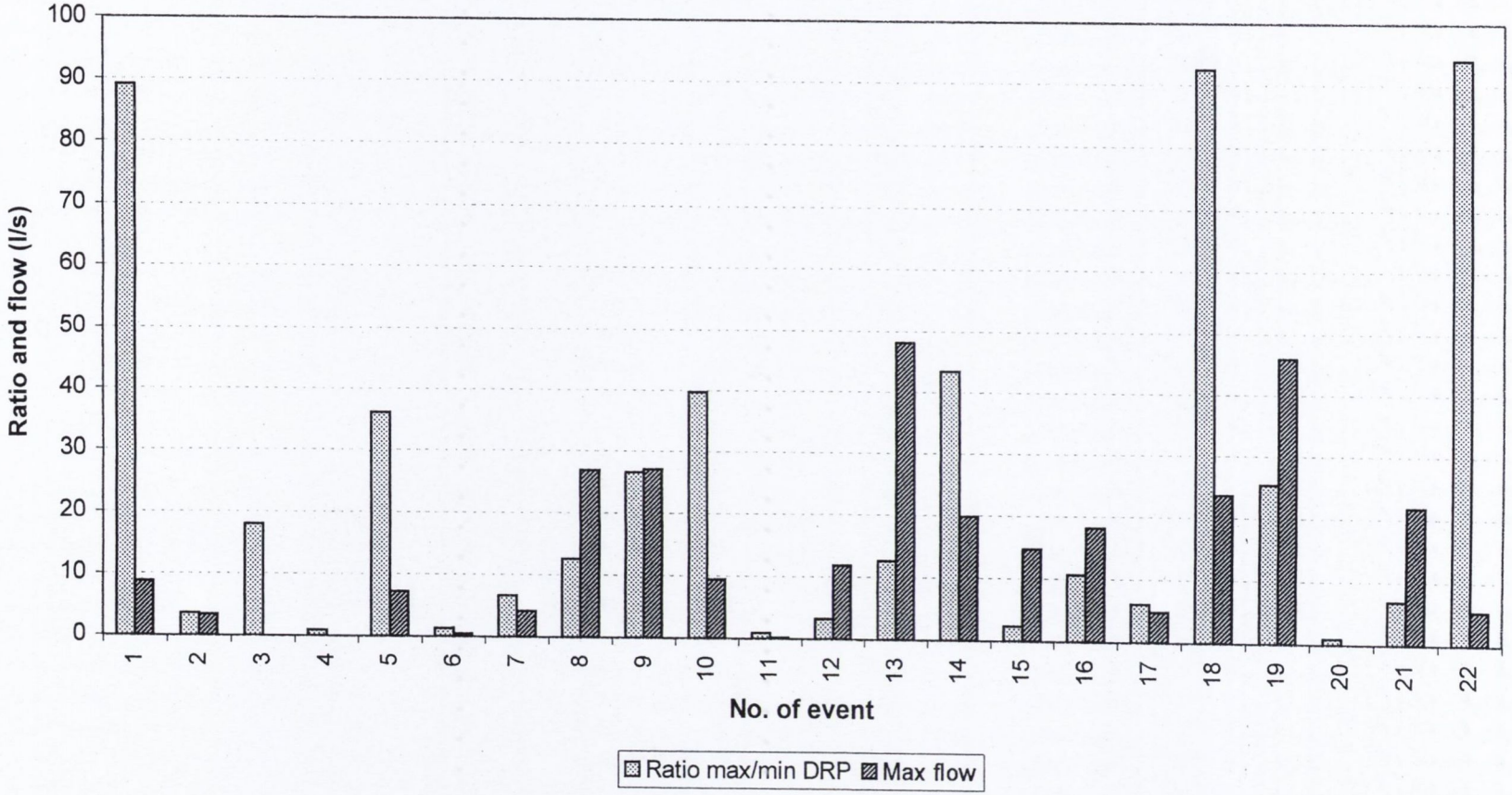


Figure 7.124: Ratios of maximum to minimum DRP concentrations per event and maximum rates of flow (l/s) per event at the Warren 1.

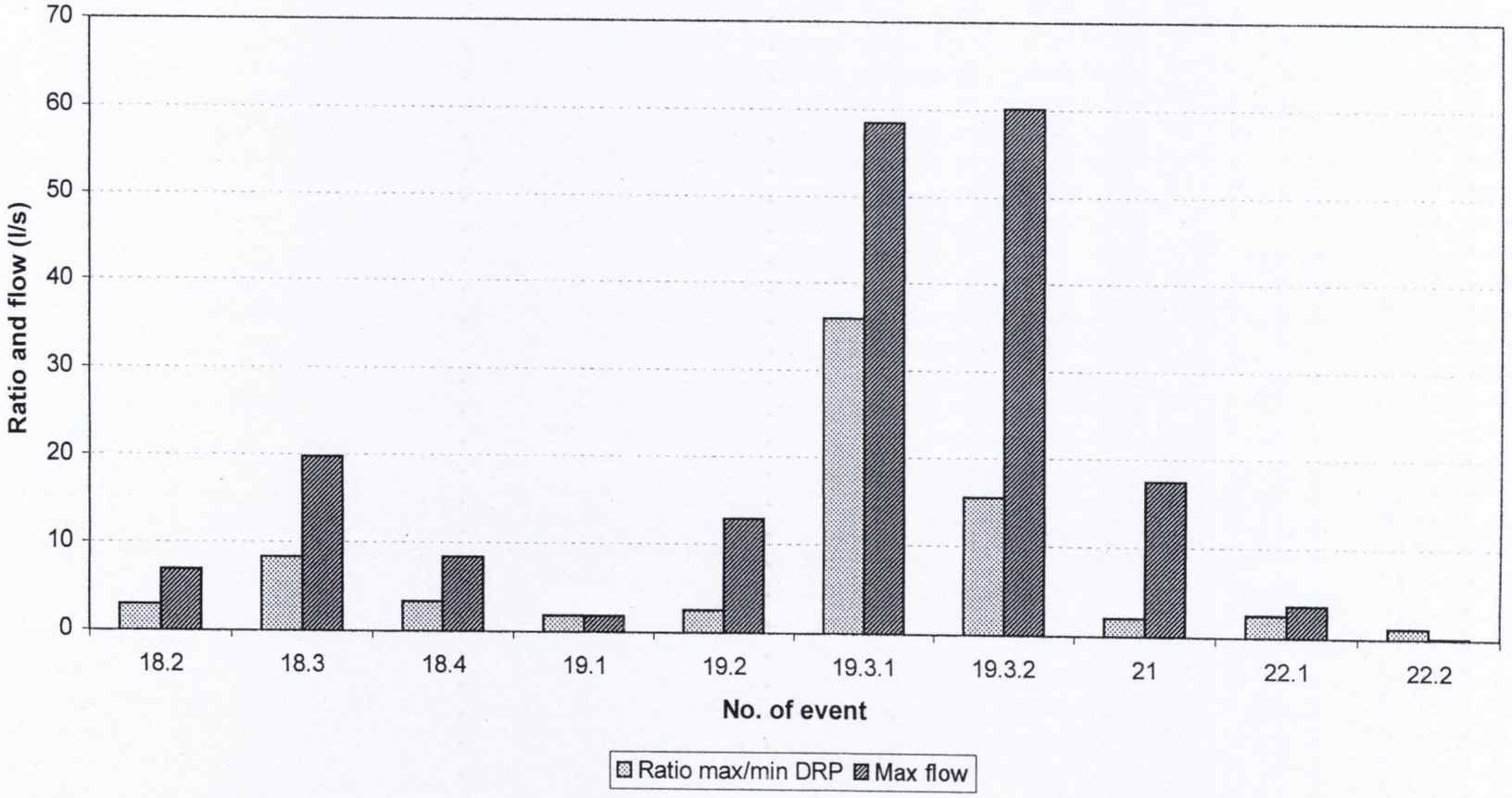


Figure 7.125: Ratios of maximum to minimum DRP concentrations per event and maximum rates of flow (l/s) per event at the Warren 2.

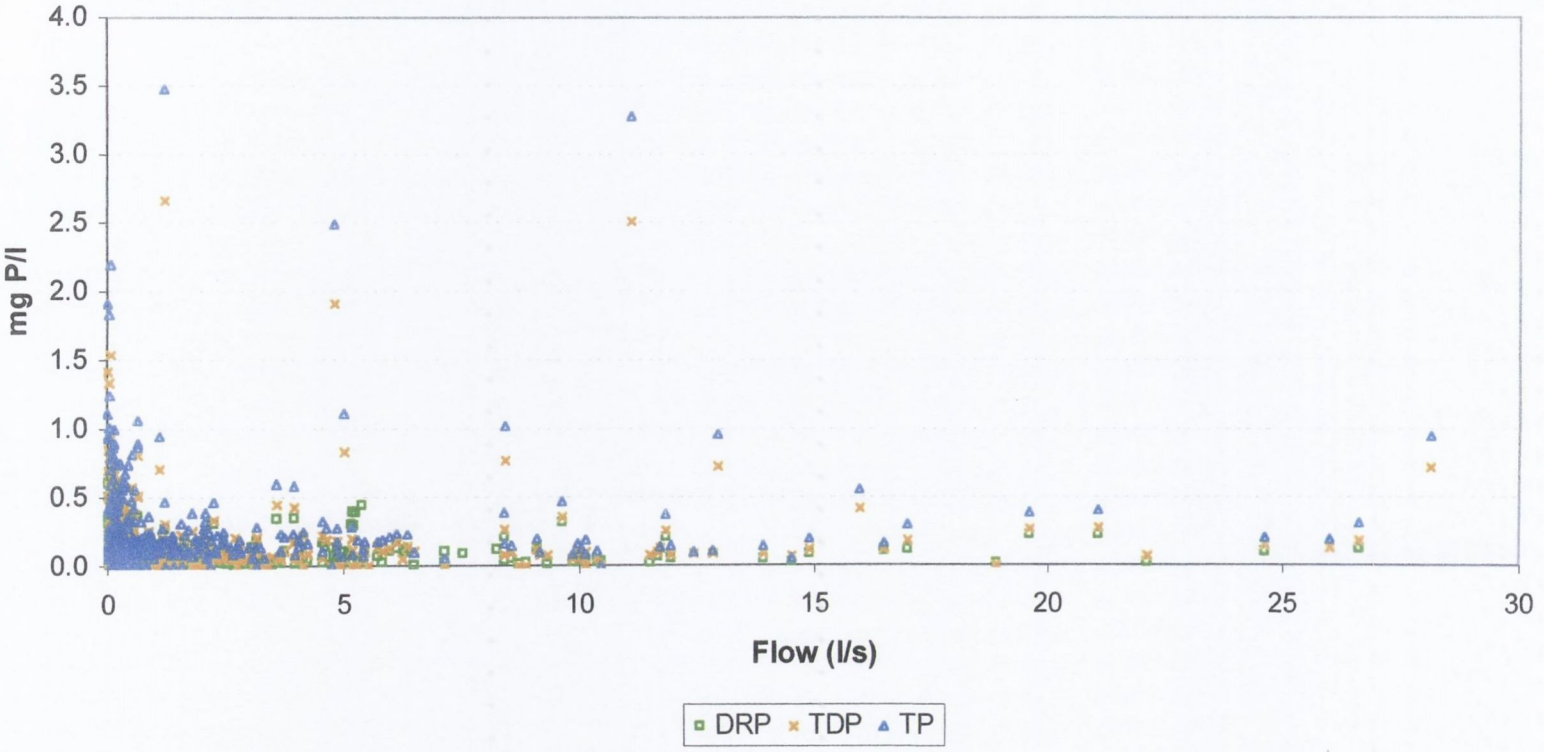


Figure 7.126: Rates of flow (l/s) plotted against P concentrations (mg P/l) at the Warren 1.

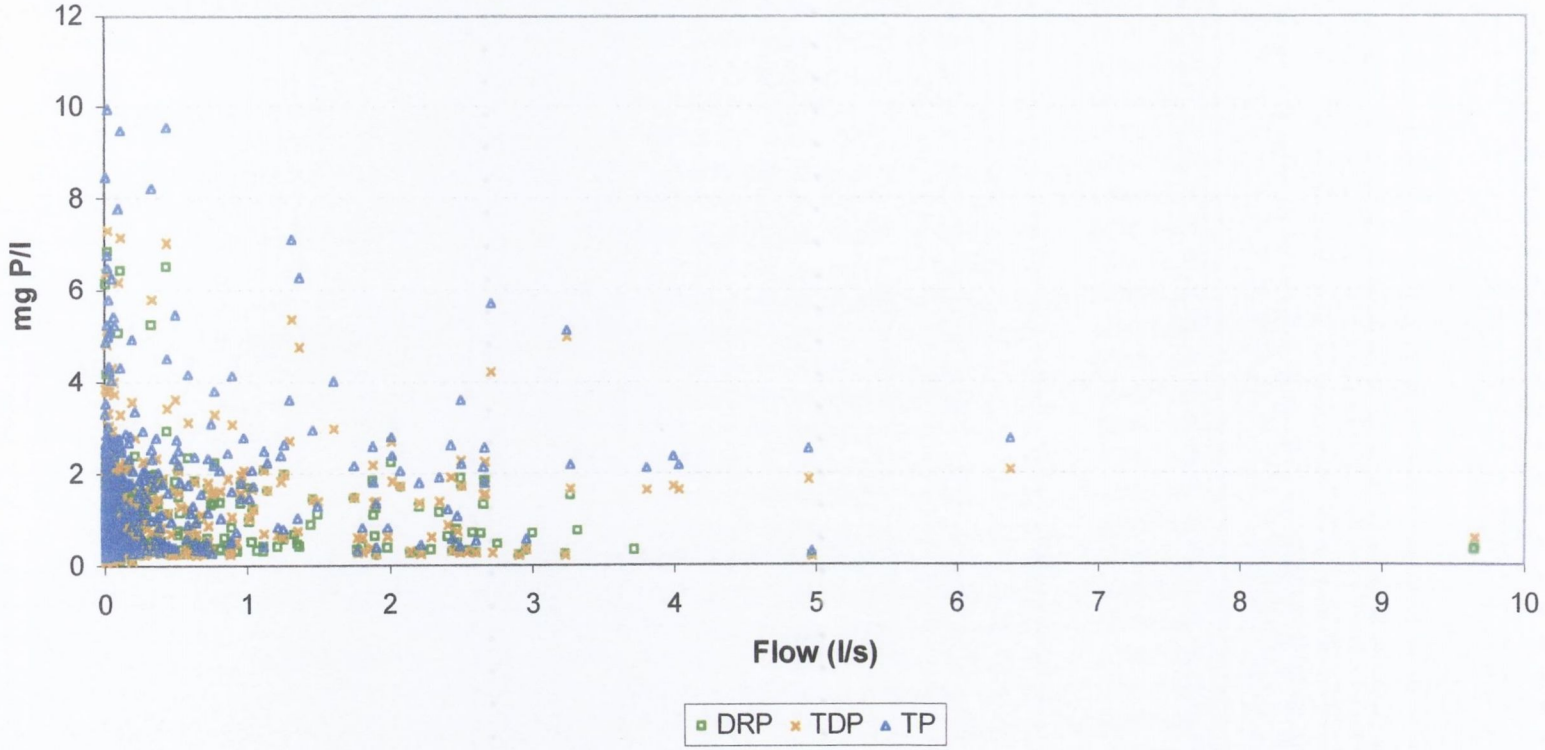


Figure 7.127: Rates of flow (l/s) plotted against P concentrations (mg P/l) at the Cowlands.

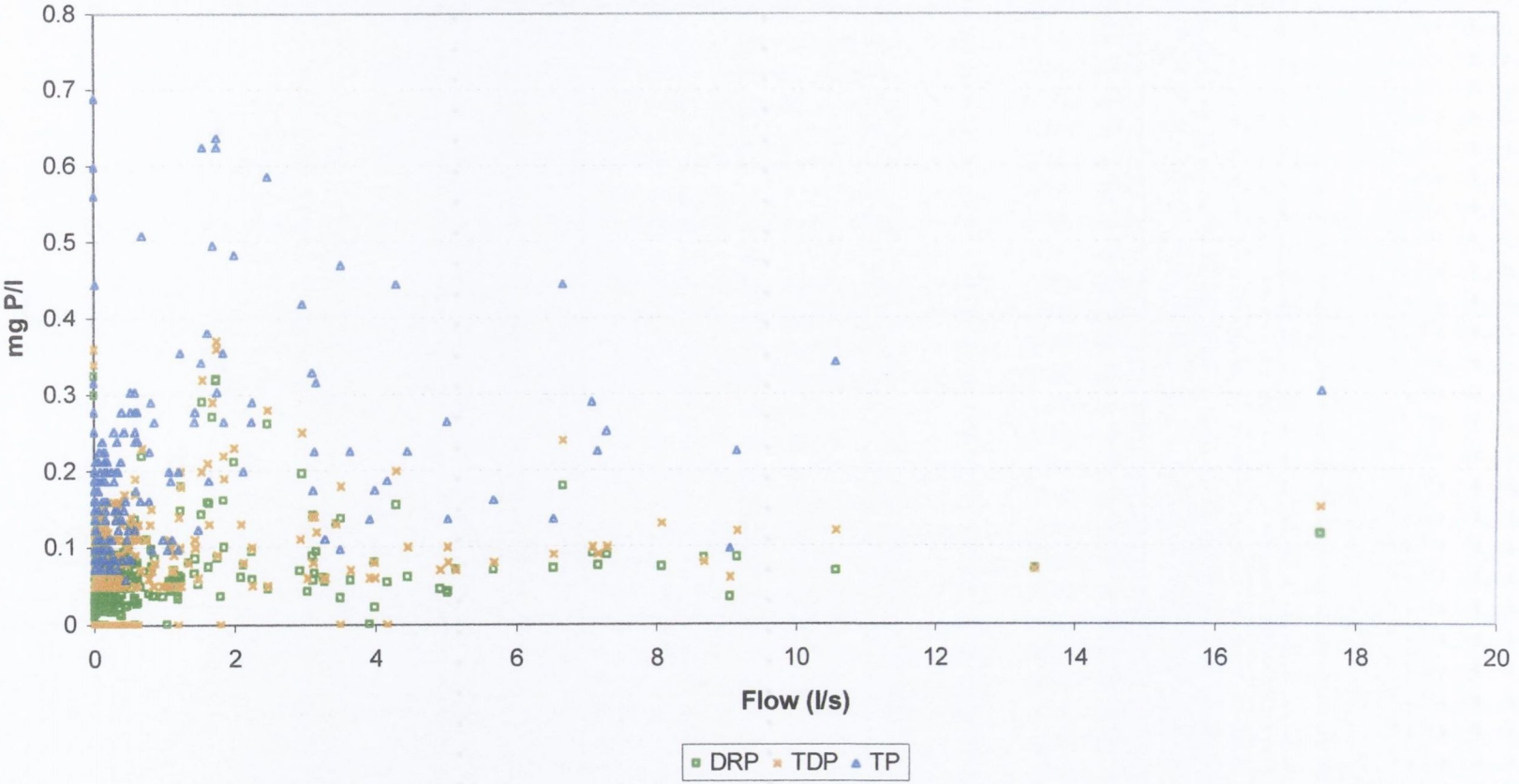


Figure 7.128: Rates of flow (l/s) plotted against P concentrations (mg P/l) at the Warren 2. Results of the two samples taken during excessively high flow on 8th (event 19.3.1) and 13th January (event 19.3.2) 1998 were omitted.

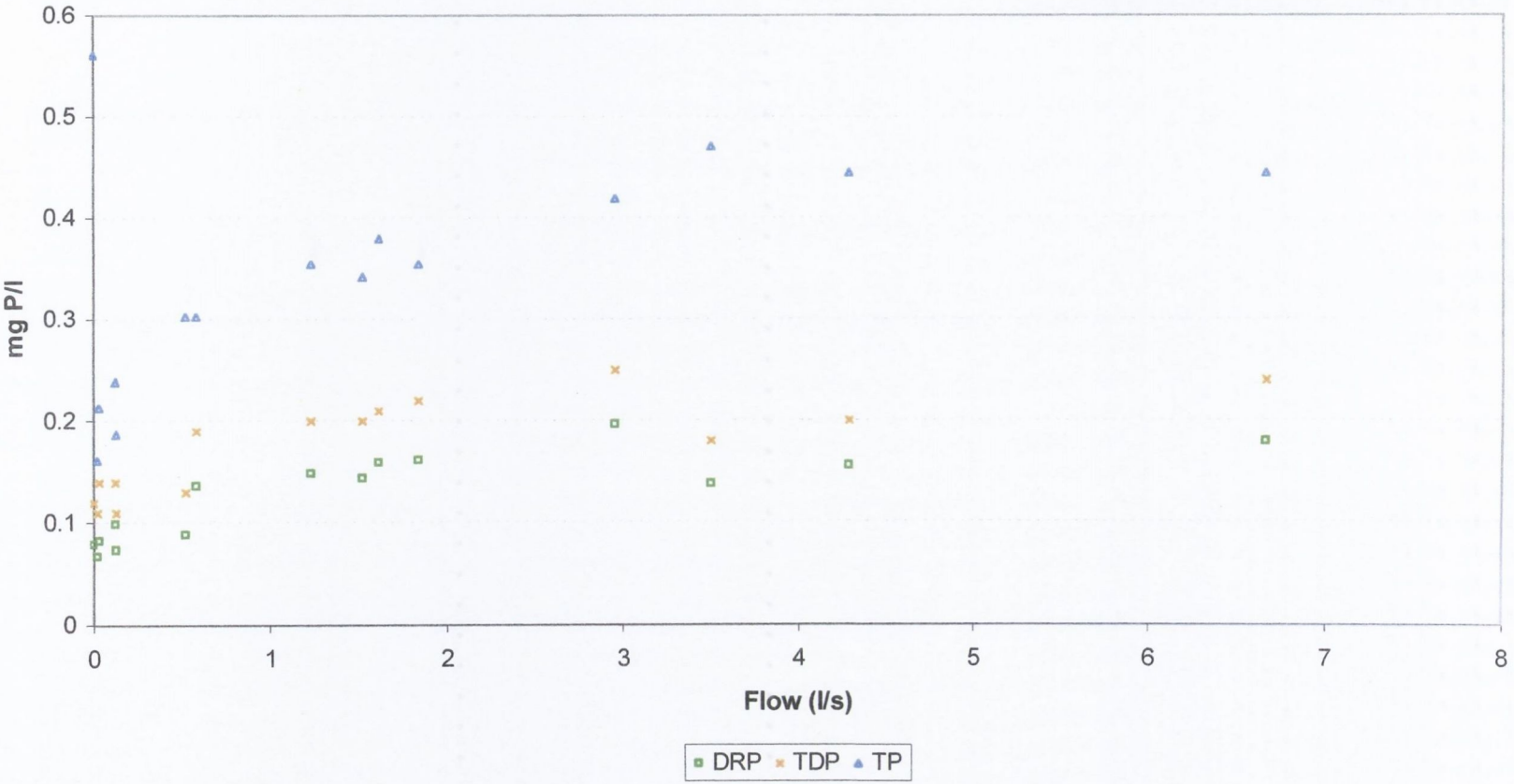


Figure 7.129: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event 18.2 at the Warren 2.

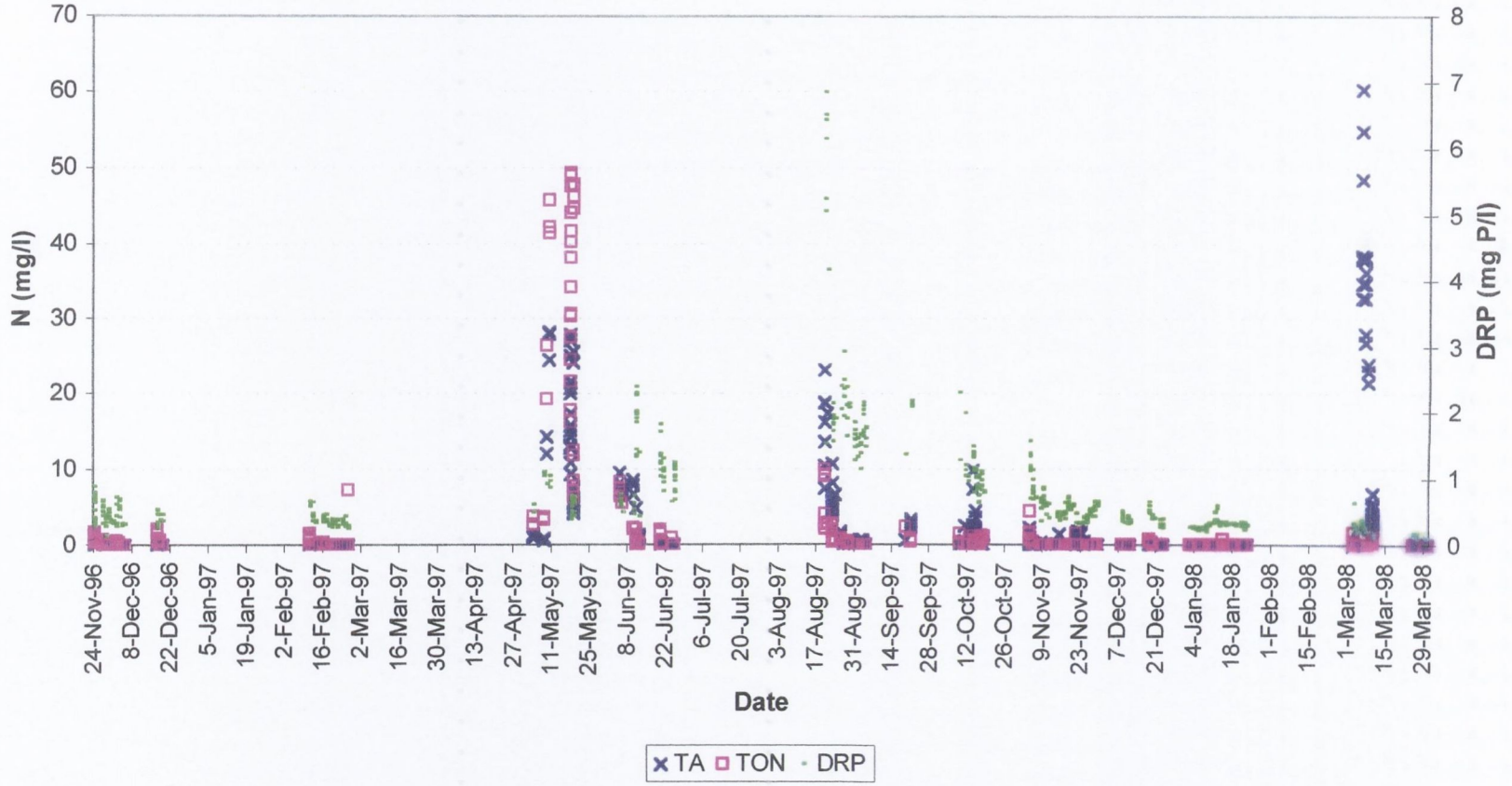


Figure 7.130: Total ammonia (TA), total oxidised nitrogen (TON) (mg N/l) and DRP (mg P/l) in overland flow from the Cowlands.

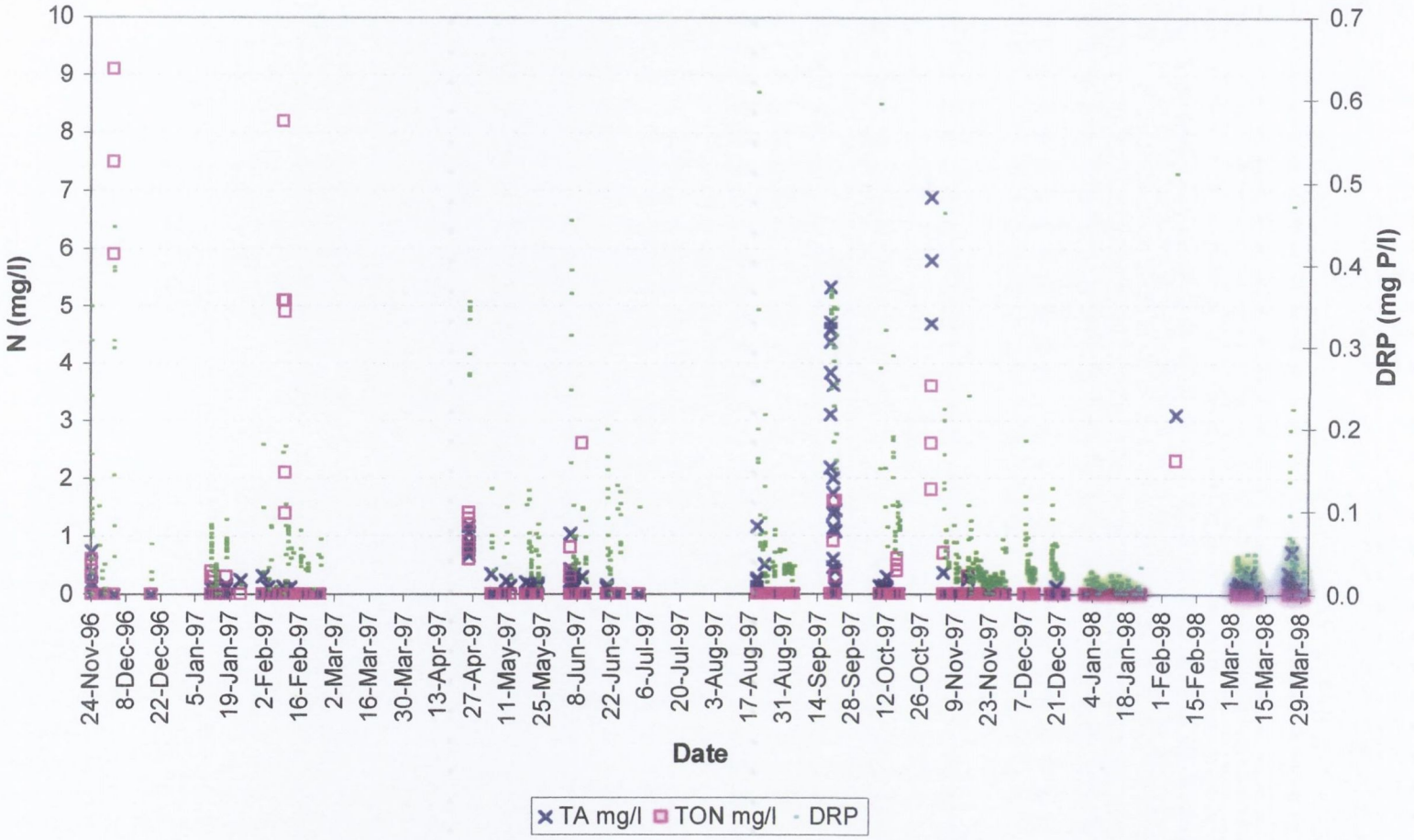


Figure 7.131: Total ammonia (TA), total oxidised nitrogen (TON) (mg N/l) and DRP (mg P/l) in overland flow from the Warren 1.

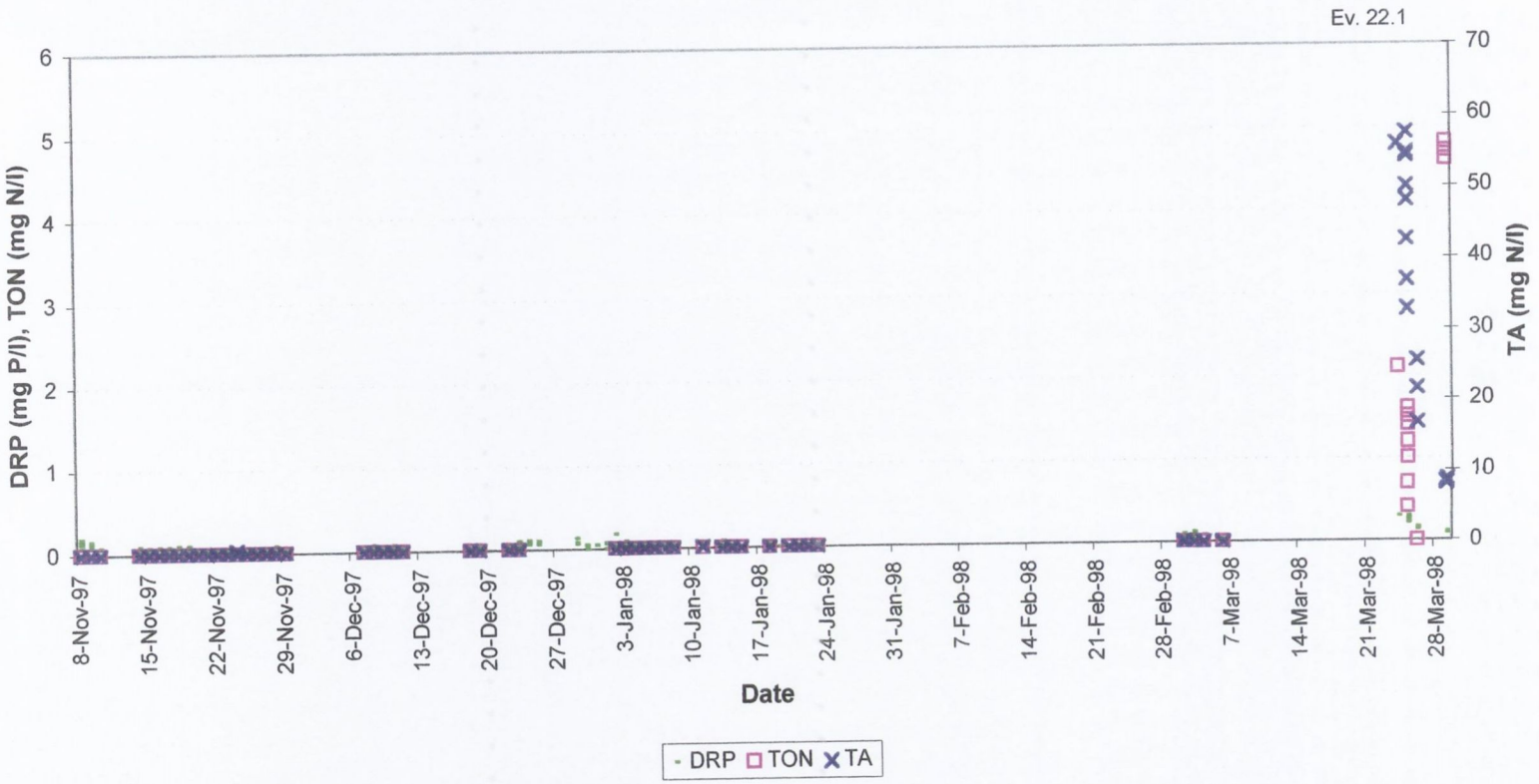


Figure 7.132: Total ammonia (TA), total oxidised nitrogen (TON) (mg N/l) and DRP (mg P/l) in overland flow from the Warren 2.

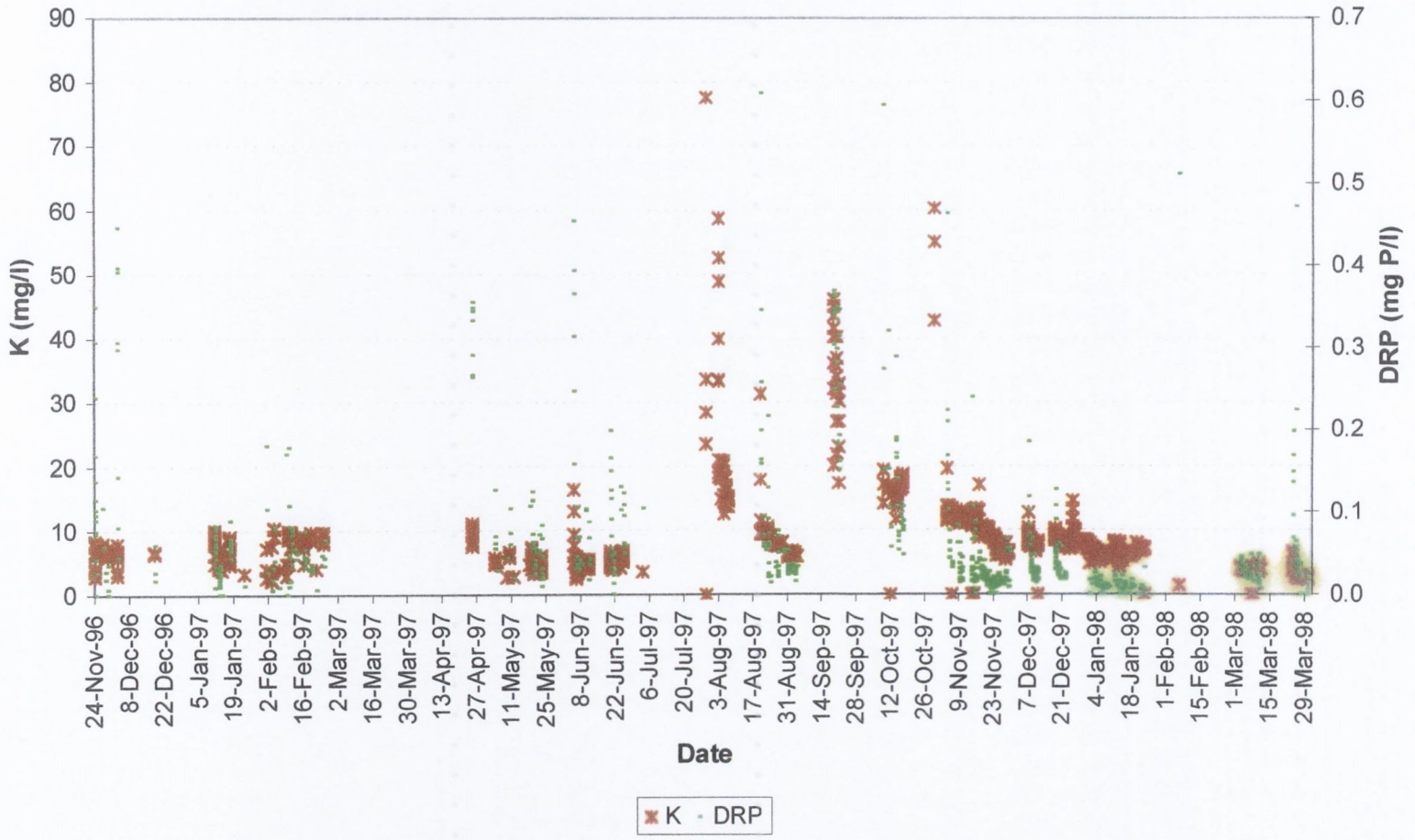


Figure 7.133: Potassium (K) (mg/l) and DRP (mg P/l) in overland flow from the Warren 1.

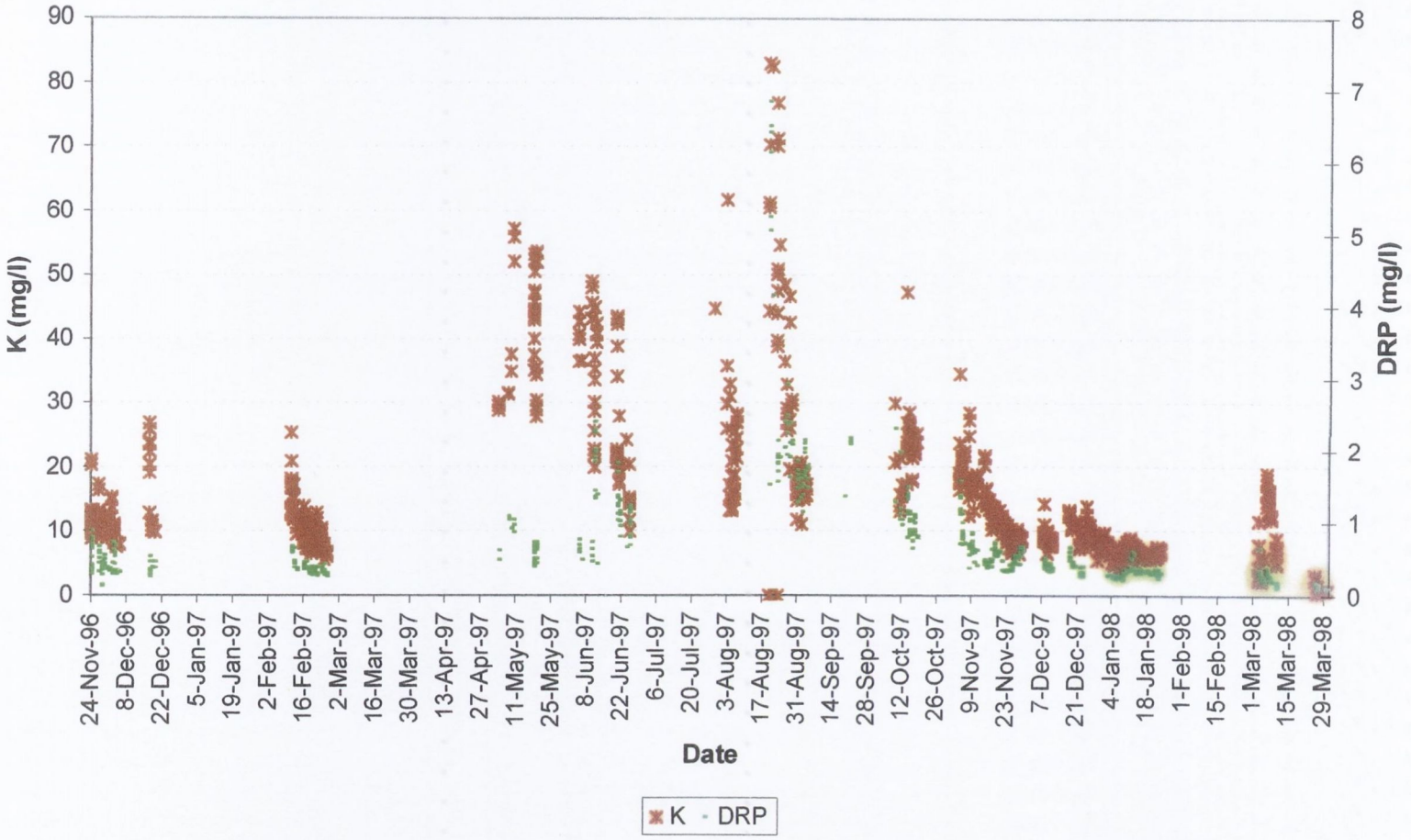


Figure 7.134: Potassium (K) (mg/l) and DRP (mg P/l) in overland flow from the Cowlands.

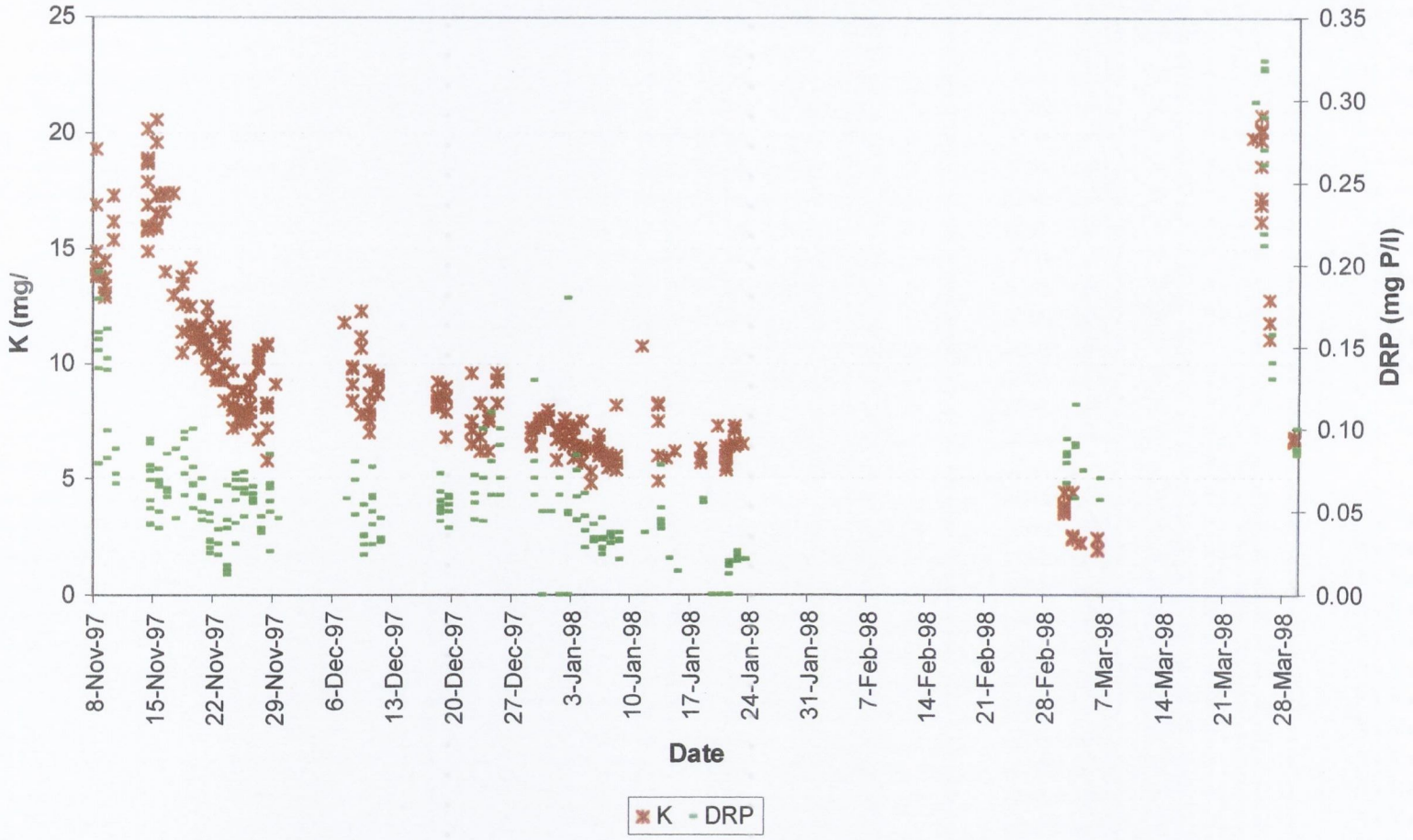


Figure 7.135: Potassium (K) (mg/l) and DRP (mg P/l) in overland flow from the Warren 2.

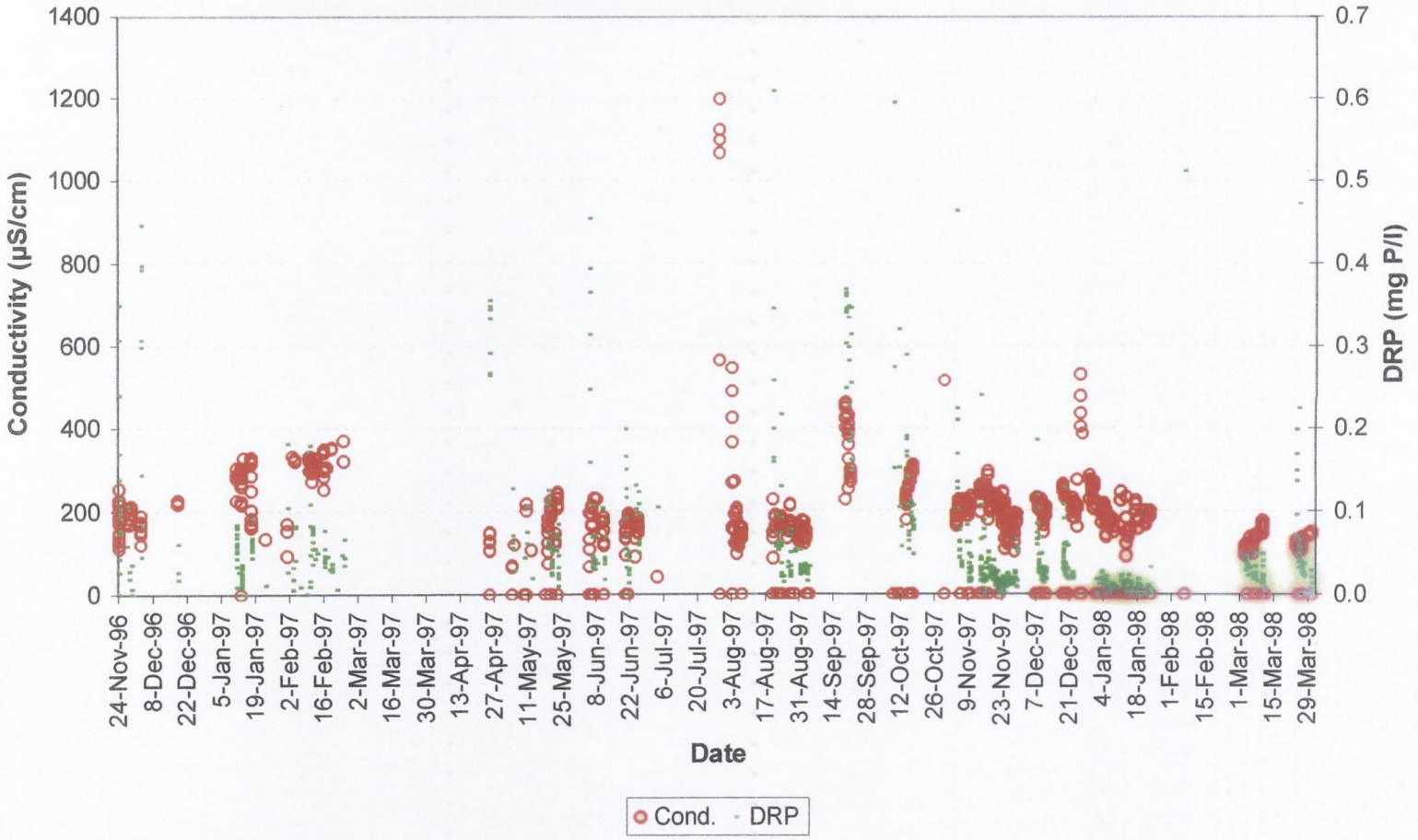


Figure 7.136: Conductivity (µS/cm) and DRP (mg P/l) in overland flow from the Warren 1.

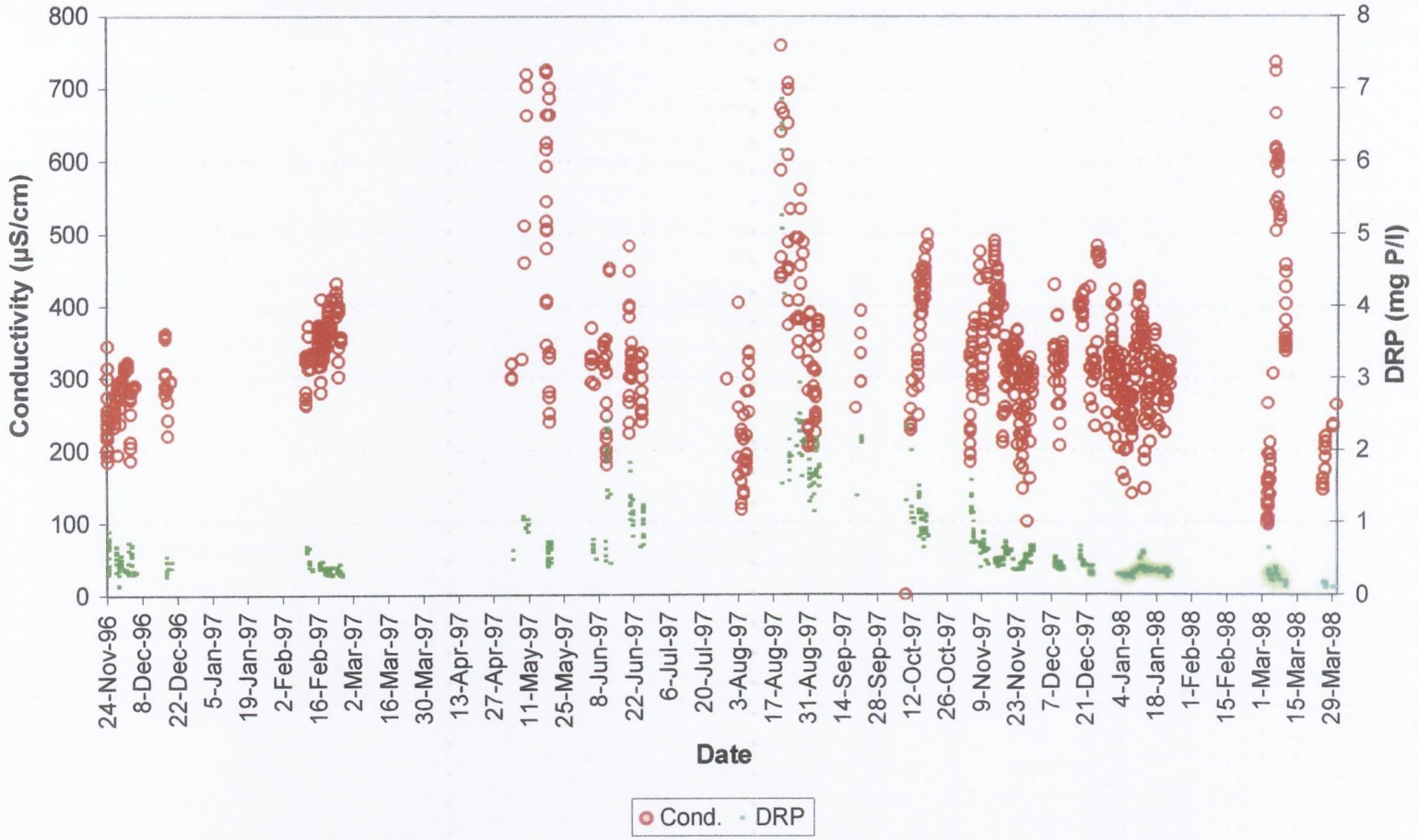


Figure 7.137: Conductivity (µS/cm) and DRP (mg P/l) in overland flow from the Cowlands.

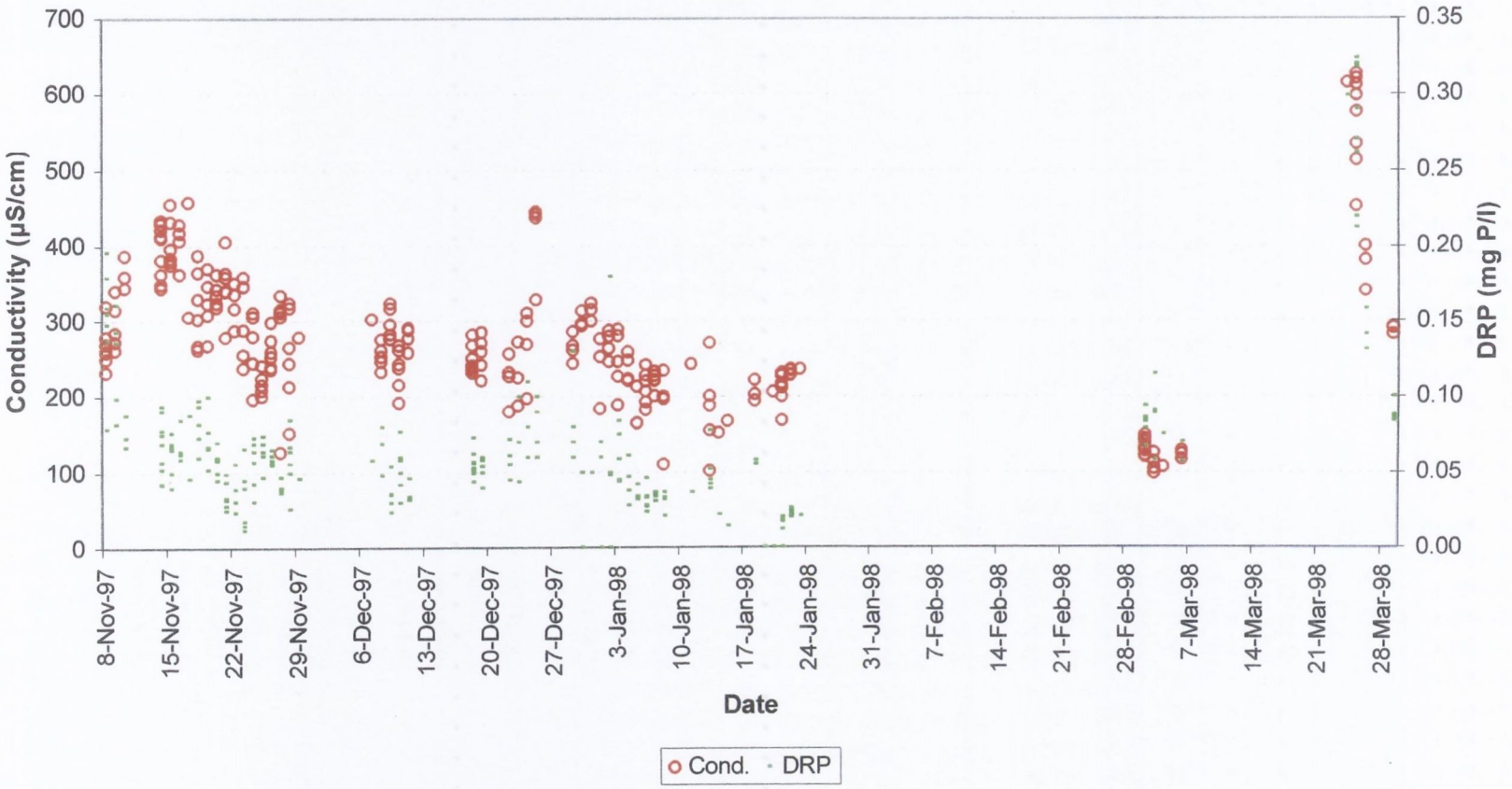


Figure 7.138: Conductivity (µS/cm) and DRP (mg P/l) in overland flow from the Warren 2.

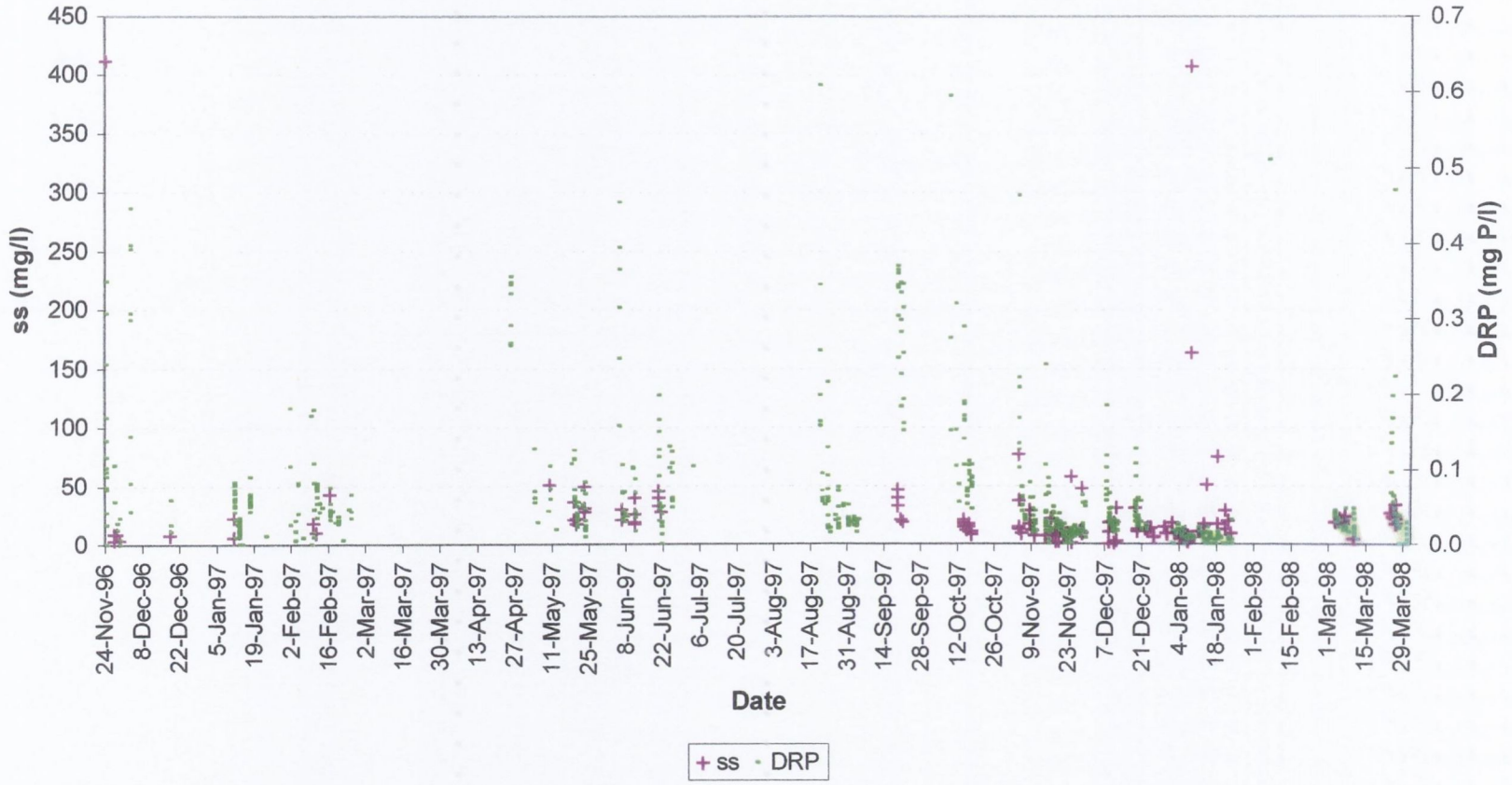


Figure 7.139: Suspended solids (ss) (mg/l) and DRP (mg P/l) in overland flow from the Warren 1.

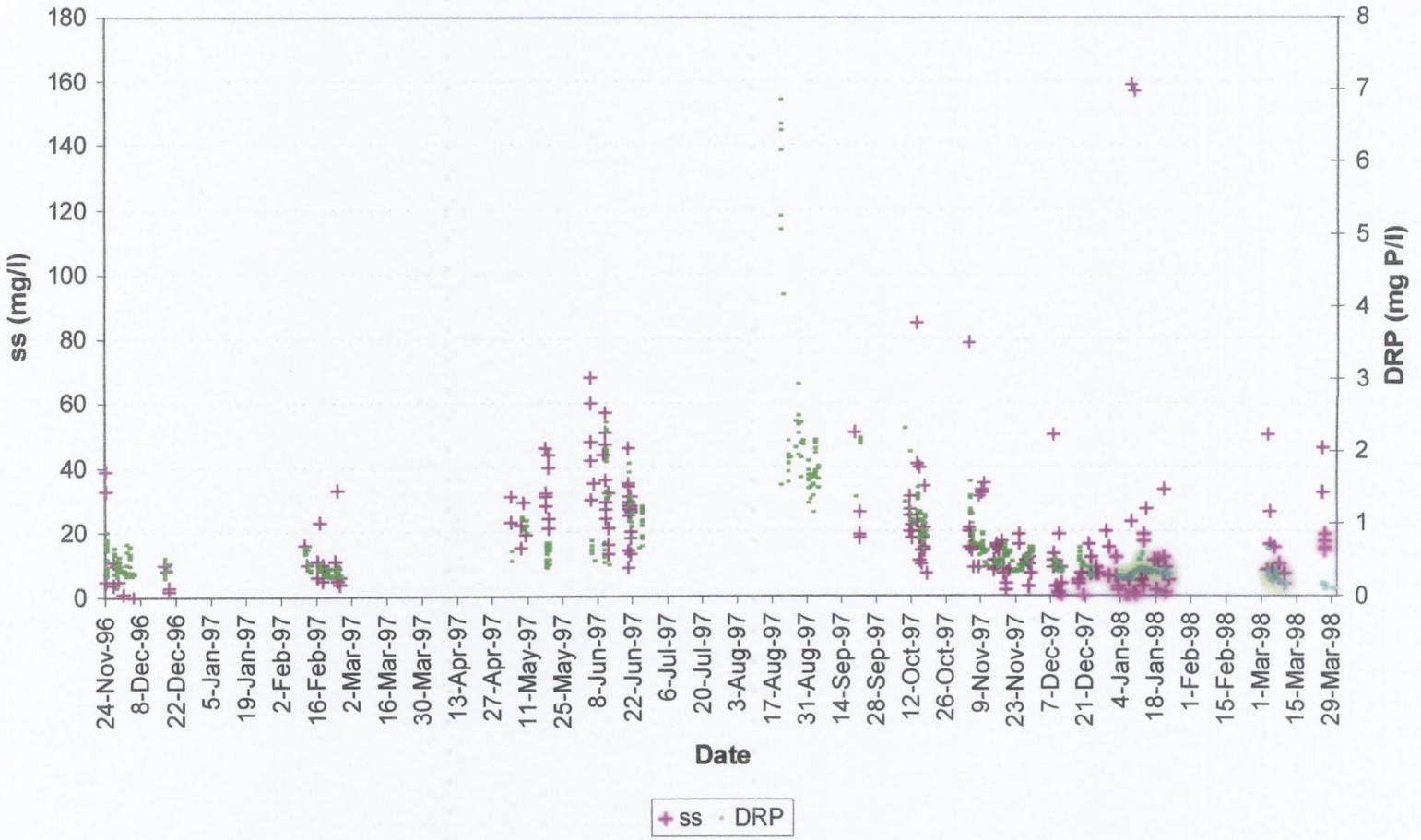


Figure 7.140: Suspended solids (ss) (mg/l) and DRP (mg P/l) in overland flow from the Cowlands.

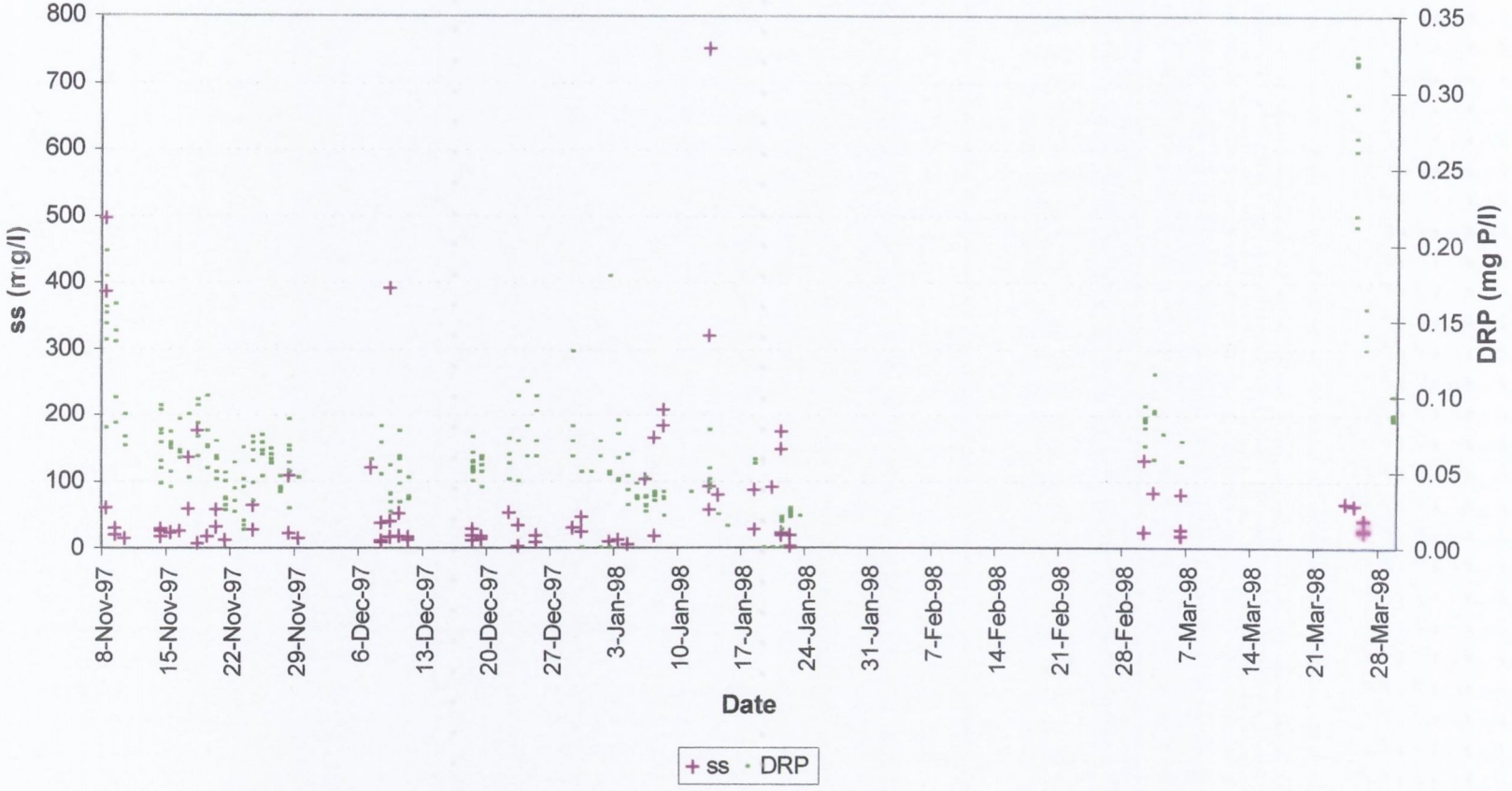


Figure 7.141: Suspended solids (ss) (mg/l) and DRP (mg P/l) in overland flow from the Warren 2.

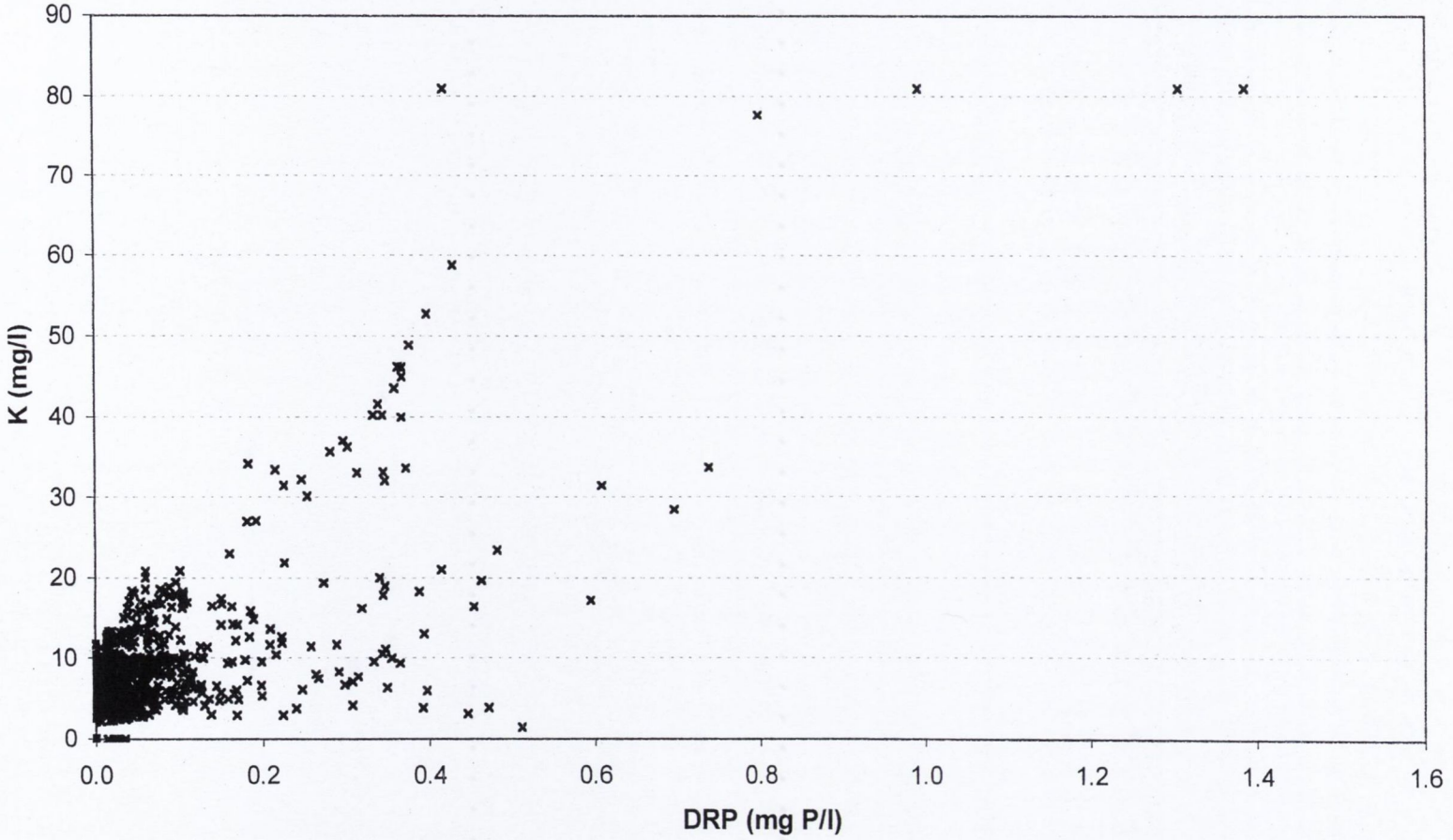


Figure 7.142: Potassium (K) levels (mg/l) plotted against DRP concentrations (mg P/l) at the Warren 1.

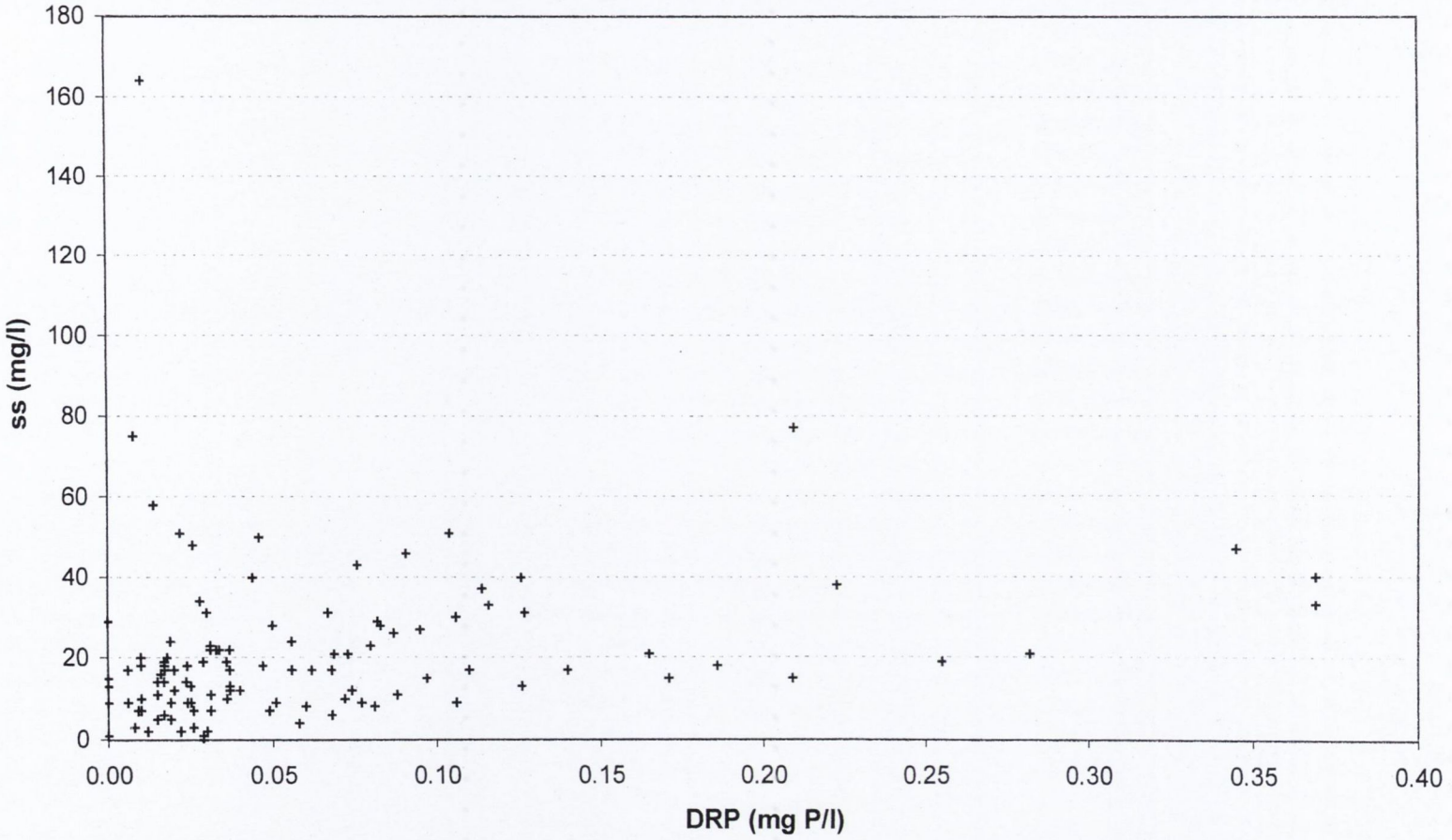


Figure 7.143: Suspended solids (ss) levels (mg/l) plotted against DRP concentrations (mg P/l) at the Warren 1 (two values in excess of 400 excluded).

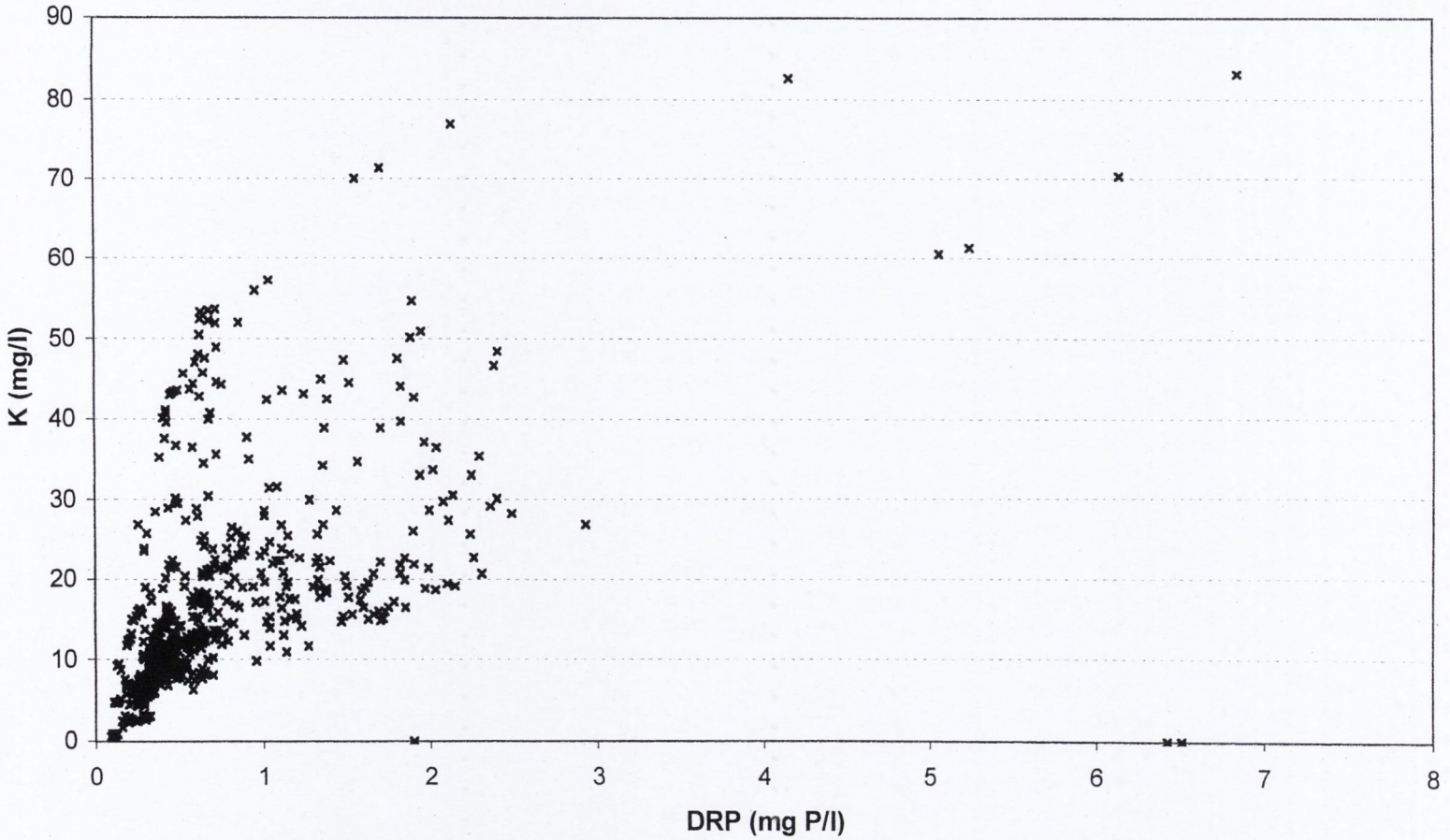


Figure 7.144: Potassium (K) levels (mg/l) plotted against DRP concentrations (mg P/l) at the Cowlands.

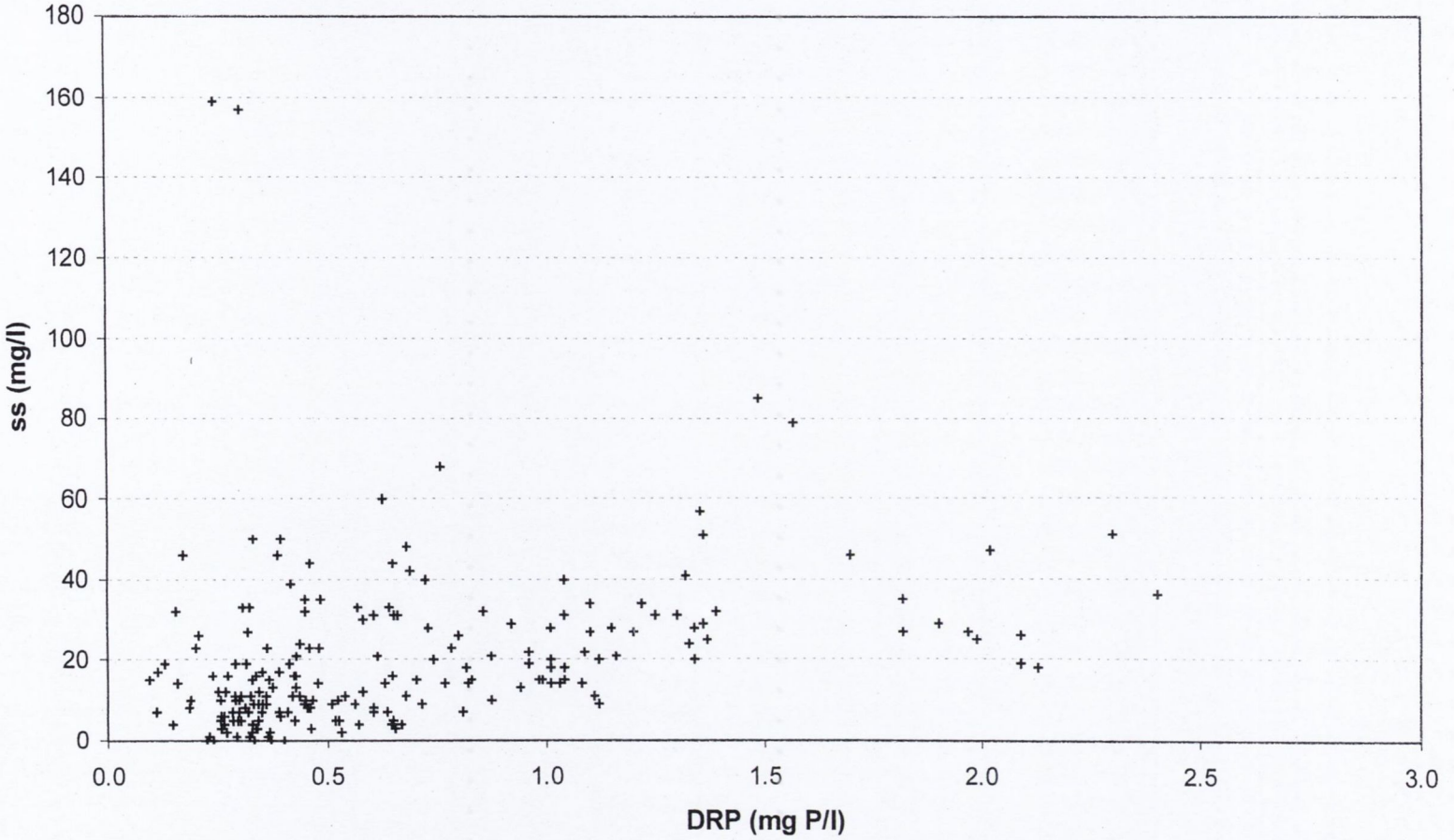


Figure 7.145: Suspended solid (ss) levels (mg/l) plotted against DRP concentrations (mg P/l) at the Cowlands.

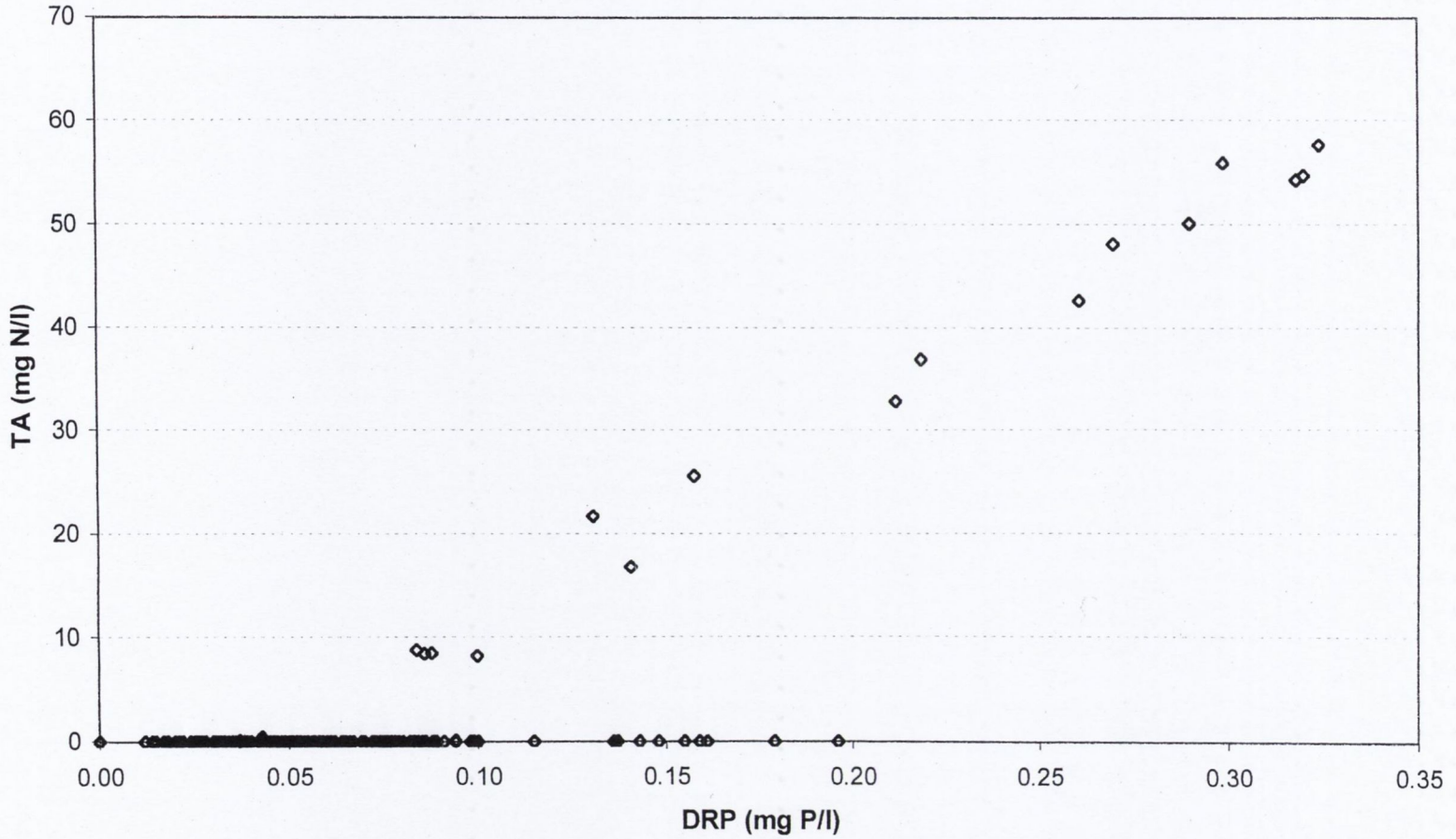


Figure 7.146: TA levels (mg N/l) plotted against DRP concentrations (mg P/l) at the Warren 2.

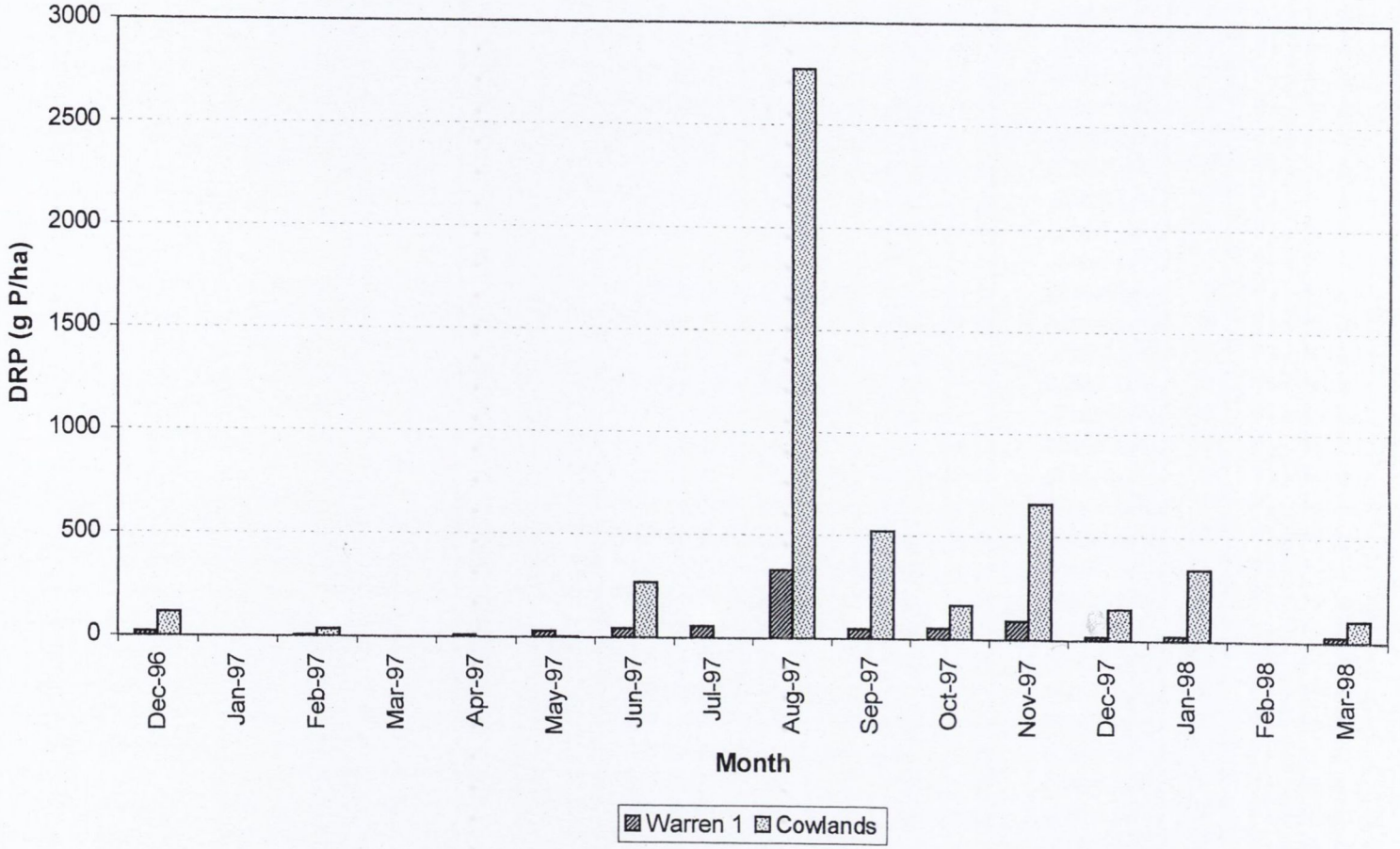


Figure 7.147: Monthly DRP (g P/ha) exports in overland flow from the Warren 1 and the Cowlands.

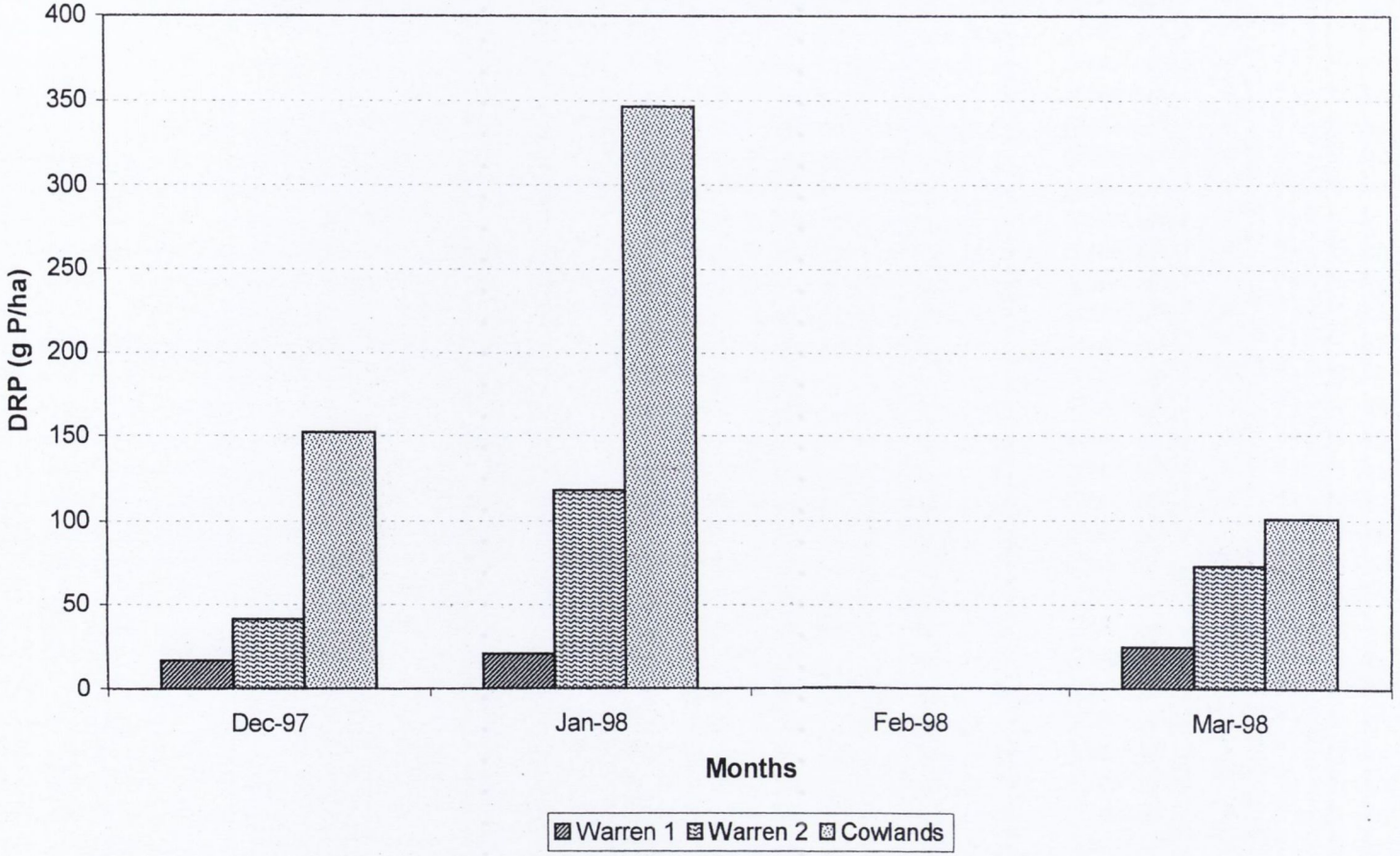


Figure 7.148: Monthly DRP (g P/ha) exports in overland flow from the Warren 1, the Warren 2 and the Cowlands.

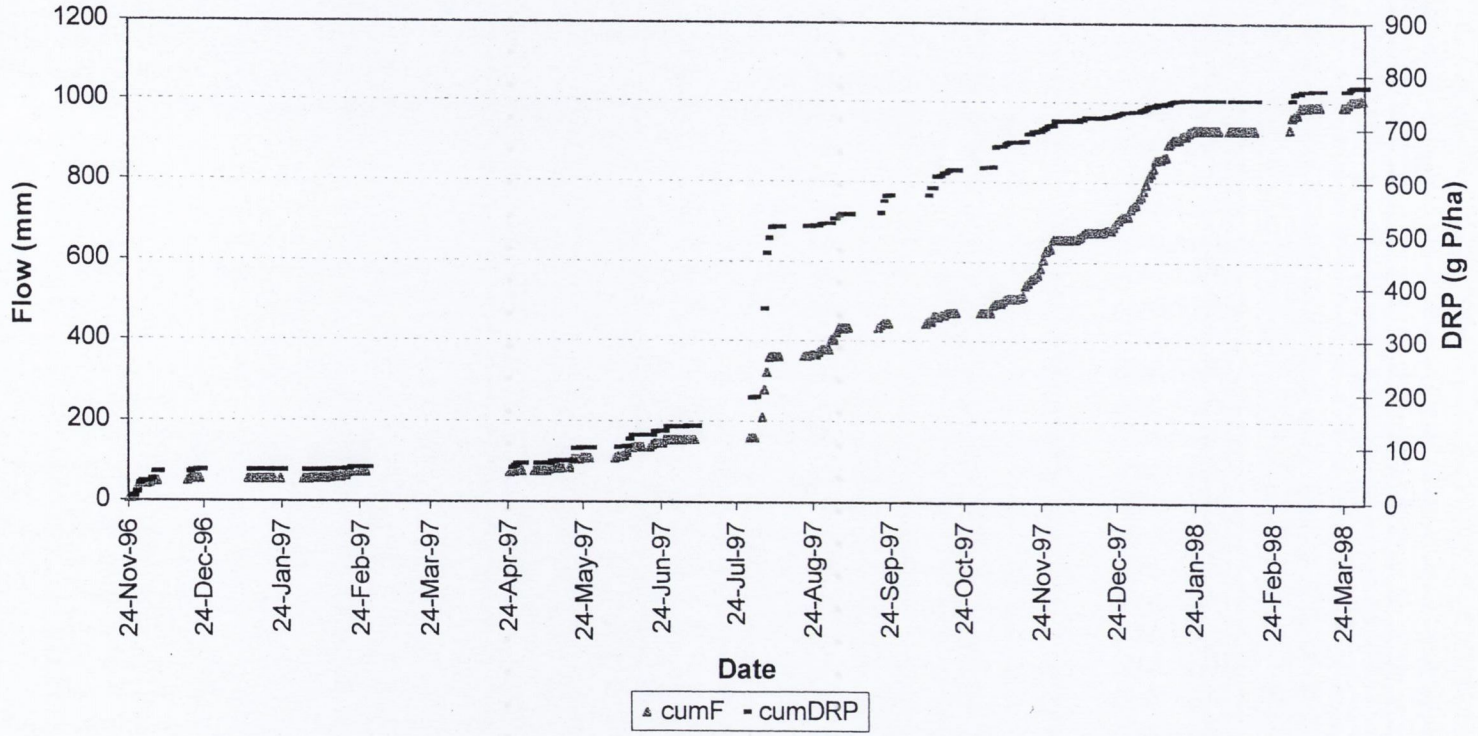


Figure 7.149: Cumulative daily flow (mm) and DRP (g/ha) export from the Warren 1.

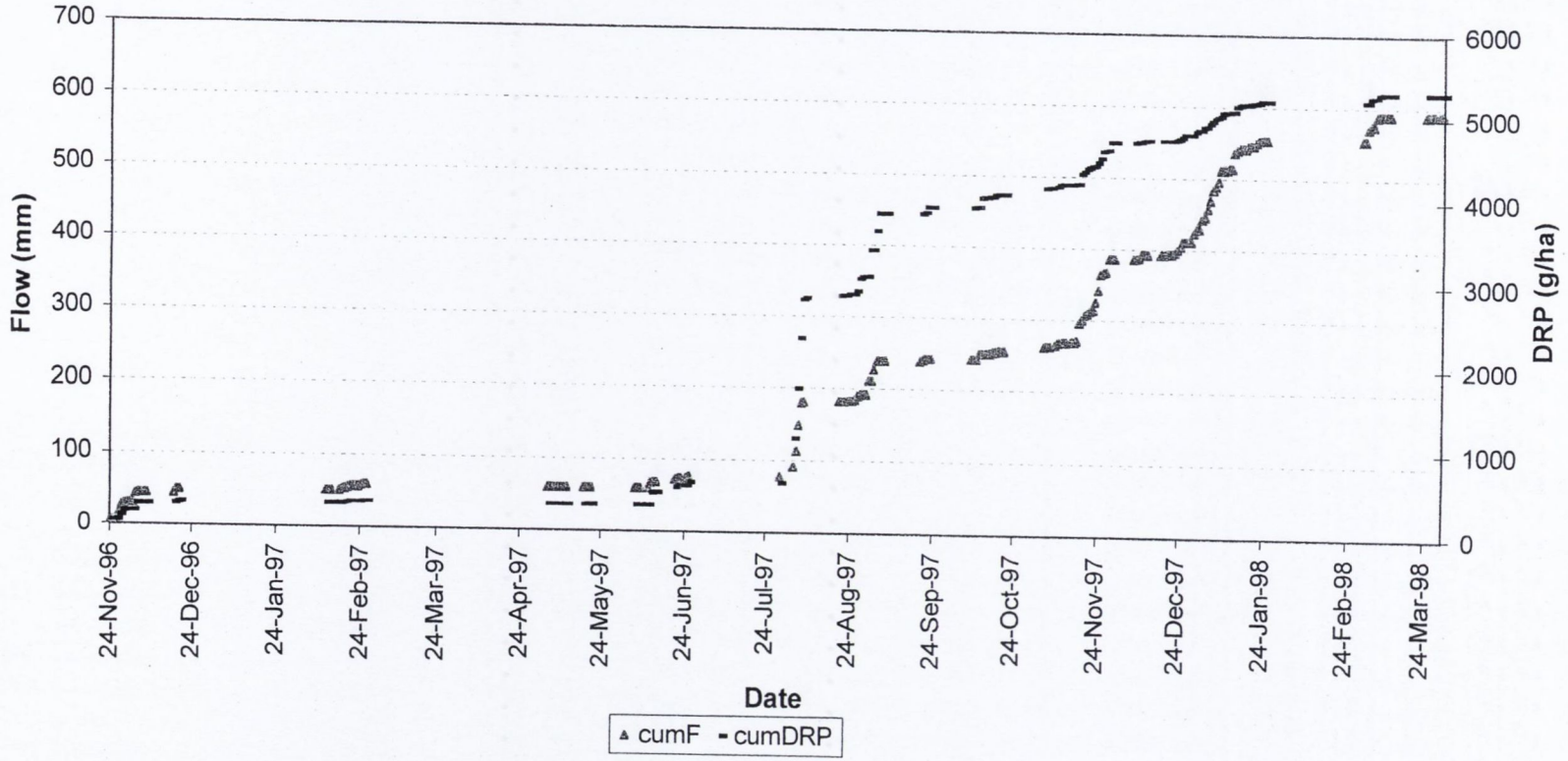
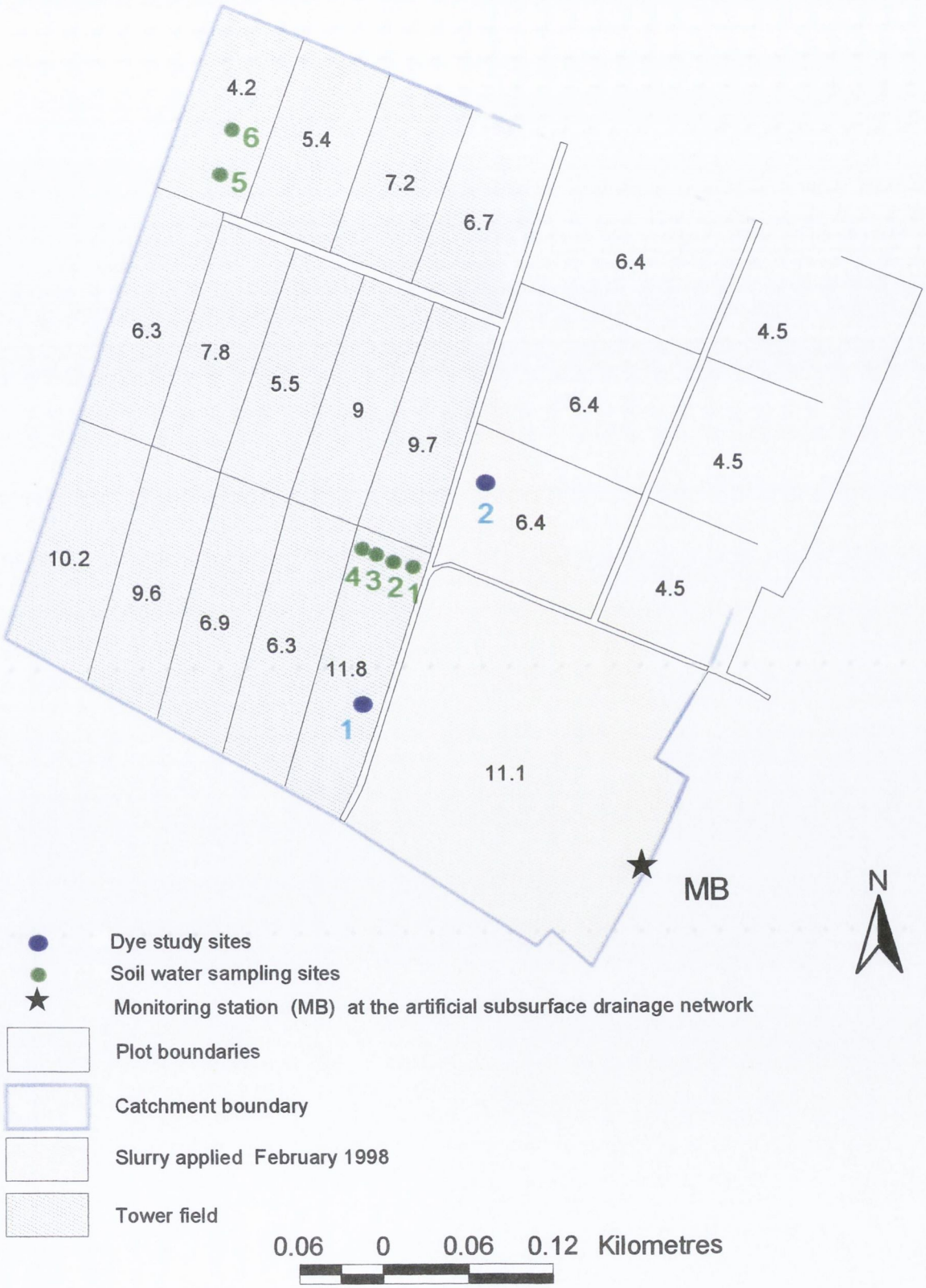


Figure 7.150: Cumulative daily flow (mm) and DRP export (g/ha) from the Cowlands.

Figure 8.1 : BEEF UNIT Plot Boundaries, Soil Water Sampling Sites, Dye Study Sites and Soil P Levels (mg P / l Morgan's)



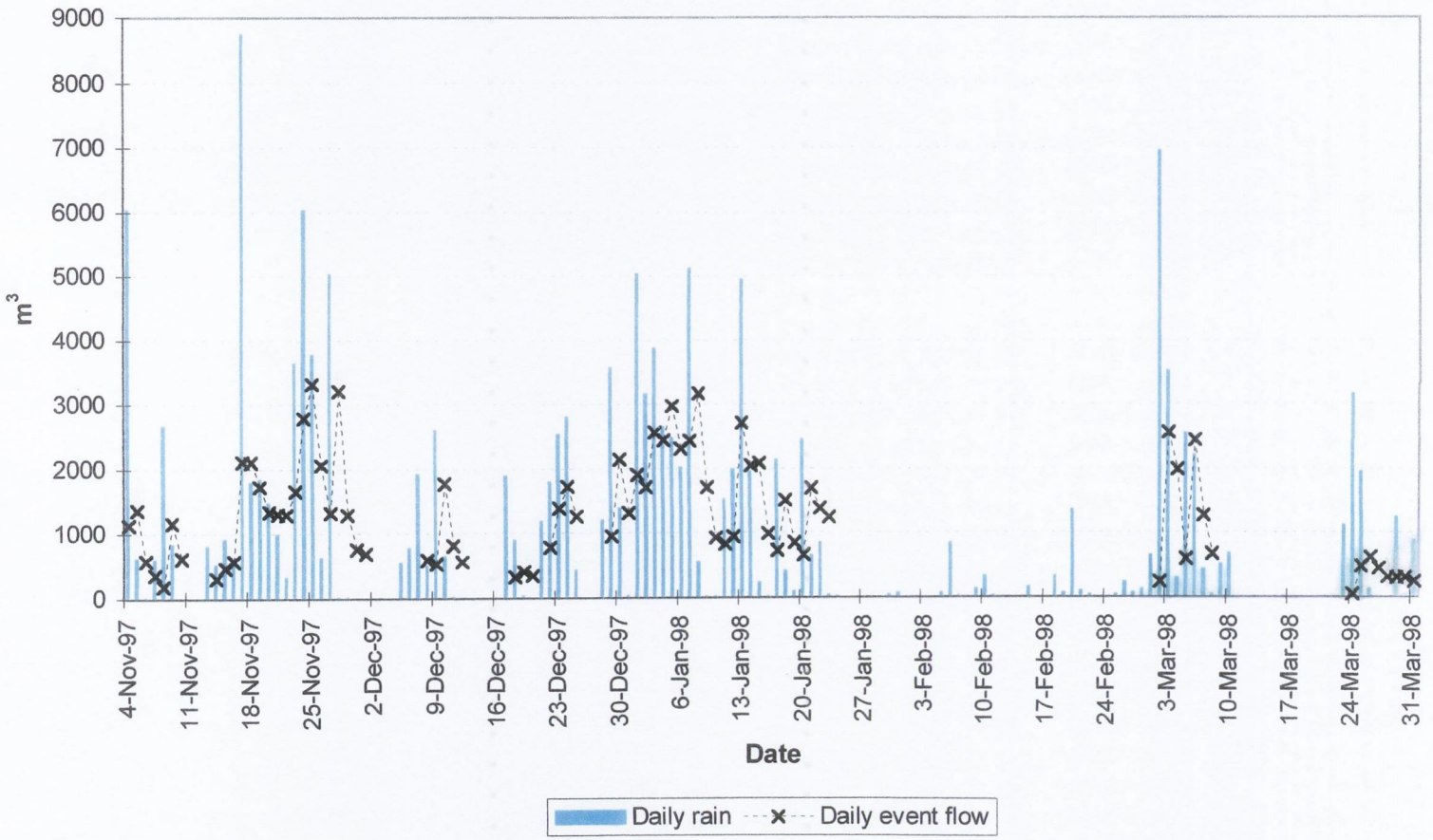


Figure 8.2: Daily rain and daily drain flow during events at the Beef Unit.

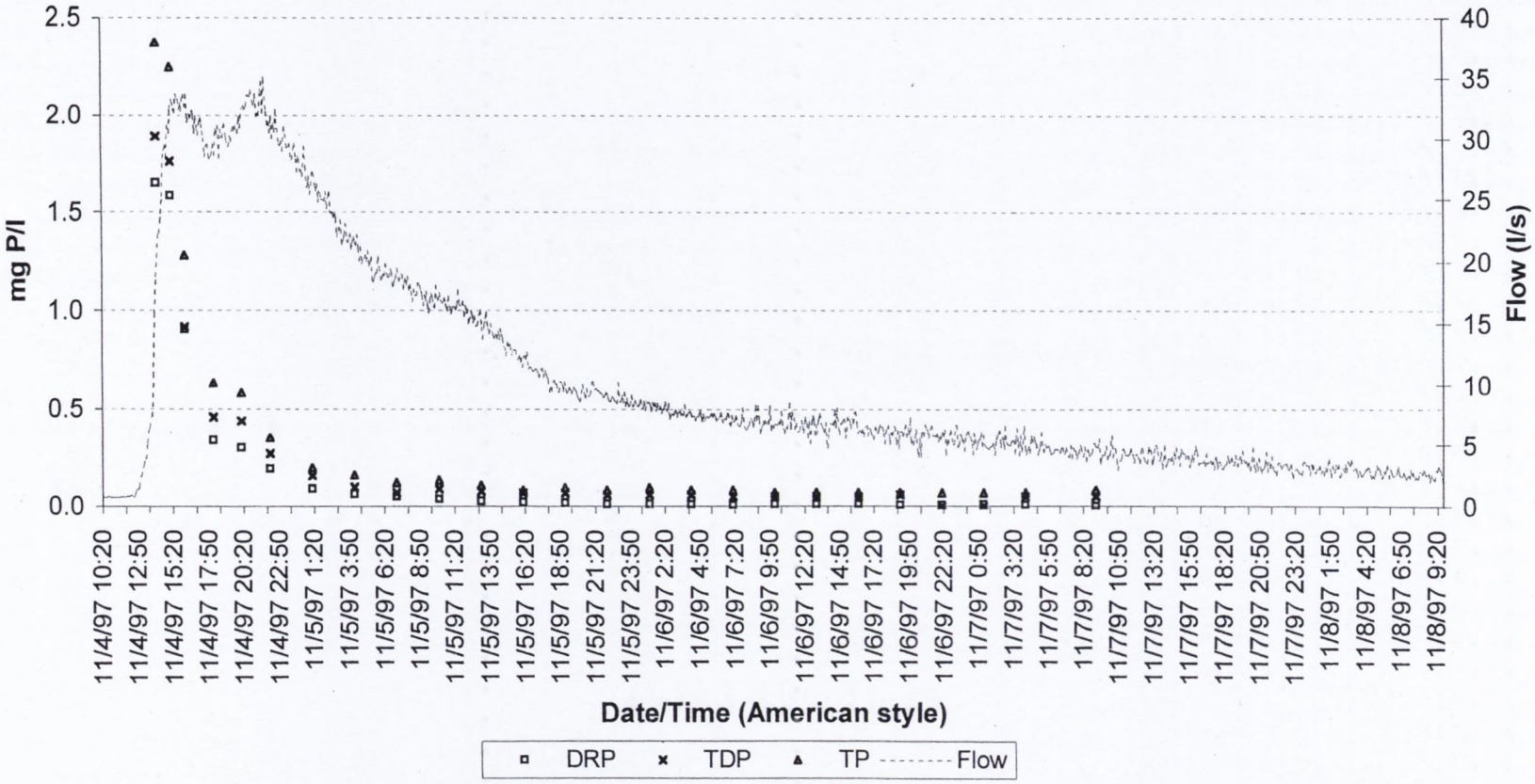


Figure 8.3: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU1 at the Beef Unit.

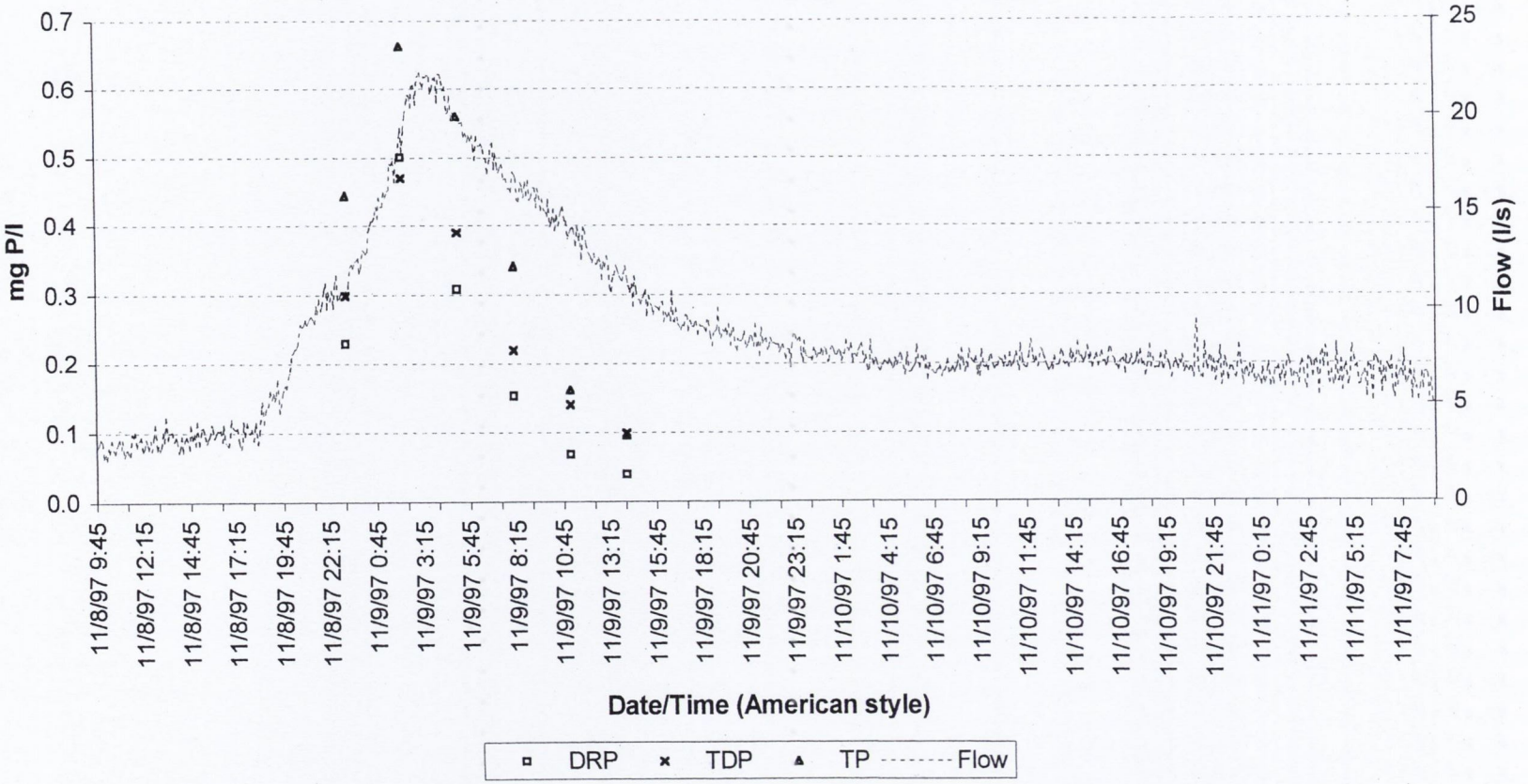


Figure 8.4: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU2 at the Beef Unit.

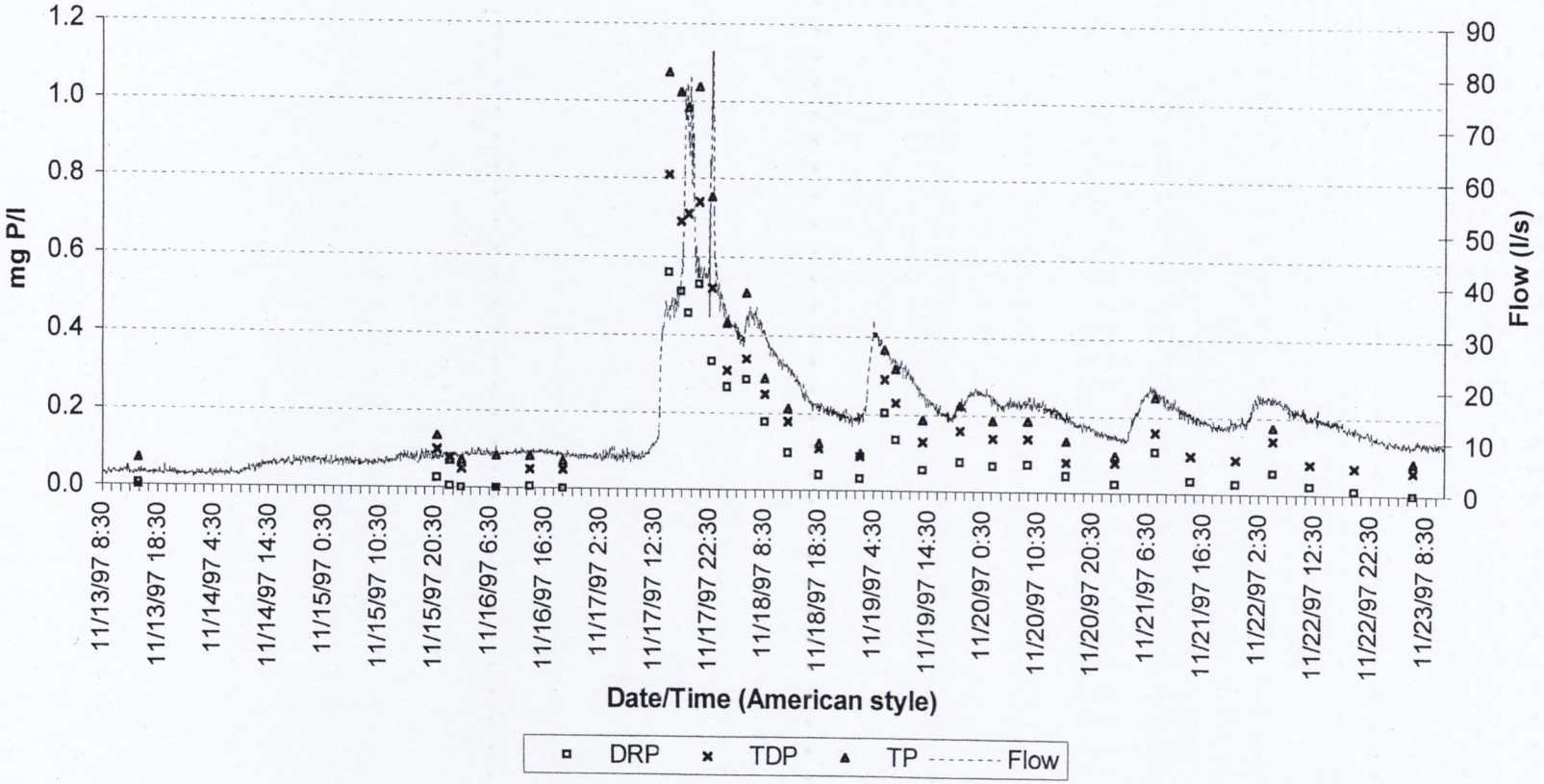


Figure 8.5: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU3 at the Beef Unit.

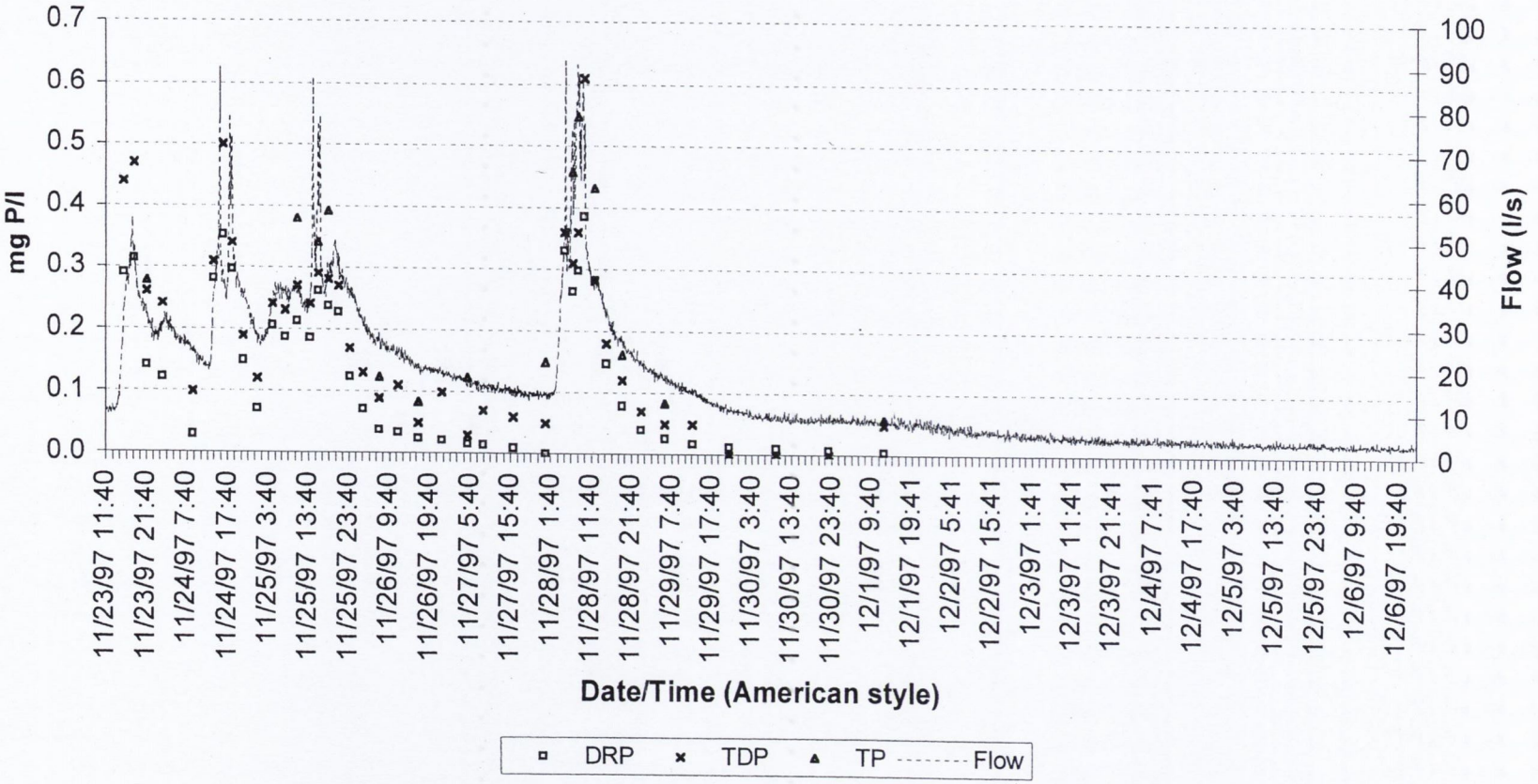


Figure 8.6: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU4 at the Beef Unit.

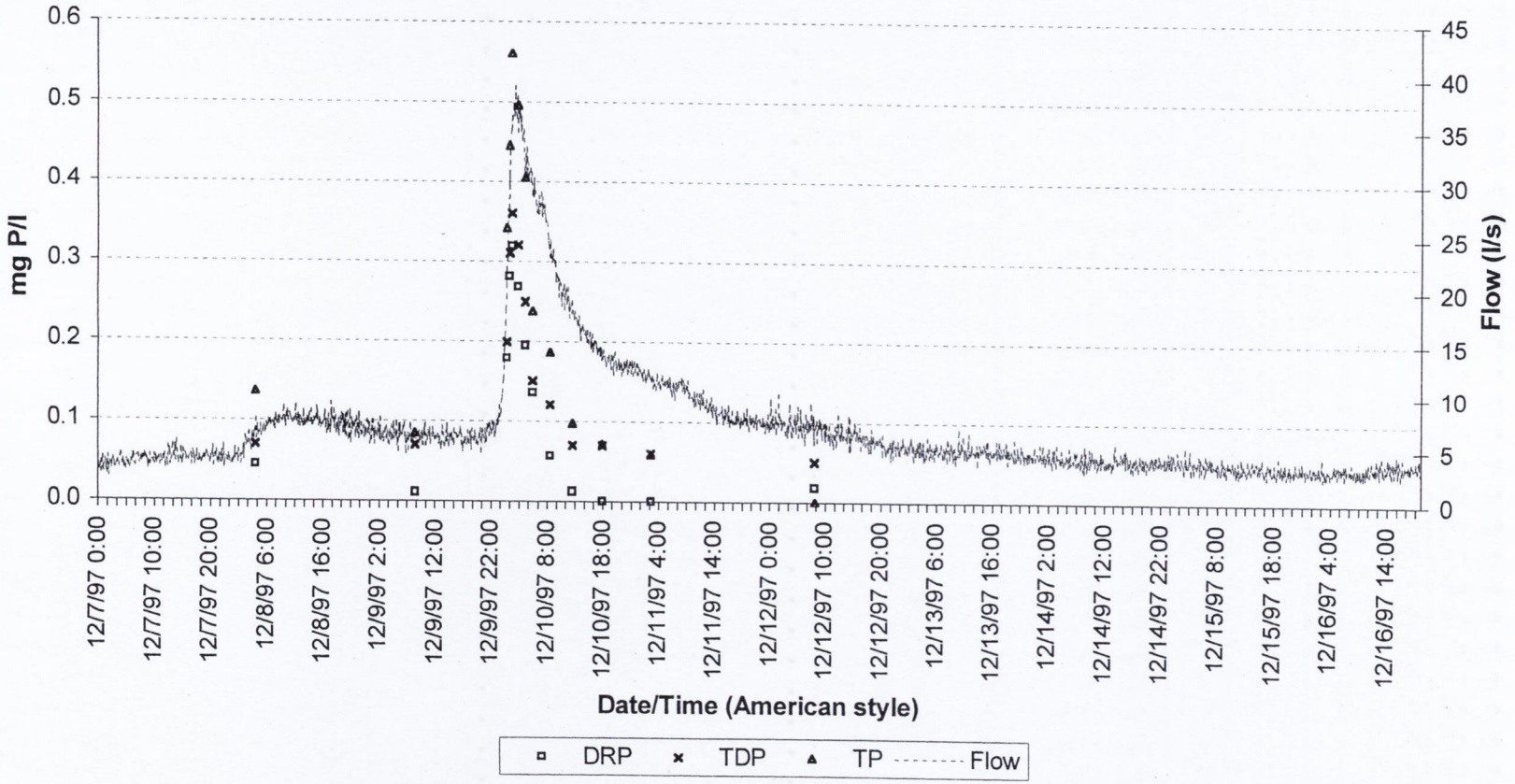


Figure 8.7: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU5 at the Beef Unit.

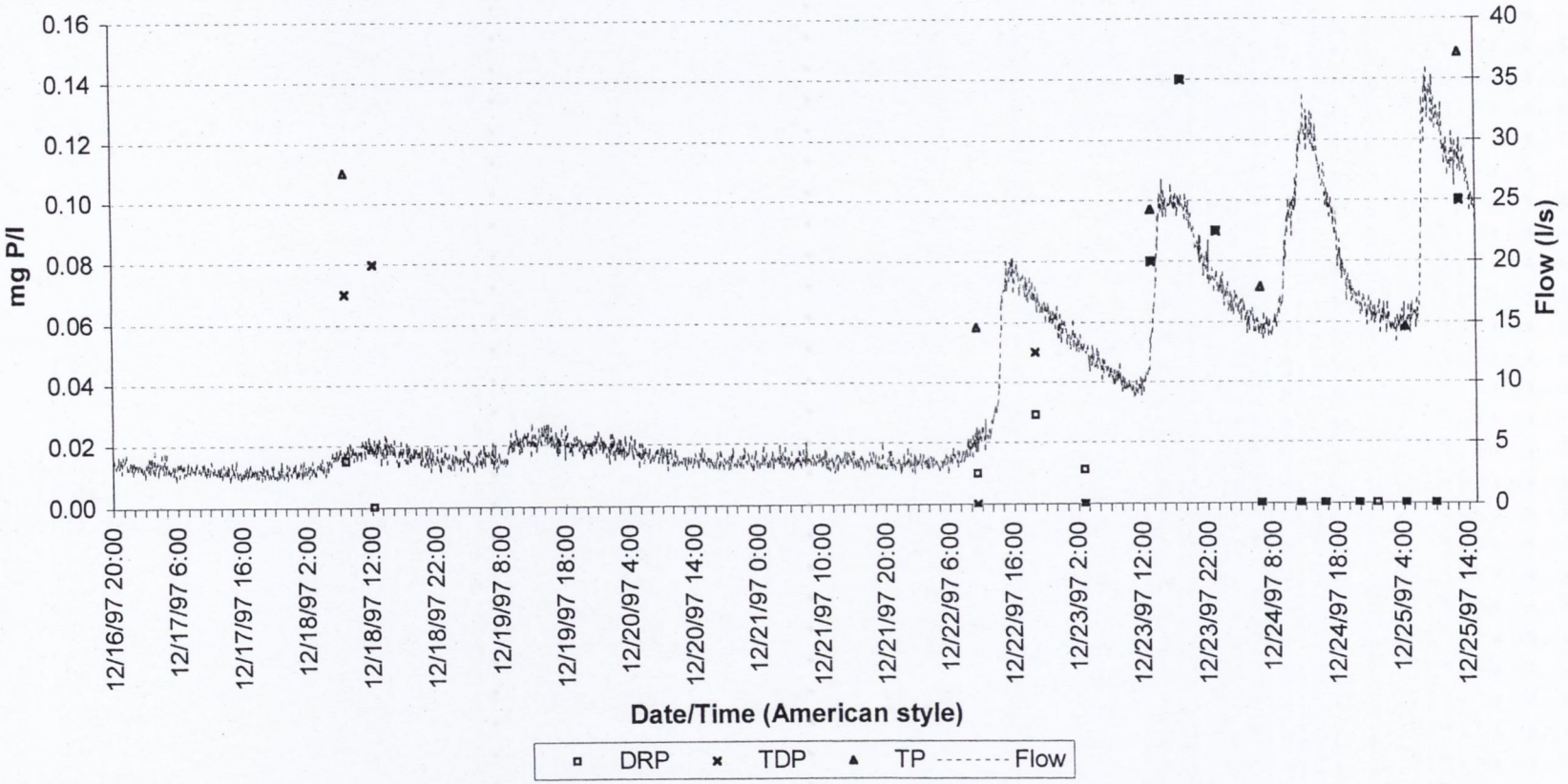


Figure 8.8: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU6 at the Beef Unit. (DRP concentrations at the end of the event calculated (Section 5.2.3)).

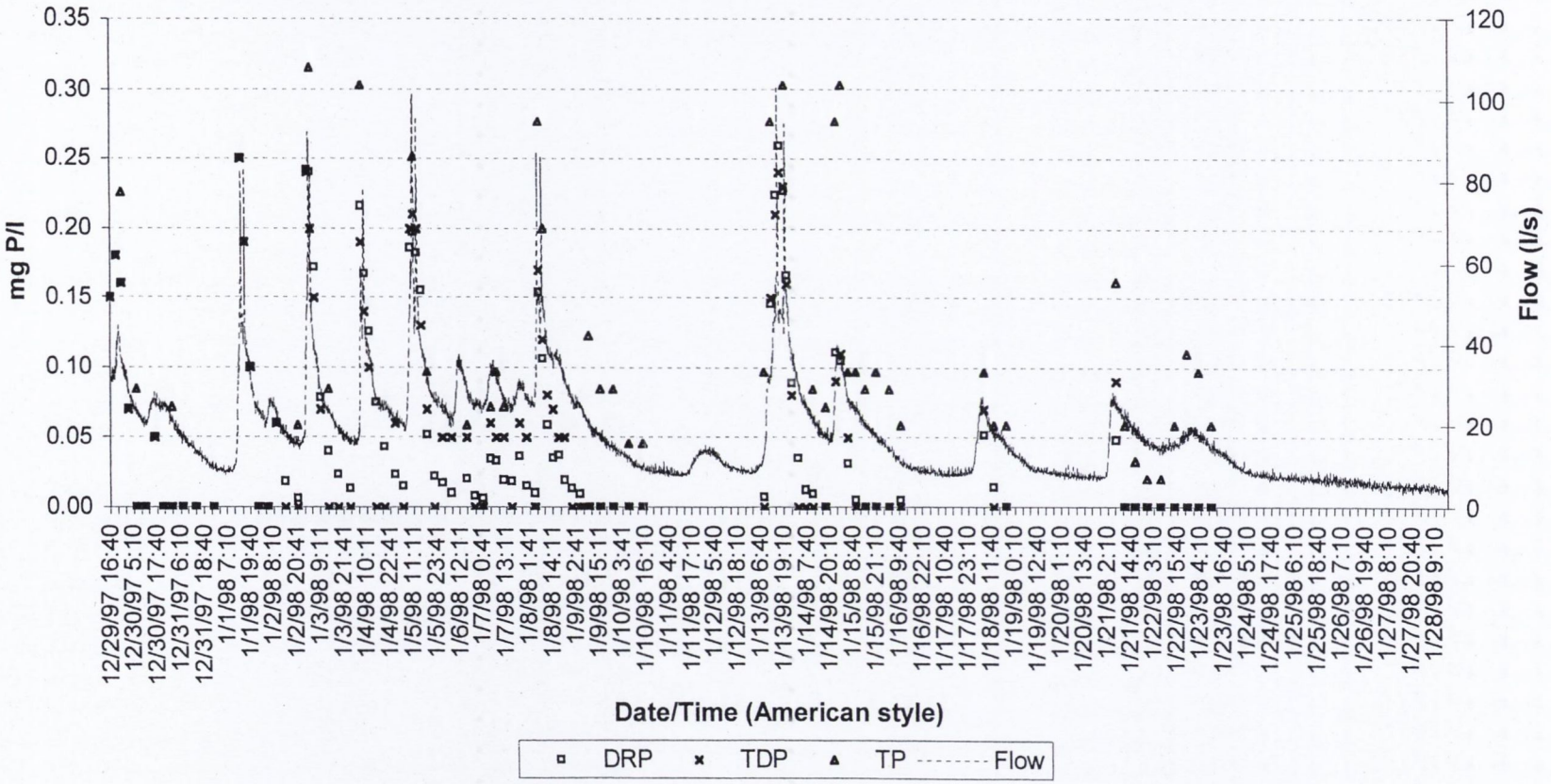


Figure 8.9: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU7 at the Beef Unit (DRP concentrations at the beginning of the event calculated (Section 5.2.3)).

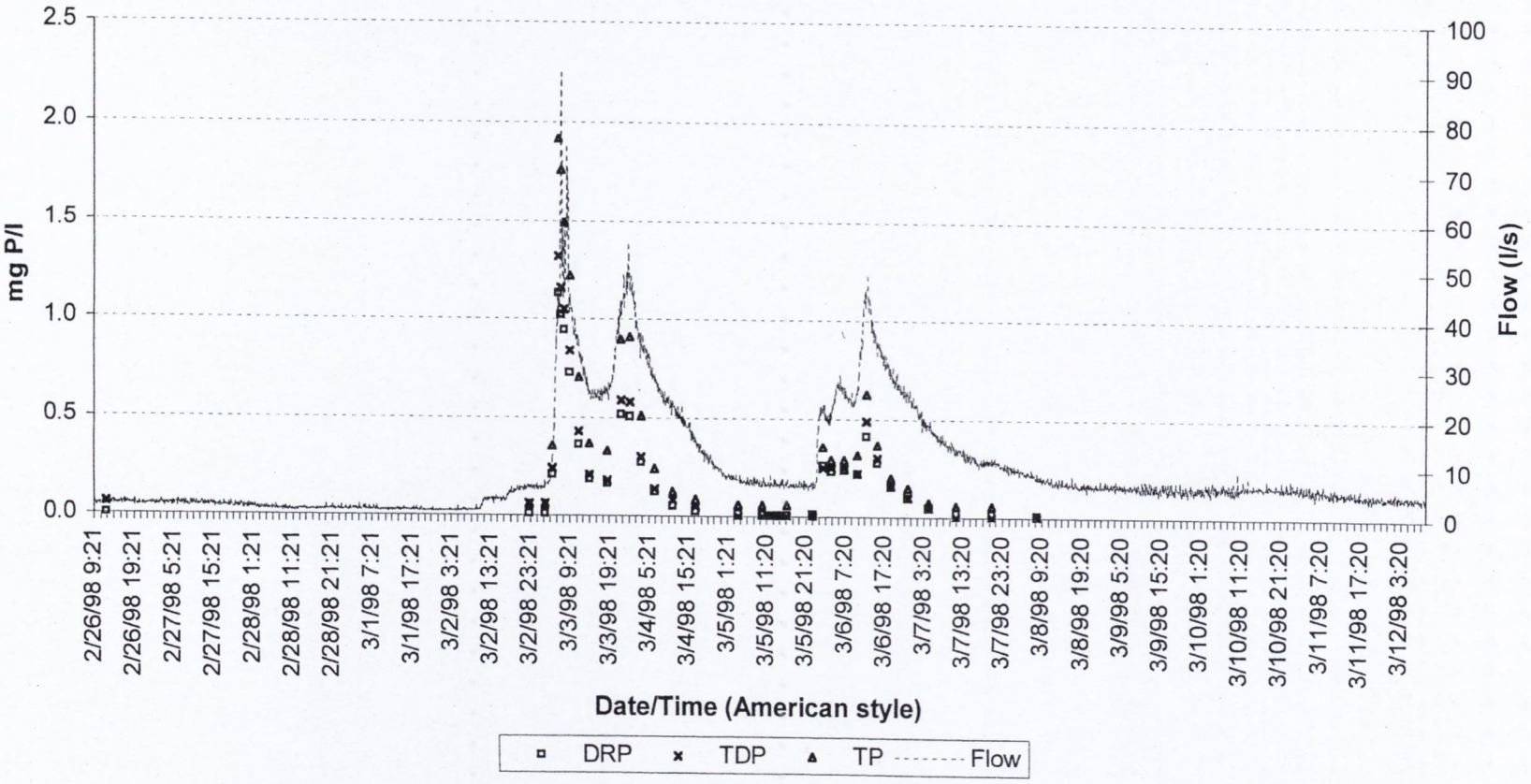


Figure 8.10: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU8 at the Beef Unit.

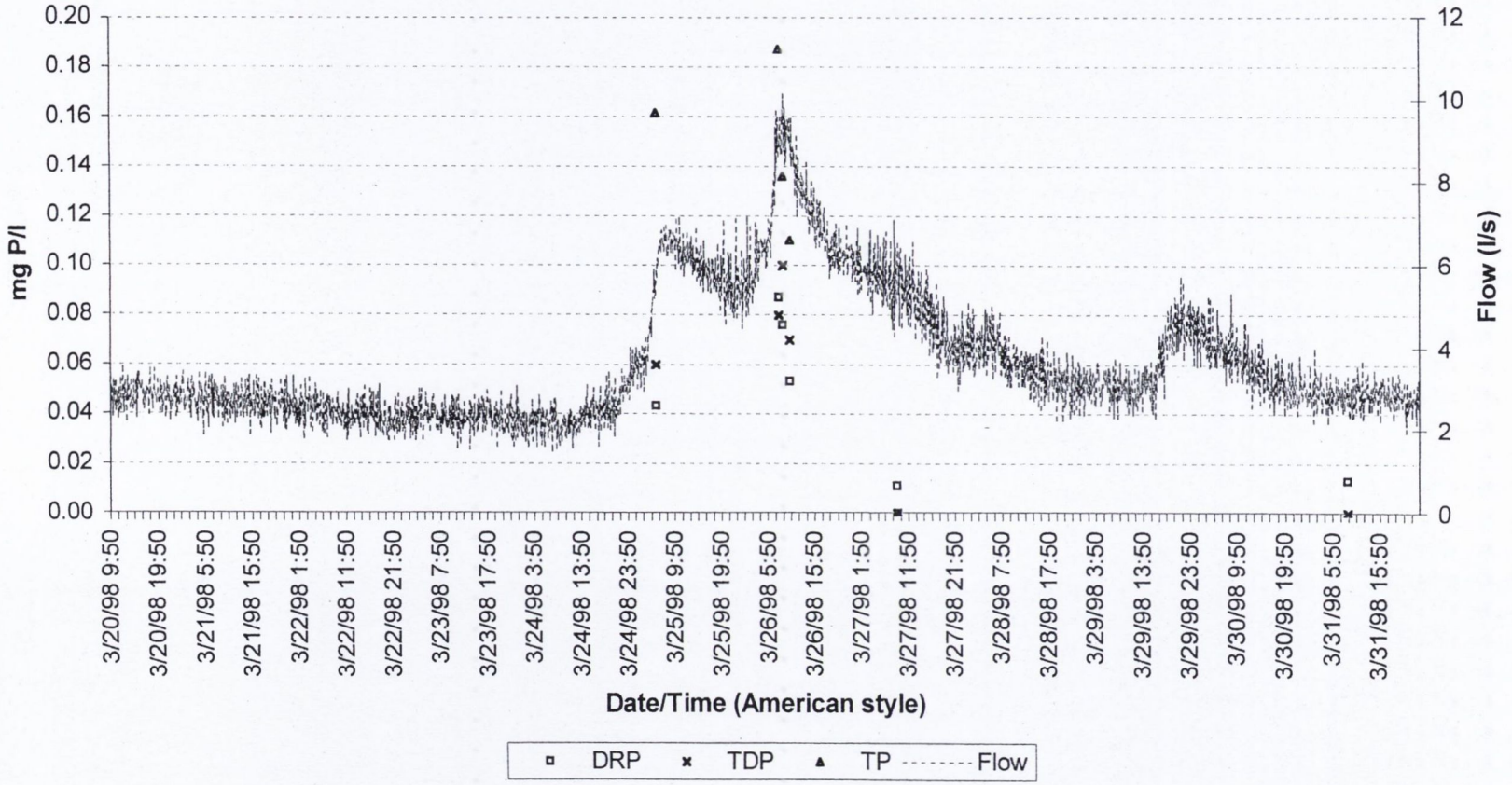


Figure 8.11: Drain flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event BU9 at the Beef Unit.

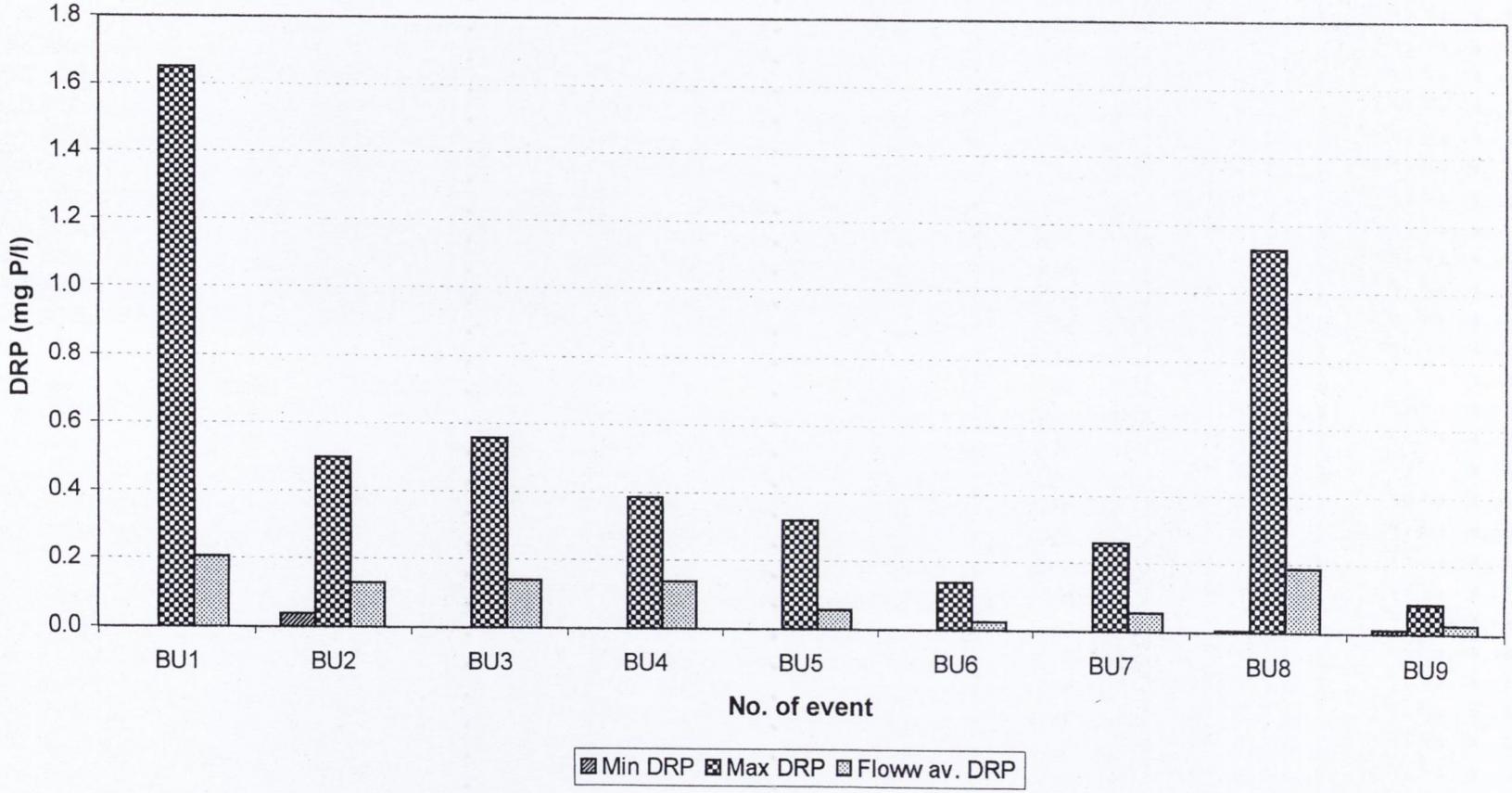


Figure 8.12: Minimum, maximum and flow-weighted average DRP concentrations (mg P/l) at the Beef Unit.

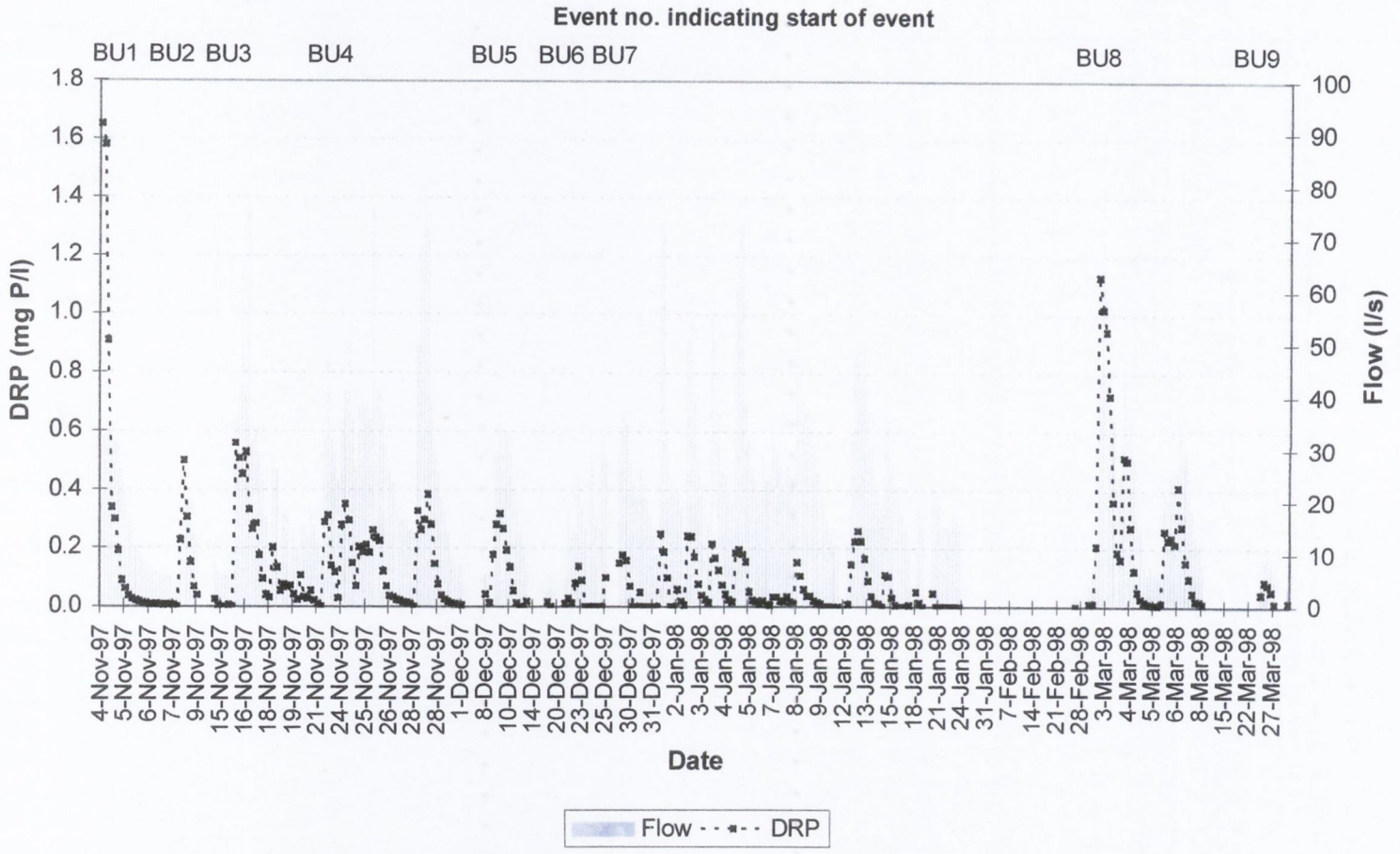


Figure 8.13: DRP concentrations (mg P/l) and flow rates (l/s) at the time of sampling for all events at the Beef Unit.

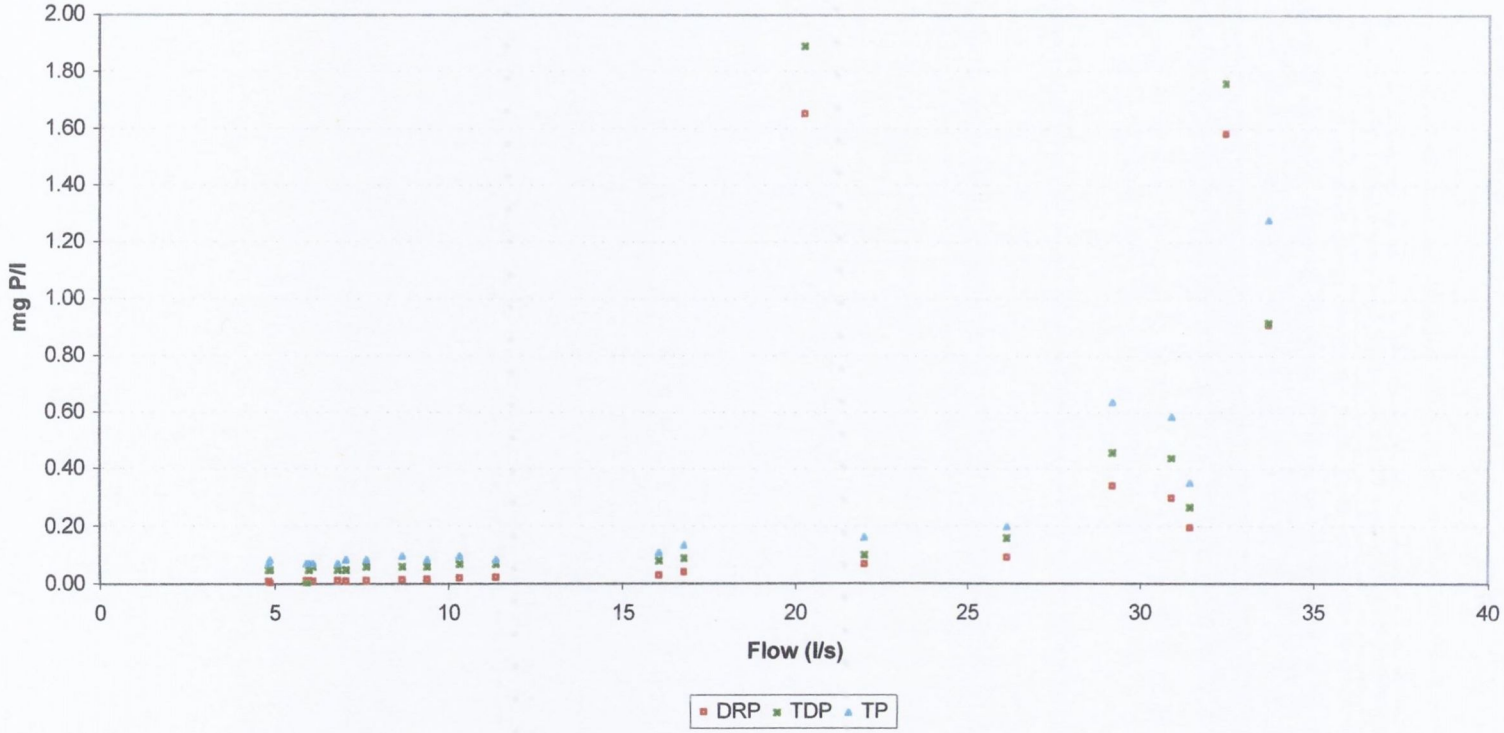


Figure 8.15: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU1 at the Beef Unit.

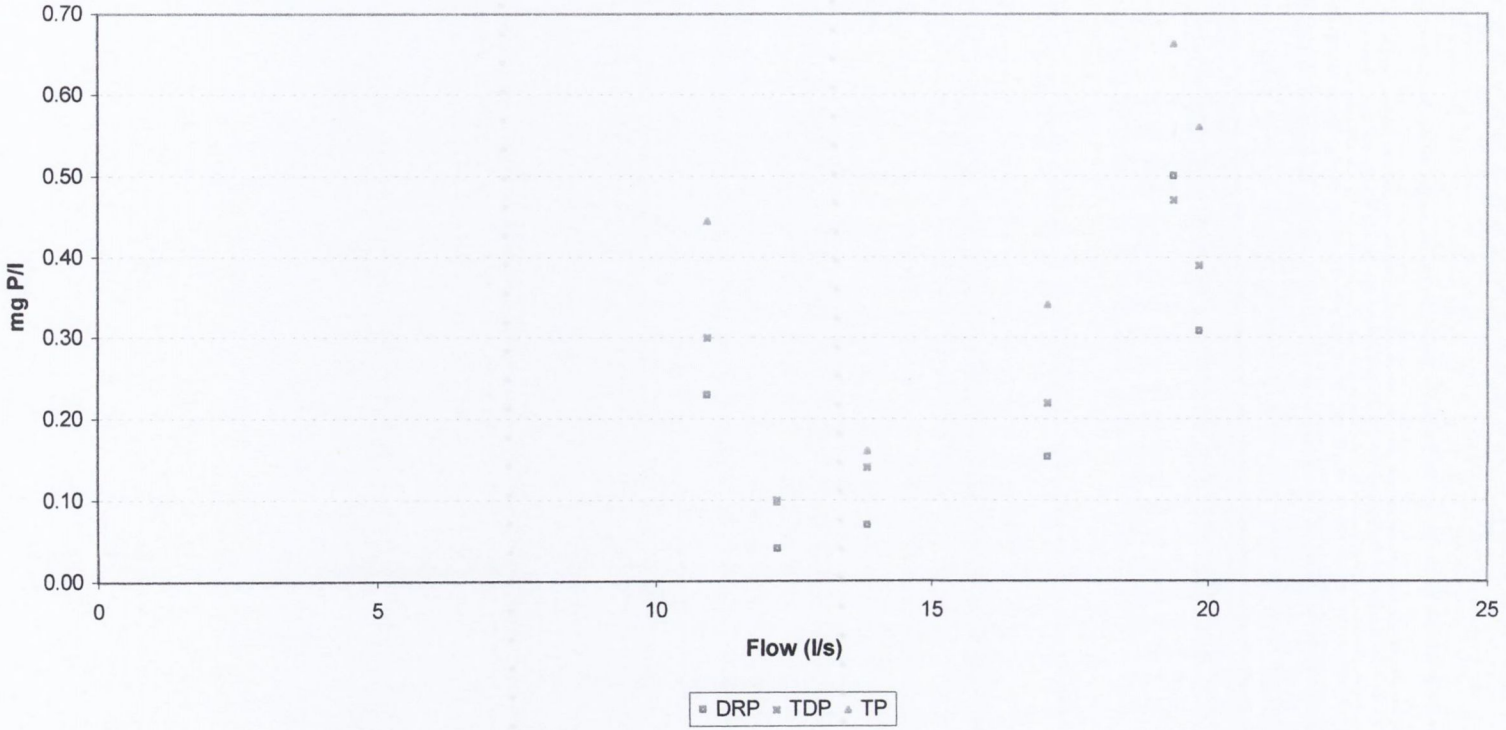


Figure 8.16: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU2 at the Beef Unit.

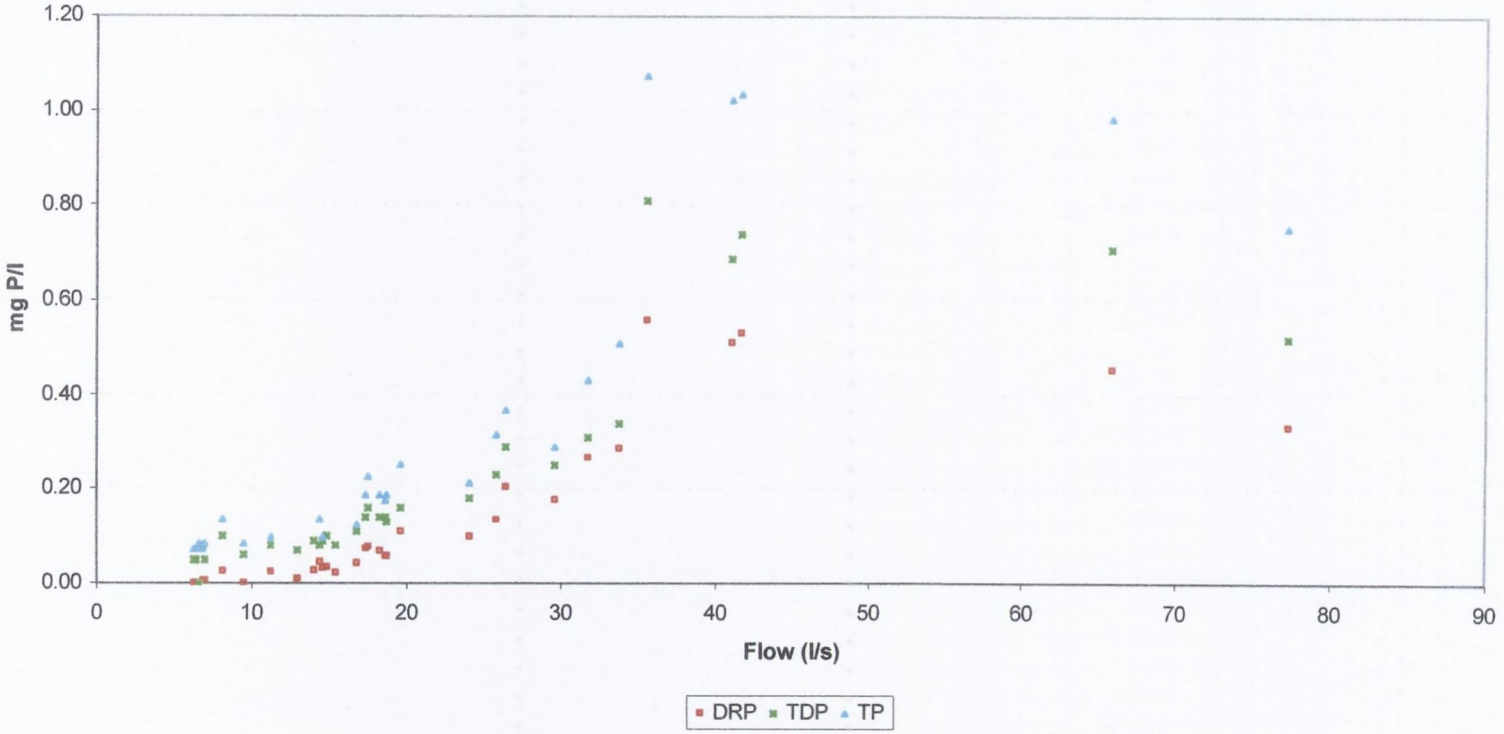


Figure 8.17: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU3 at the Beef Unit.

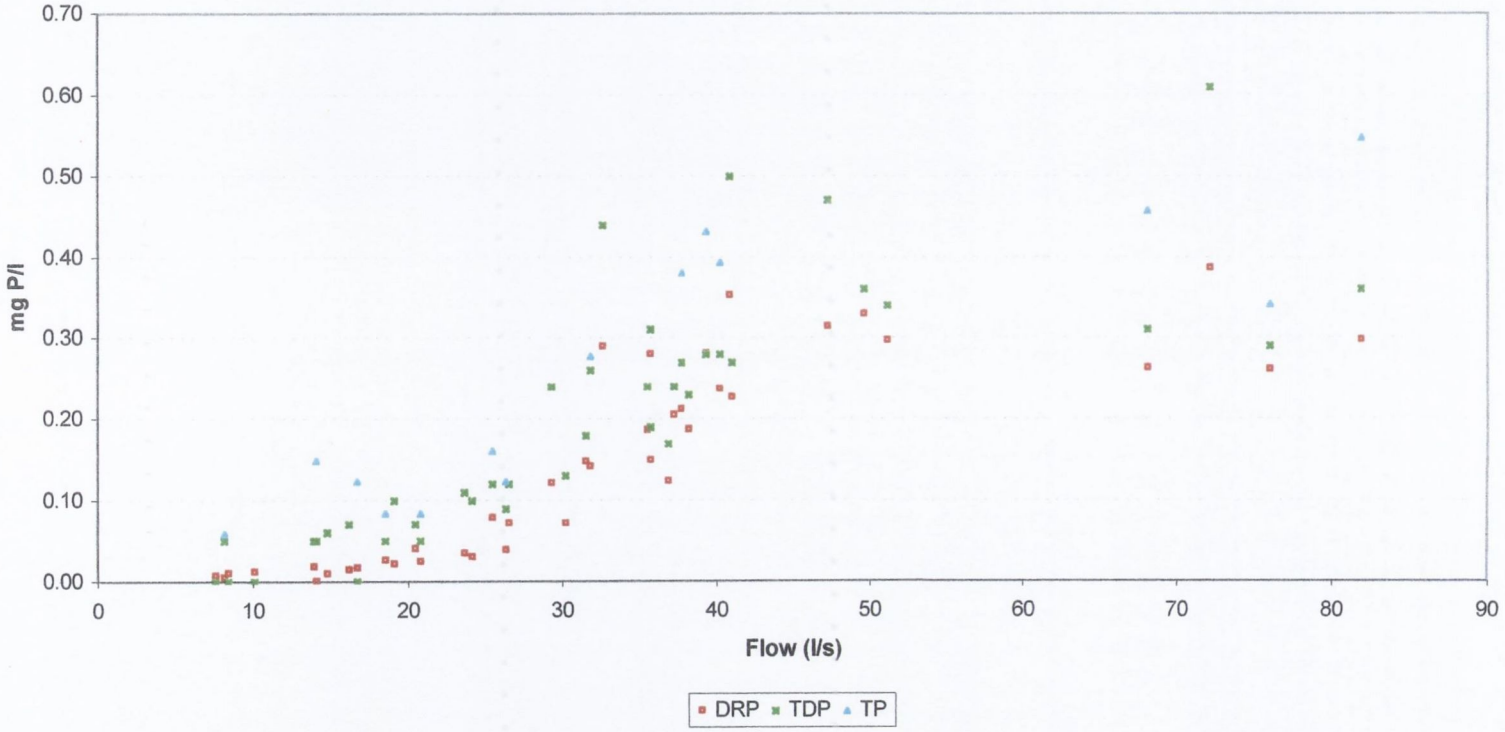


Figure 8.18: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU4 at the Beef Unit.

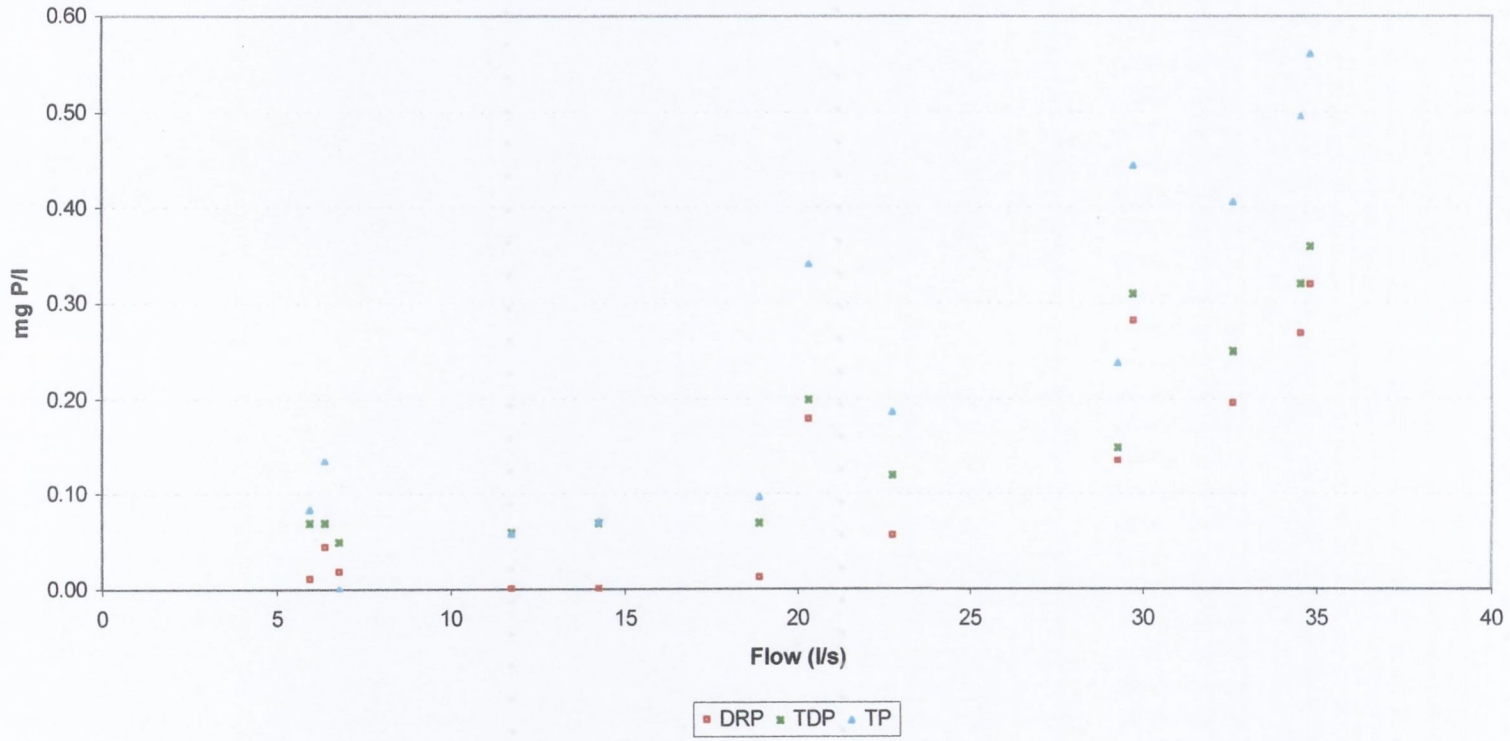


Figure 8.19: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU5 at the Beef Unit.

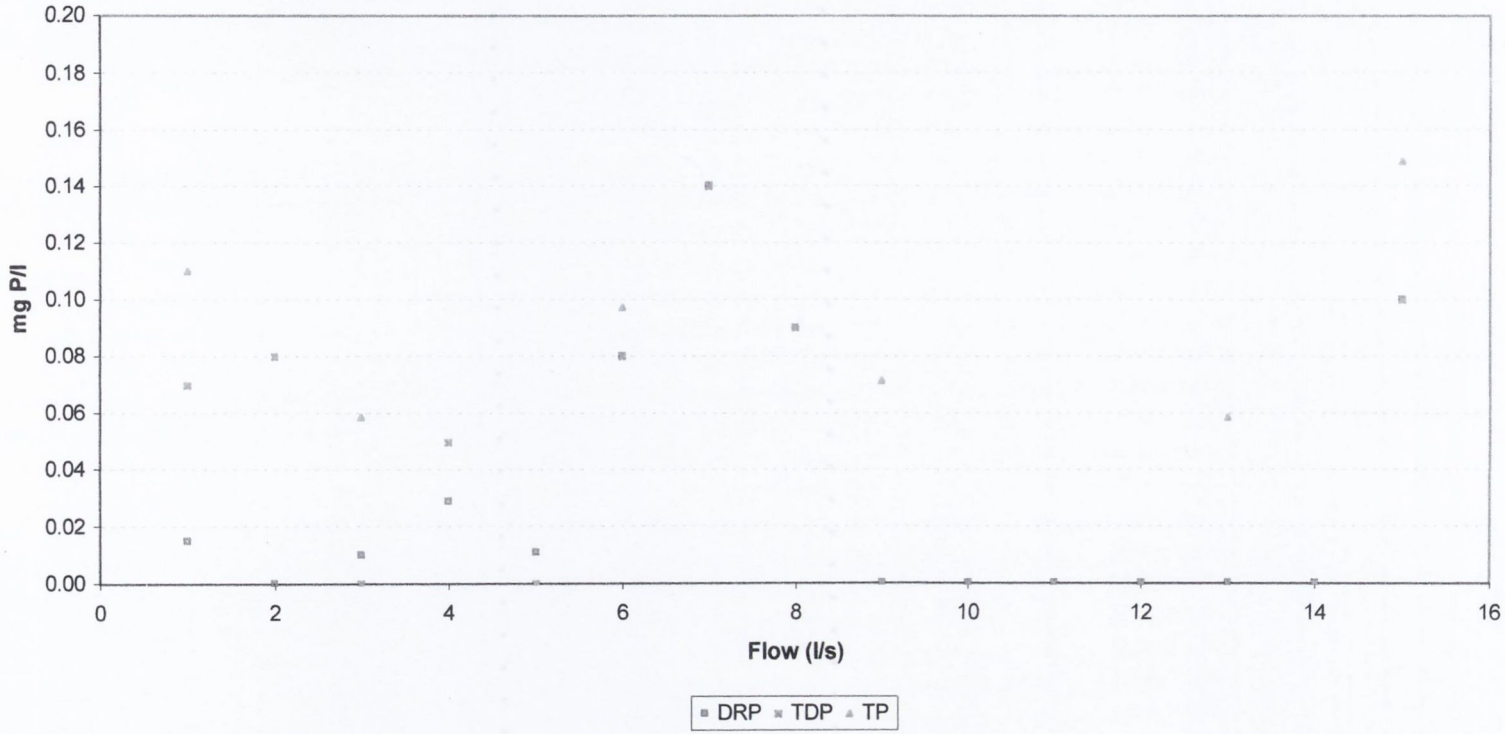


Figure 8.20: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU6 at the Beef Unit.

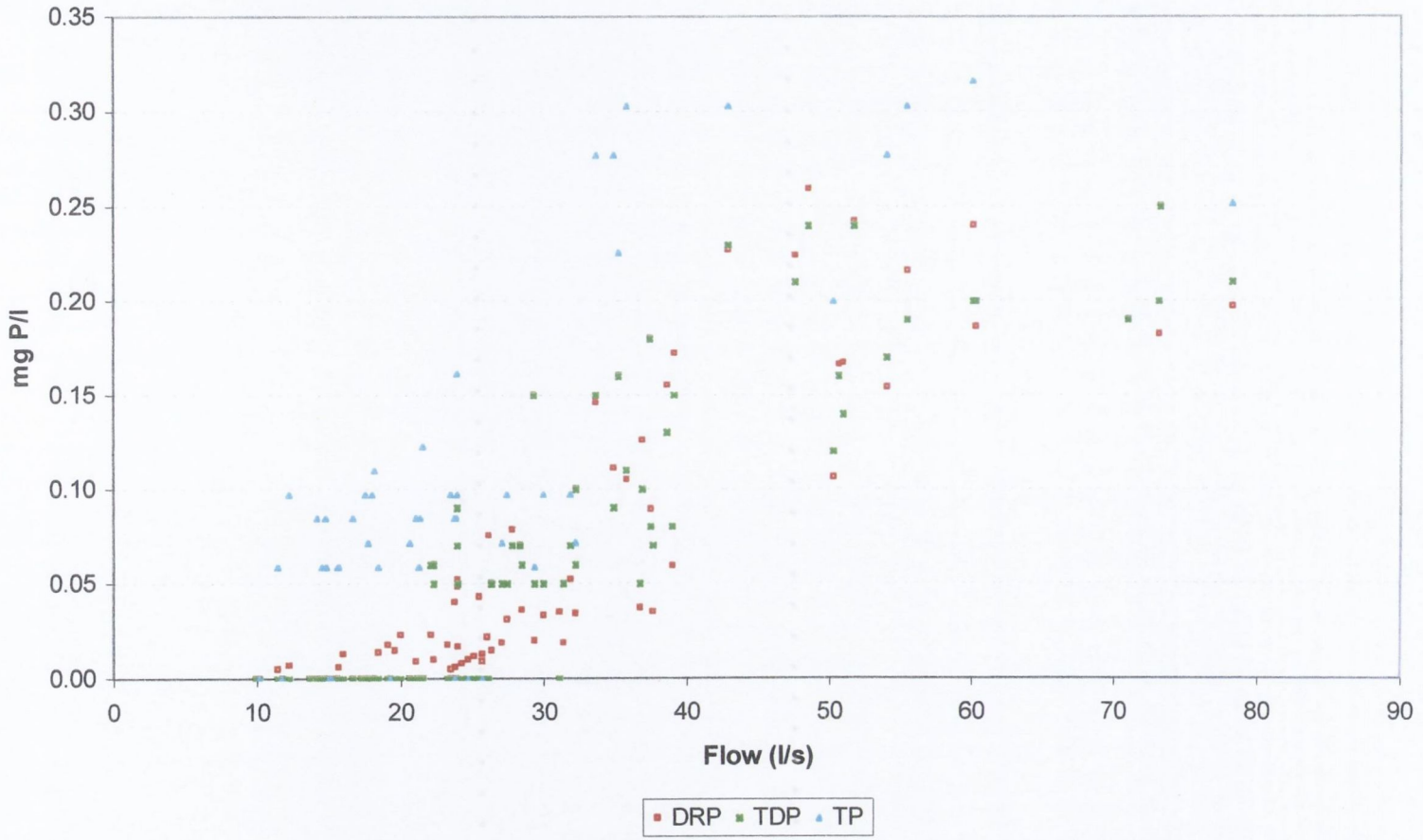


Figure 8.21: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU7 at the Beef Unit.

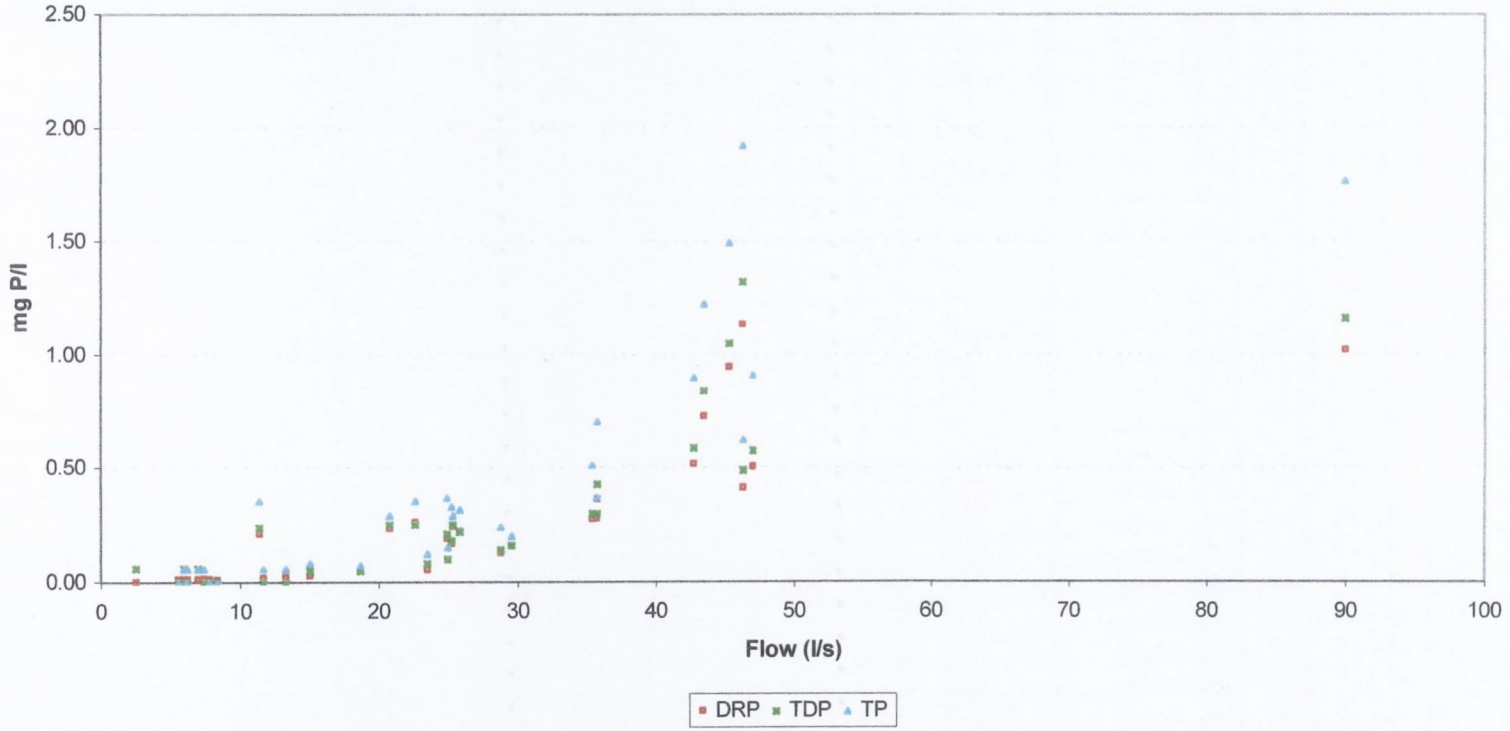


Figure 8.22: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU8 at the Beef Unit.

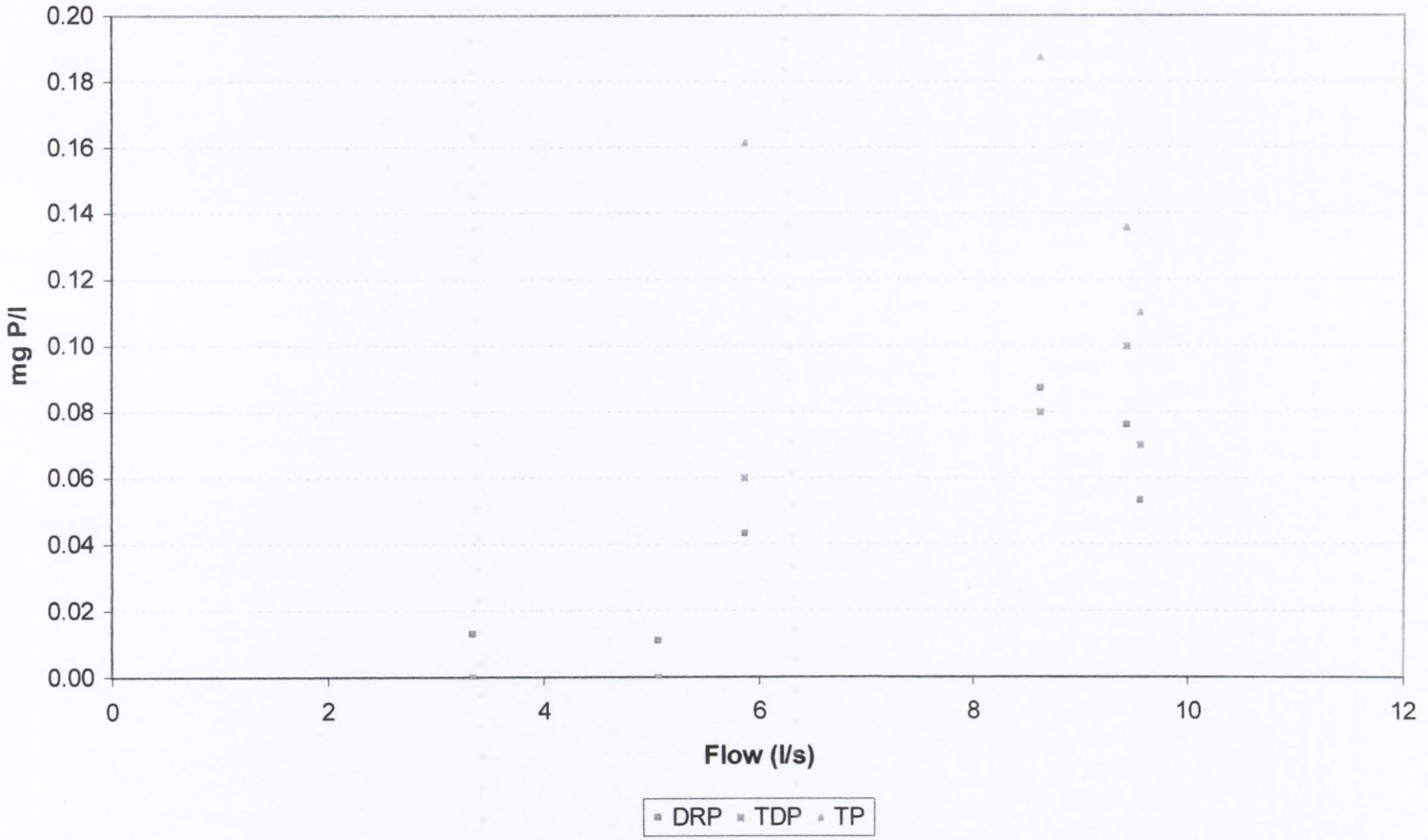


Figure 8.23: Rates of flow (l/s) plotted against P concentrations (mg P/l) for event BU9 at the Beef Unit.

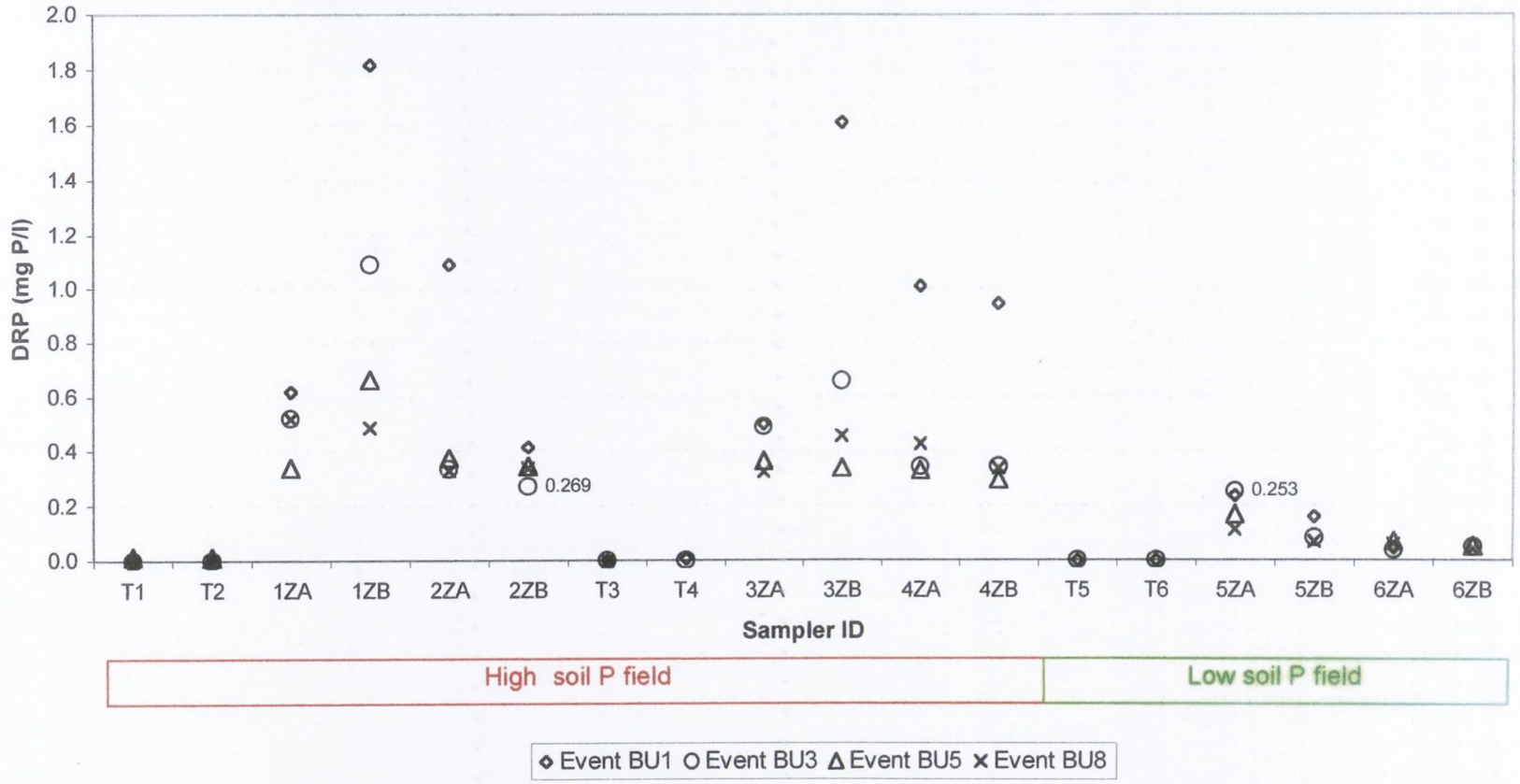


Figure 8.24: DRP concentrations (mg P/l) of soil water samples from the Beef Unit (Note that T indicates Teflon suction cup and Z indicates zero-tension sampler – see Table 8.2 for details).

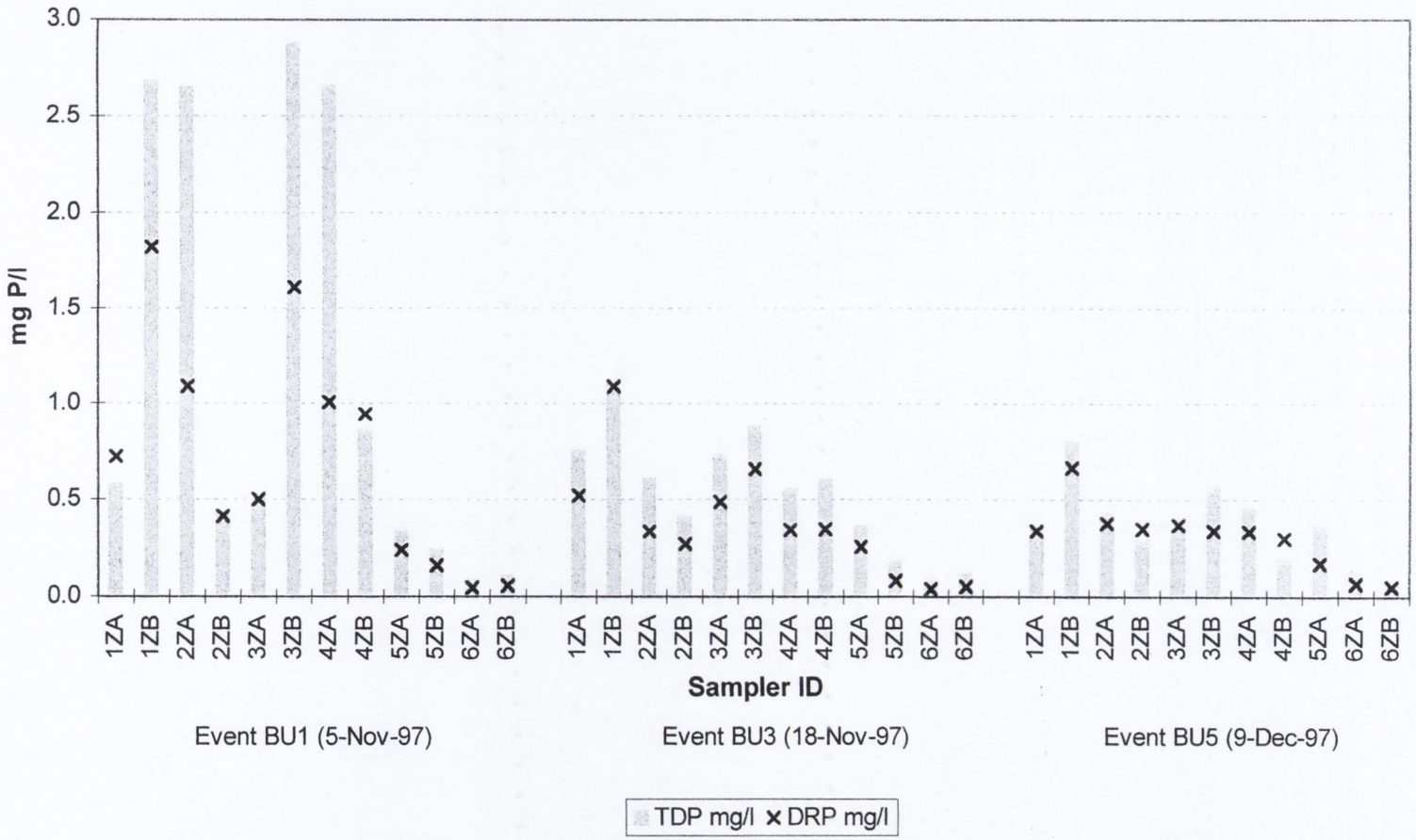


Figure 8.25: DRP and TDP (mg P/l) concentrations in zero-tension samples taken during events BU1, BU3 and BU5.

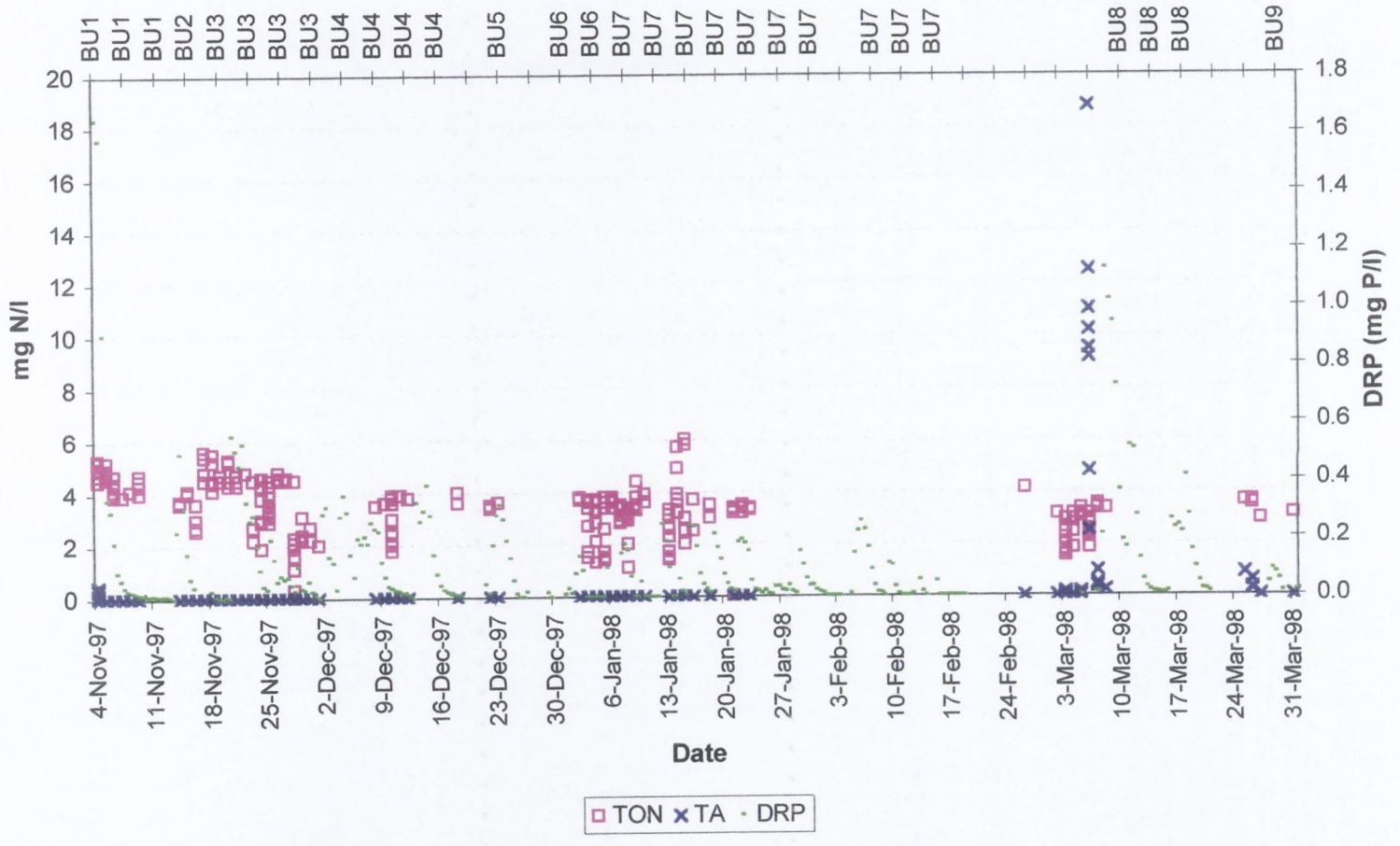


Figure 8.26: TA, TON (mg N/l) and DRP (mg P/l) in artificial subsurface drainage water at the Beef Unit for all monitored events (BU1 to BU9).

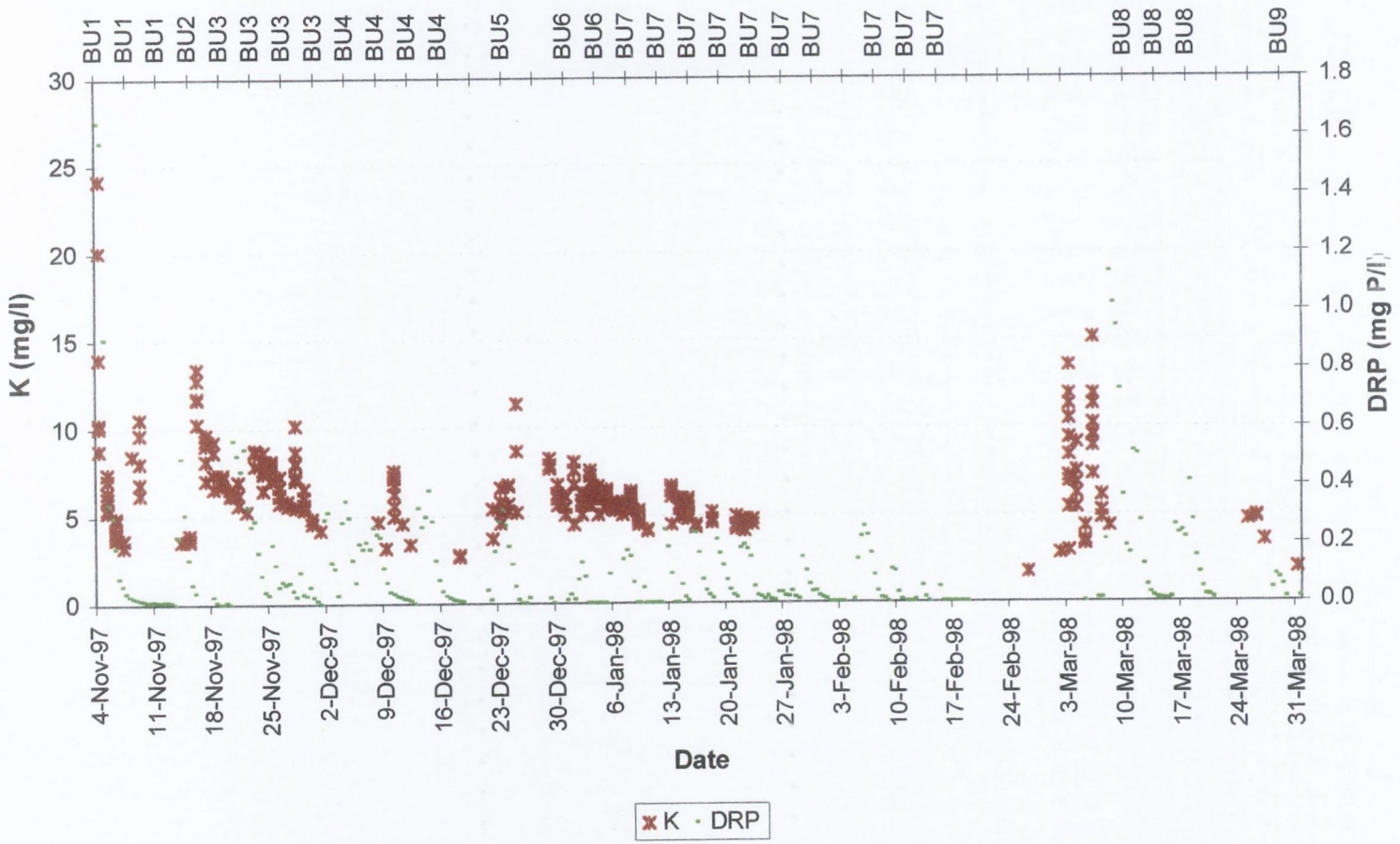


Figure 8.27: K (mg /l) and DRP (mg P/l) in artificial subsurface drainage water at the Beef Unit for all monitored events (BU1 to BU9).

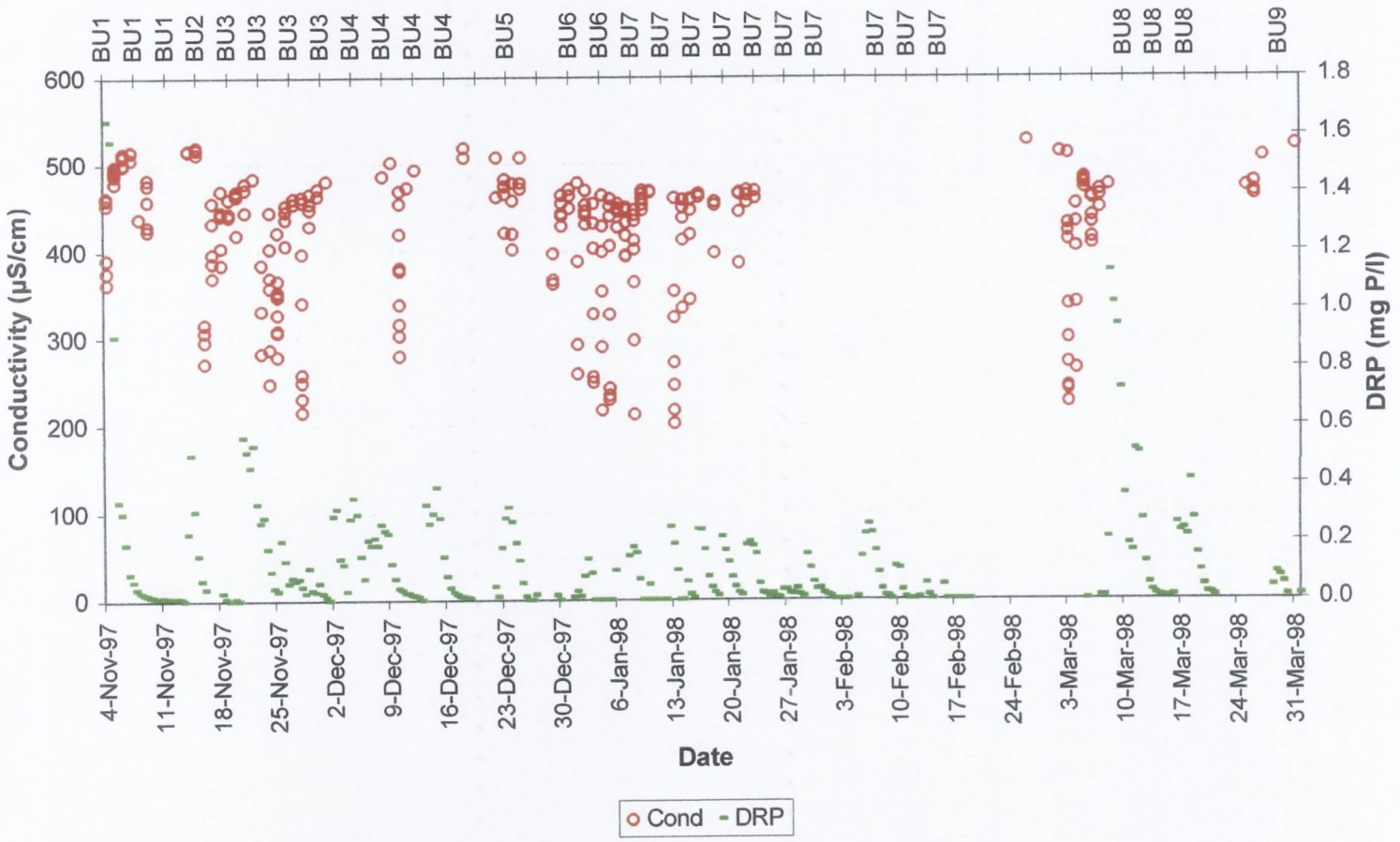


Figure 8.28: Conductivity (µS/cm) and DRP (mg P/l) in artificial subsurface drainage water at the Beef Unit for all monitored events (BU1 to BU9).

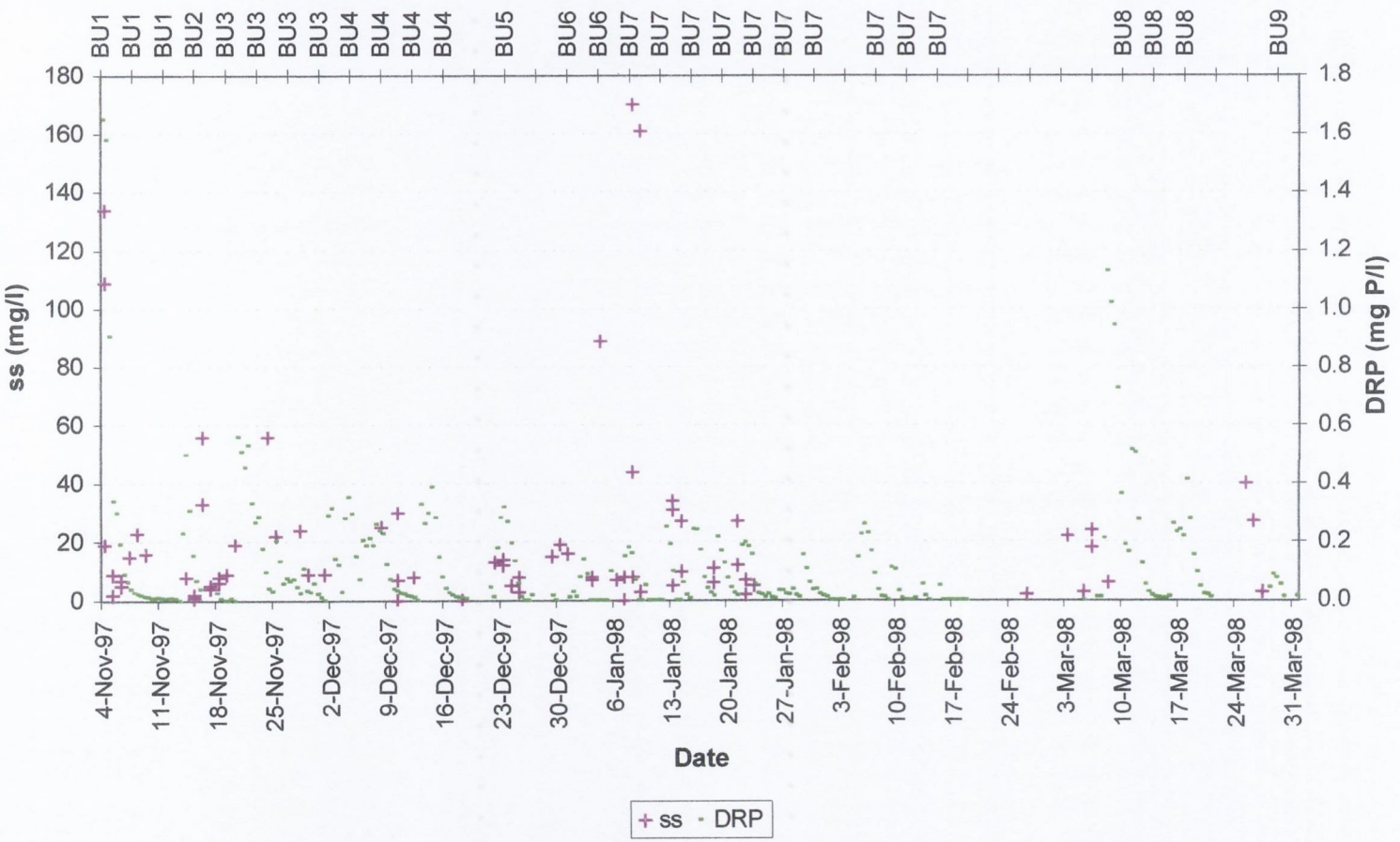


Figure 8.29: Suspended solids (mg/l) and DRP (mg P/l) in artificial subsurface drainage water at the Beef Unit.

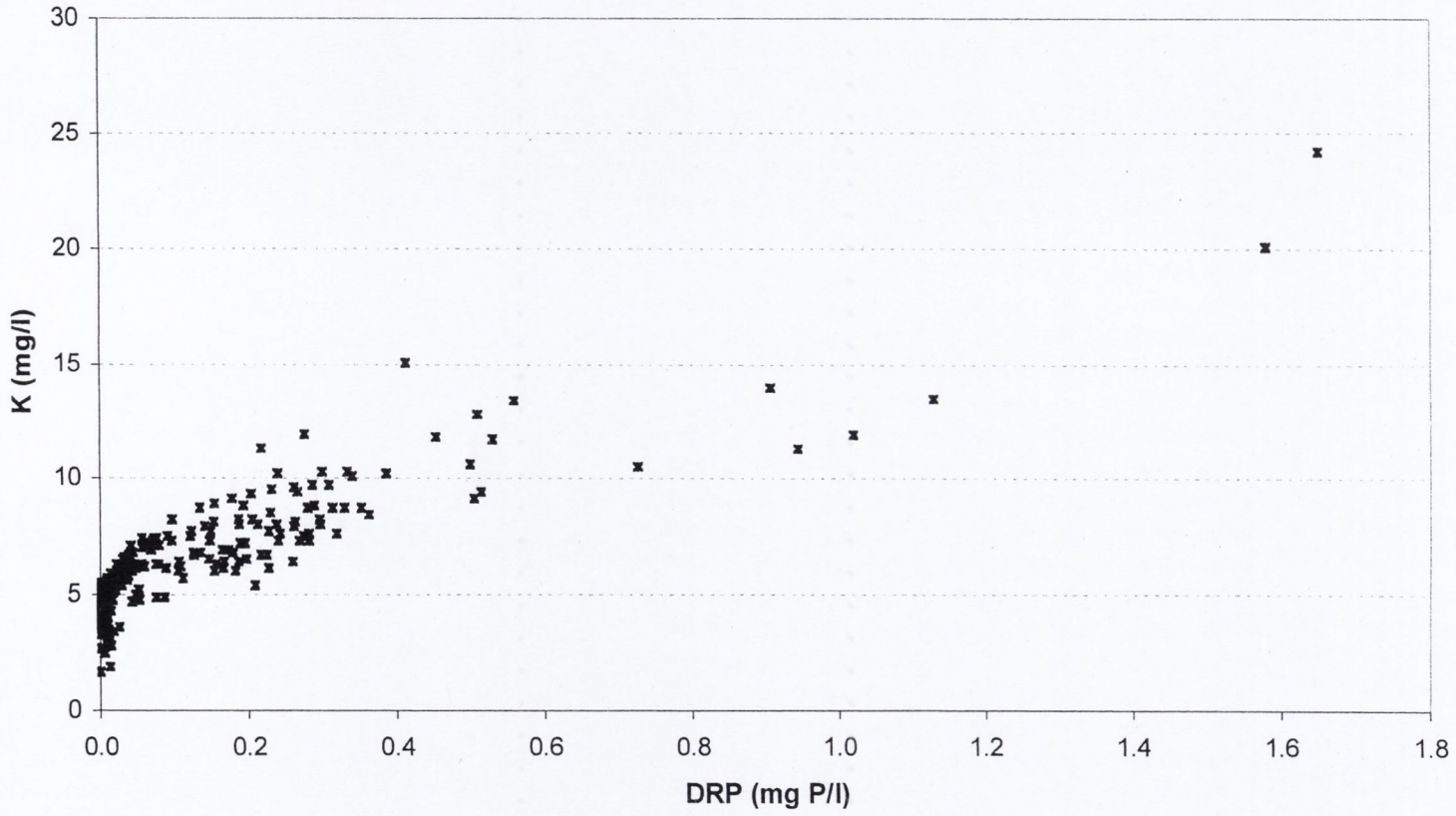


Figure 8.30: K (mg/l) levels plotted against DRP concentrations (mg P/l) in artificial subsurface drainage water at the Beef Unit.

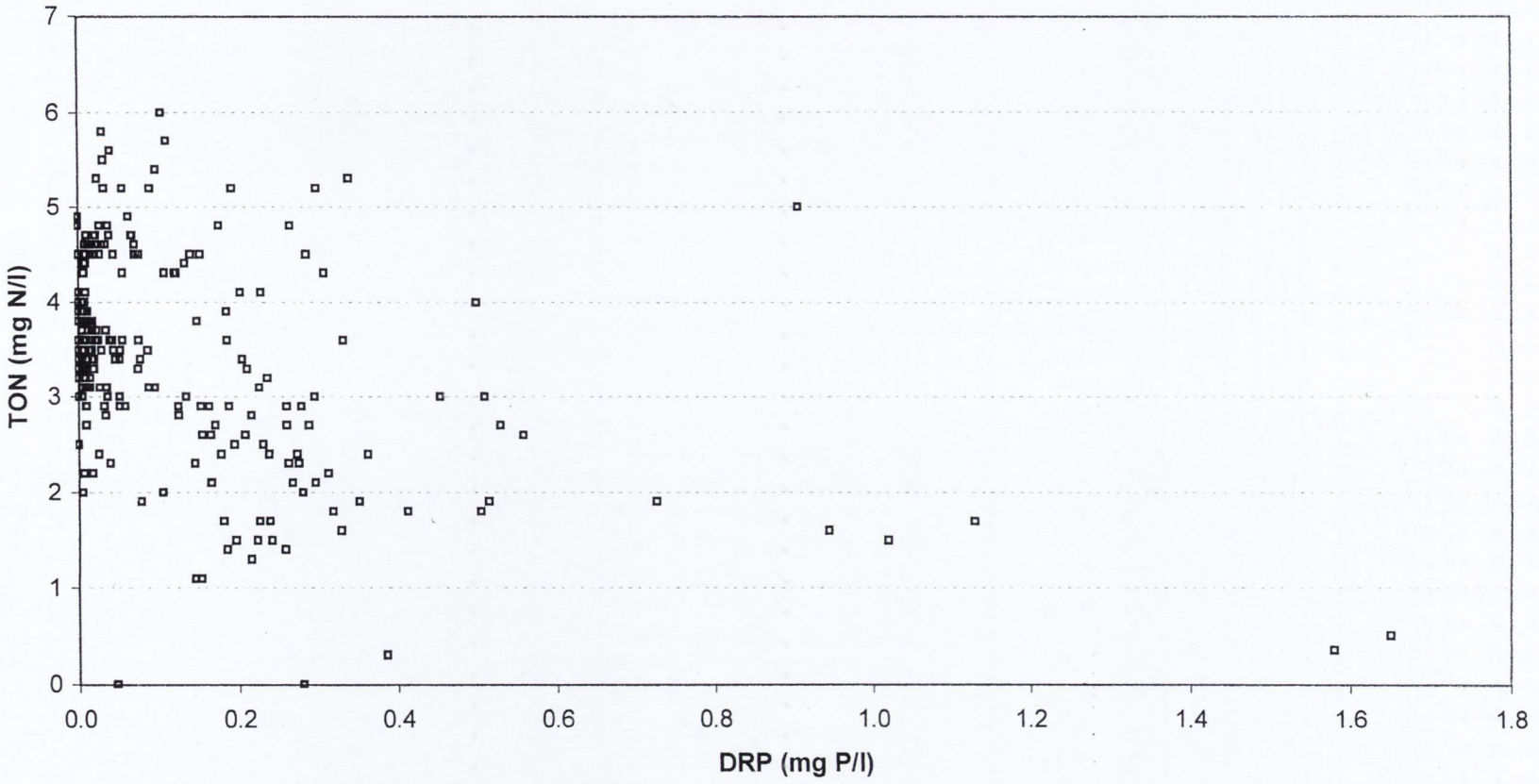


Figure 8.31: TON (mg N/l) levels plotted against DRP concentrations (mg P/l) in artificial subsurface drainage water at the Beef Unit.

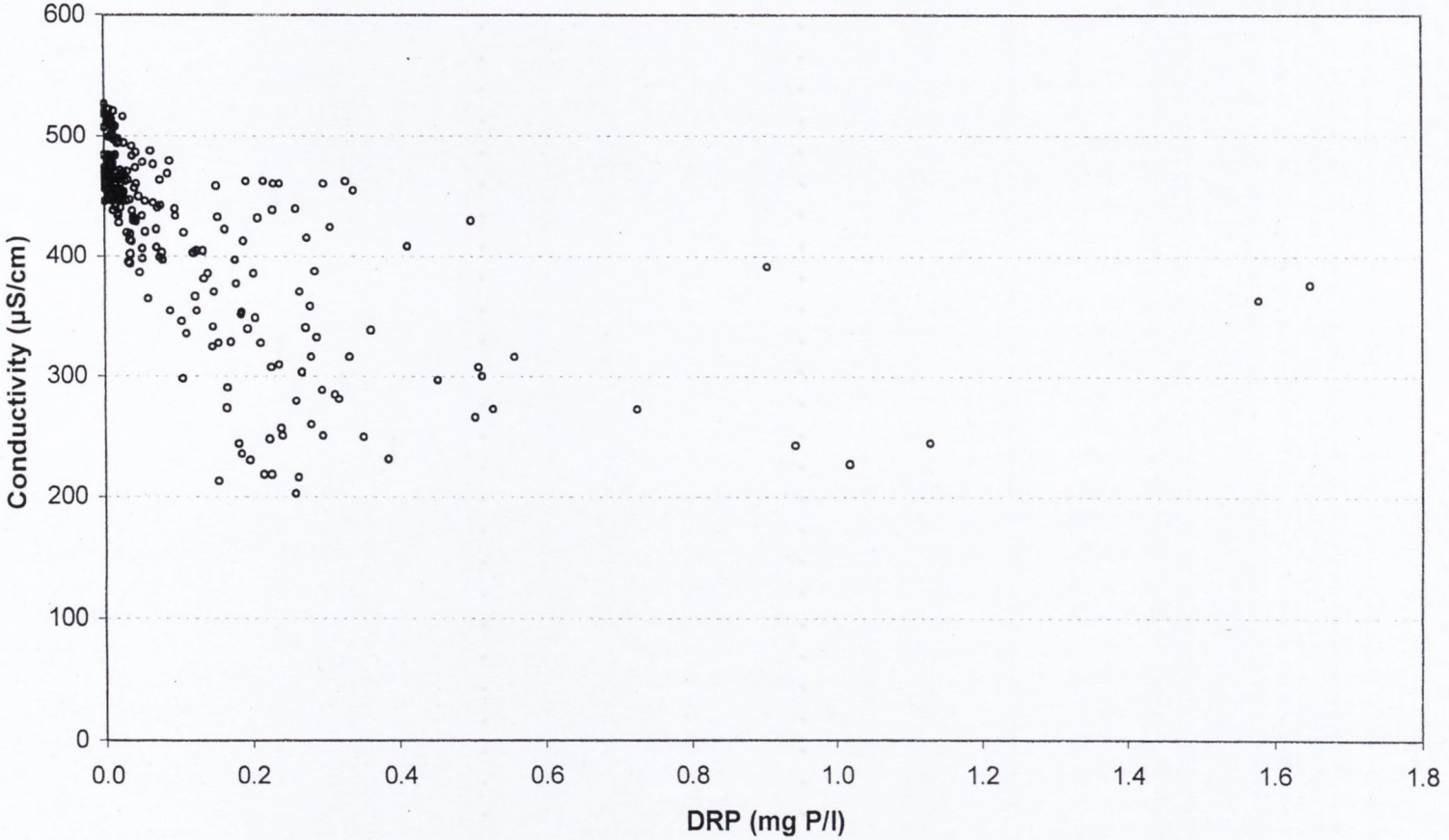


Figure 8.32: Conductivity (µS/cm) levels plotted against DRP concentrations (mg P/l) in artificial subsurface drainage water at the Beef Unit.

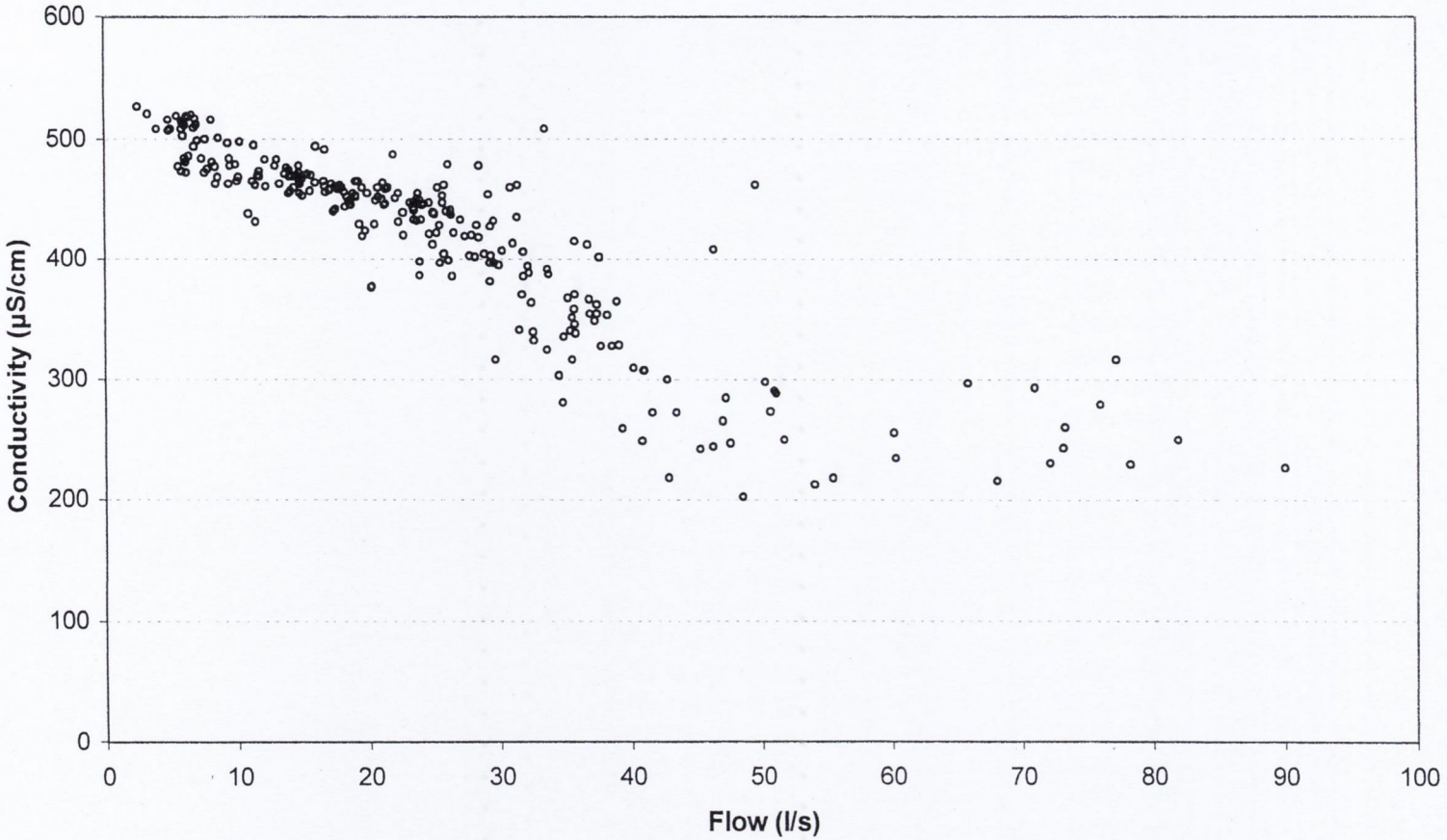


Figure 8.33: Conductivity (µS/cm) levels plotted against rates of flow (l/s) when samples of water in the artificial subsurface drainage system at the Beef Unit were taken.

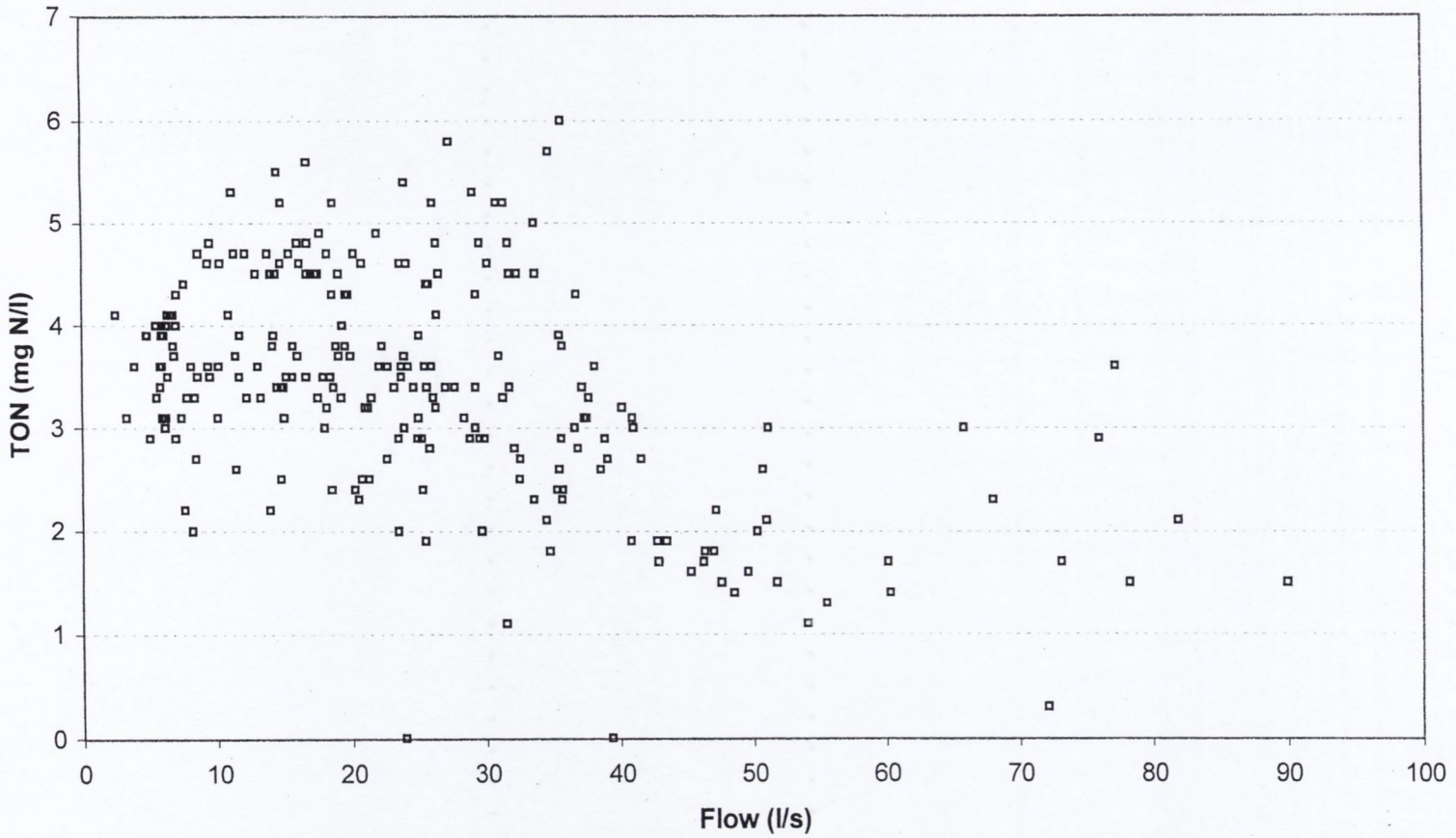


Figure 8.34: TON (mg N/l) levels plotted against rates of flow (l/s) when samples of water in the artificial subsurface drainage system at the Beef Unit were taken.

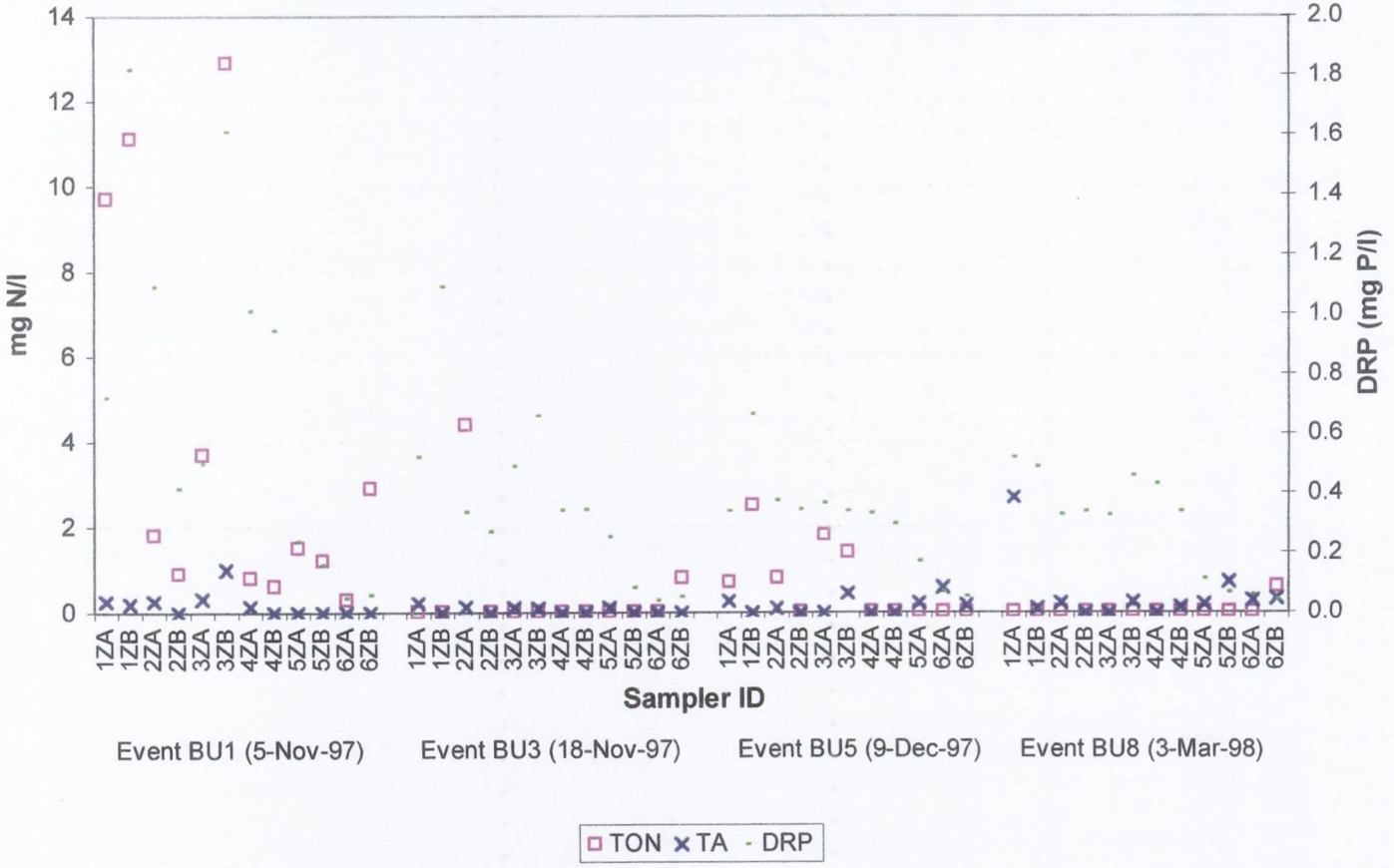


Figure 8.35: TA, TON (mg N/l) and DRP (mg P/l) in soil water from zero-tension samplers at the Beef Unit.

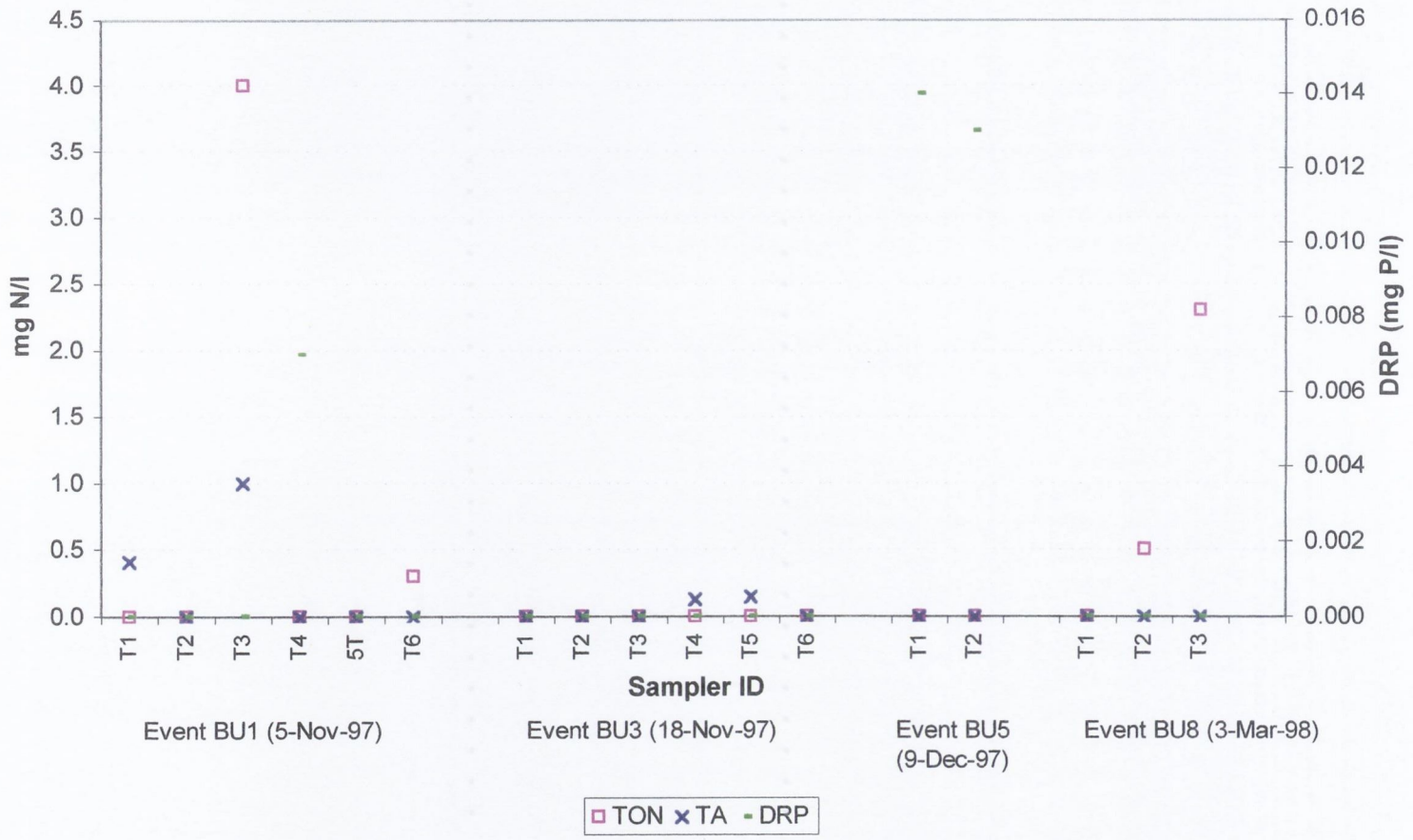


Figure 8.36: TA, TON (mg N/l) and DRP (mg P/l) in soil water from Teflon suction cup samplers at the Beef Unit.

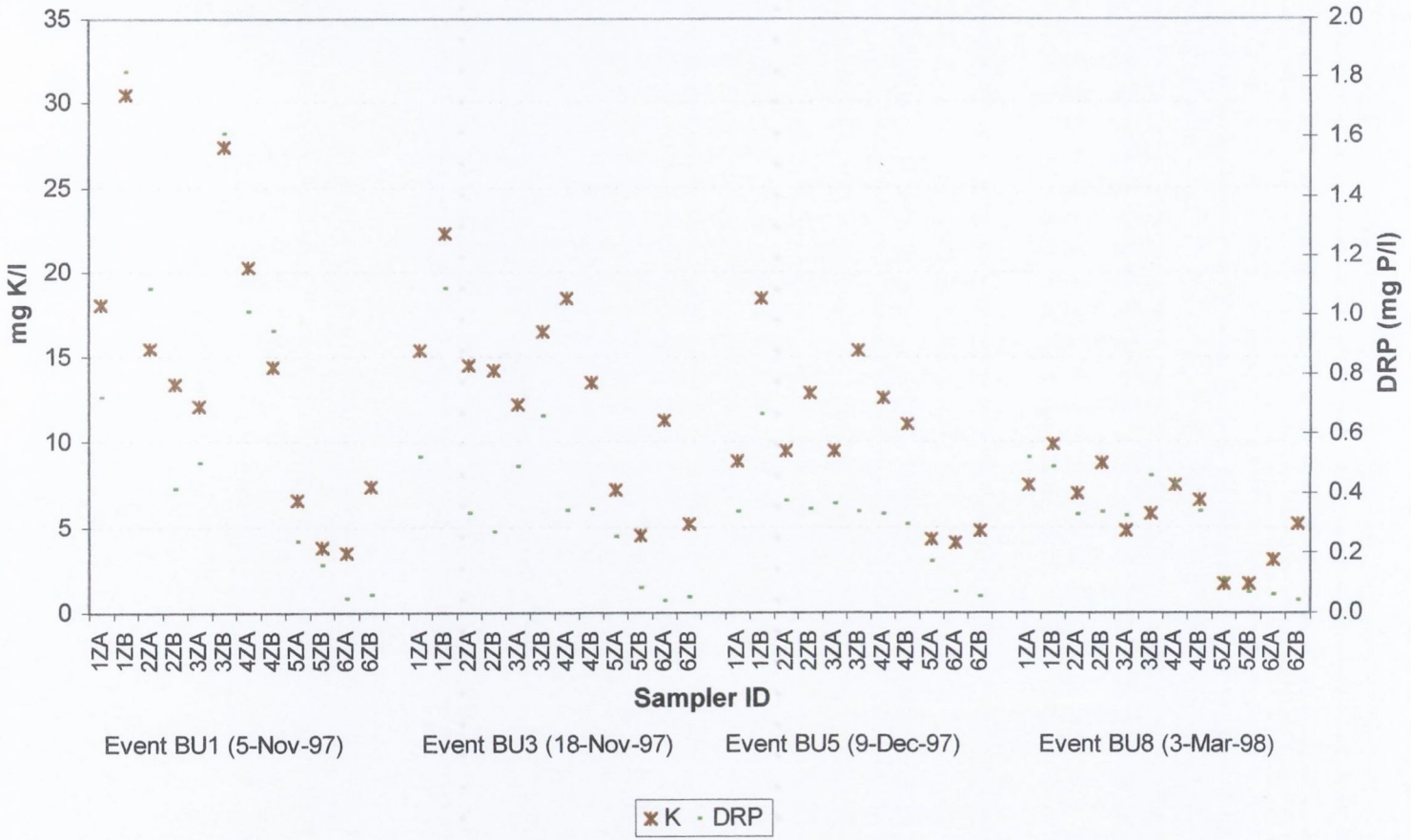


Figure 8.37: K (mg K/l) and DRP (mg P/l) in soil water from zero-tension samplers at the Beef Unit.

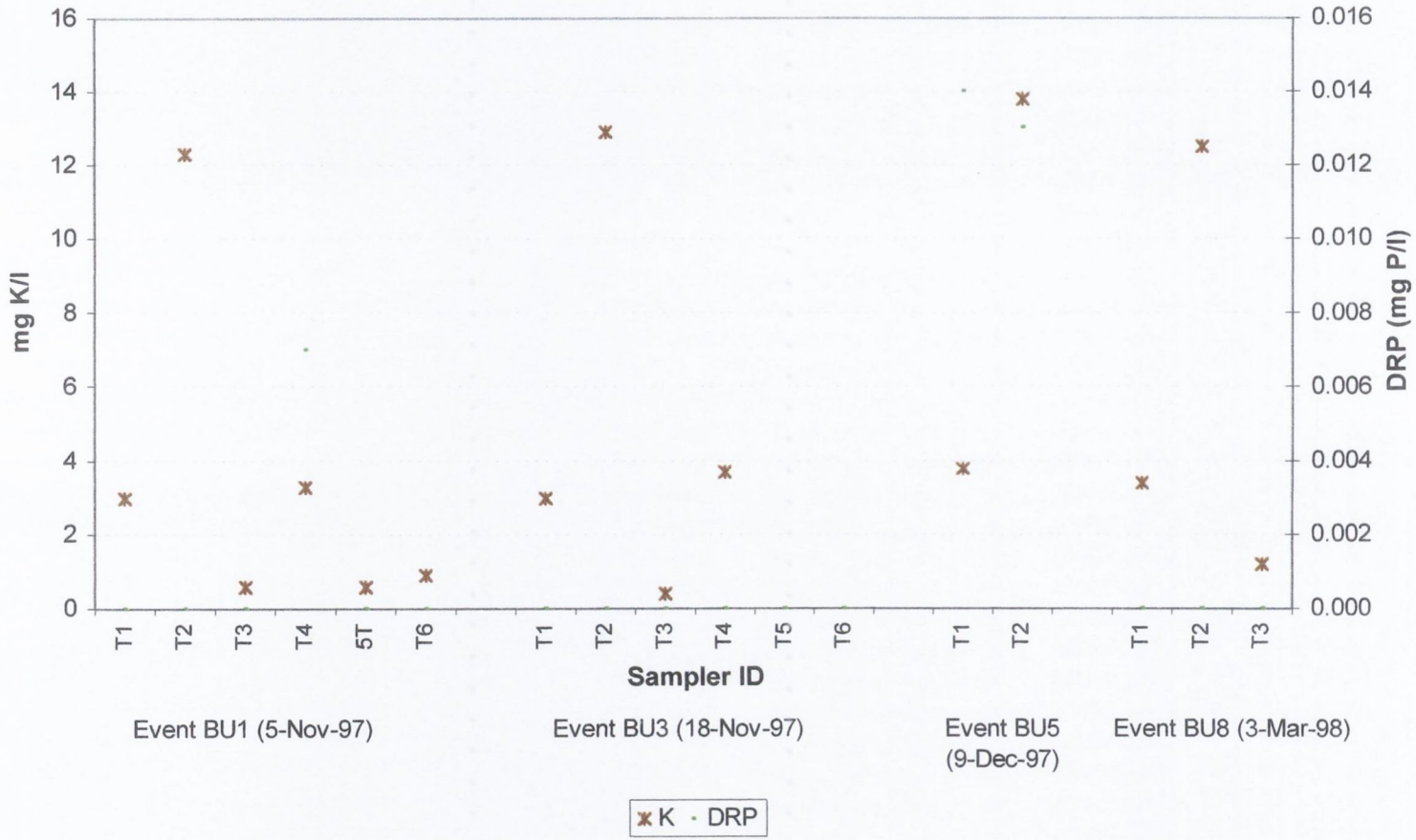


Figure 8.38: K (mg/l) and DRP (mg P/l) in soil water from Teflon suction cup samplers at the Beef Unit.

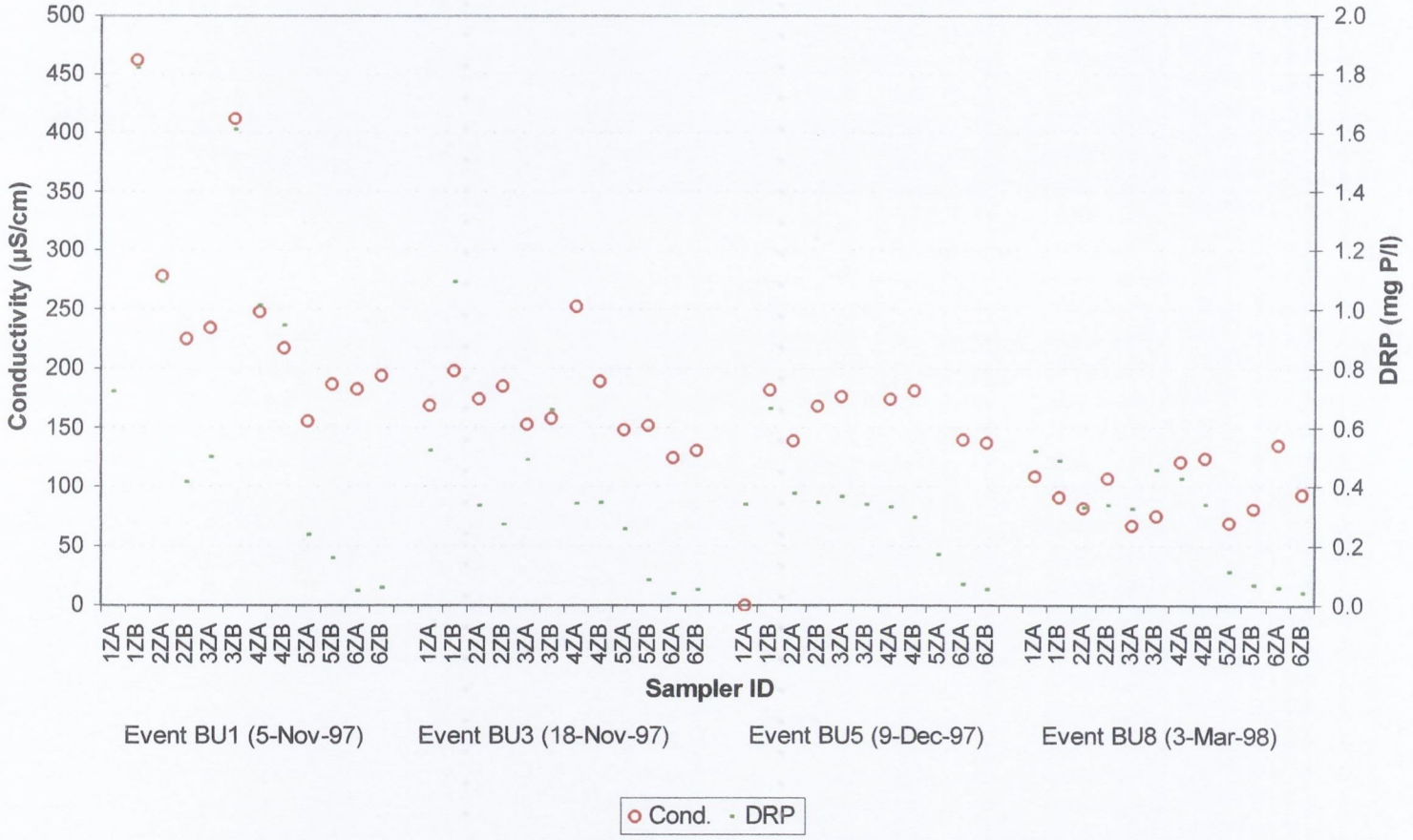


Figure 8.39: Conductivity (µS/cm) and DRP (mg P/l) in soil water from zero-tension samplers at the Beef Unit.

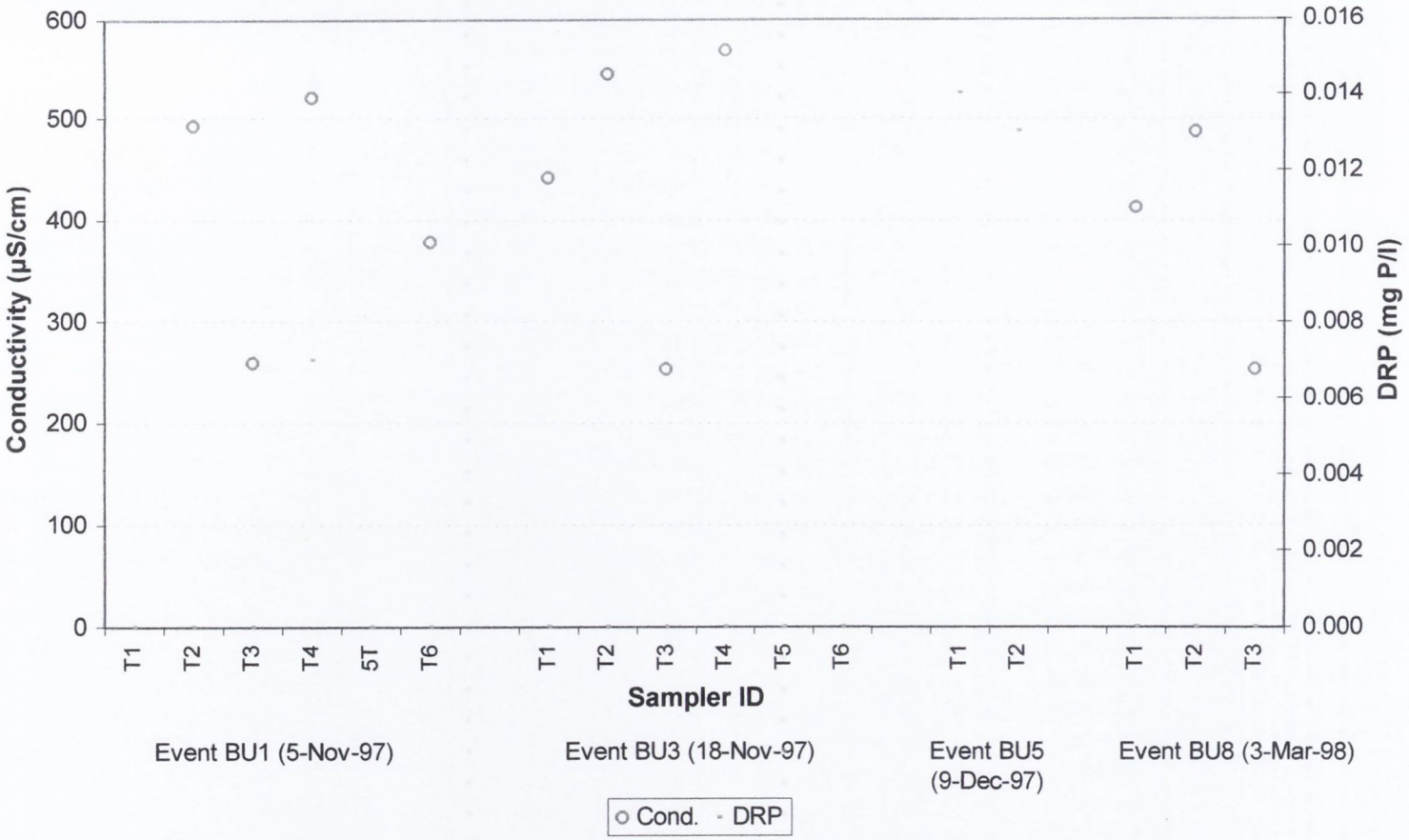


Figure 8.40: Conductivity (µS/cm) and DRP (mg P/l) in soil water from Teflon suction cup samplers at the Beef Unit.

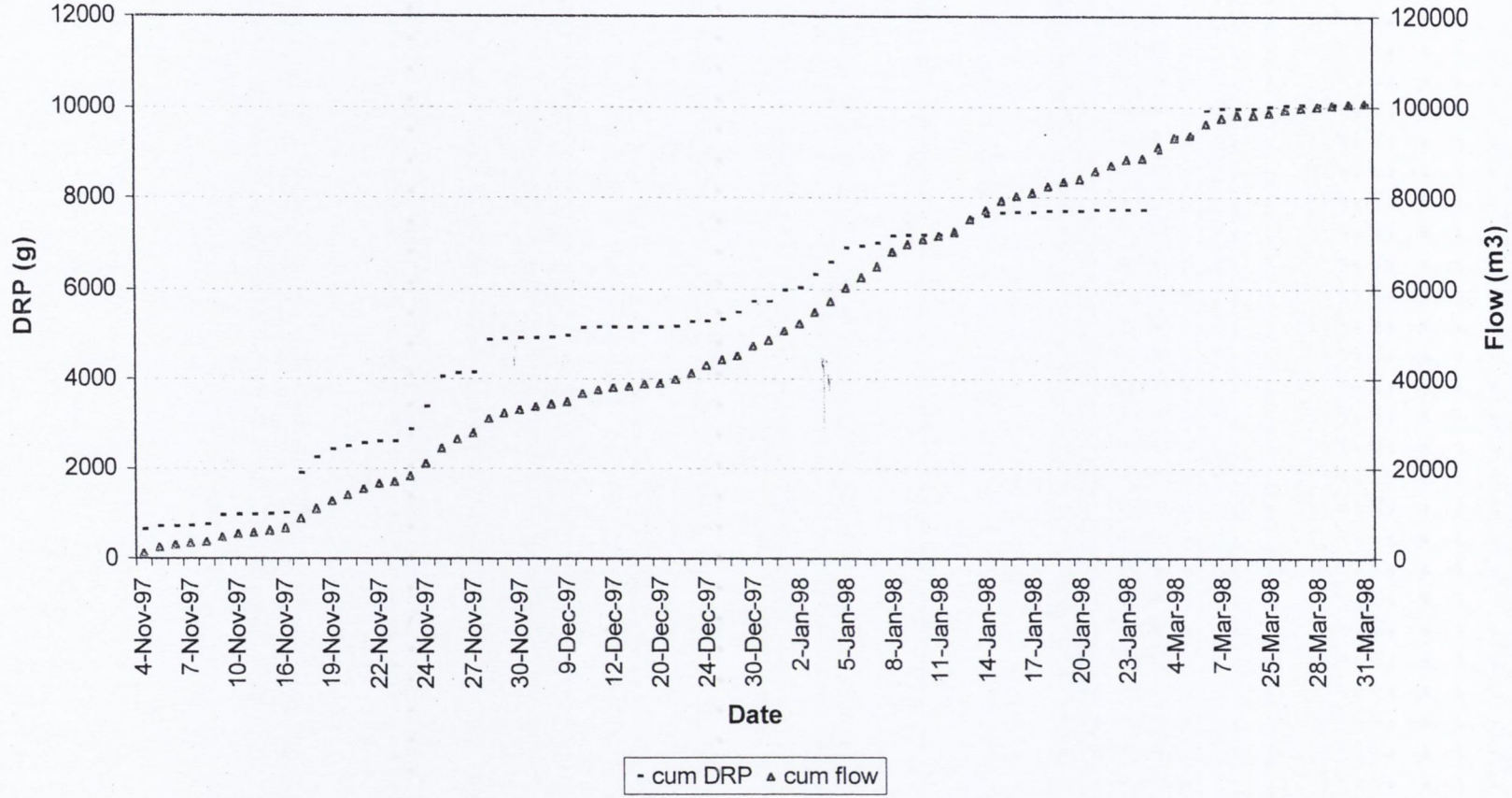


Figure 8.41: Cumulative daily flow (m^3) and DRP export (g) via artificial subsurface drains at the Beef Unit (Nov. 97 to March 98).

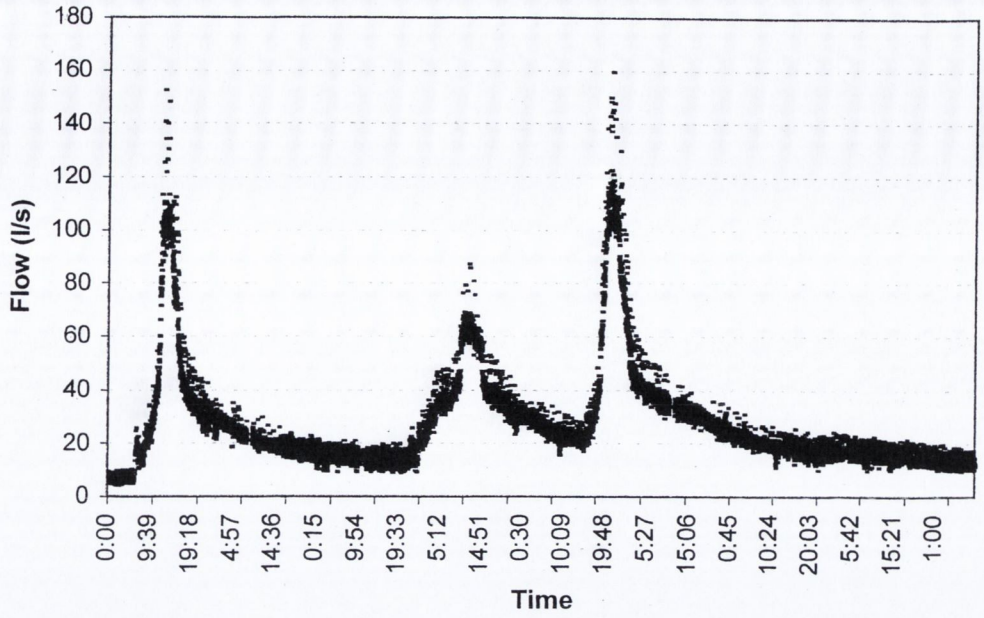


Figure 9.1: One minute flow measurements at the upstream monitoring site (M1) at the Dairy Farm (24th November –2nd December 1996).

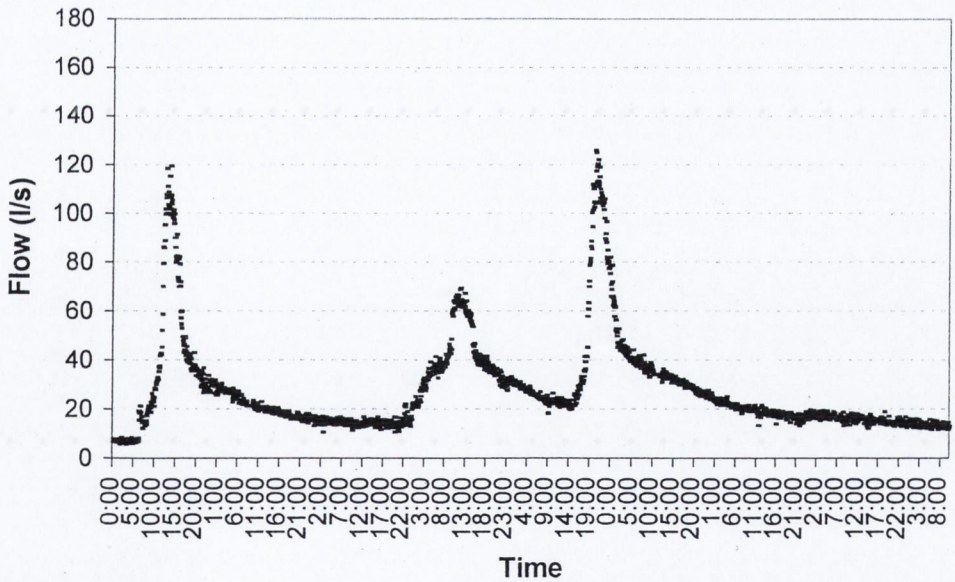


Figure 9.2: Five minute flow measurements at the upstream monitoring site (M1) at the Dairy Farm (24th November –2nd December 1996).

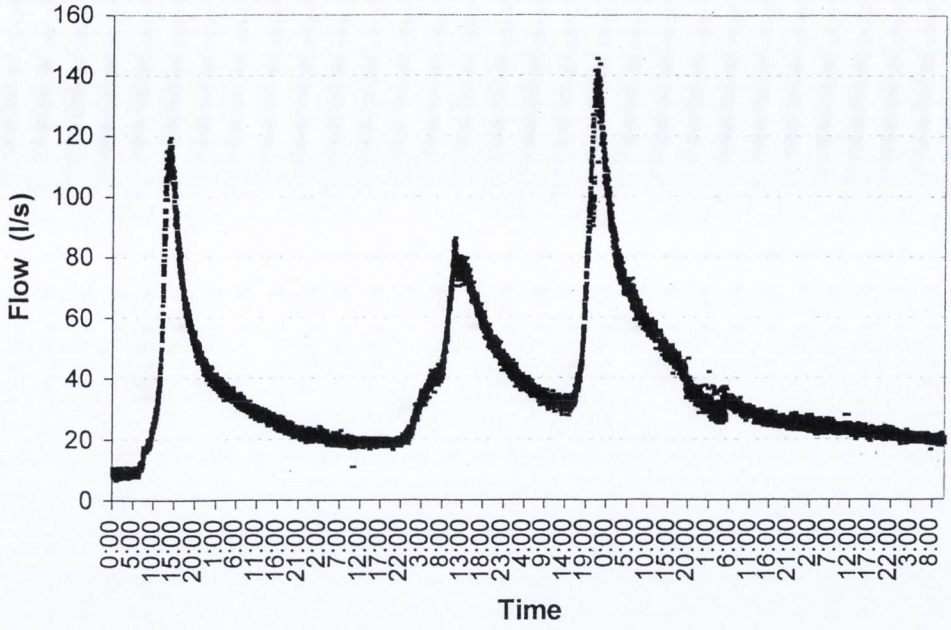


Figure 9.3: One minute flow measurements at the downstream monitoring site (M2) at the Dairy Farm (24th November –2nd December 1996).

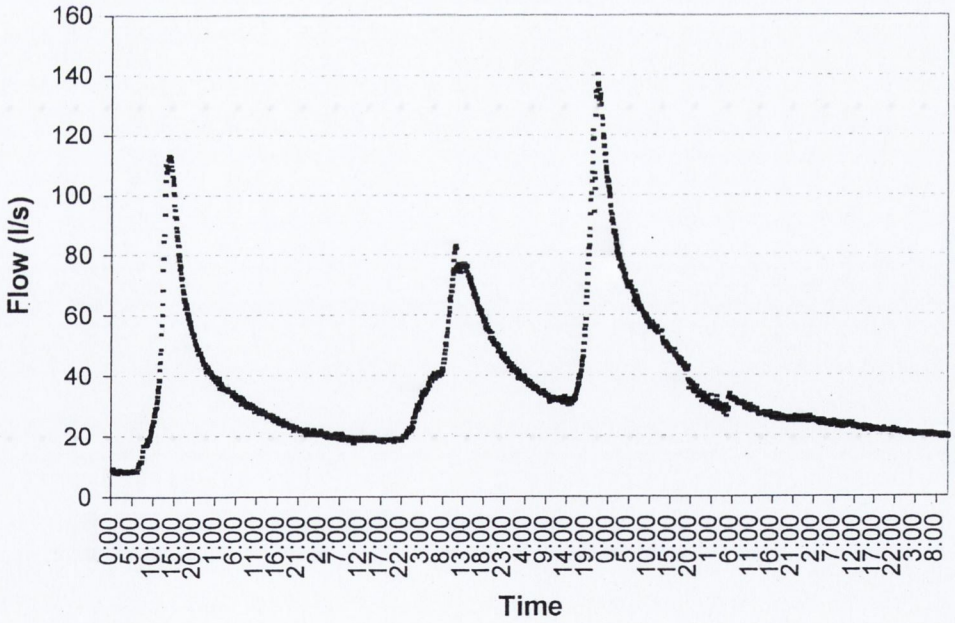


Figure 9.4: Five minute flow measurements at the downstream monitoring site (M2) at the Dairy Farm (24th November –2nd December 1996).

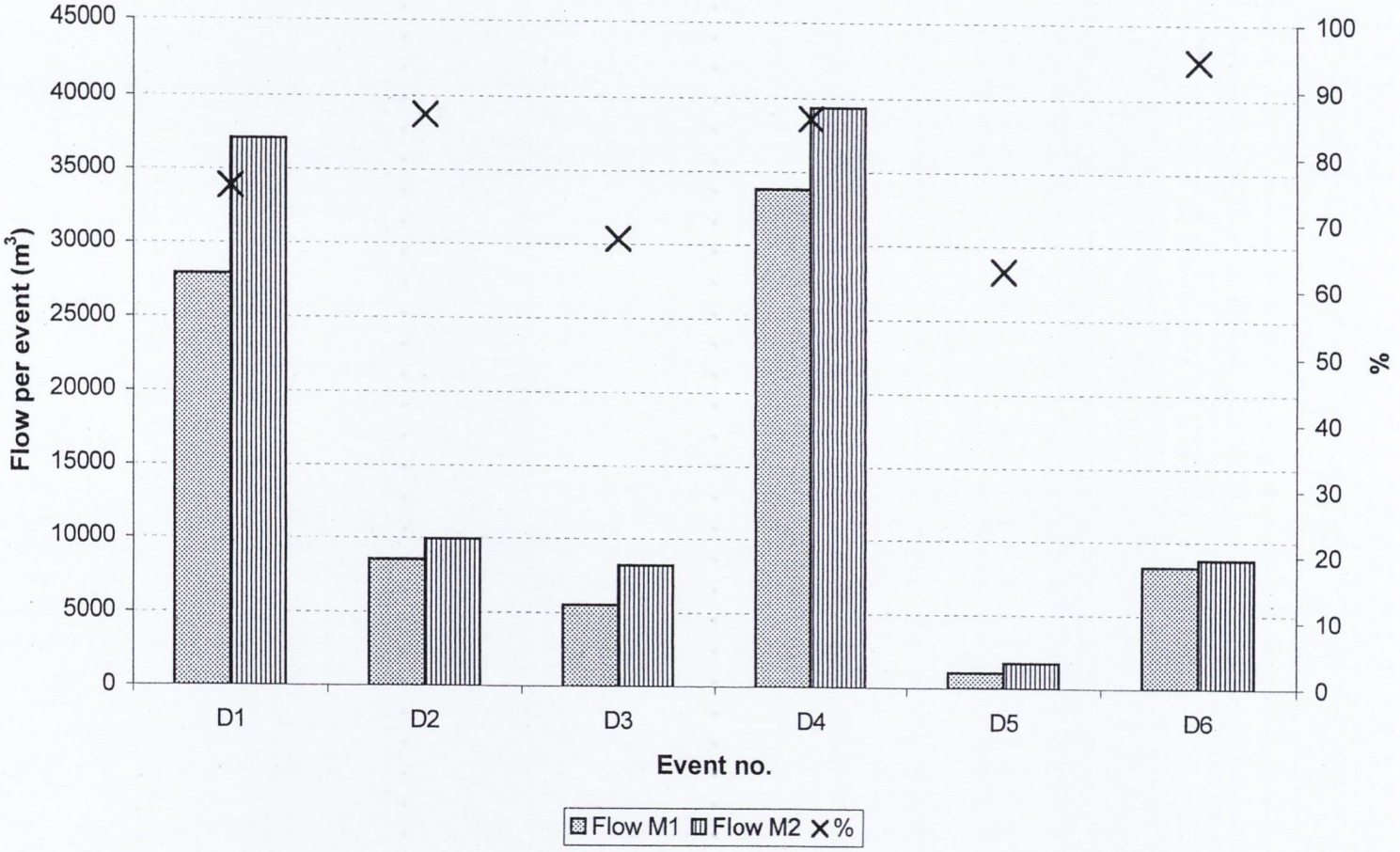


Figure 9.5: Flow per event at the upstream (M1) and the downstream (M2) monitoring stations of the Dairy Farm sub-catchment, and % of downstream (M2) flow measured upstream (M1).

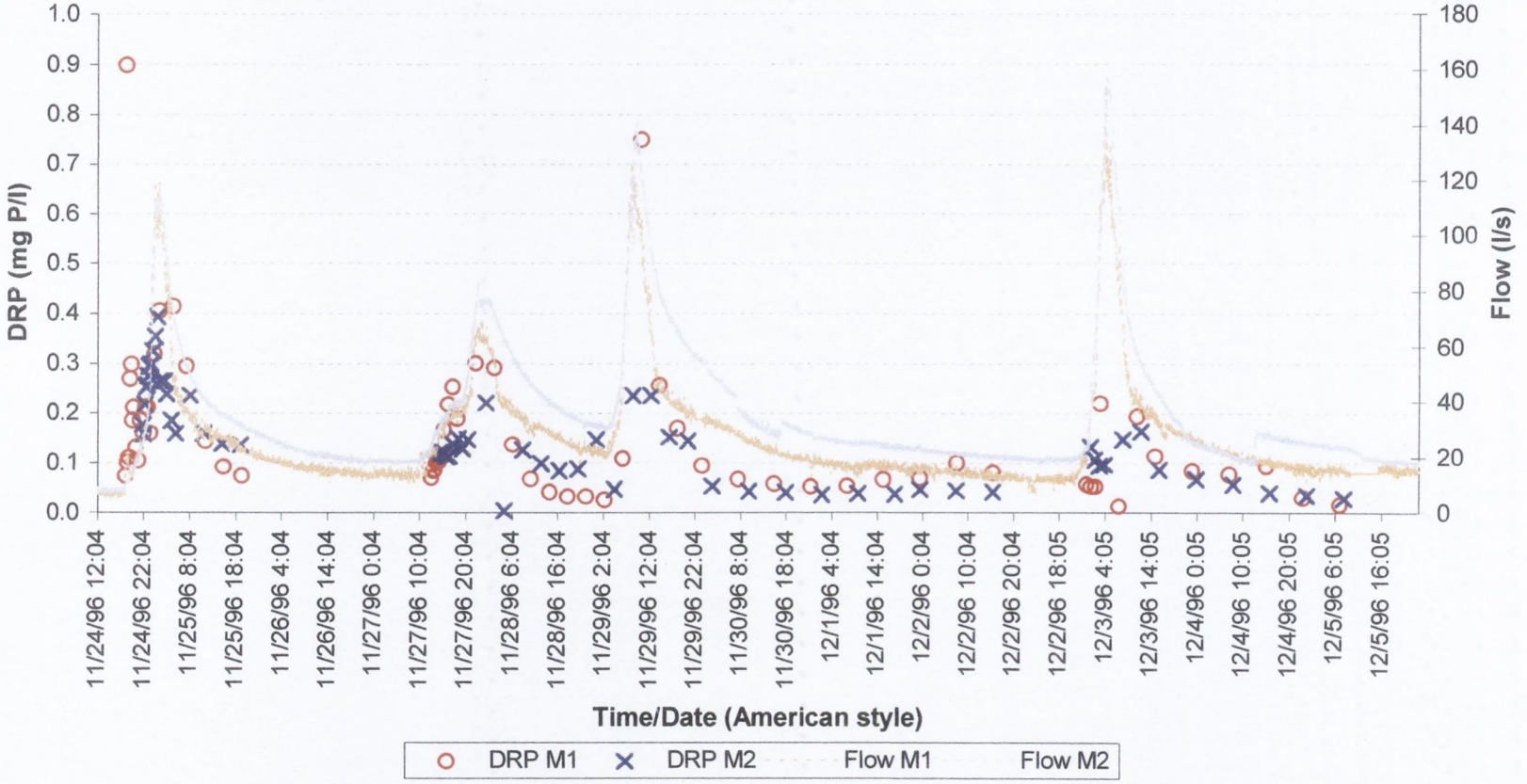


Figure 9.6: Flow (l/s) and DRP concentrations (mg P/l) at the upstream (M1) and downstream (M2) monitoring stations for event D1.

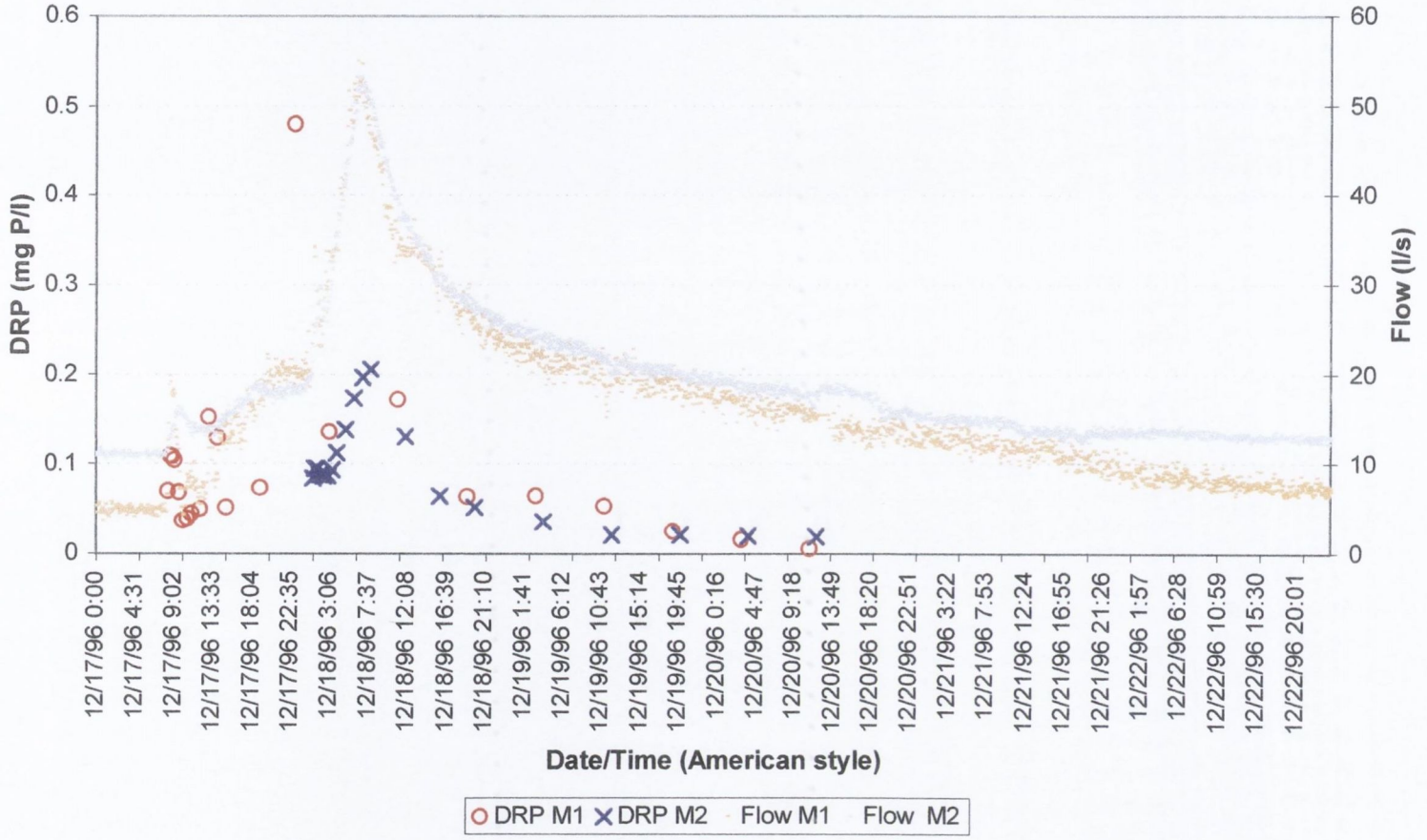


Figure 9.7: Flow (l/s) and DRP concentrations (mg P/l) at the upstream (M1) and downstream (M2) monitoring stations for event D2.

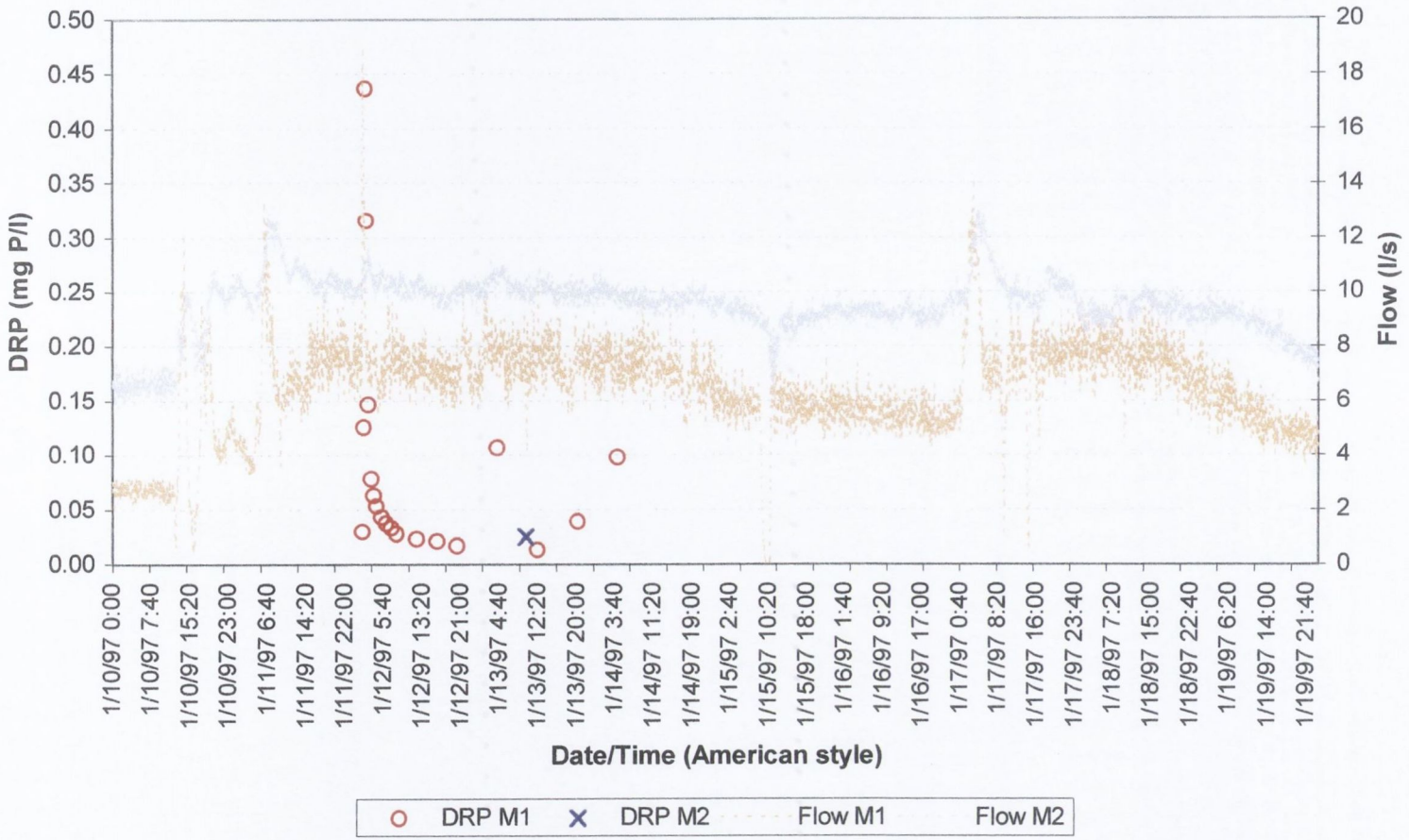


Figure 9.8: Flow (l/s) and DRP concentrations (mg P/l) at the upstream (M1) and downstream (M2) monitoring stations for event D3.

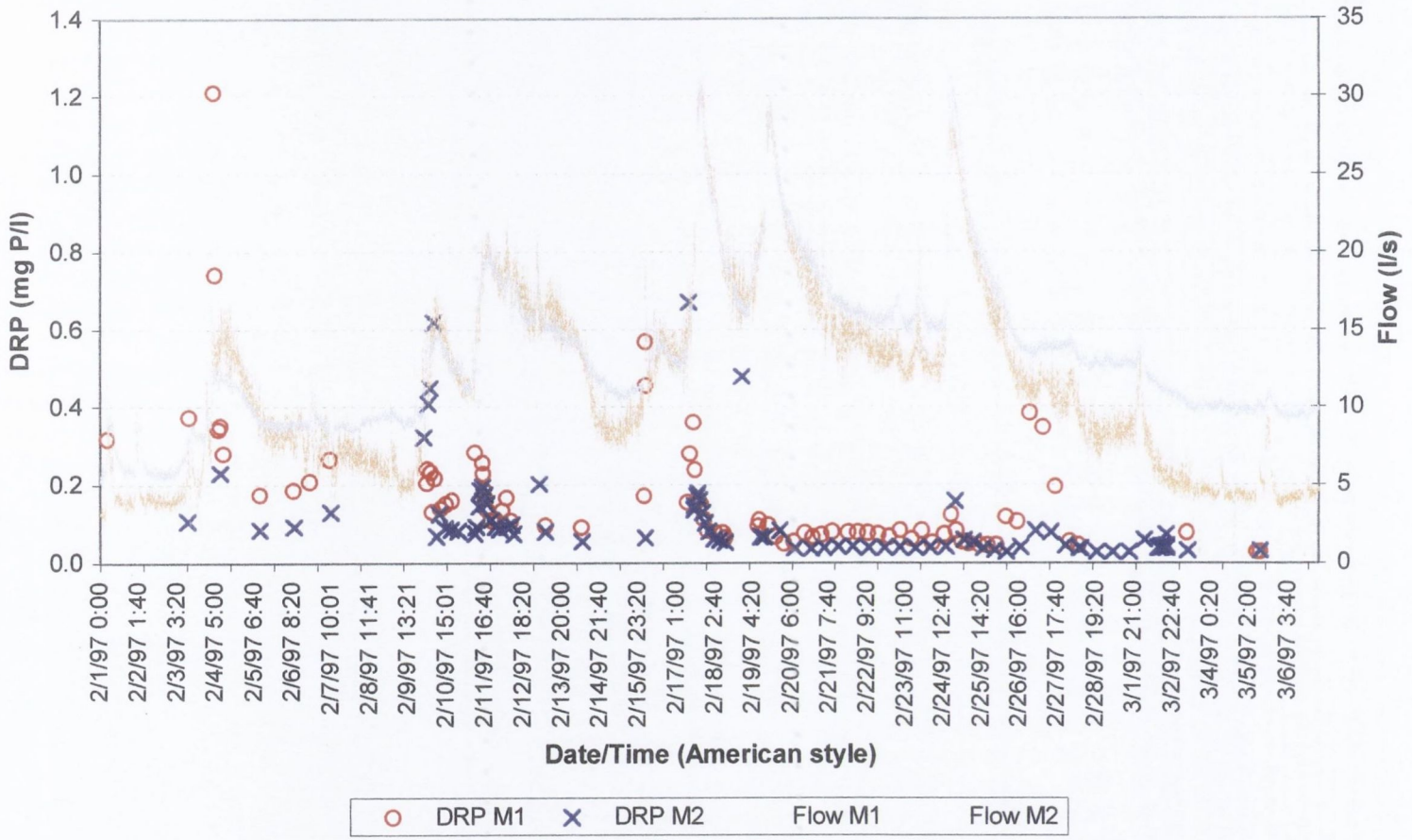


Figure 9.9: Flow (l/s) and DRP concentrations (mg P/l) at the upstream (M1) and downstream (M2) monitoring stations for event D4.

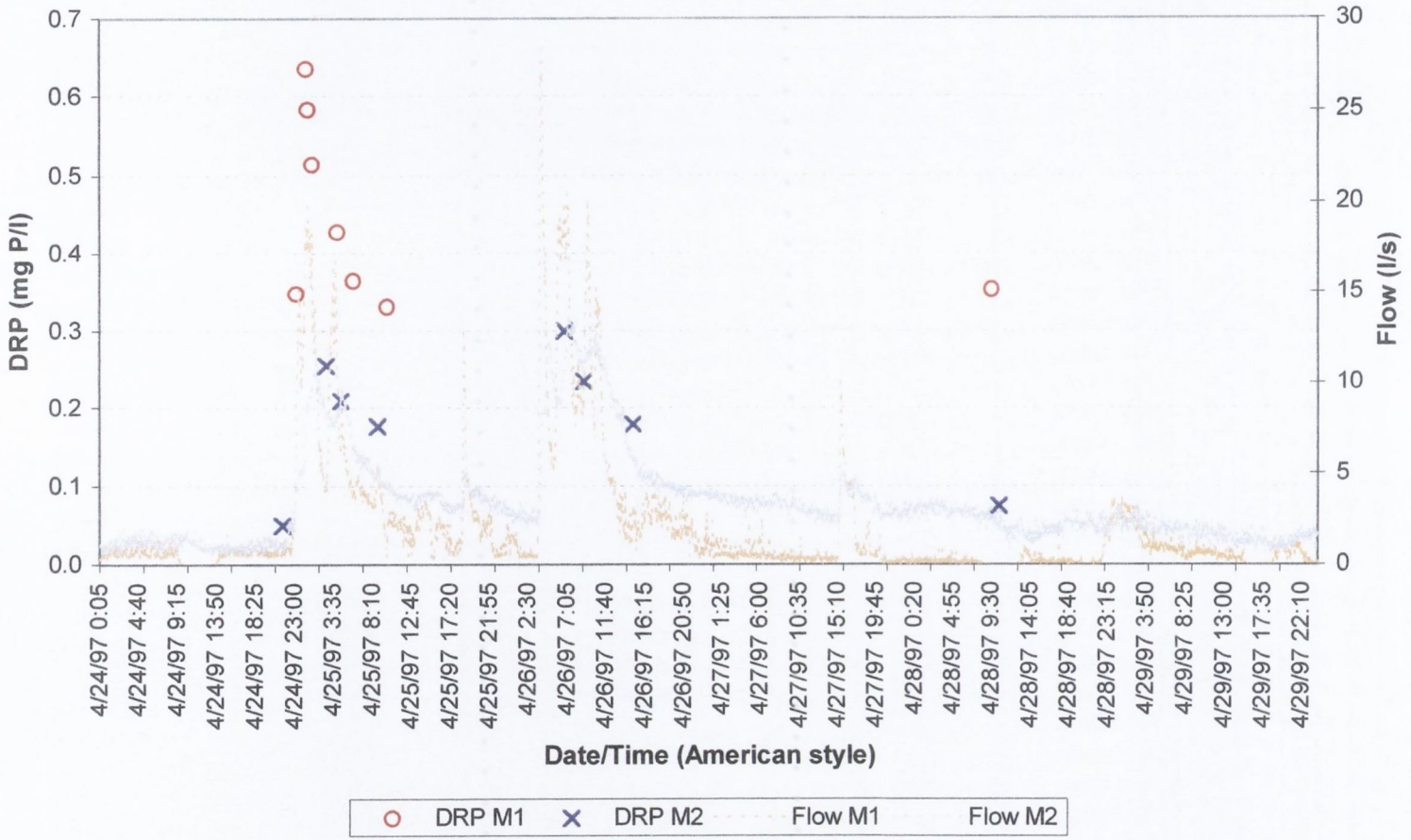


Figure 9.10: Flow (l/s) and DRP concentrations (mg P/l) at the upstream (M1) and downstream (M2) monitoring stations for event D5.

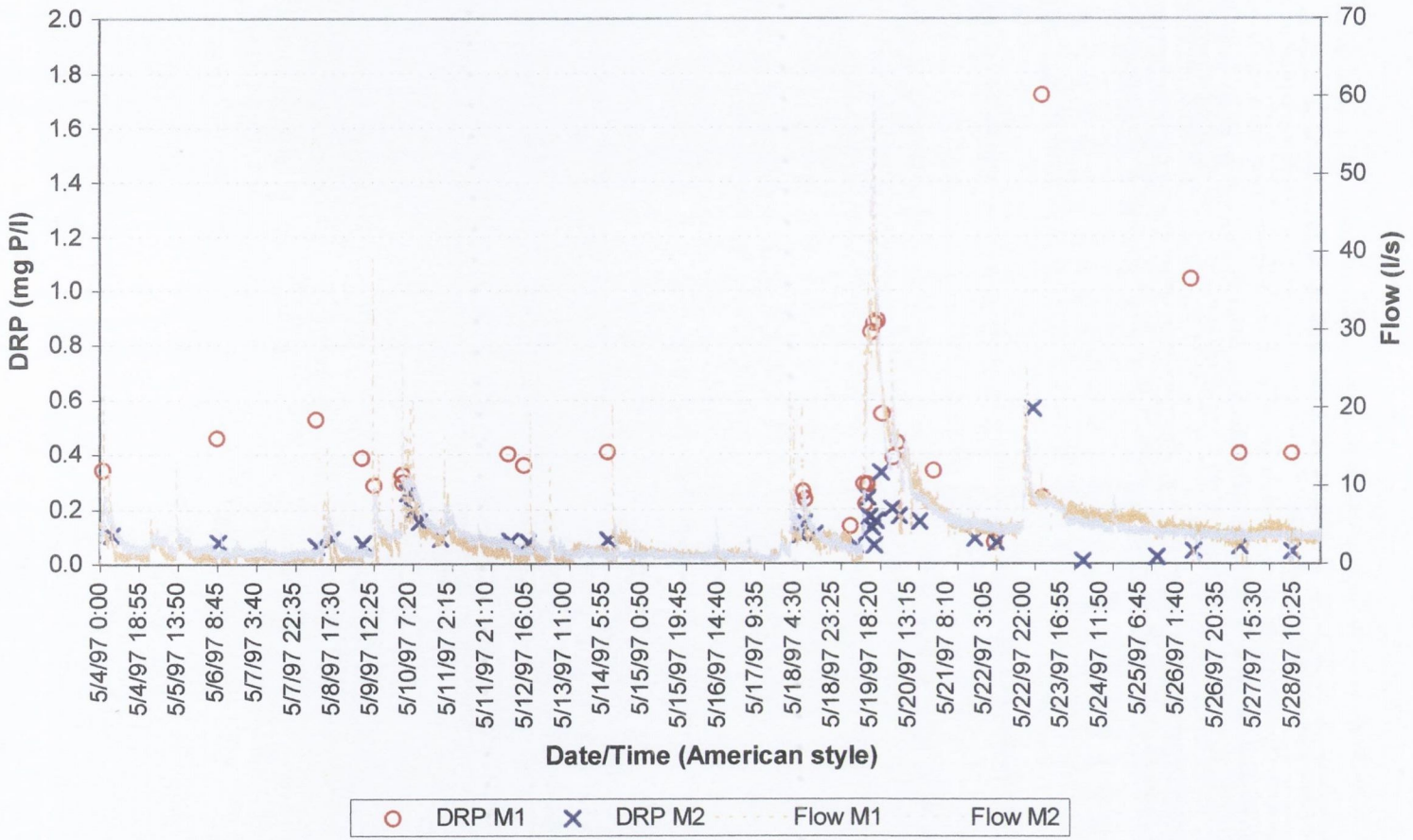


Figure 9.11: Flow (l/s) and DRP concentrations (mg P/l) at the upstream (M1) and downstream (M2) monitoring stations for event D6.

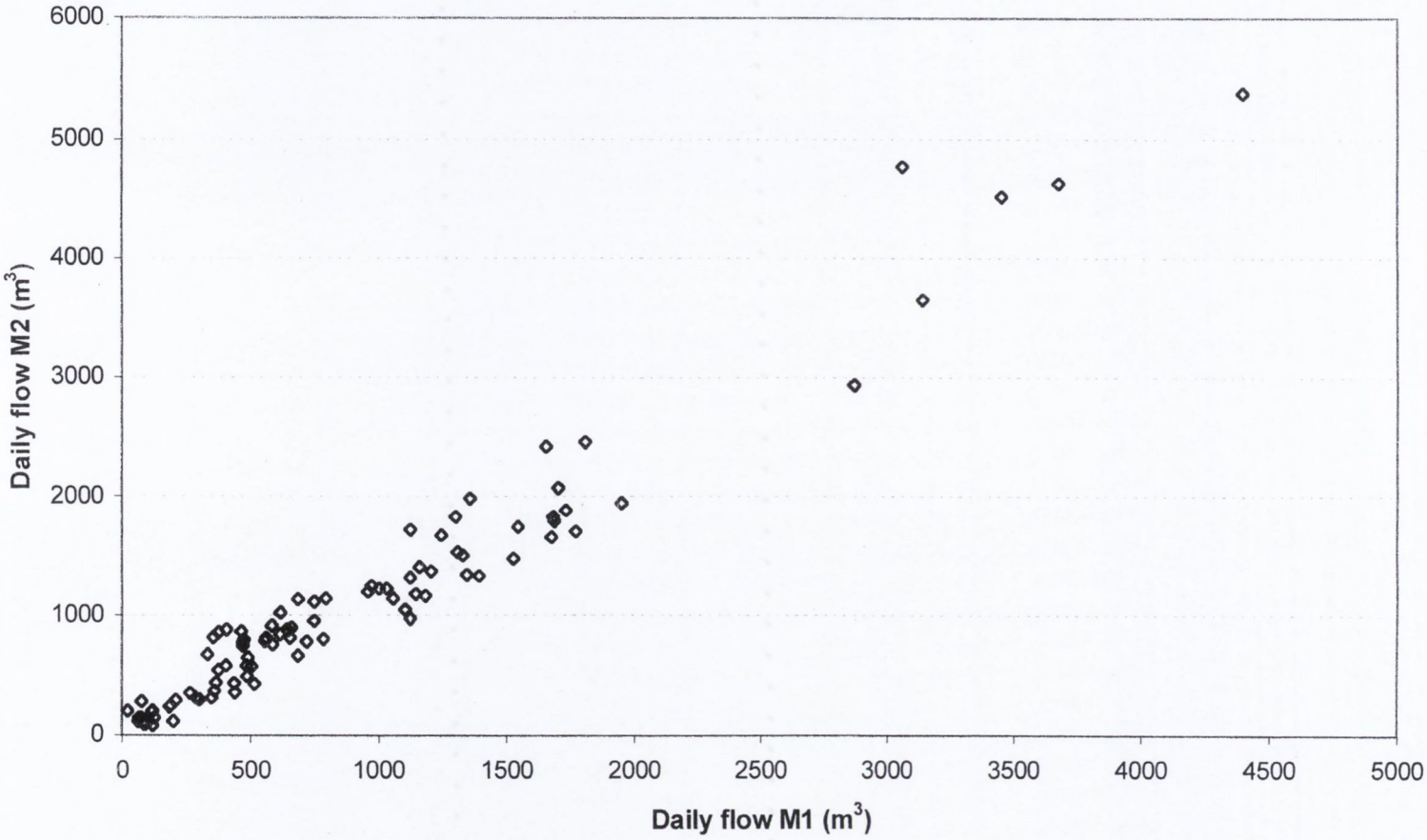


Figure 9.12: Daily flows (m^3) at the downstream monitoring station (M2) plotted against daily flows (m^3) at the u/s monitoring station.

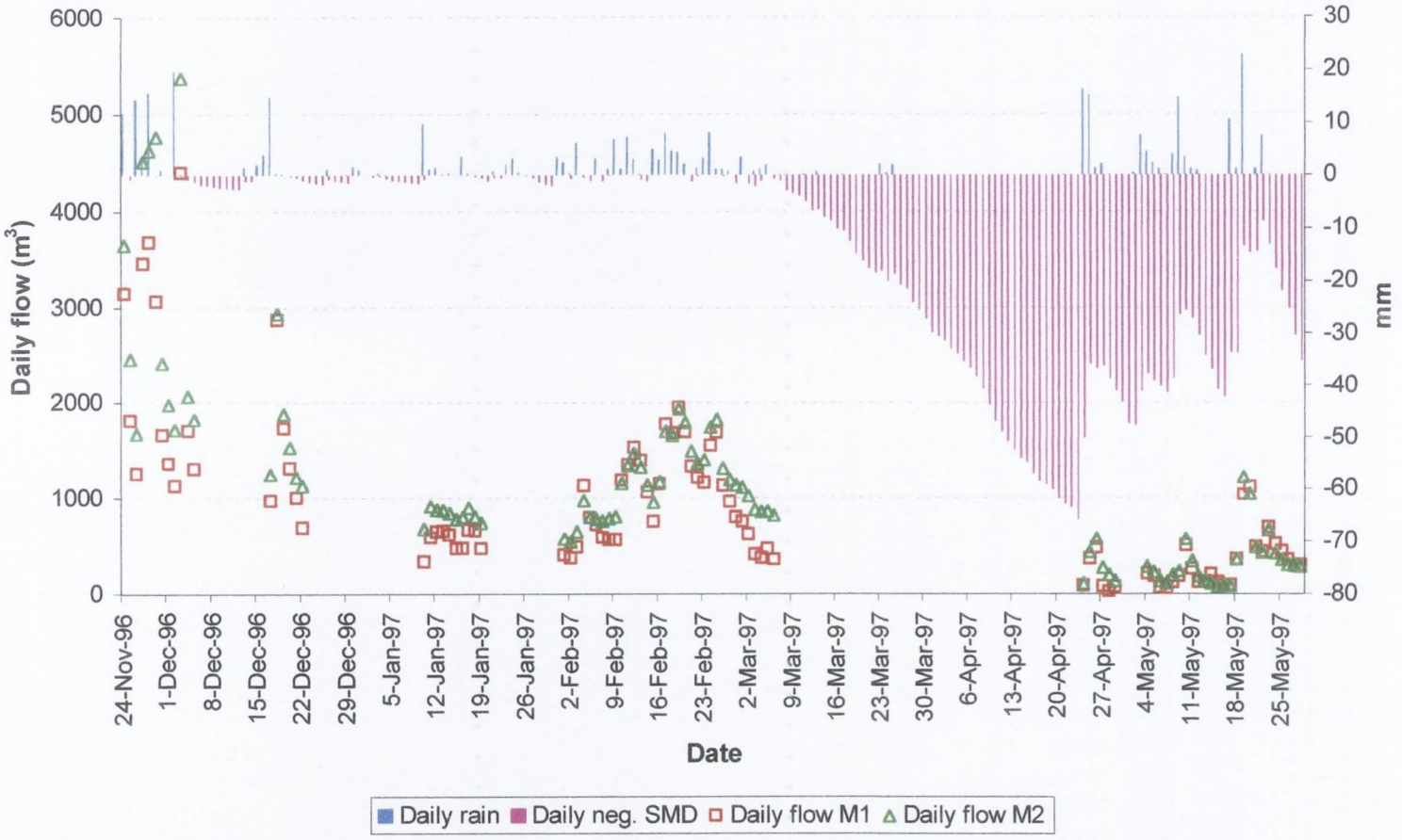


Figure 9.13: Daily amounts of rain (mm), flow (m^3) at the upstream (M1) and downstream (M2) monitoring station and the daily negative soil moisture Deficit (SMD) (mm) value.

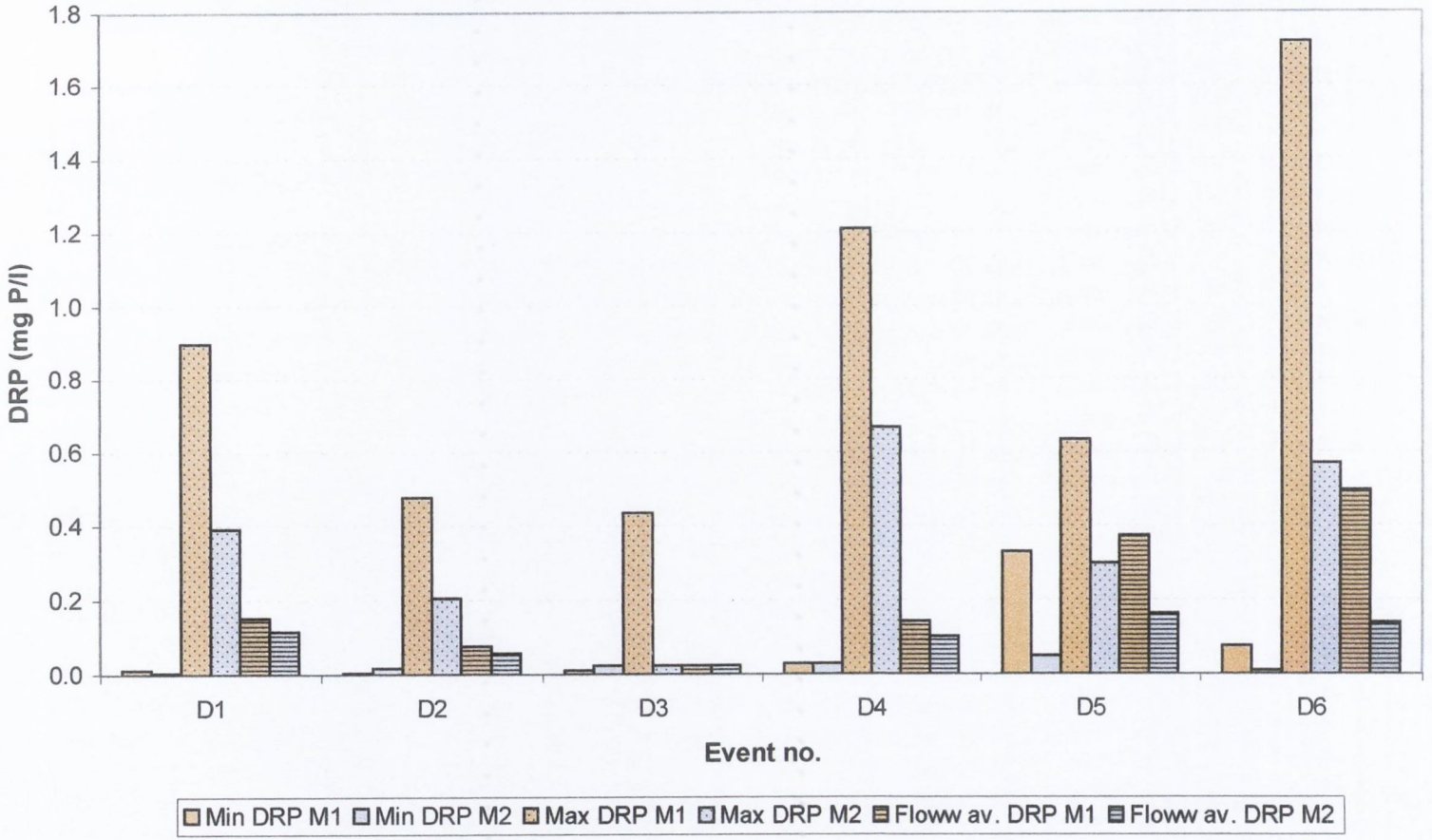


Figure 9.14: Minimum, maximum and flow-weighted average DRP concentrations (mg P/l) at the upstream (M1) and downstream (M2) monitoring stations of the Dairy Farm sub-catchment.

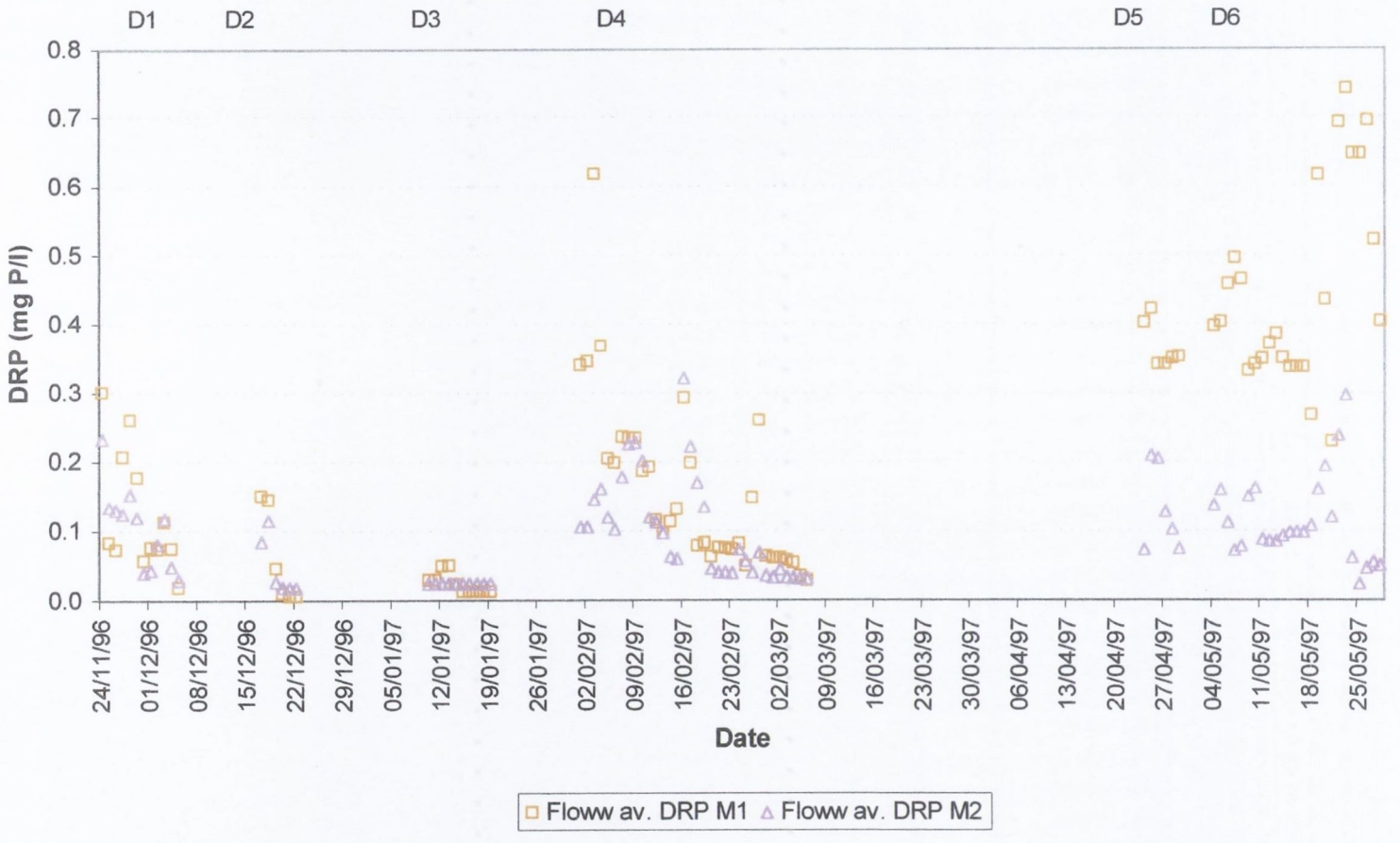


Figure 9.15: Daily flow-weighted average DRP concentrations (mg P/l) at the upstream (M1) and downstream (M2) monitoring stations.

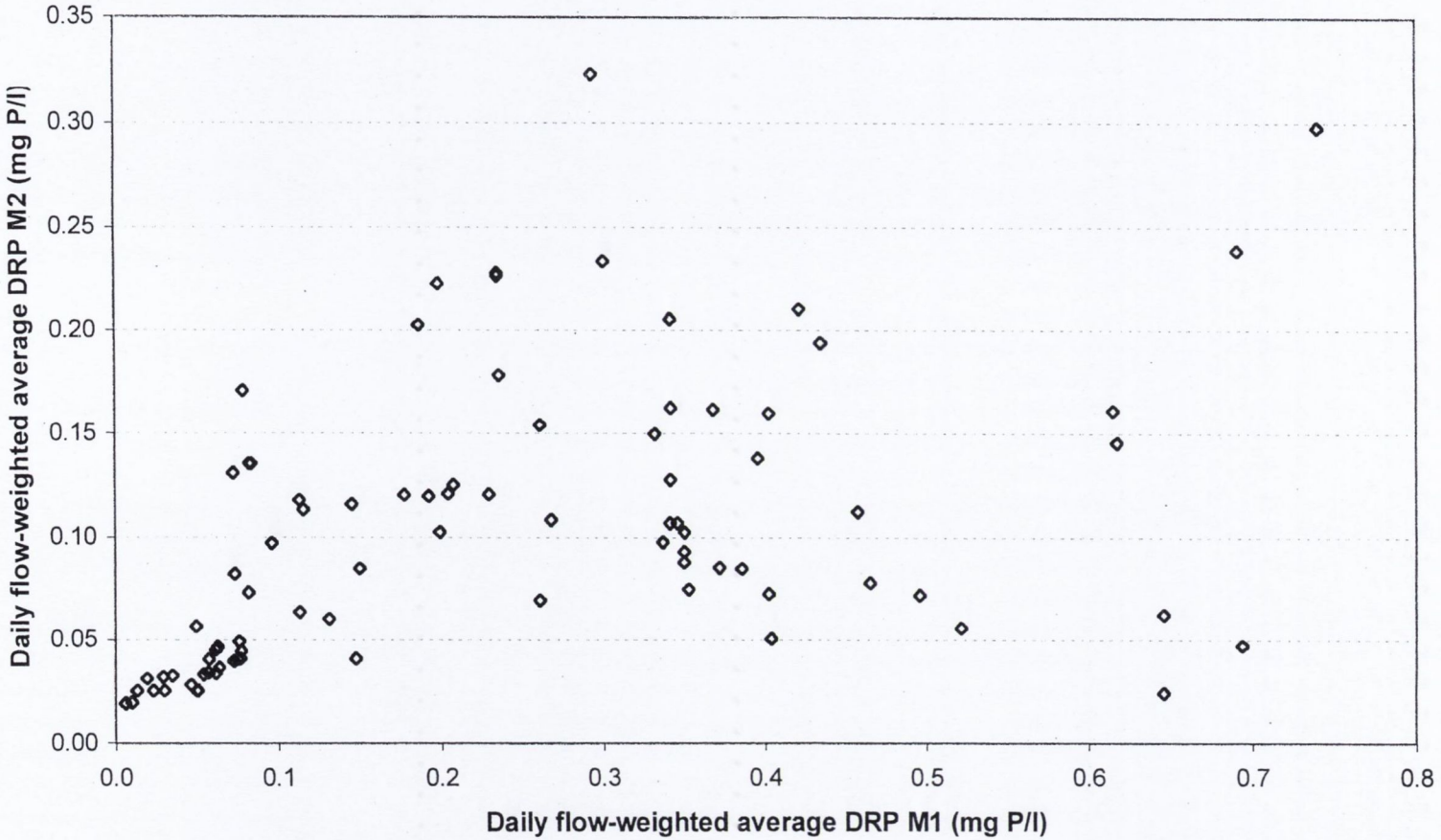


Figure 9.16: Daily flow-weighted average DRP concentrations (mg P/l) at the downstream (M2) monitoring station plotted against daily flow-weighted average DRP concentrations (mg P/l) at the upstream (M2) monitoring station.

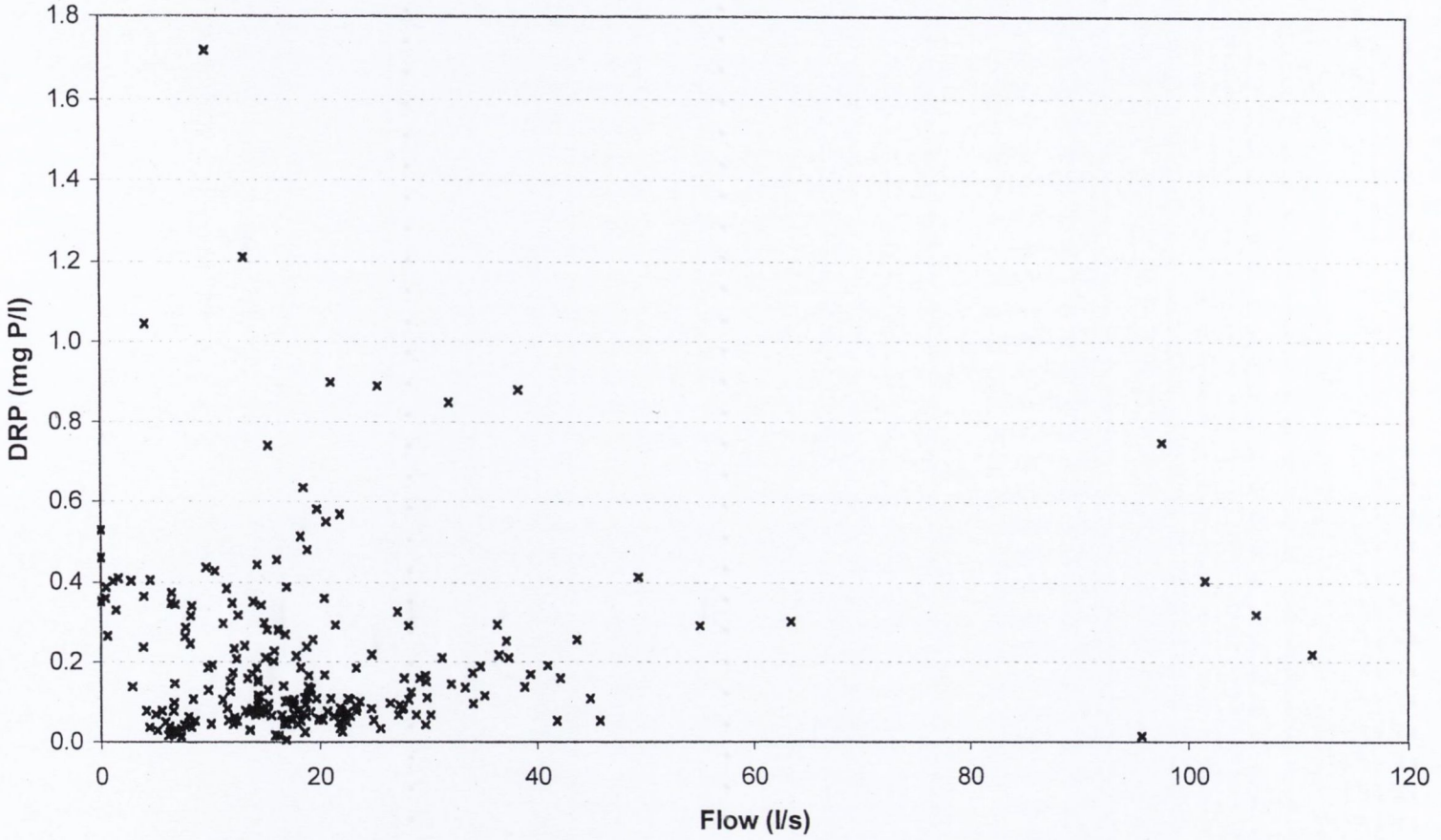


Figure 9.17: DRP concentrations (mg P/l) plotted against rates of flow (l/s) measured at the upstream monitoring station (M1).

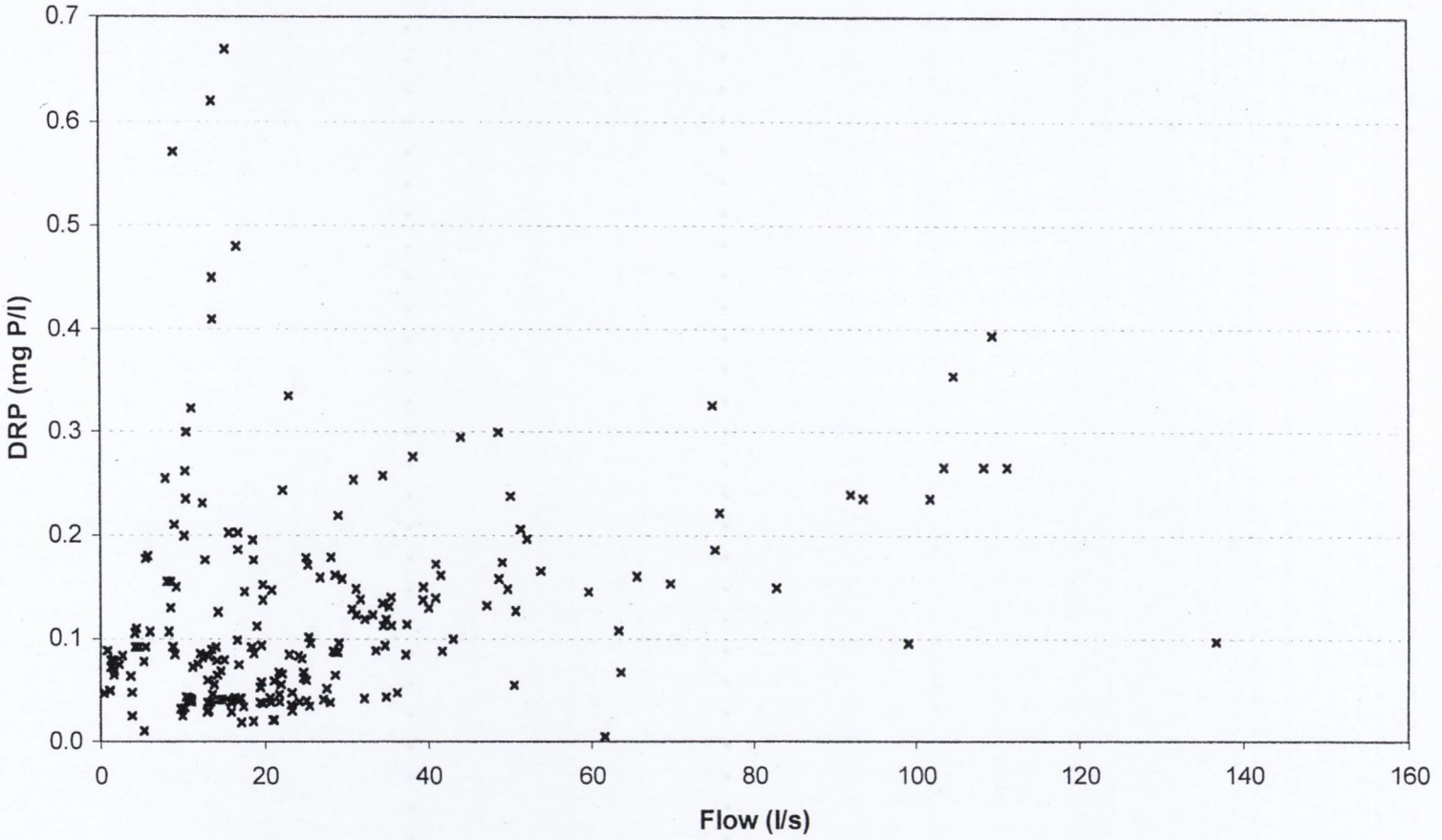


Figure 9.18: DRP concentrations (mg P/l) plotted against rates of flow (l/s) measured at the downstream monitoring station (M2).

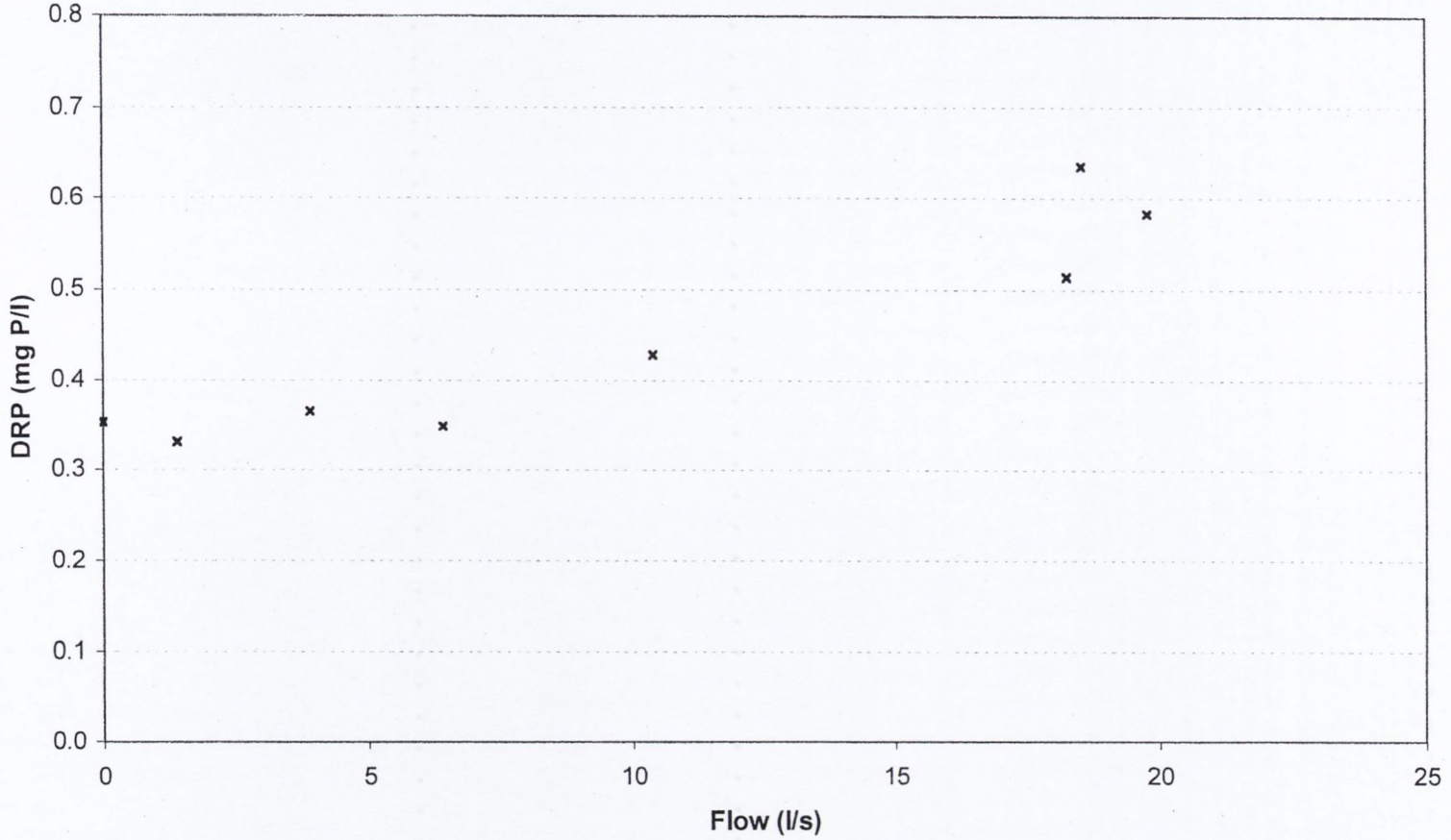


Figure 9.19: DRP concentrations (mg P/l) plotted against rates of flow (l/s) measured at the upstream monitoring station (M1) during event D5.

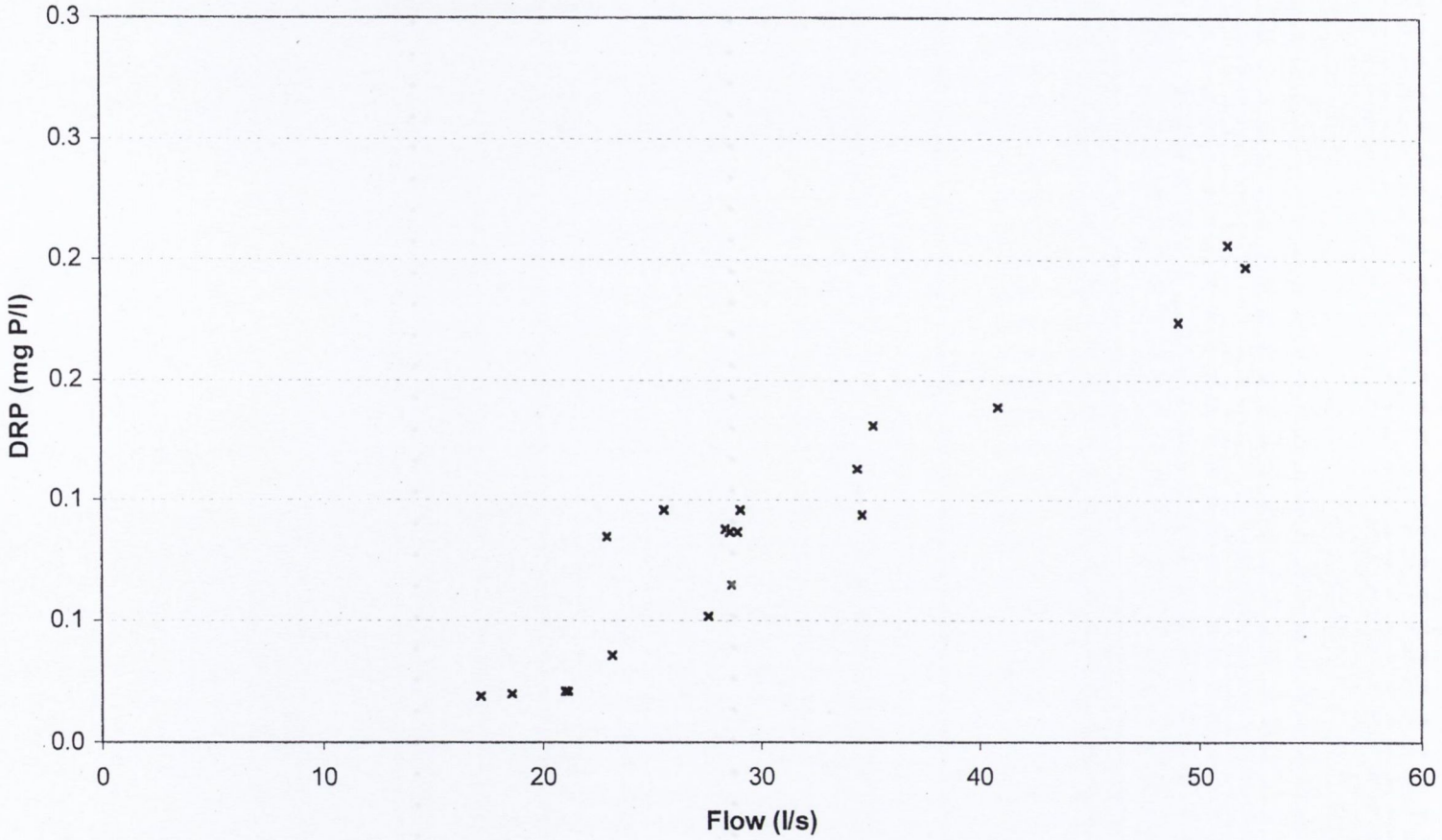


Figure 9.20: DRP concentrations (mg P/l) plotted against rates of flow (l/s) measured at the downstream monitoring station (M2) during event D2.

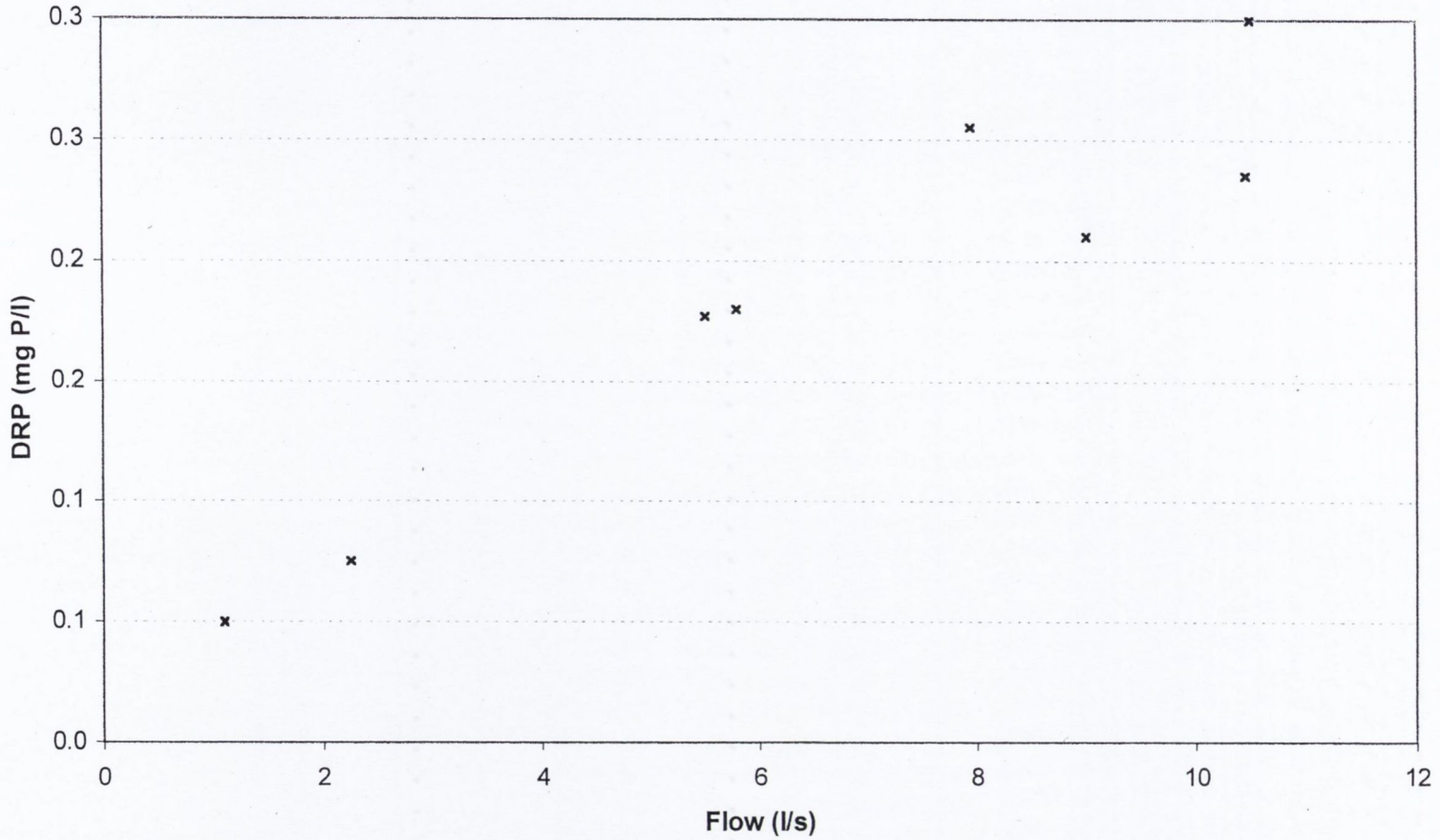


Figure 9.21: DRP concentrations (mg P/l) plotted against rates of flow (l/s) measured at the downstream monitoring station (M2) during event D5.

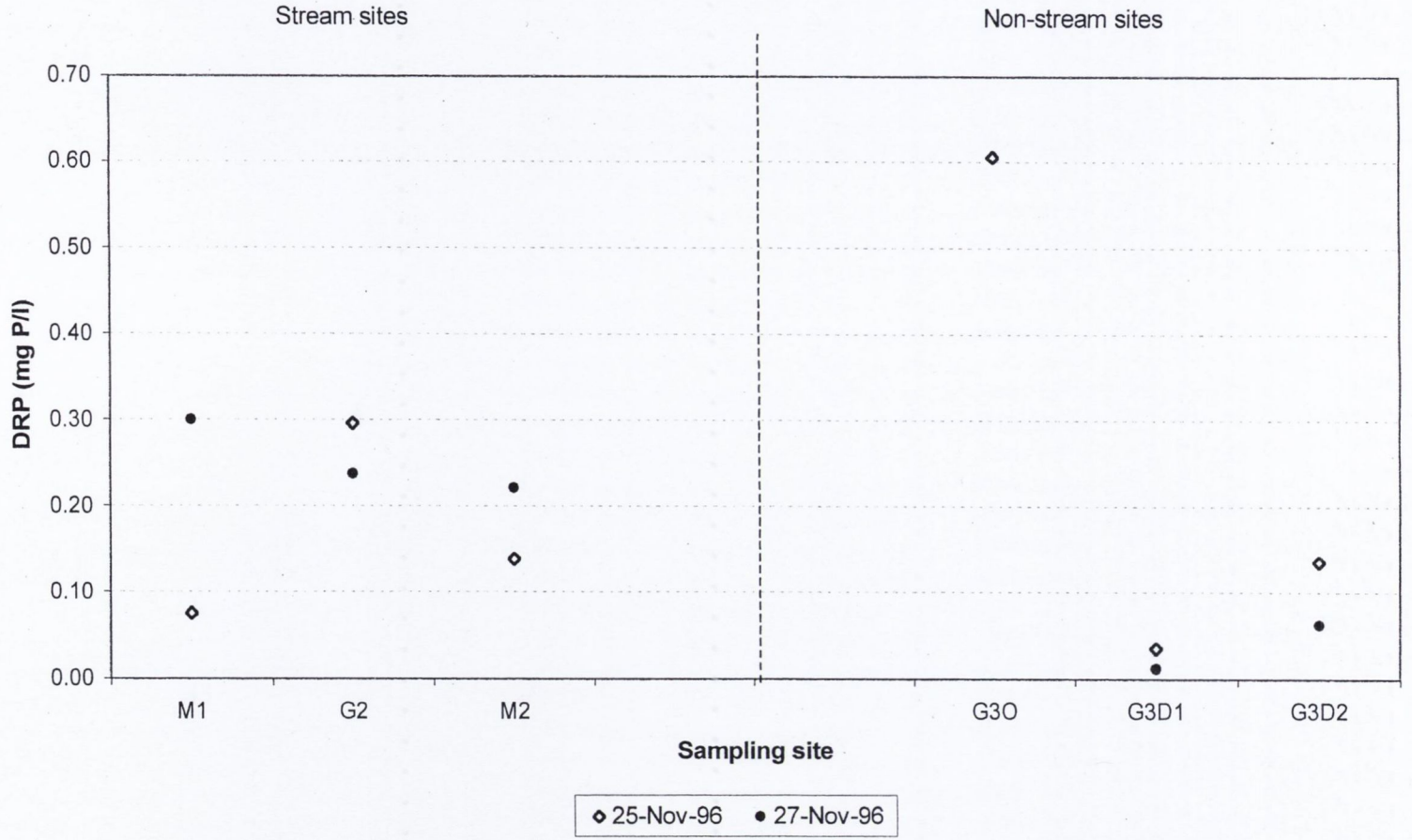


Figure 9.22: Event D1: DRP concentrations (mg P/l) of stream grab samples taken at the weir (G2) and of corresponding samples at the upstream (M1) and downstream (M2) monitoring stations, and DRP concentrations (mg P/l) of grab samples of overland flow (G3O) and flow from sbusrface drains (G3D1 and G3D2) running into the stream access hole in the middle of the Dairy Farm.

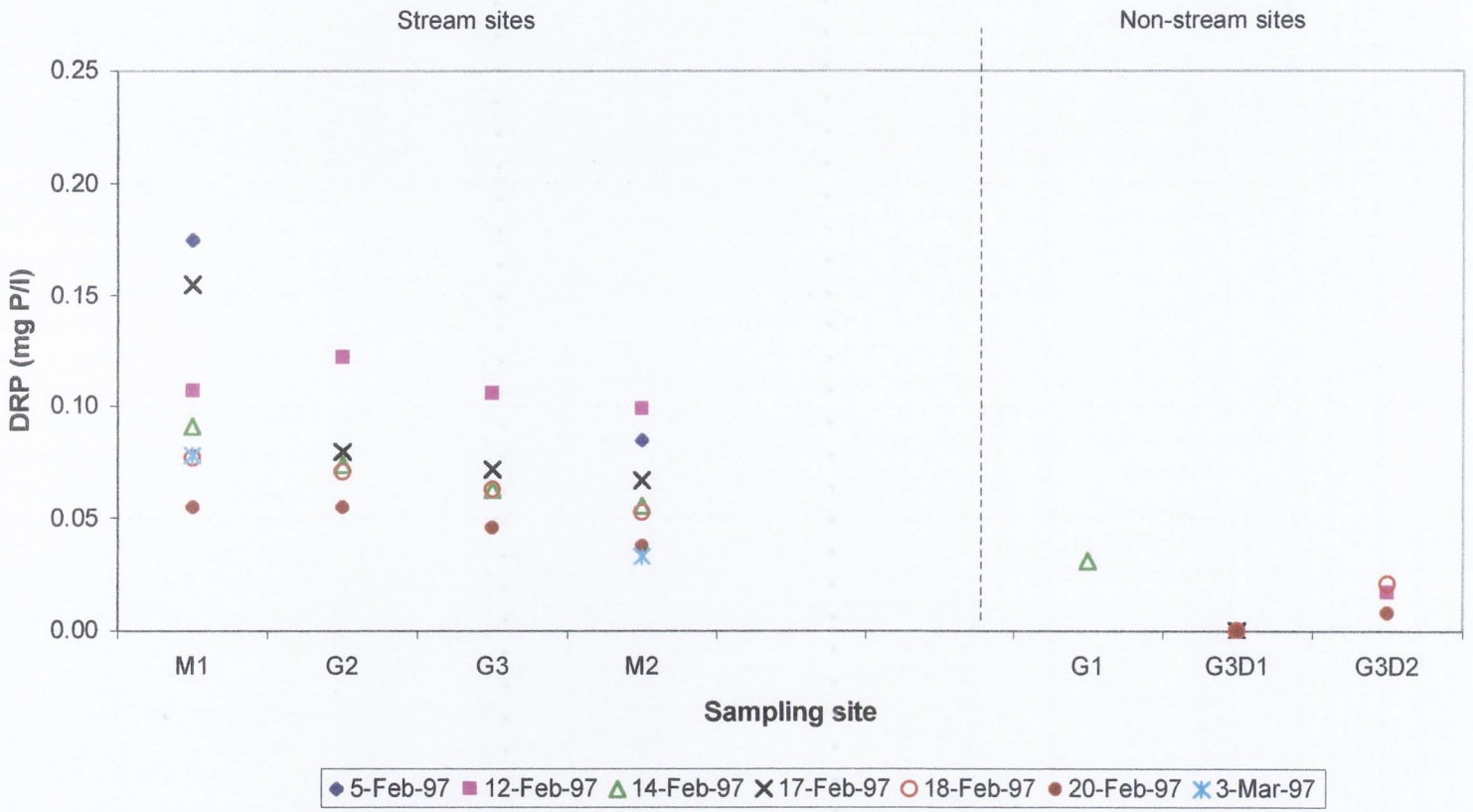


Figure 9.23: Event D4: DRP concentrations (mg P/l) of stream grab samples taken at the tank at the Beef Unit (A2), at the stream access hole at the castle wall (A3), at the weir (G2) and at the stream access hole in the middle of the Dairy Farm (G3), and of corresponding samples at the upstream (M1) and downstream (M2) monitoring stations. DRP concentrations (mg P/l) of grab samples taken at the drain catching the spring north of the Bogwood (G1) and at the subsurface drains (G3D1 and G3D2) running into the stream access hole in the middle of the Dairy Farm (G3).

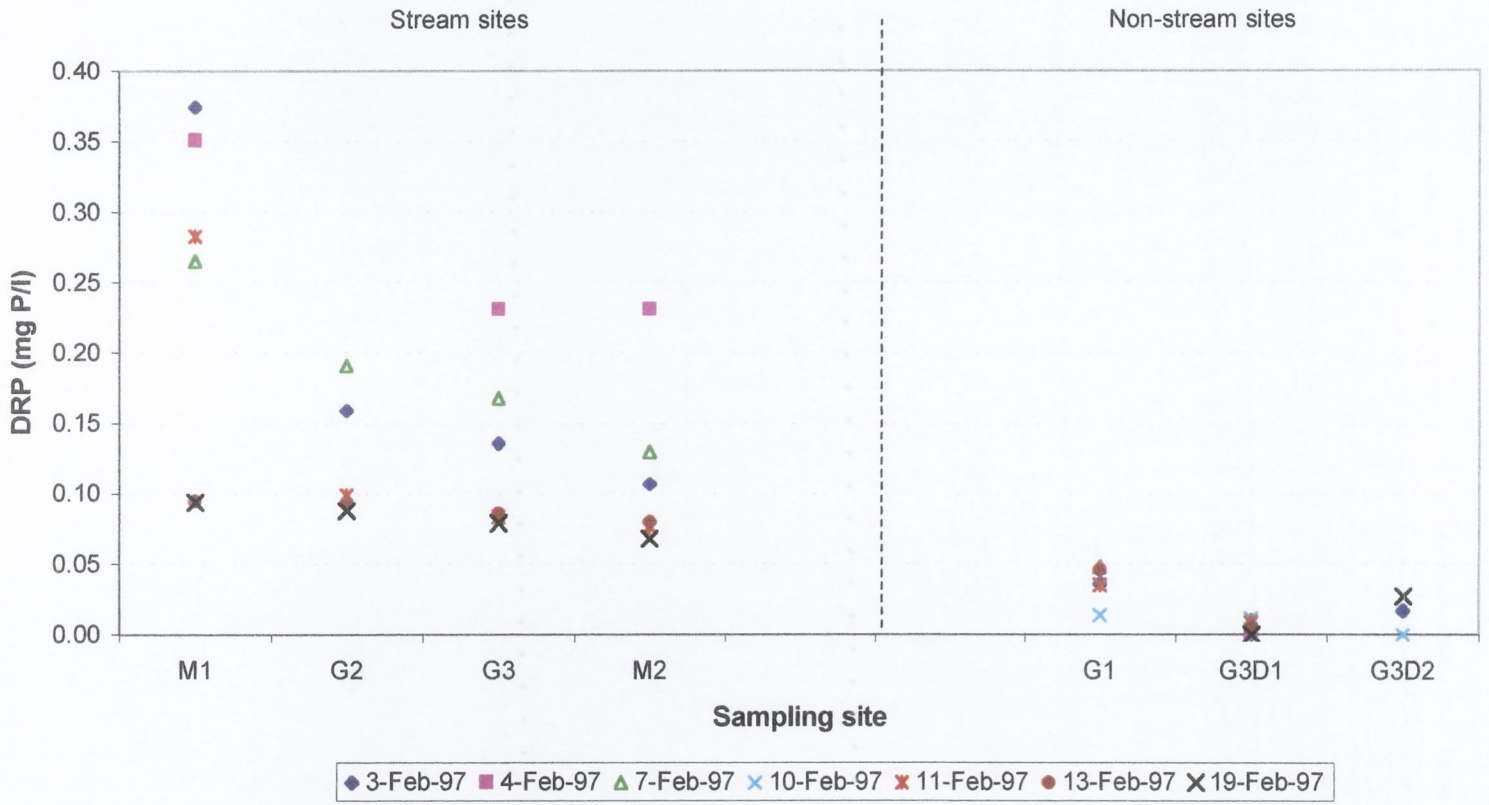


Figure 9.24: Event D4: DRP concentrations (mg P/l) of stream grab samples (days when tank at the Beef Unit (A2) not sampled) taken at the weir (G2) and at the stream access hole in the middle of the Dairy Farm (G3), and of corresponding samples at the upstream (M1) and downstream (M2) monitoring stations. DRP concentrations (mg P/l) of grab samples taken at the drain catching the spring north of the Bogwood (G1) and at the subsurface drains (G3D1 and G3D2) running into the stream access hole in the middle of the Dairy Farm (G3).

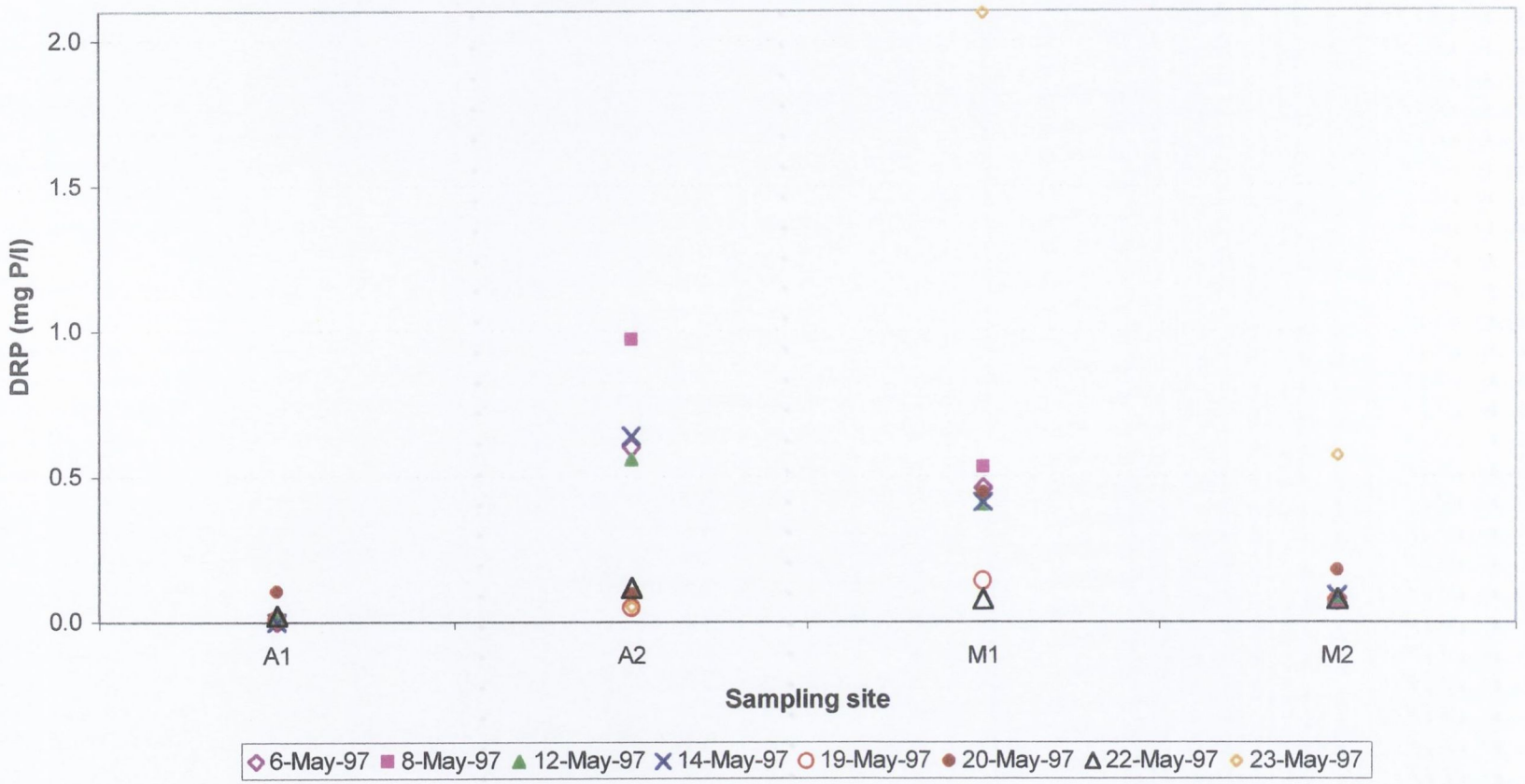


Figure 9.25: Event D6: DRP concentrations of grab samples taken at drain at the Beef Unit (A1) and at the tank at the Beef Unit (A2), and of corresponding samples at the upstream (M1) and downstream (M2) monitoring stations.

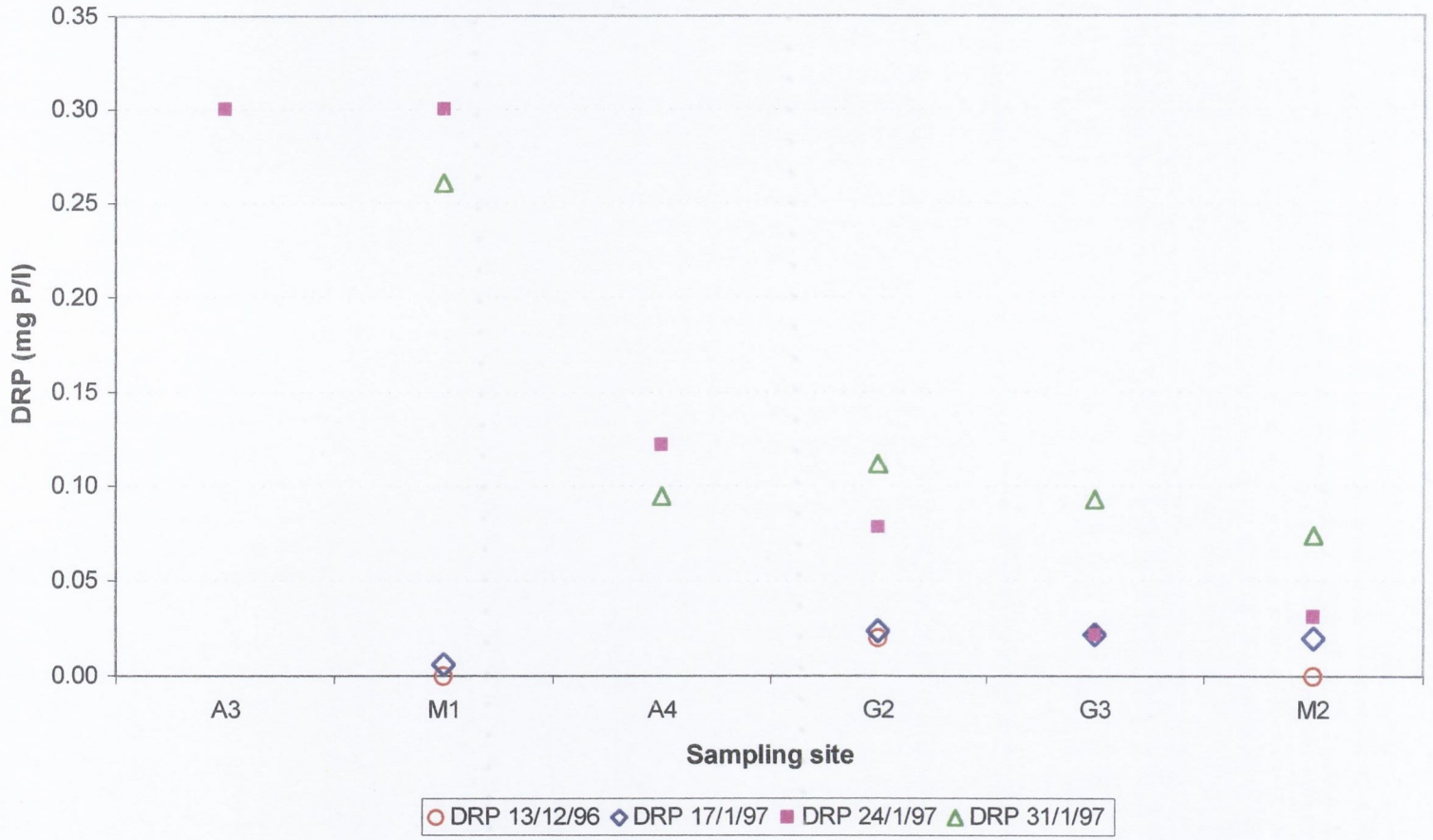


Figure 9.26: Low flow grab sampling December 1996 to end of January 1997: DRP concentrations (mg P/l) of samples taken at the stream access hole at the castle wall (A3), at the end of the Bogwood (A4) at the weir (G2), at the stream access hole in the middle of the Dairy Farm (G3), at the upstream (M1) and at the downstream (M2) monitoring stations.

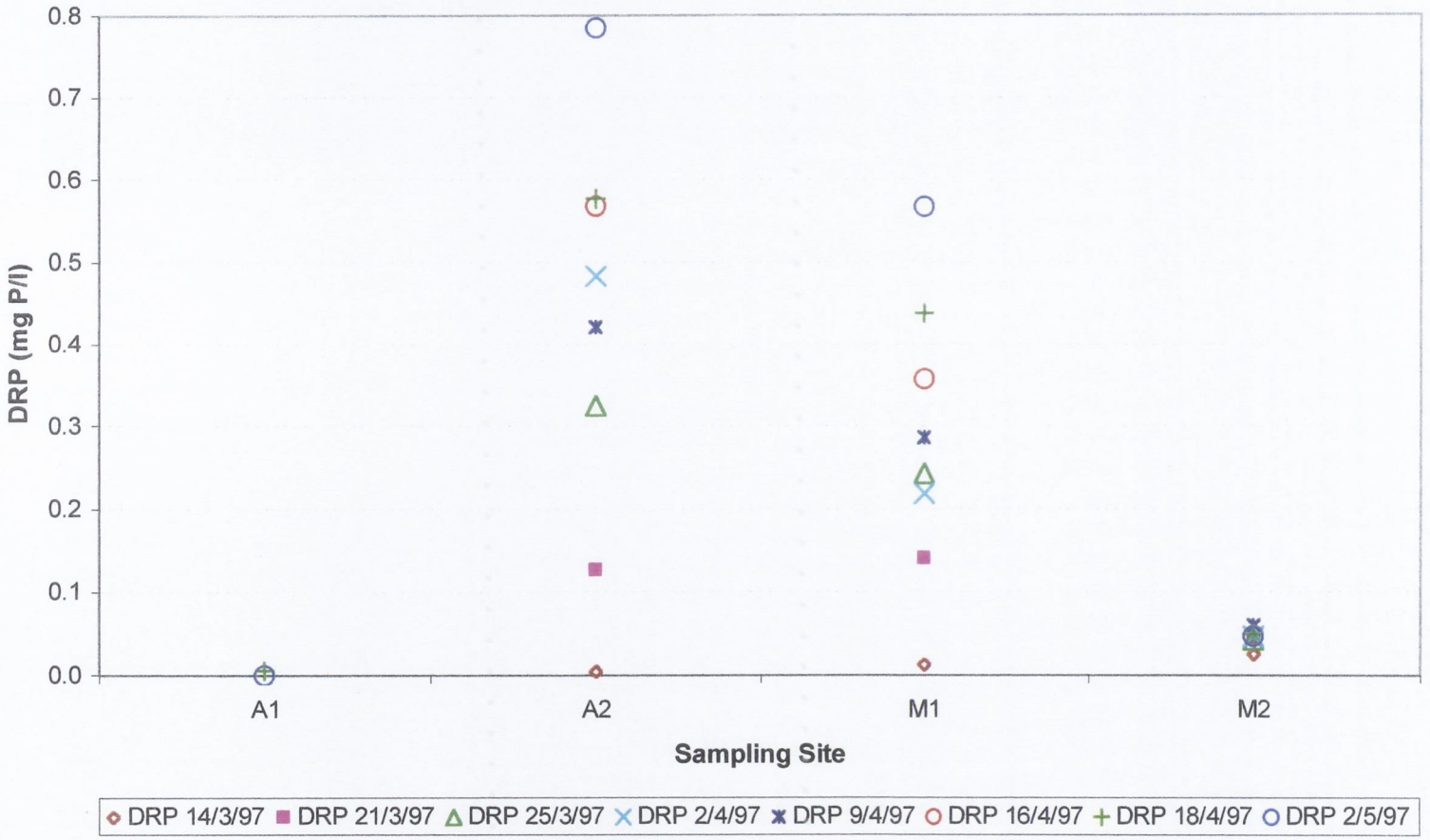


Figure 9.27: Low flow grab sampling March 1997 to 2nd May 1997: DRP concentrations (mg P/l) of samples taken at the drain at the Beef Unit (A1), at the tank at the Beef Unit (A2), at the upstream (M1) and at the downstream (M2) monitoring stations.

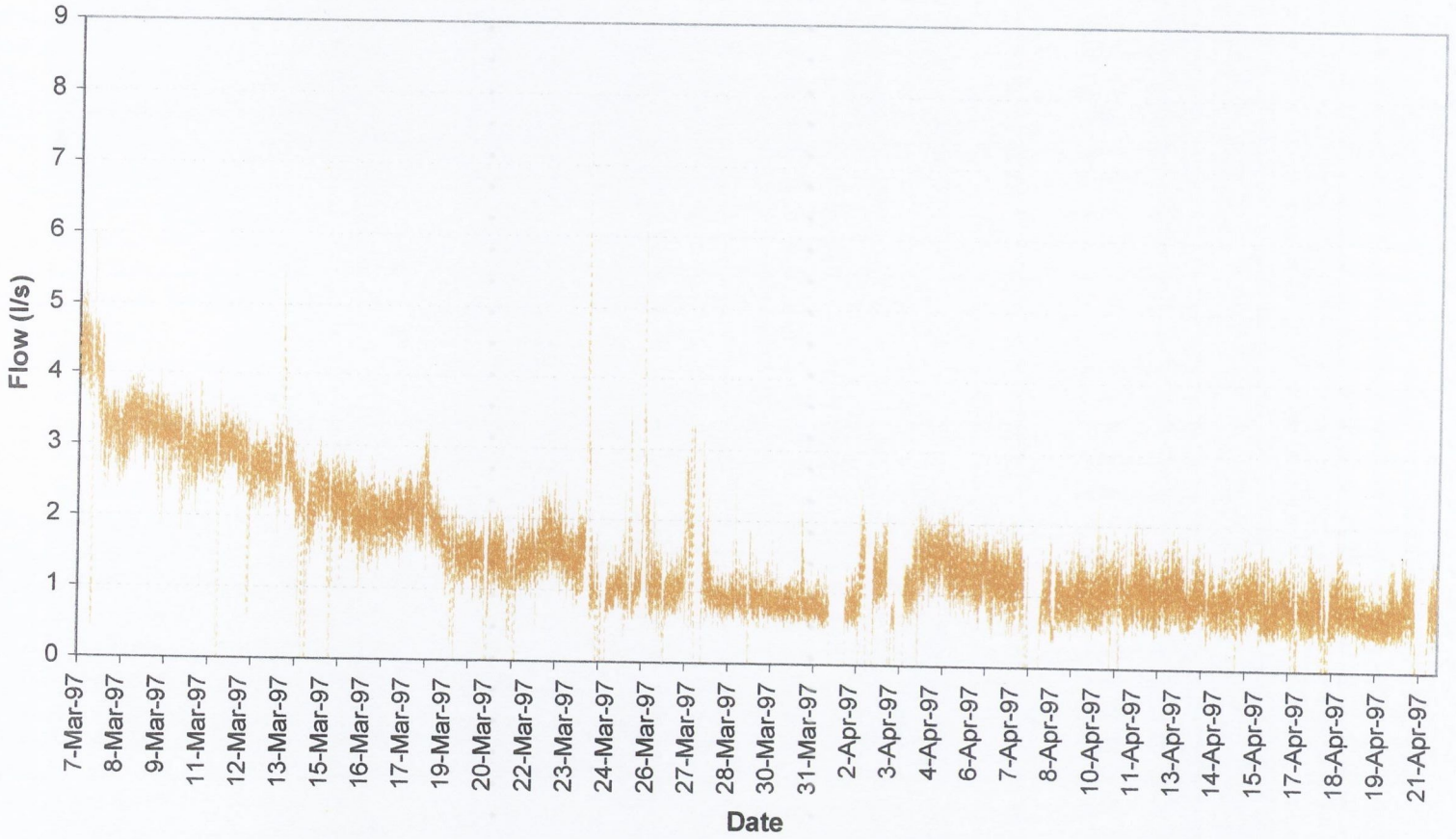


Figure 9.28: Rates of flow at the u/s monitoring station at the Dairy Farm 7th March to 21st April.

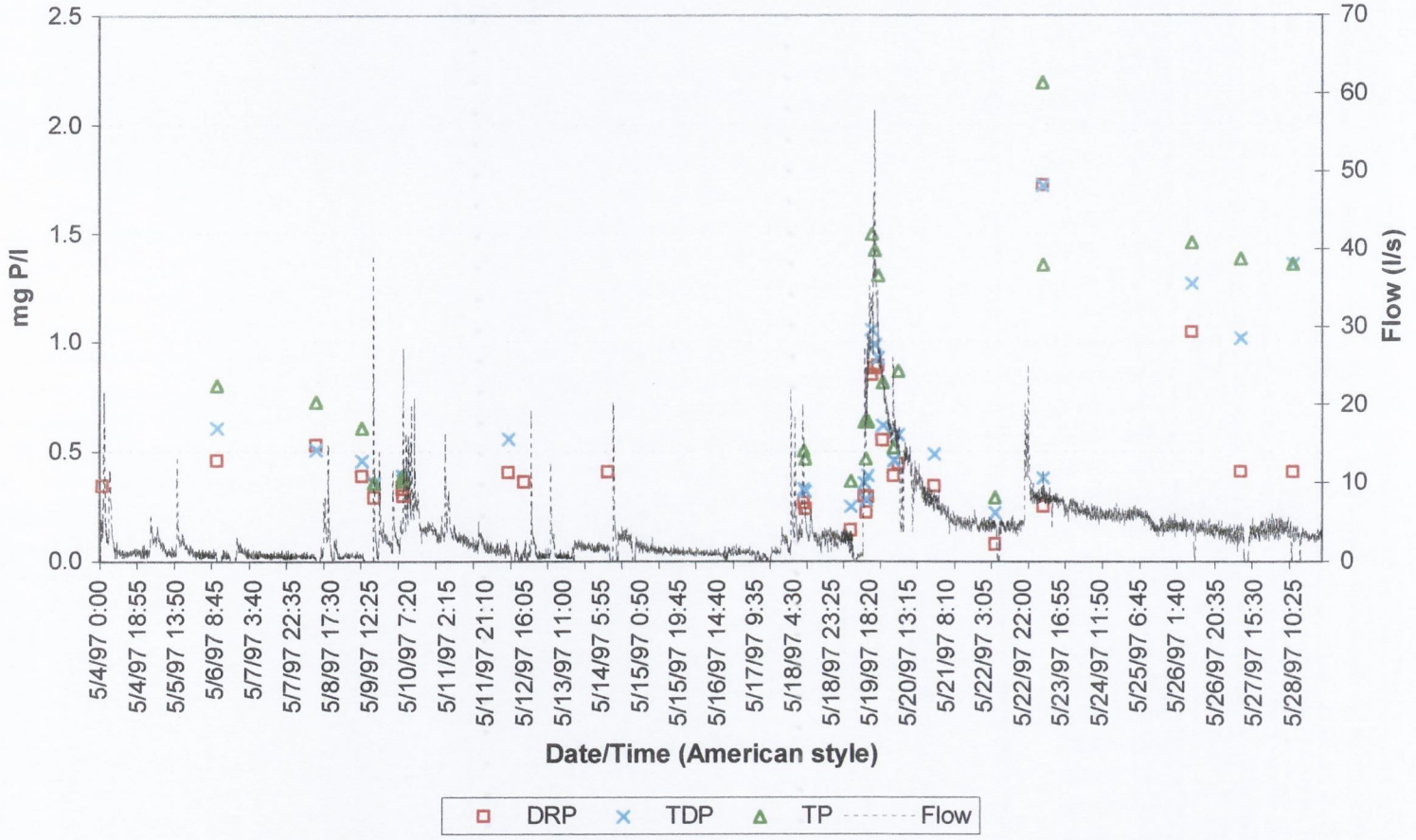


Figure 9.29: Flow (l/s) and DRP (mg P/l), TDP (mg P/l) and TP (mg P/l) concentrations for event D6 at the upstream monitoring station (M1).

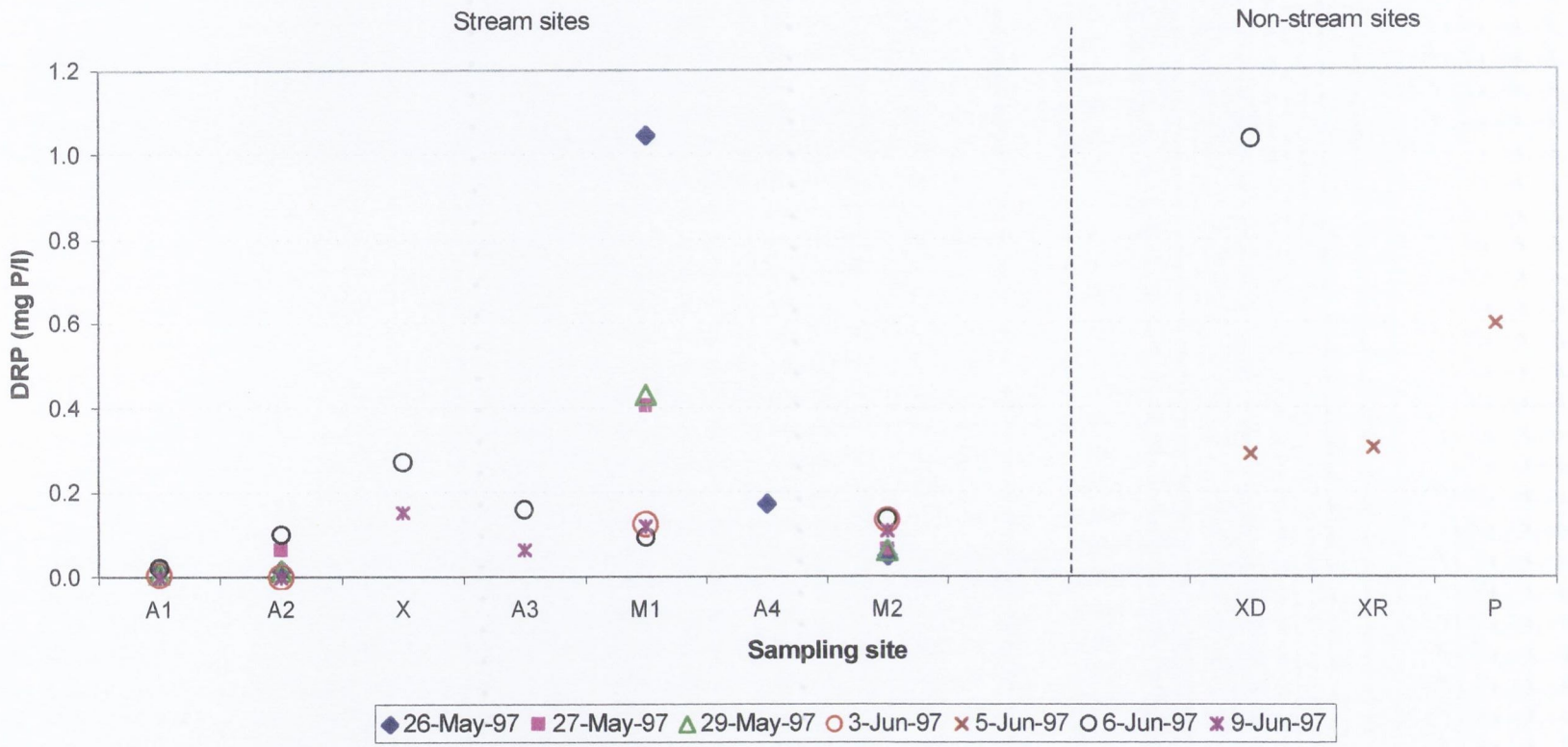


Figure 9.30: Pollution incident: DRP concentrations (mg P/l) of stream samples taken at the drain at the Beef Unit (A1), at the tank at the Beef Unit (A2), at the access hole (X) to the underground pipe leading from A2 to A3, at the stream access hole at the castle wall (A3), at the end of the Bogwood (A4), at the upstream (M1) and downstream (M2) monitoring stations. DRP concentrations (mg P/l) in samples from a drain discharging into to the underground pipe leading from A2 to A3 at X, of overland flow from the road (XR) and at the discharge pipe from the peat filter beds.

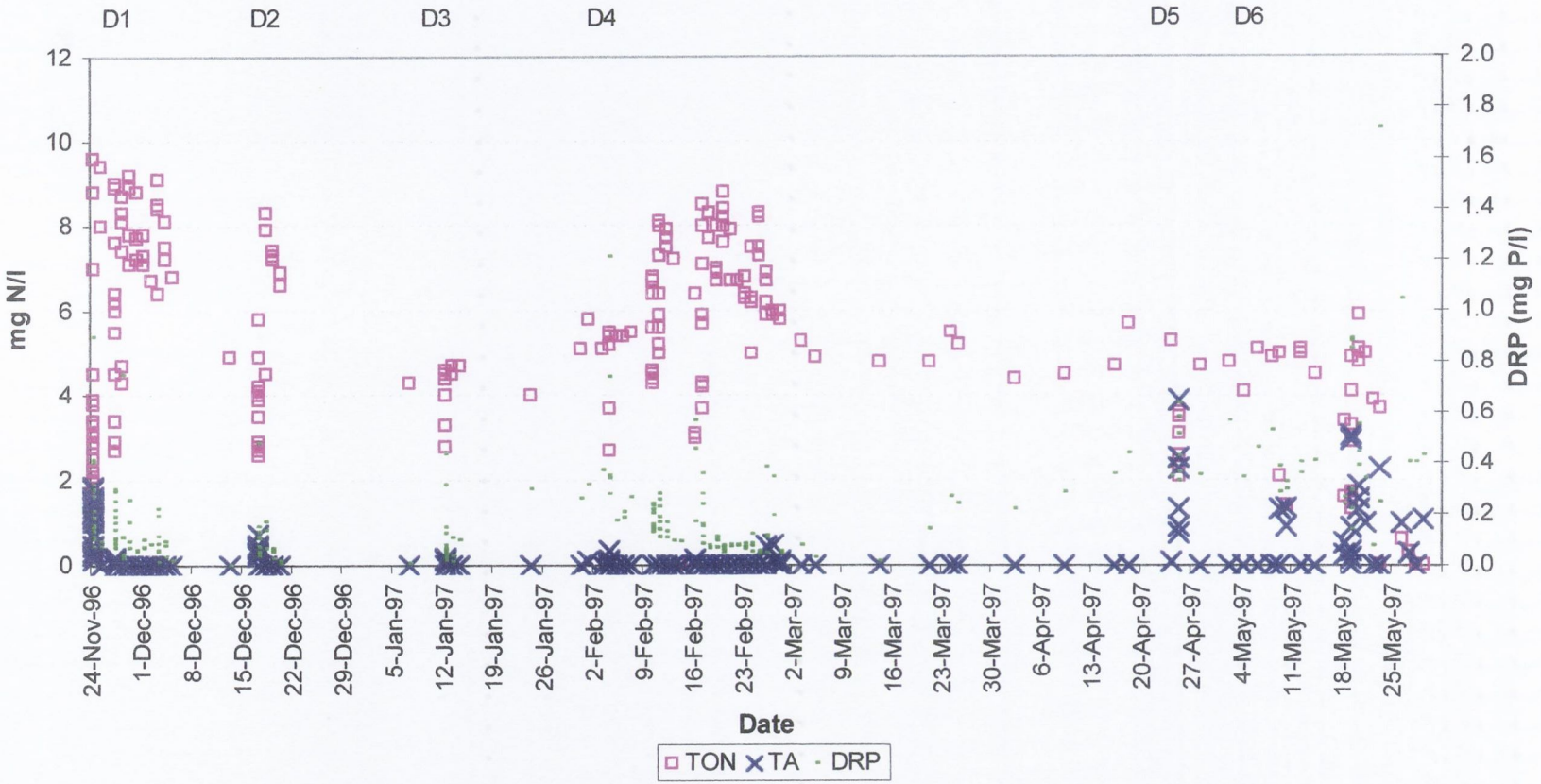


Figure 9.31: Total oxidised nitrogen (TON), total ammonia (TA) (mg/l) and DRP (mg P/l) concentrations at the upstream monitoring station (M1).

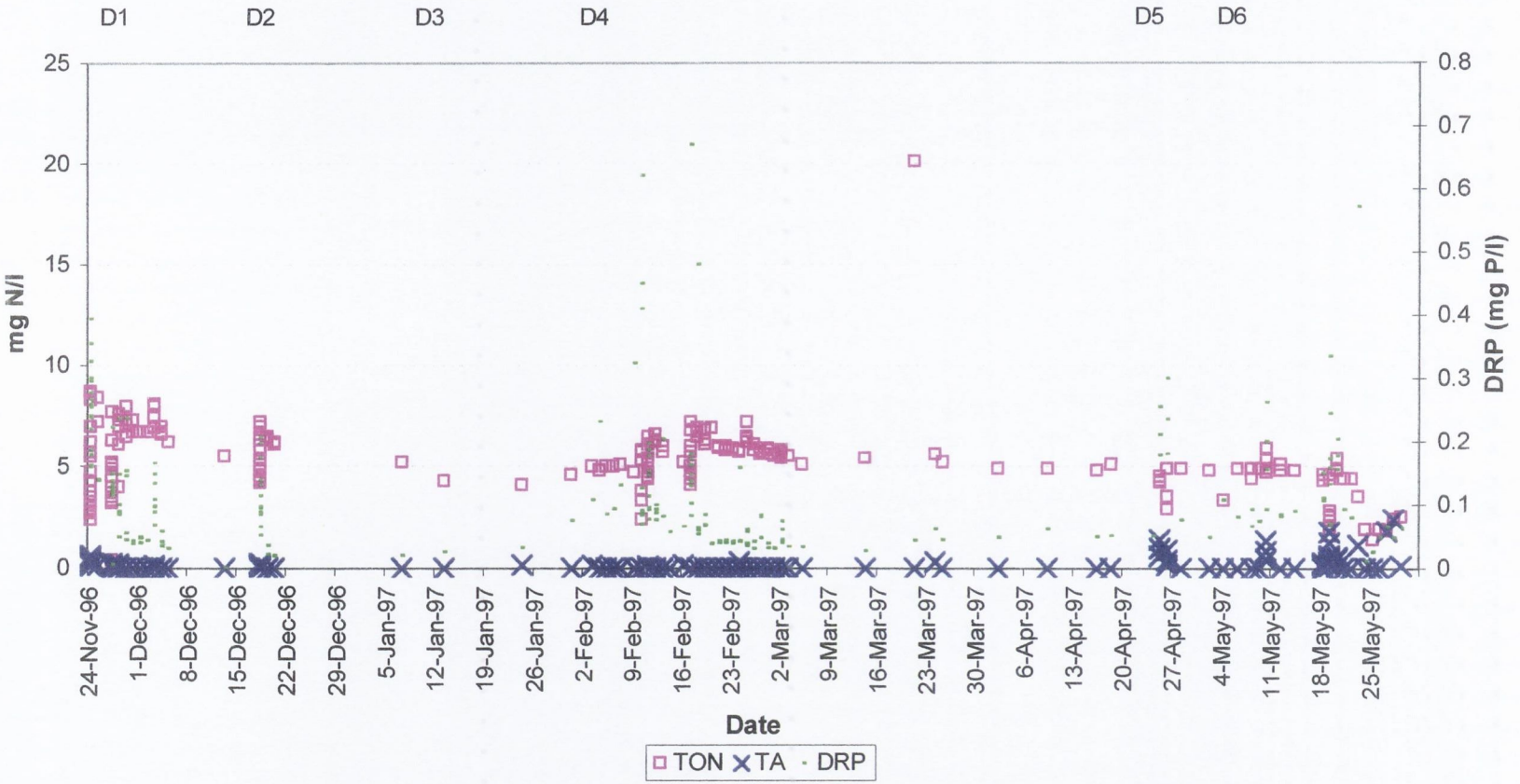


Figure 9.32: Total oxidised nitrogen (TON), total ammonia (TA) and DRP (mg P/l) concentrations at the downstream monitoring station (M2).

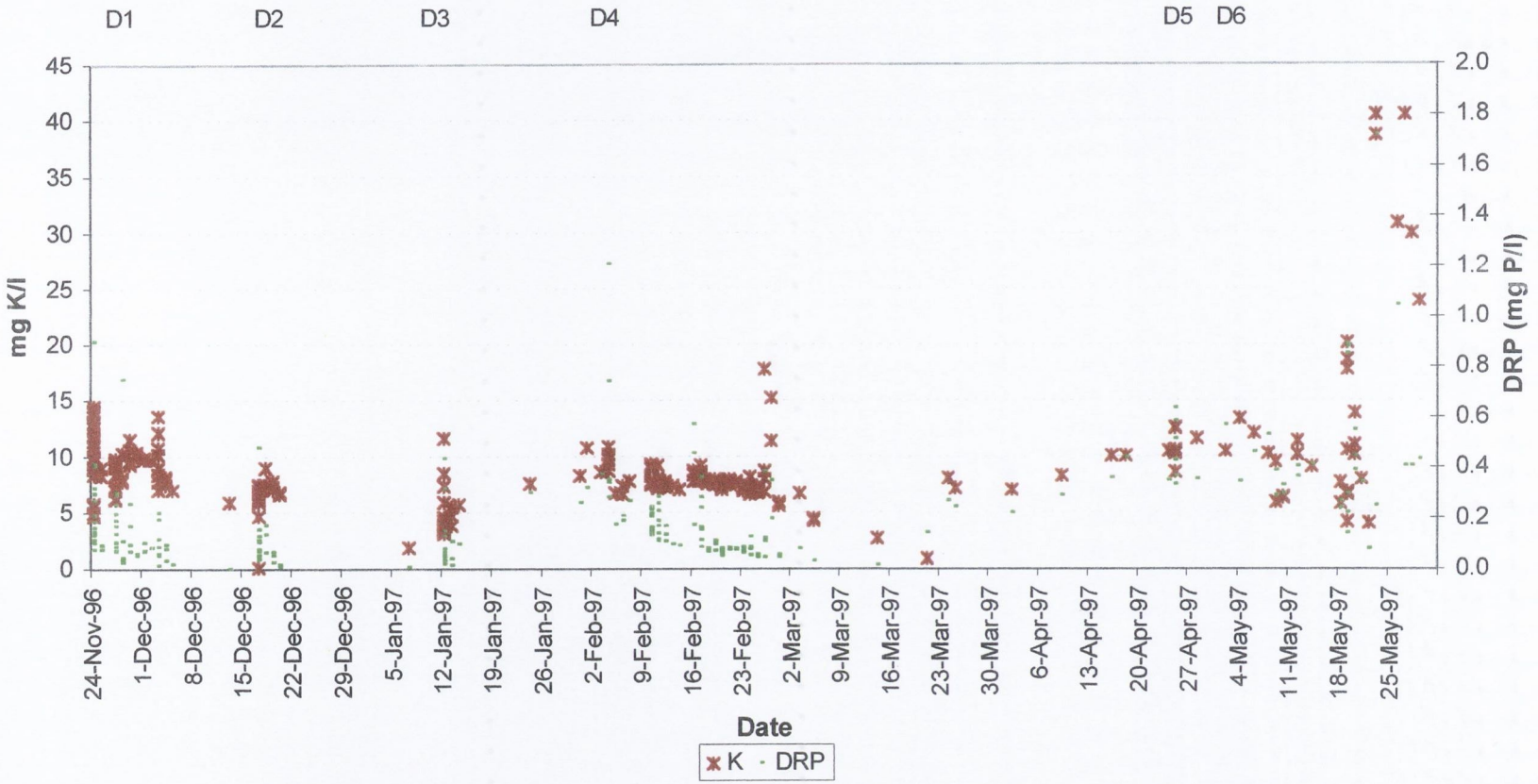


Figure 9.33: Potassium (K) (mg/l) and DRP (mg P/l) concentrations at the upstream monitoring station (M1).

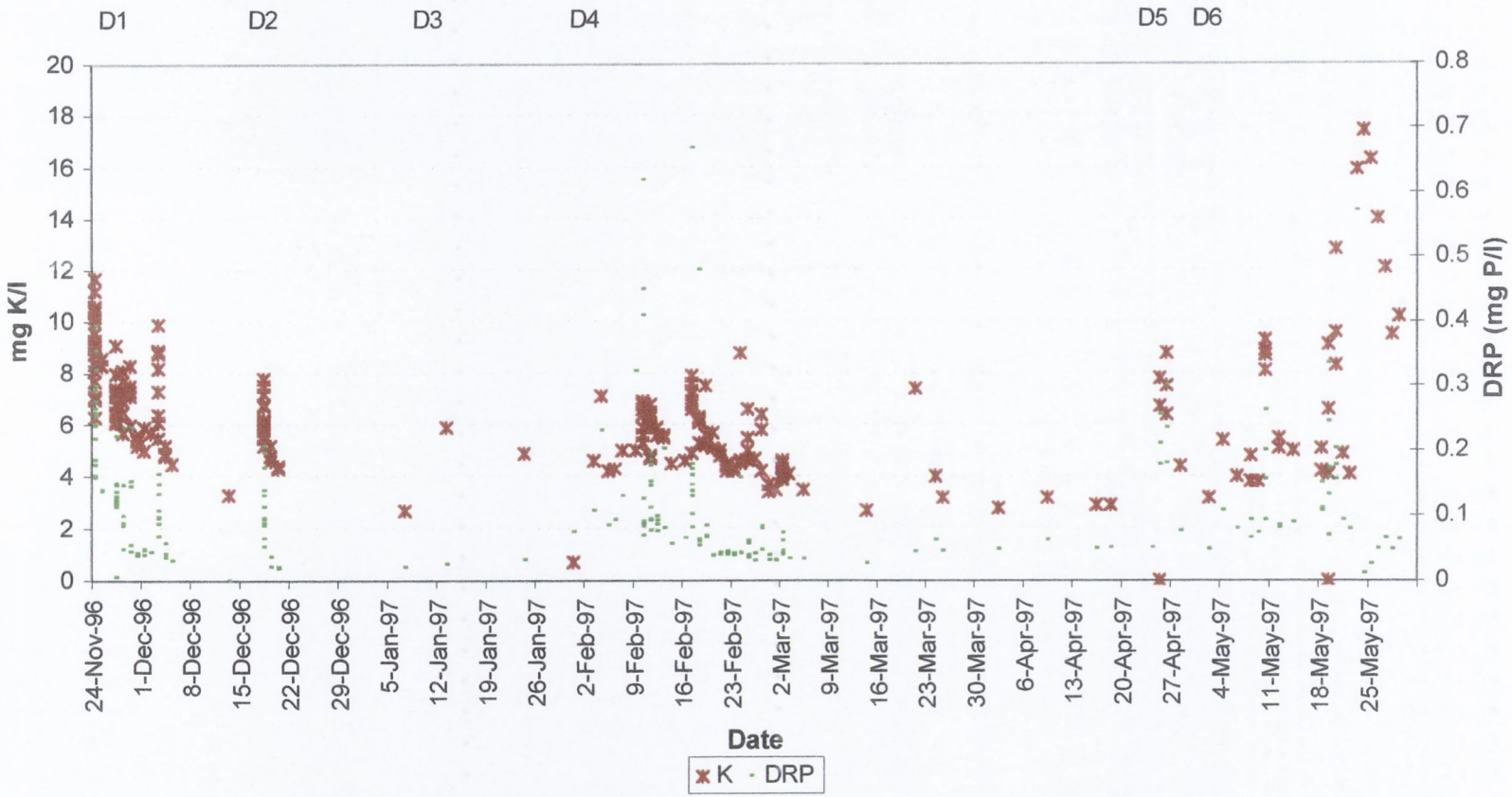


Figure 9.34: Potassium (K) (mg/l) and DRP (mg P/l) concentrations at the downstream monitoring station (M2).

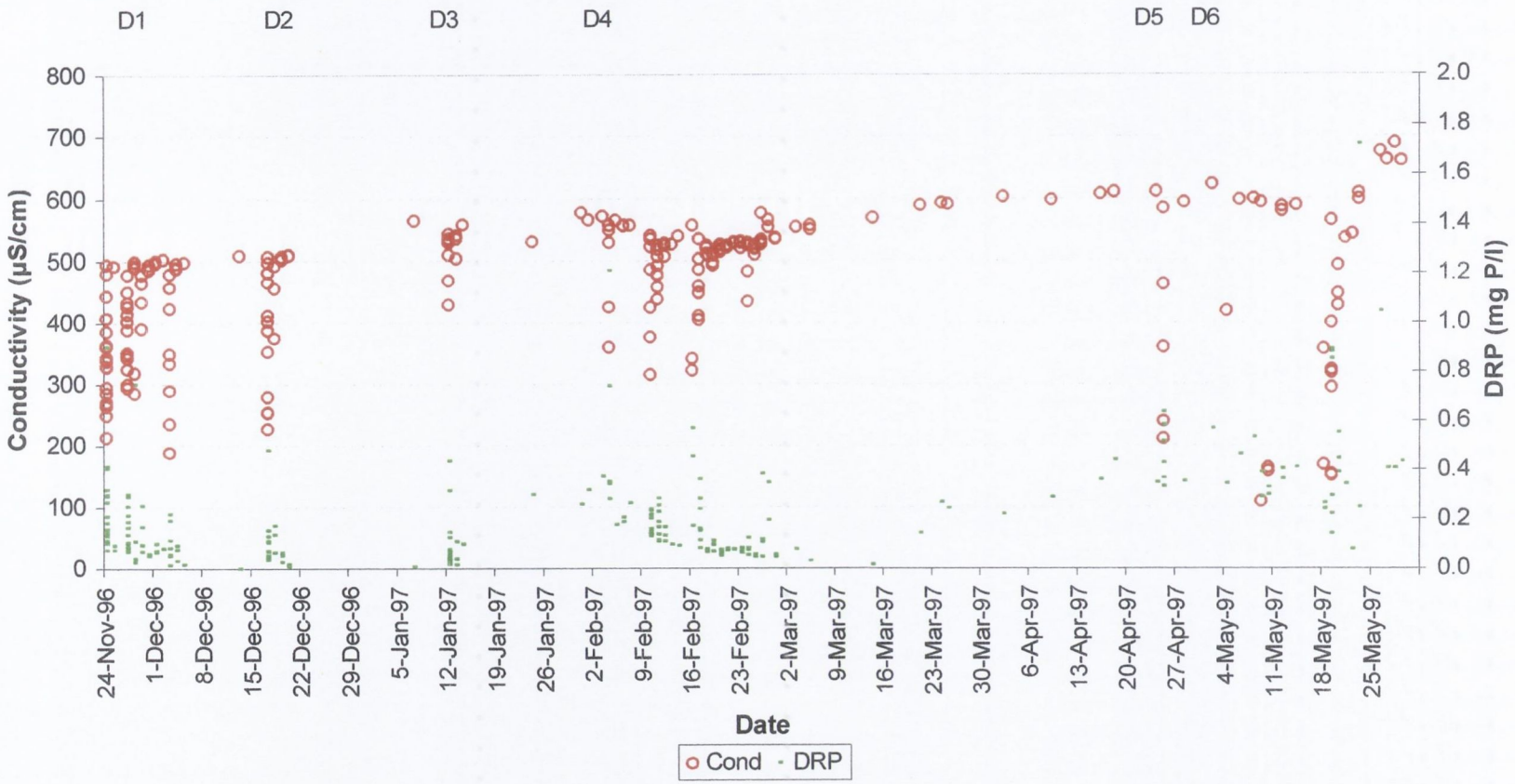


Figure 9.35: Conductivity (µS/cm) and DRP (mg P/l) levels at the upstream monitoring station (M1).

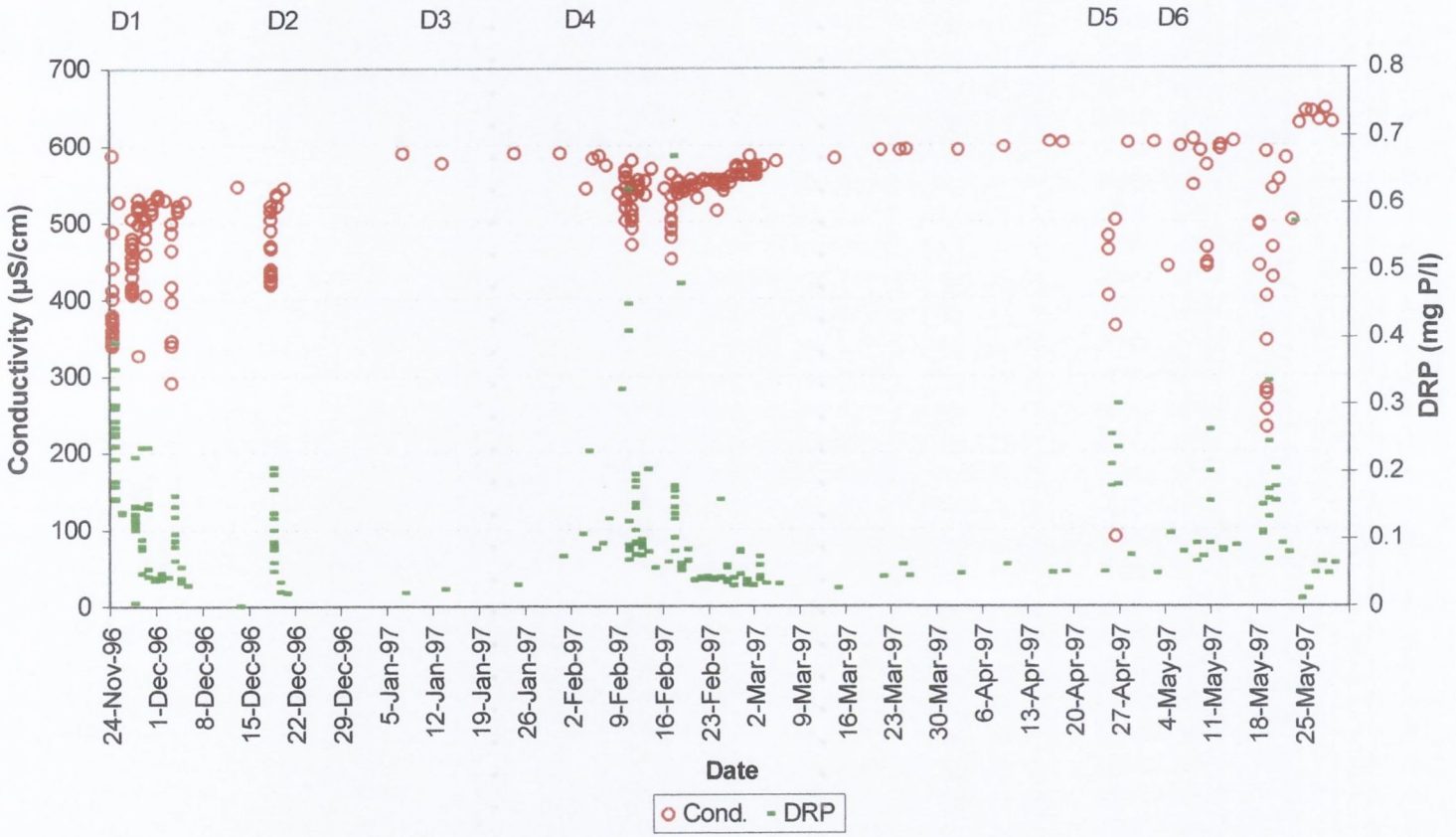


Figure 9.36: Conductivity (µS/cm) and DRP (mg P/l) levels at the downstream monitoring station (M2).

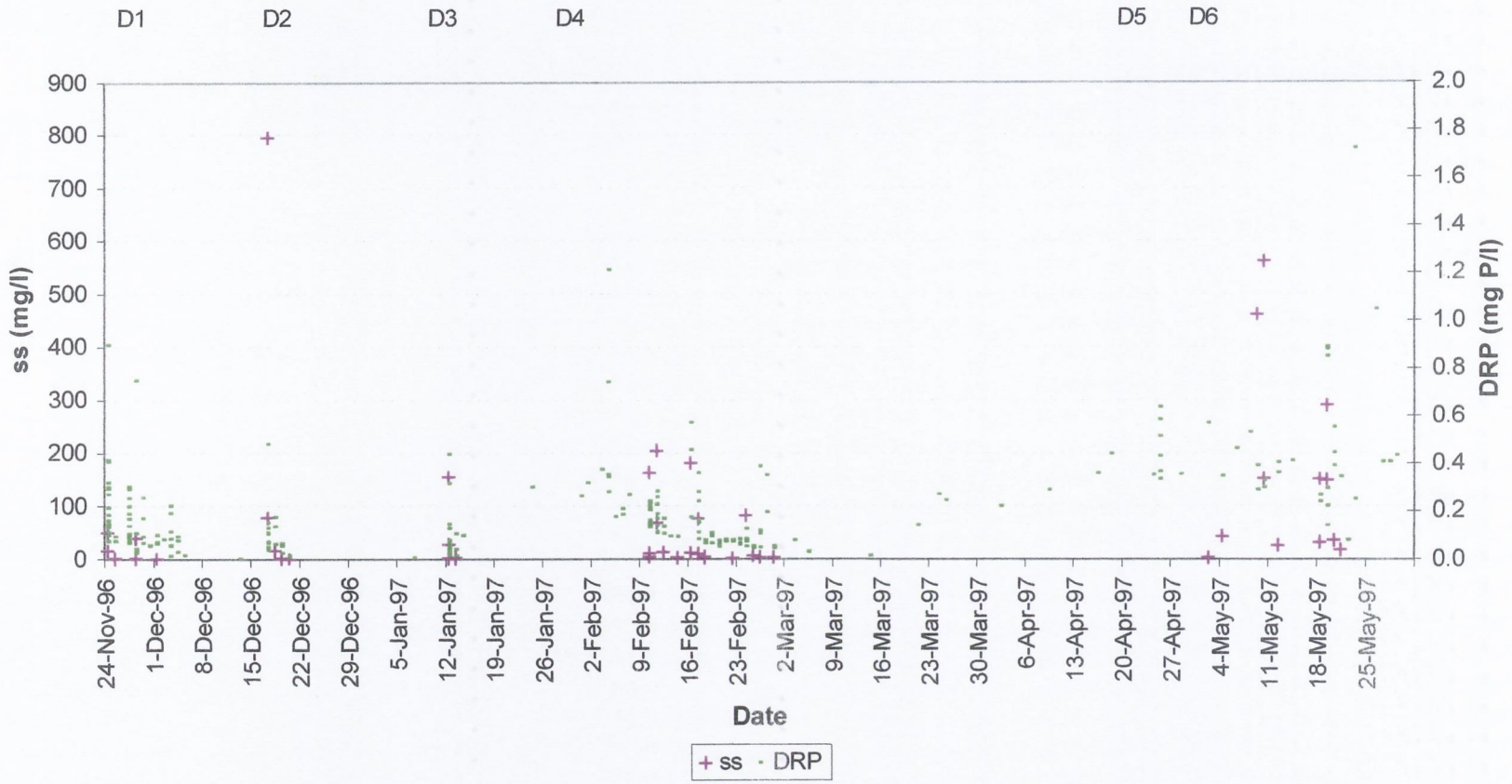


Figure 9.37: Suspended solids (ss) (mg/l) and DRP (mg P/l) levels at the upstream monitoring station (M1).

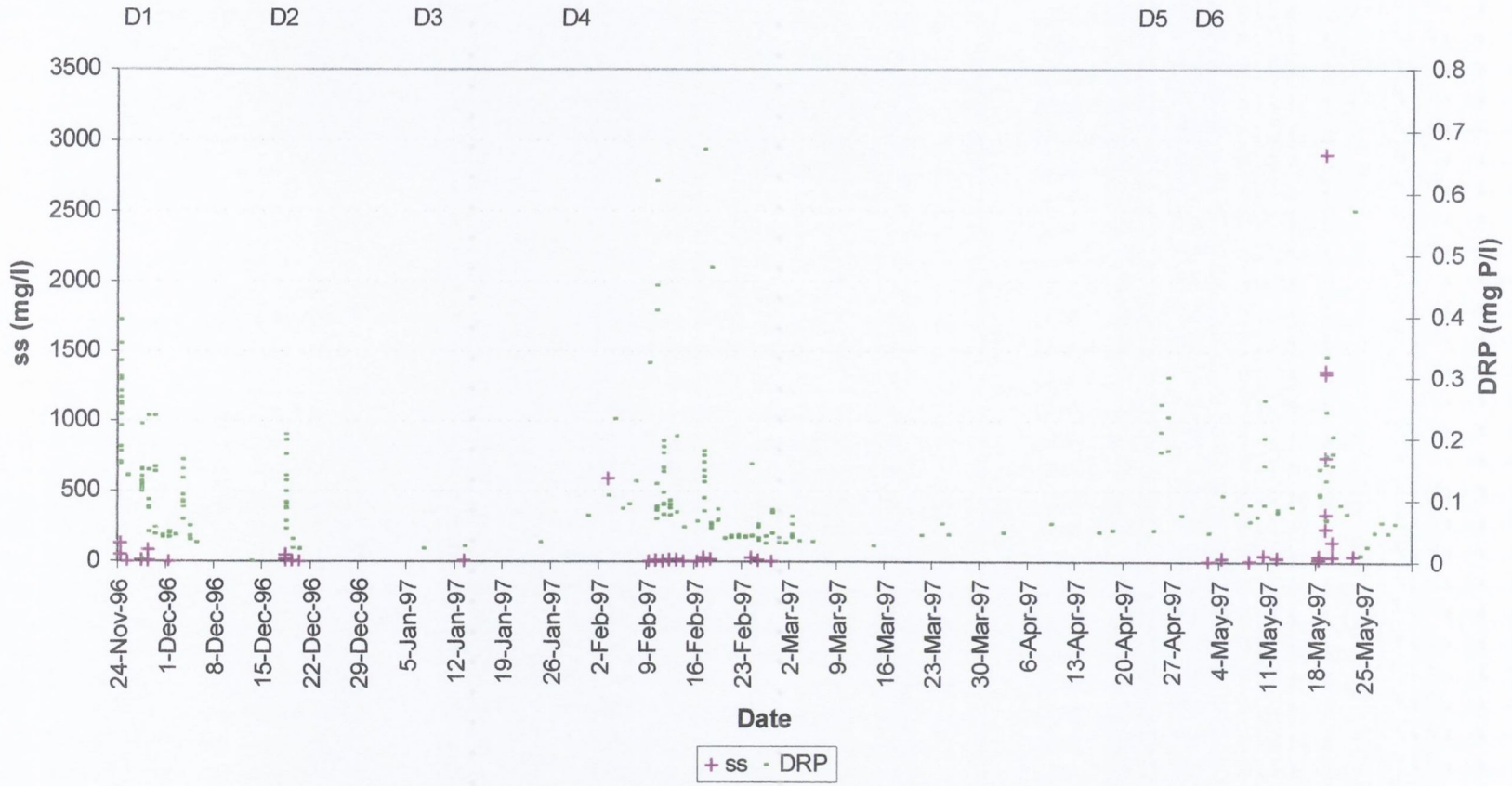


Figure 9.38: Suspended solids (ss) (mg/l) and DRP (mg P/l) levels at the downstream monitoring station (M2).

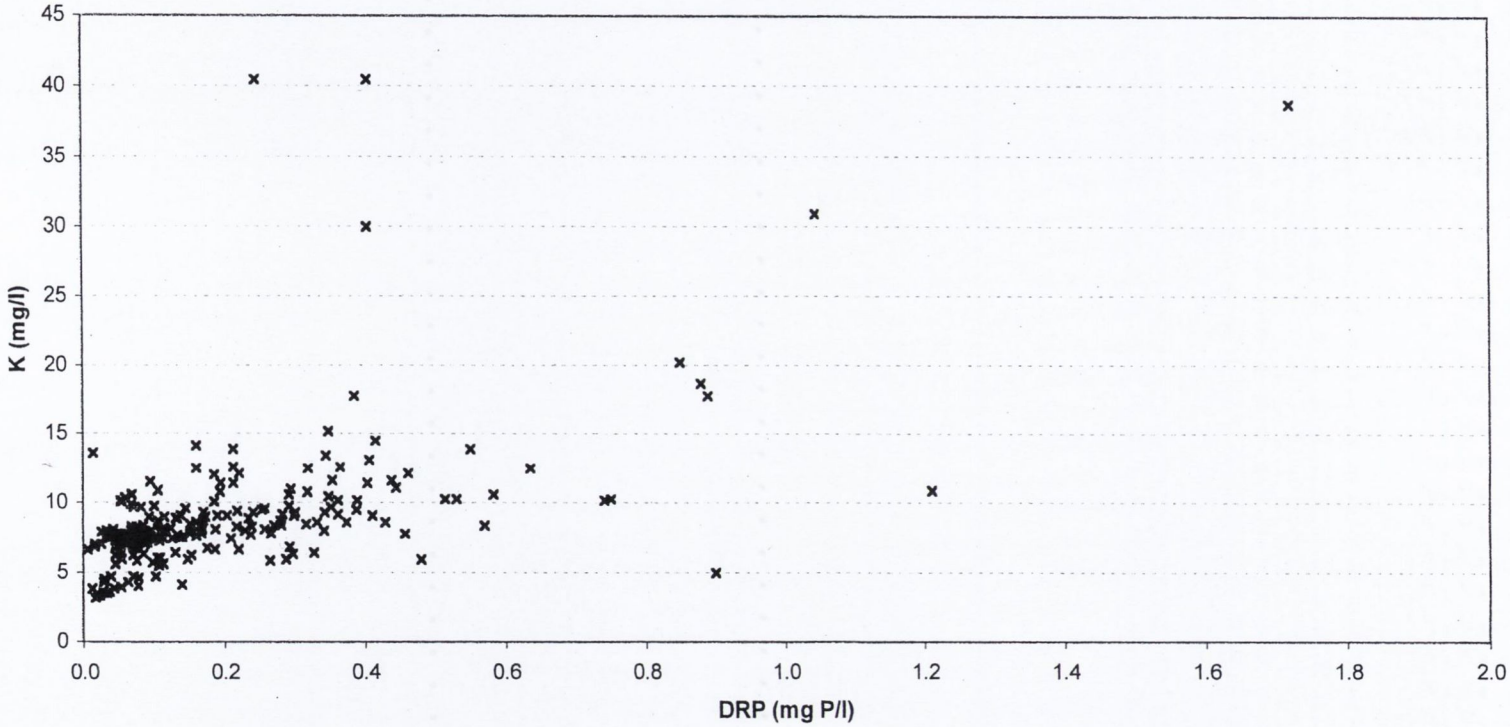


Figure 9.39: Potassium (K) (mg/l) plotted against DRP (mg P/l) levels at the upstream monitoring station (M1).

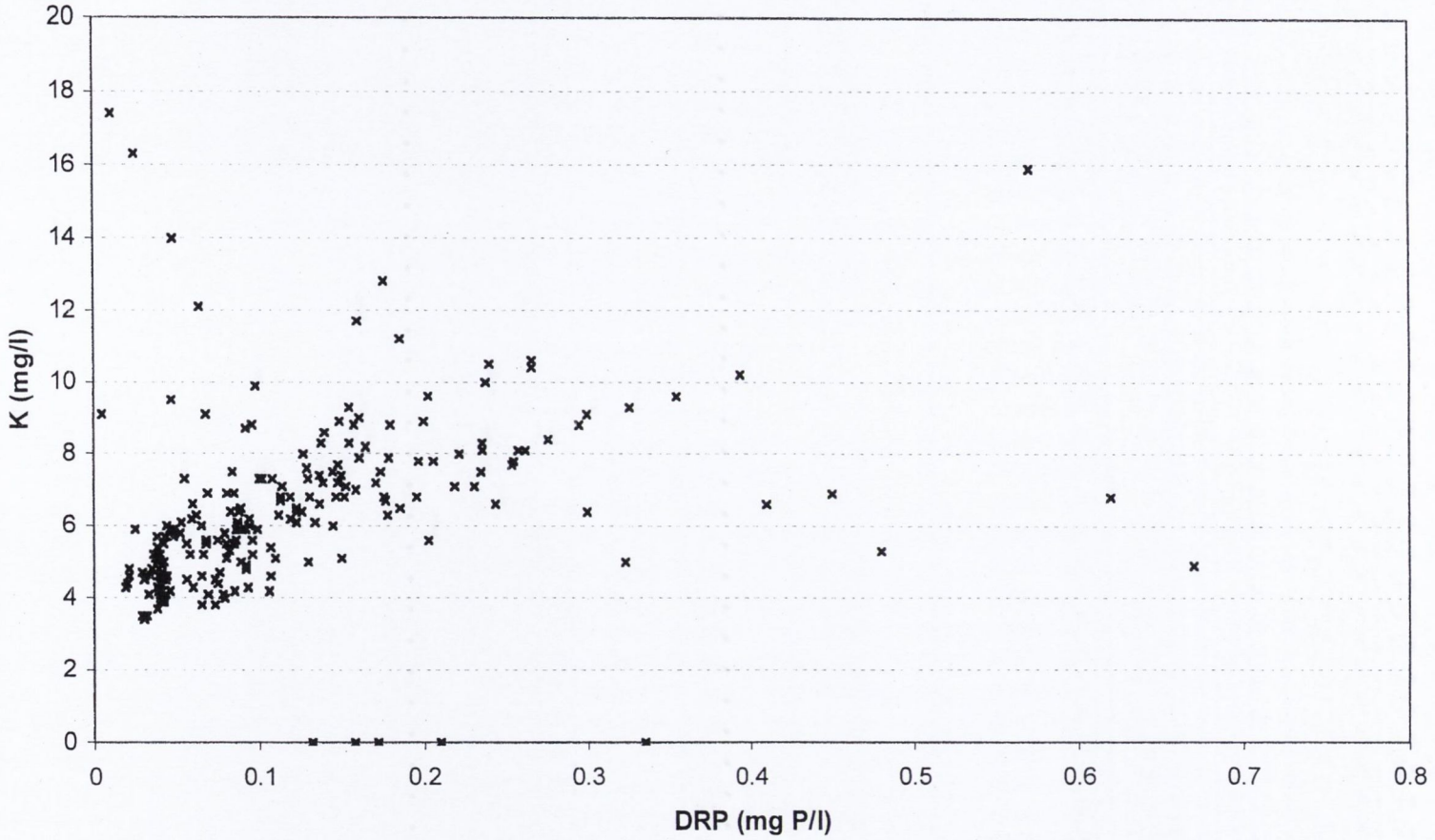


Figure 9.40: Potassium (K) (mg/l) plotted against DRP (mg P/l) levels at the downstream monitoring station (M2).

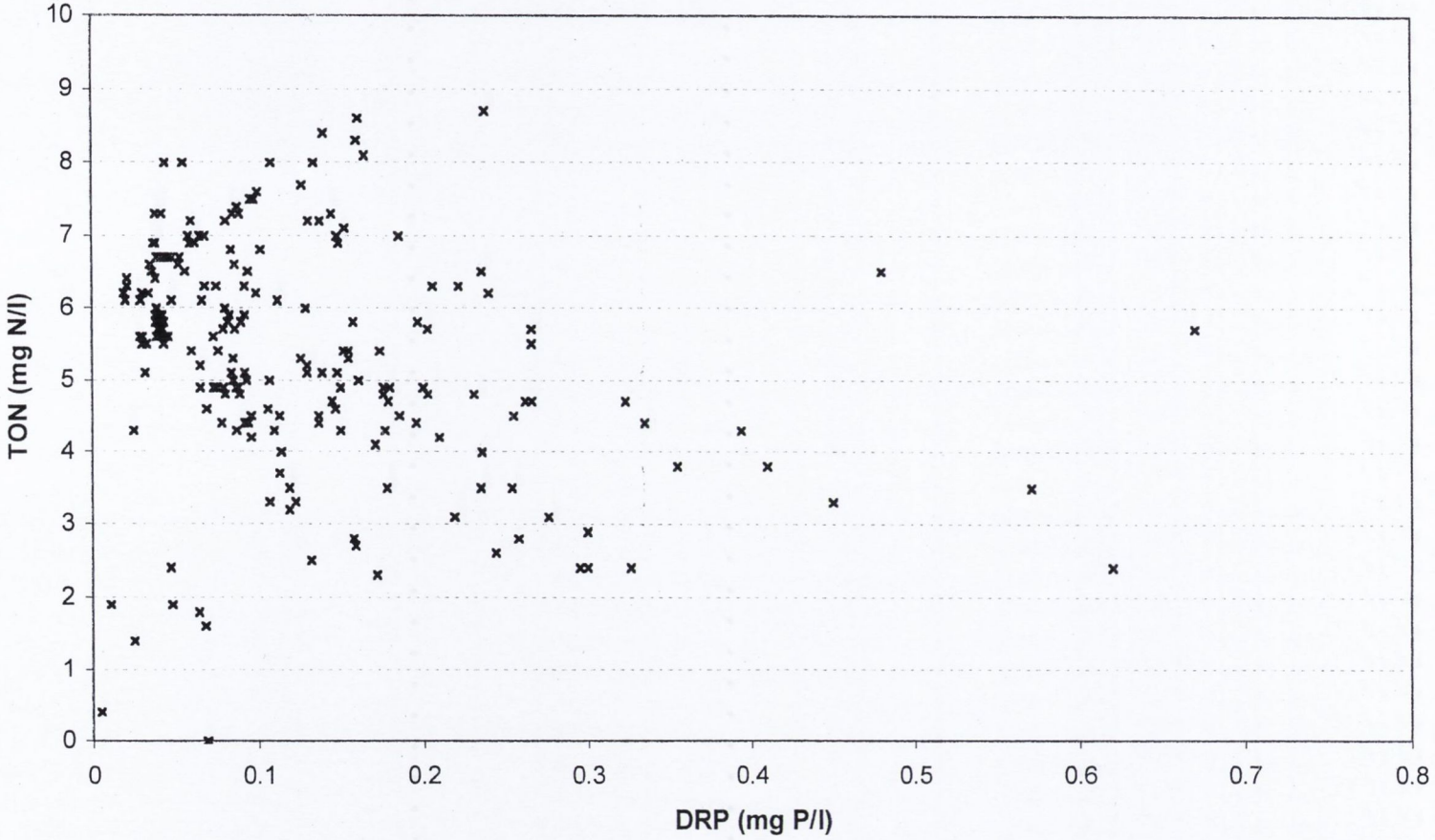


Figure 9.41: Total oxidised nitrogen (TON) (mg N/l) plotted against DRP (mg P/l) levels at the downstream monitoring station (M2).

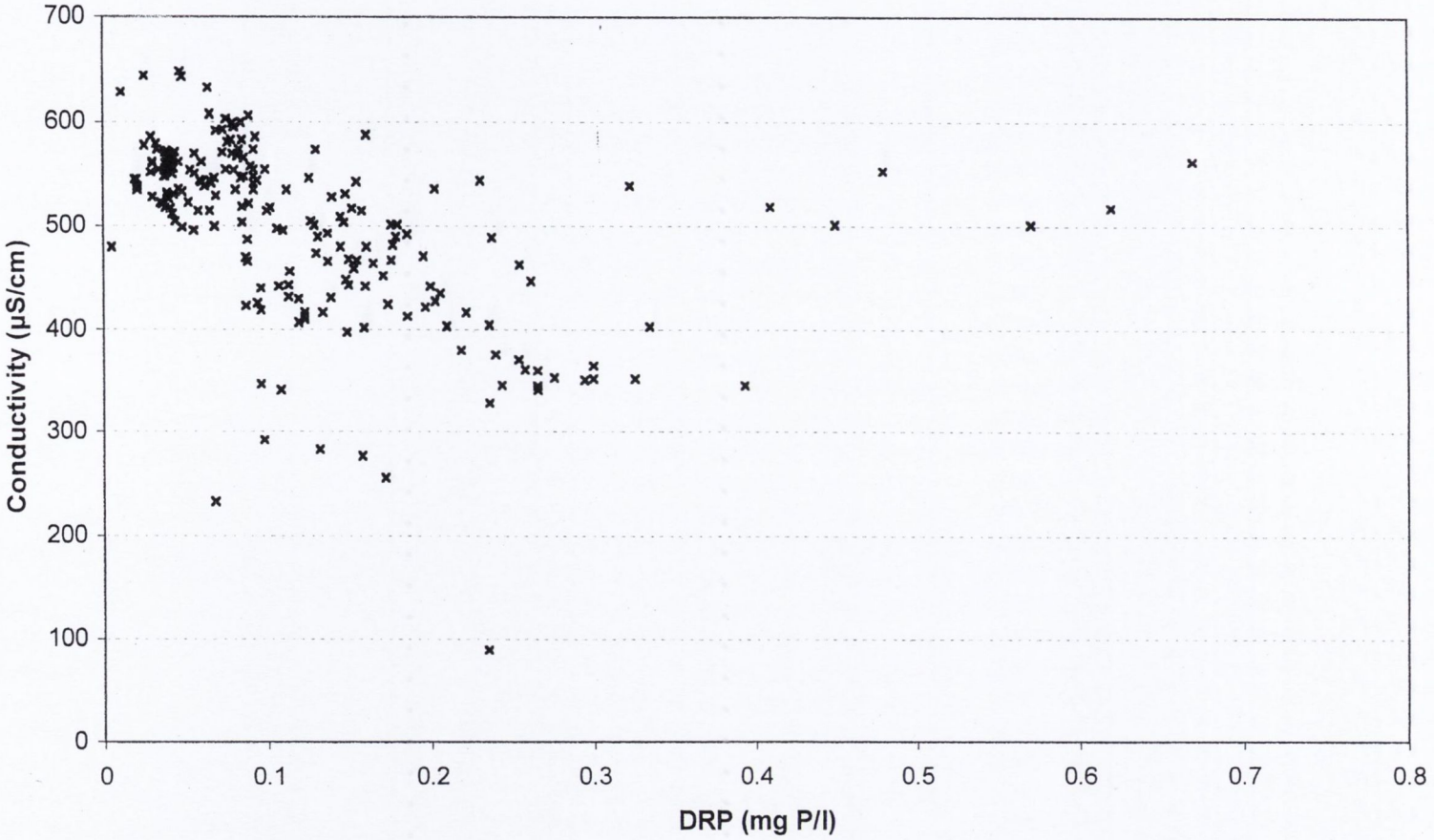


Figure 9.42: Conductivity (µS/cm) plotted against DRP (mg P/l) levels at the downstream monitoring station (M2).

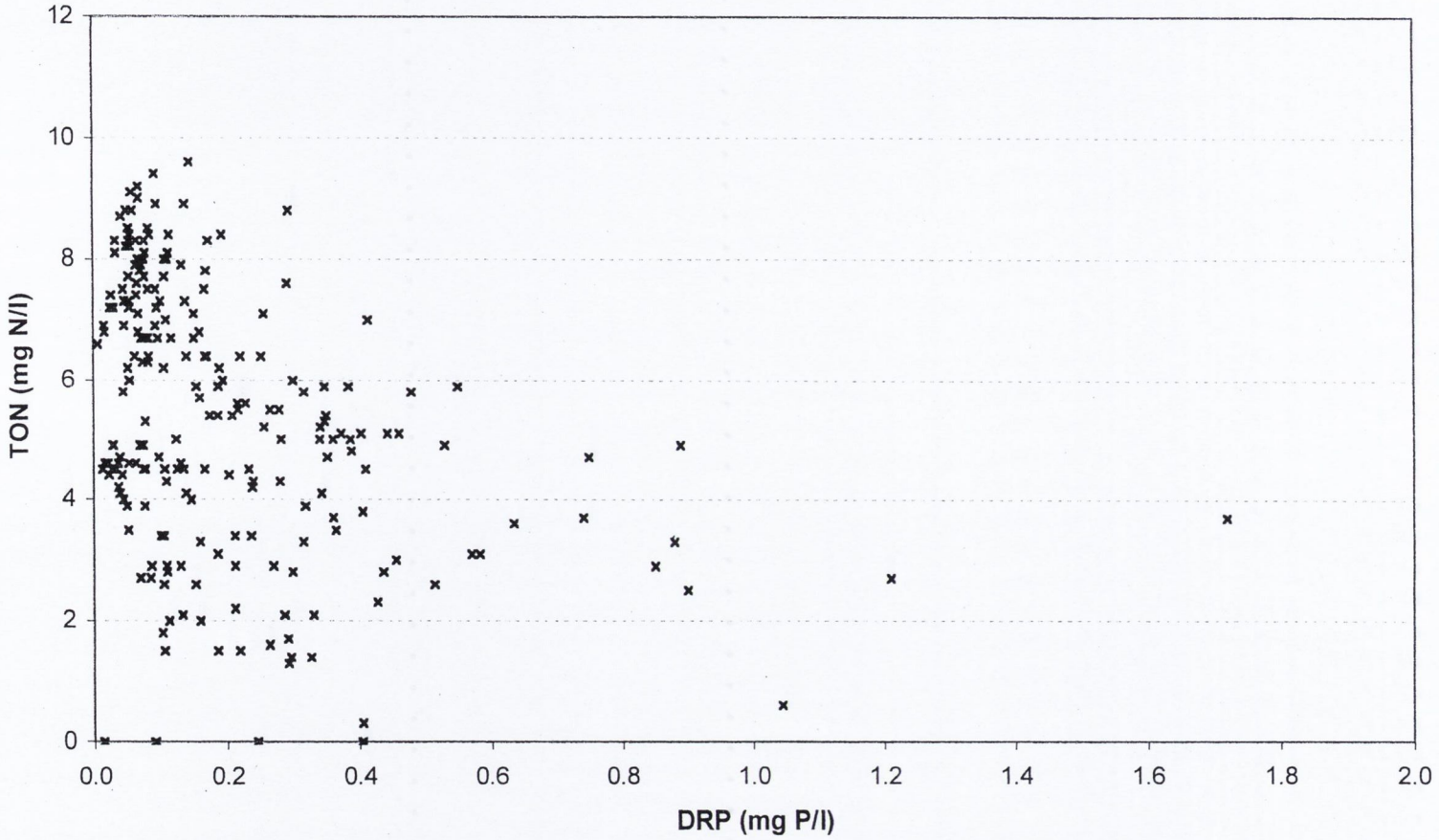


Figure 9.43: Total oxidised nitrogen (TON) (mg N/l) plotted against DRP (mg P/l) levels at the upstream monitoring station (M1).

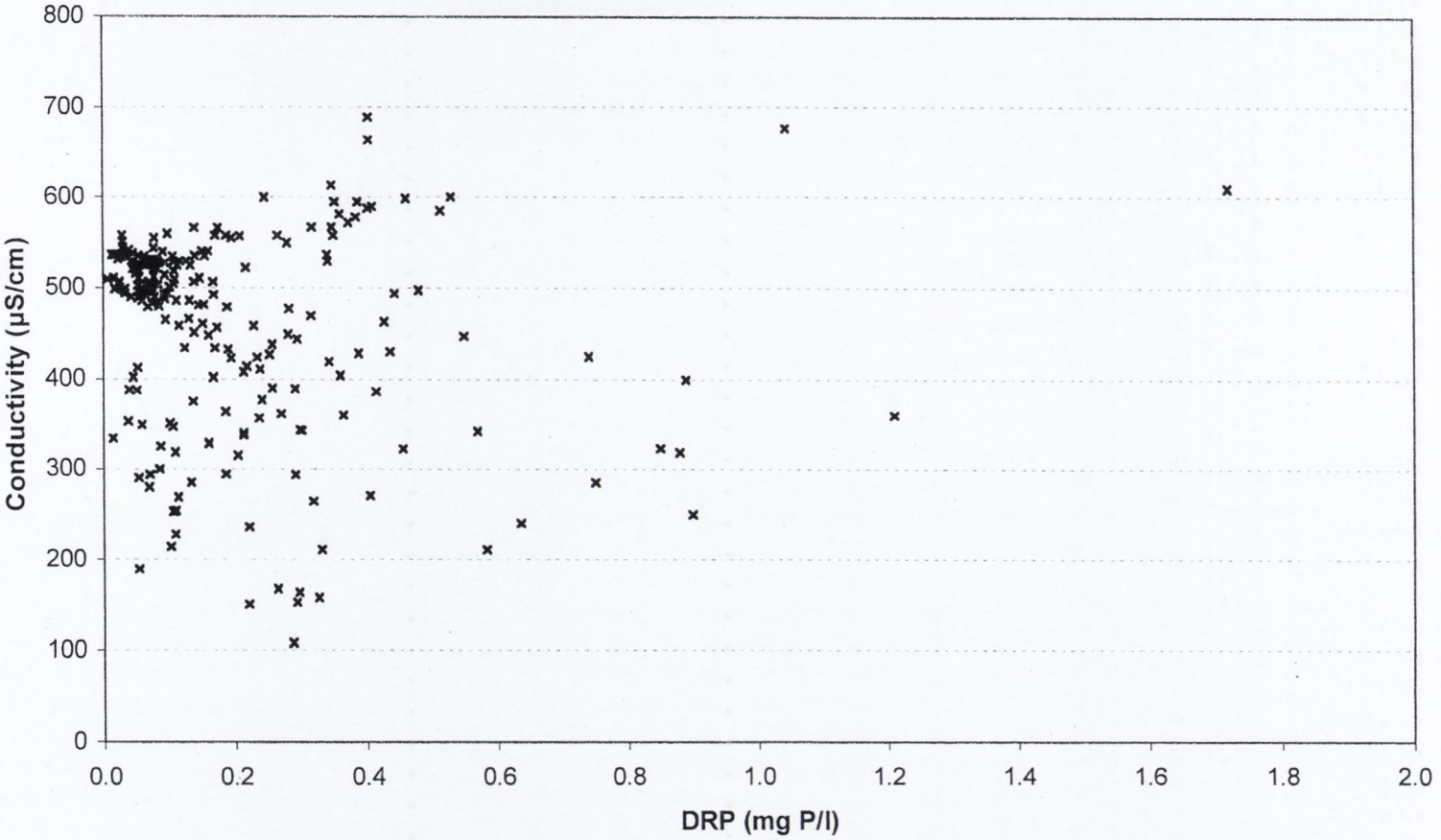


Figure 9.44: Conductivity (µS/cm) plotted against DRP (mg P/l) levels at the upstream monitoring station (M1).

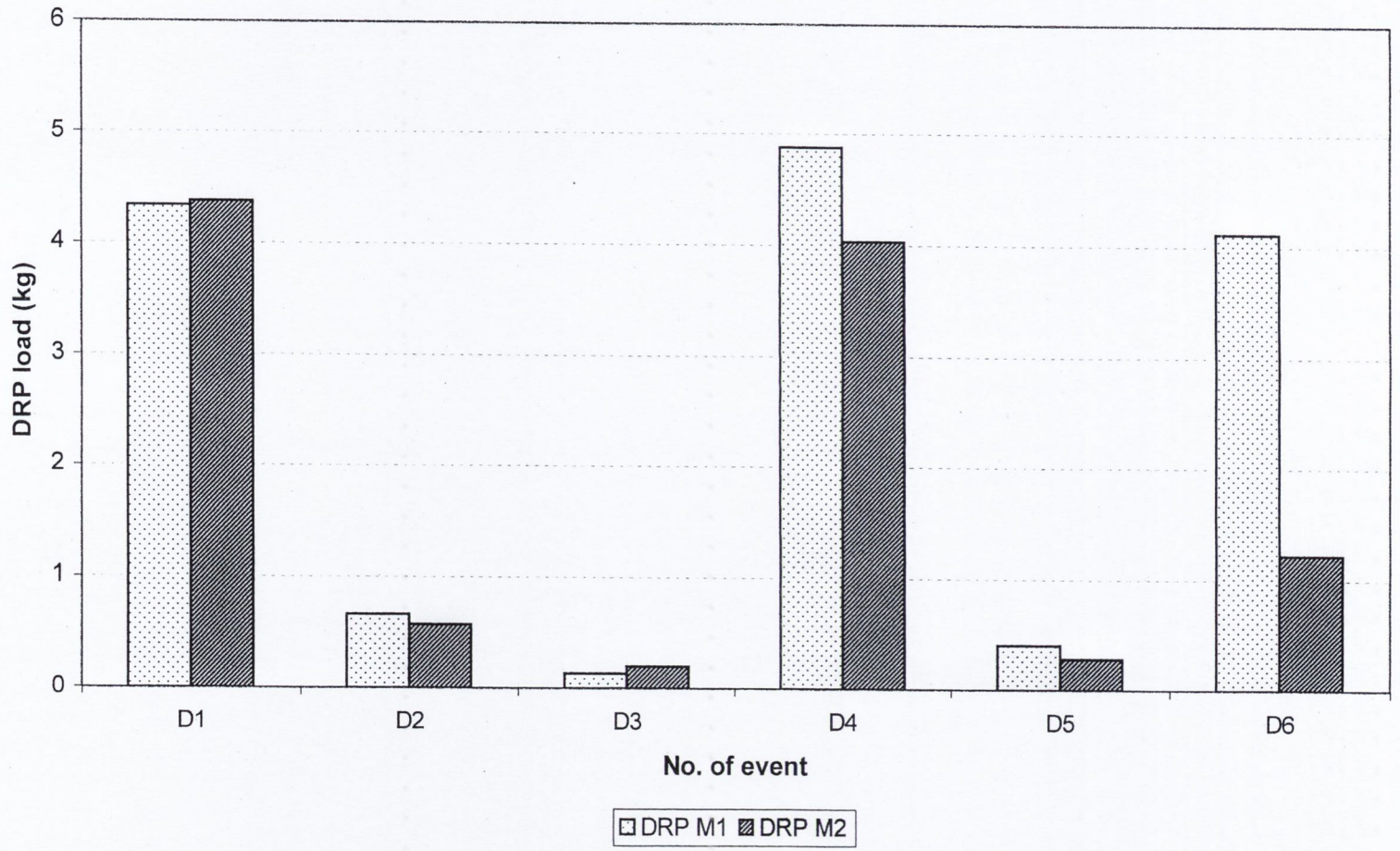


Figure 9.45: DRP loads at the upstream (M1) and downstream (M2) monitoring stations.

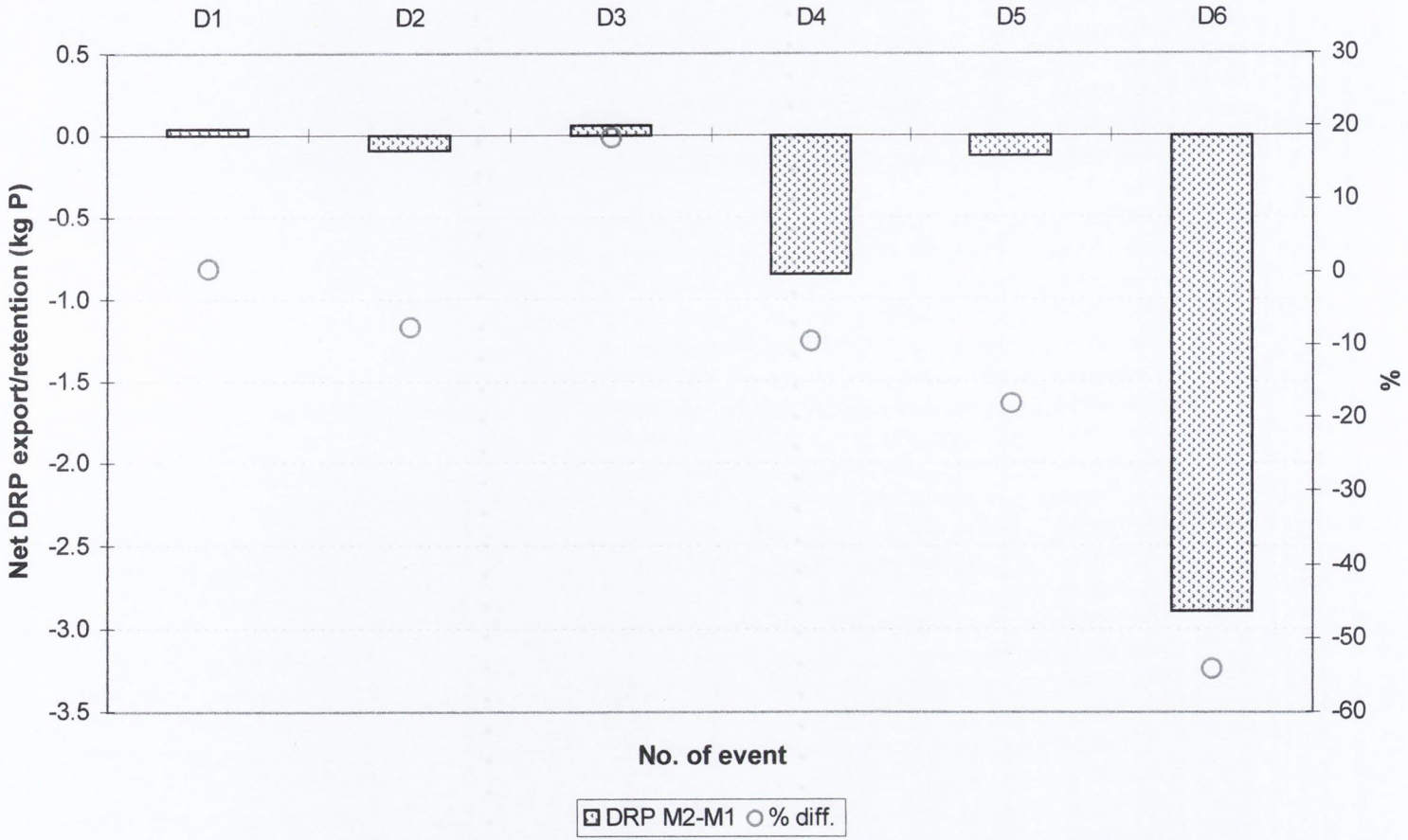


Figure 9.46: Net DRP exports (load downstream (M2) minus load upstream (M1)) from the Dairy Farm sub-catchment: absolute figures and % in reference to the sum of DRP loads upstream (M1) and downstream (M2).

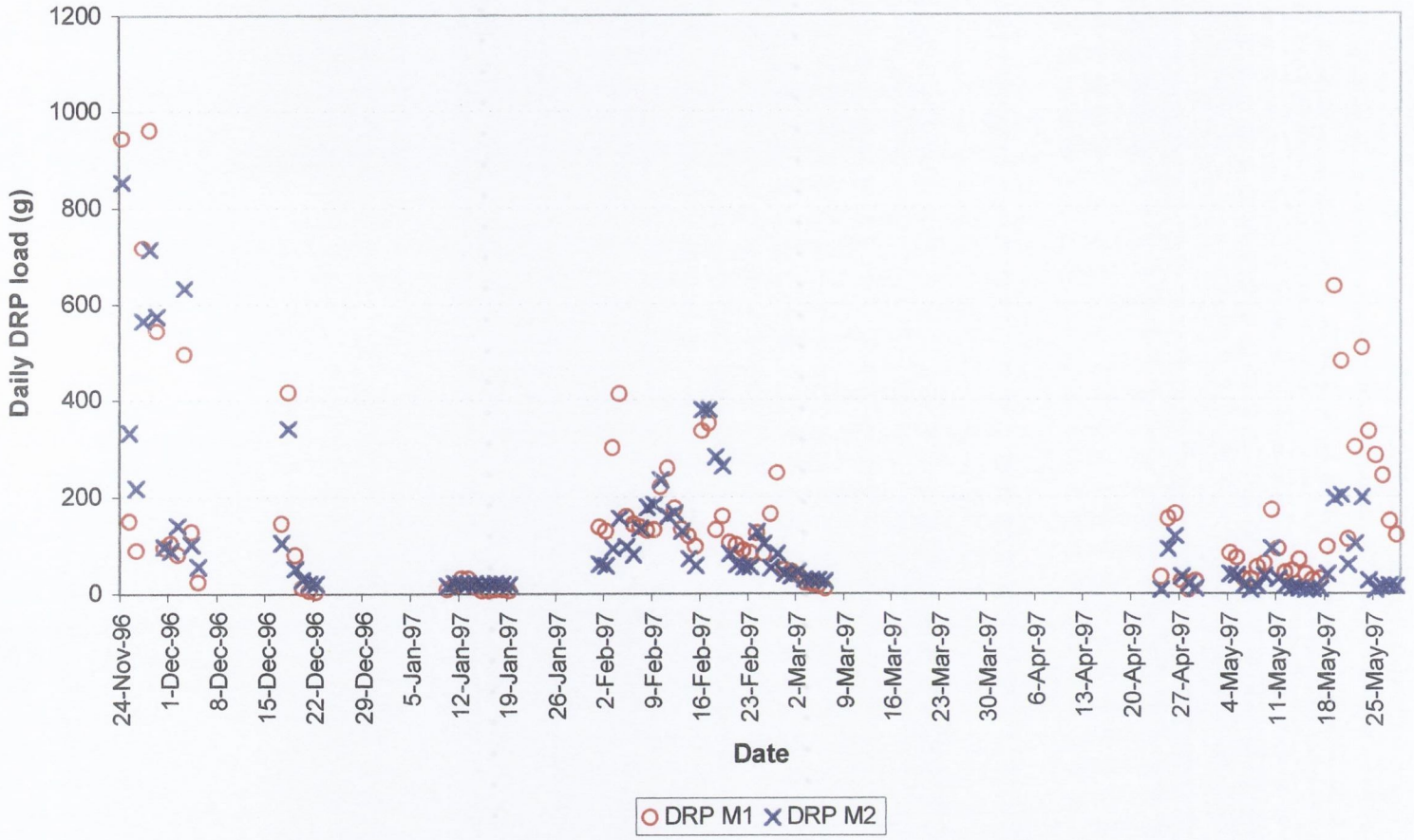


Figure 9.47: Daily DRP loads (g) at the upstream (M1) and downstream (M2) monitoring stations.

Plate 4.1: Dye distribution down the soil profile at site Dye 1.

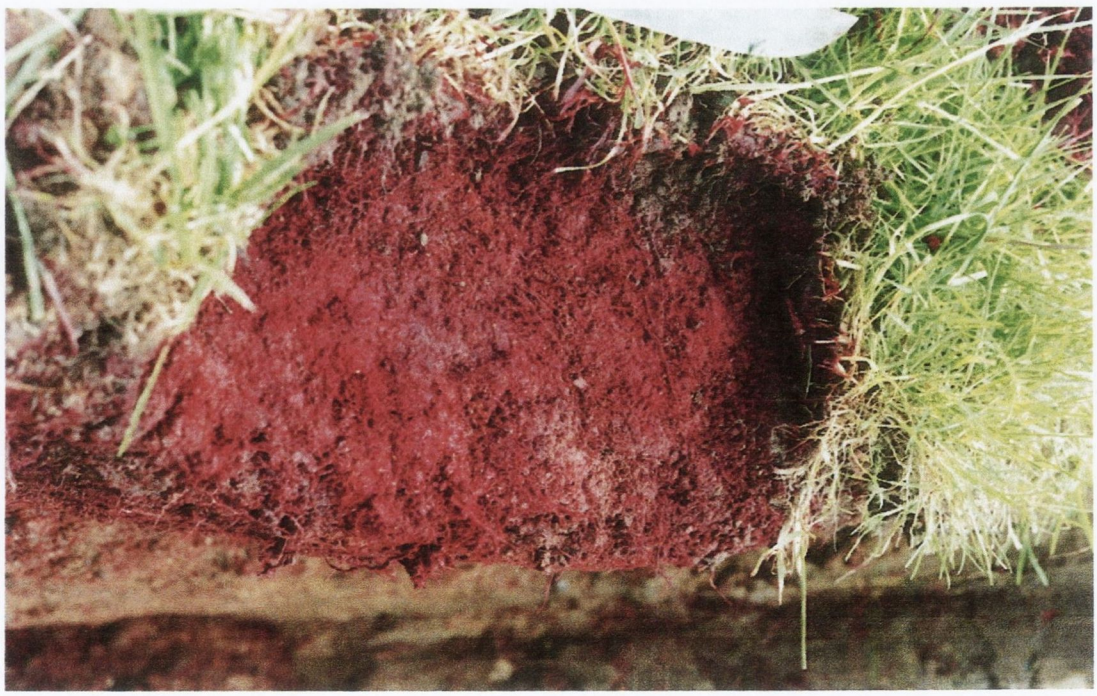


Plate 4.2: Evenly coloured topsoil at site Dye 1.

Plate 4.3: Vertical coloured tongues divided by uncoloured areas below the topsoil at site Dye 1.

Plate 4.4: Bleached zones penetrated by roots at site Dye 1.

Plate 4.5: Dye distribution down the soil profile at site Dye 2.

Plate 4.6: Unevenly coloured topsoil at site Dye 2.

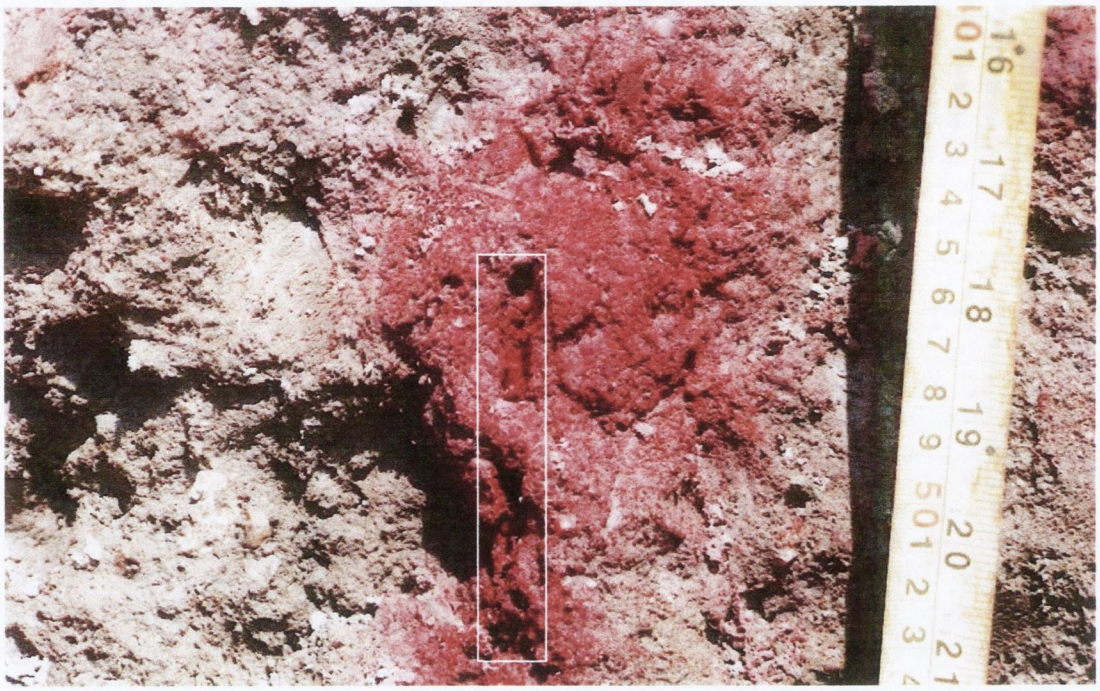


Plate 4.7: A large macropore (inside white rectangle) forms the centre of a coloured finger extending down the soil profile.

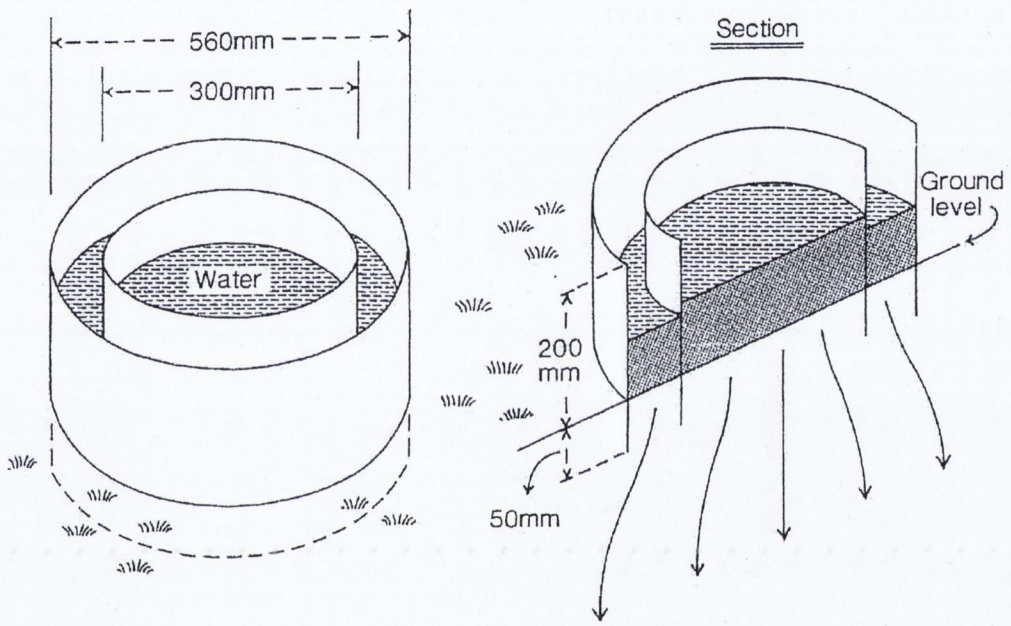


Plate 4.8: Double ring infiltrometer (from Diamond and Shanley, in print).

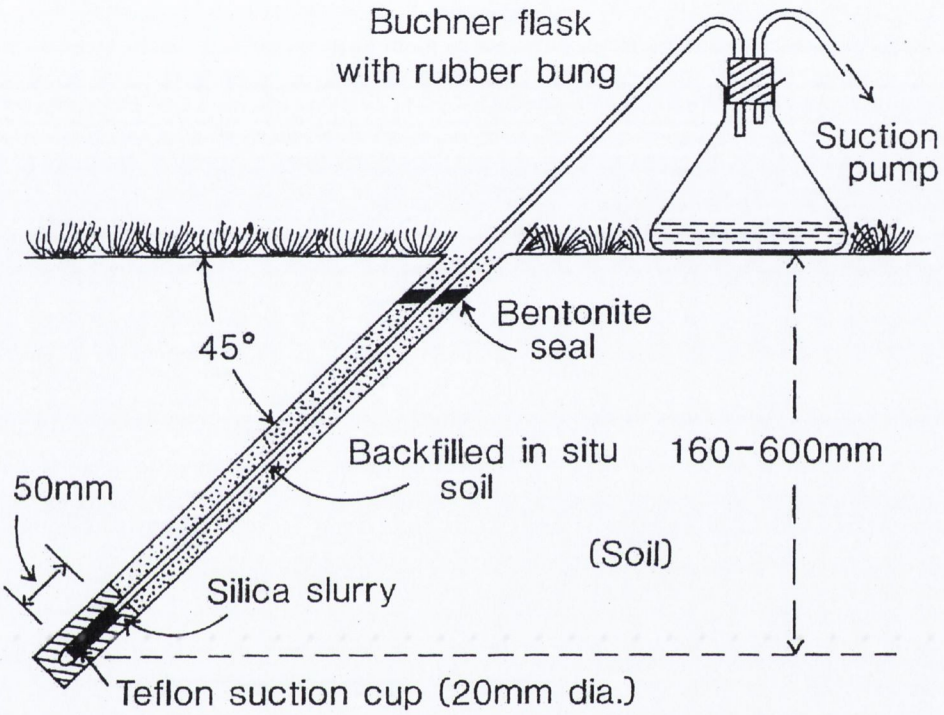


Plate 8.1: Teflon suction cup installed as specified in Section 8.2.2.

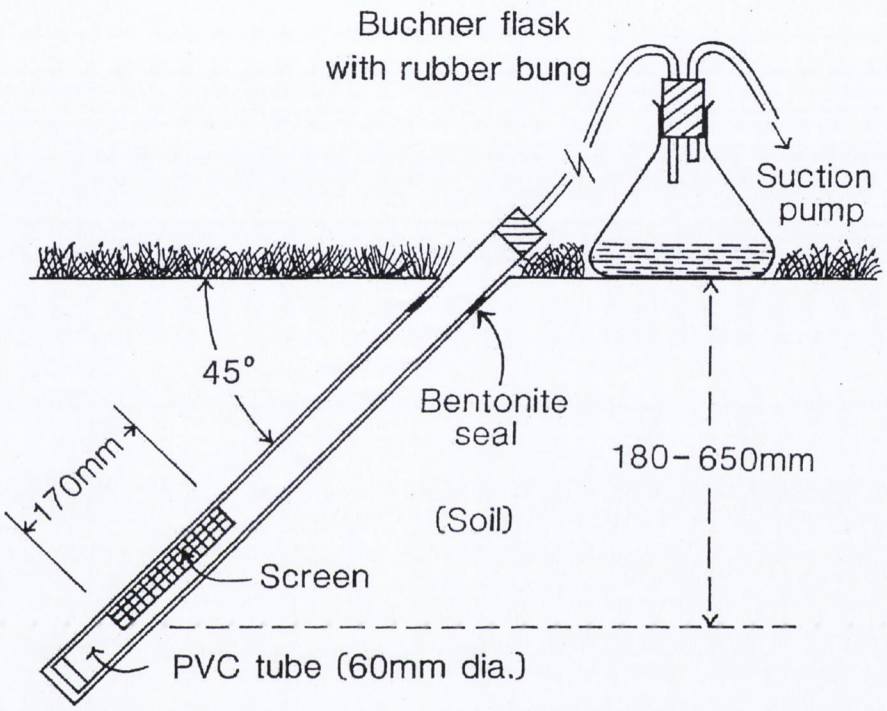


Plate 8.2: Zero-tension sampler installed as specified in Section 8.2.2.

Appendix 1: Soil Profiles

Dye 1

Depth cm	Description
0 - 20	Sandy loam; dark yellowish brown (10YR 3/4) with few, very fine, prominent, sharp, yellowish red (5YR 4/6) mottles; weakly developed medium granular structure; moderately weak consistence, semi-deformable; moderately plastic, slightly sticky; slightly stony with very small to medium angular tabular to rounded stones; very fine and fine vertical to horizontal pores (2%); many fibrous, very fine and fine roots; smooth, abrupt boundary to
20 - 50	Loamy sand; brownish yellow (10YR 6/8) and dark yellowish brown (10 YR 4/6) with common, very fine, distinct, sharp, black (7.5YR 2/0) and reddish yellow (5YR 6/8) mottles; weakly developed medium subangular blocky structure; very weak consistence, semi-deformable, non-plastic, not sticky; slightly stony and bouldery with very small to very large stones subangular platy to rounded stones; very fine and fine vertical to horizontal pores (0.5%); few fibrous, very fine and fine roots; smooth, sharp boundary to
> 50	Loam; strong brown (7.5YR 4/6) and pink (5YR 7/3) with common, very fine and fine, prominent, sharp, black (2.5YR 2.5/0) mottles; moderately developed, coarse, angular blocky structure; moderately firm consistence, deformable, very plastic, moderately sticky; very slightly stony with very small, subrounded tabular to rounded stones; very fine, vertical to horizontal pores (0.1%); few fibrous, very fine roots.

Dye 2

Depth cm	Description
0 - 30	Sandy loam; brown to dark brown (10YR 4/3) with common, fine, distinct, sharp, black (2.5YR 2.5/0) and brown to dark brown (7.5YR 4/4) mottles; weakly developed, fine to medium granular structure; moderately weak consistence, semi-deformable, slightly plastic, non-sticky; slightly stony with very small to medium stones platy and angular subrounded to rounded stones; very fine to medium, vertical to horizontal pores (2%); common, very fine to medium, fibrous and fleshy roots; sharp smooth boundary to
> 30 - (70-100)	Sandy loam; yellowish brown (10YR 5/4) with many coarse, distinct, clear, dark brown (7.5YR 3/2) mottles; weakly developed very coarse subangular blocky structure; moderately weak consistence, semi-deformable, not plastic, non-sticky; slightly stony with very small to medium subangular to rounded stones; very fine to medium, mainly vertical pores; few, very fine to medium fibrous and fleshy roots; smooth and boundary to
> (70 - 100)	Loamy sand; light grey (10YR 7/2) and strong brown (7.5YR 5/8) with common, coarse, distinct, clear black (2.5YR 2.5/0) mottles; weakly developed, coarse subangular blocky structure; very weak consistence, semi-deformable, slightly plastic, non-sticky; very slightly stony with very small, subangular platy stones; mainly very fine and some fine vertical to horizontal pores (0.5%); few very fine fibrous roots.

Warren 2

Depth cm	Description
0-20	Loam; brown to dark brown (10YR 4/3) with common, yellowish brown (10YR 5/6), extremely fine to medium, distinct and sharp mottles; coarse granular, weakly developed structure; semi-deformable and slightly plastic; slightly stony with angular tabular very small to medium stones; 5% very fine to medium pores; sharp smooth boundary to
20-22/40	Loamy sand; light grey (2.5Y 7/2) with common, very pale brown (10YR 7/4), yellow (10YR 7/8) and black (2.5YR 2.5/0), prominent, very fine to coarse, clear and diffuse mottles; massive structure; brittle and non-plastic consistence; very slightly stony with most very small and some medium subangular rounded stones; 0.5% very fine to fine pores; few very fine fibrous roots; sharp tongued boundary to
>22/40	Clay; strong brown (7.5YR 5/6) and light grey (10YR 7/2) with very few, very fine, distinct, sharp, black (2.5YR 2.5/0) mottles; weakly developed, subangular blocky, very coarse structure; deformable and moderately plastic consistence; very slightly stony with very small angular platy stones; 0.5% very fine and fine random pores; few very fine, fibrous and very few fine wooden roots.

Appendix 2

DRP, TDP and TP concentrations in spring/subsurface water samples from the Warren 1

Date	DRP (mg P/l)	TDP (mg P/l)	TP (mg P/l)
24-Jan-97	<0.005		
31-Jan-97	<0.005		
03-Feb-97	<0.005		
04-Feb-97	0.016		
05-Feb-97	<0.005		
06-Feb-97	<0.005		
07-Feb-97	<0.005		
10-Feb-97	0.069		
11-Feb-97	<0.005		
12-Feb-97	0.019		
13-Feb-97	0.015		
14-Feb-97	0.008		
17-Feb-97	0.005		
18-Feb-97	<0.005		
19-Feb-97	0.13		
20-Feb-97	<0.005		
21-Feb-97	<0.005		
24-Feb-97	<0.005		
25-Feb-97	0.008		
26-Feb-97	<0.005		
27-Feb-97	<0.005		
28-Feb-97	<0.005		
03-Mar-97	<0.005		
14-Mar-97	<0.005		
21-Mar-97	0.005		
25-Mar-97	<0.005		
02-Apr-97	<0.005		
09-Apr-97	0.005		
16-Apr-97	<0.005		
18-Apr-97	<0.005		
28-Apr-97	<0.005	<0.05	<0.05
02-May-97	<0.005	<0.05	<0.05
06-May-97	<0.005	<0.05	<0.05
08-May-97	<0.005	<0.05	<0.05
09-May-97	<0.005	<0.05	<0.05
12-May-97	<0.005	0.08	
14-May-97	<0.005		
19-May-97	<0.005	0.07	0.11
20-May-97	0.013	0.09	0.17
21-May-97	<0.005	0.07	
22-May-97	<0.005	0.08	0.10
23-May-97	<0.005	0.10	0.15
26-May-97	<0.005	0.07	0.10
03-Jun-97	<0.005	0.07	0.07
06-Jun-97	<0.005	0.09	0.08
09-Jun-97	<0.005	0.05	<0.05
11-Jun-97	<0.005	<0.05	0.08
12-Jun-97	0.008	<0.05	<0.05
17-Jun-97	<0.005	<0.05	<0.05
20-Jun-97	<0.005	<0.05	
23-Jun-97	0.025	<0.05	0.08
25-Jun-97	0.009	<0.05	<0.05
26-Jun-97	<0.005	0.10	<0.05
01-Jul-97	<0.005	<0.05	<0.05
04-Jul-97	<0.005	<0.05	0.08
07-Jul-97	0.005	<0.05	<0.05
16-Jul-97	<0.005	<0.05	<0.05
23-Jul-97	<0.005	<0.05	<0.05
20-Aug-97	0.016	0.13	0.23
25-Aug-97	<0.005	<0.05	0.10
27-Aug-97	<0.005	0.07	0.10
28-Aug-97	0.005	0.06	<0.05
29-Aug-97	<0.005	<0.05	<0.05
02-Sep-97	<0.005	<0.05	0.06
03-Sep-97	<0.005	<0.05	<0.05
22-Sep-97	<0.005	<0.05	<0.05
13-Oct-97	<0.005	<0.05	<0.05
15-Oct-97	<0.005	0.05	0.06
16-Oct-97	<0.005	<0.05	0.06
17-Oct-97	<0.005	<0.05	0.06
20-Oct-97	<0.005	<0.05	<0.05
30-Oct-97	<0.005		
31-Oct-97	<0.005		
05-Nov-97	0.009	<0.05	0.07
06-Nov-97	<0.005	<0.05	<0.05
07-Nov-97	<0.005	<0.05	<0.05
10-Nov-97	<0.005	<0.05	0.06
11-Nov-97	<0.005	<0.05	<0.05
14-Nov-97	<0.005	<0.05	<0.05
18-Nov-97	<0.005	<0.05	<0.05
19-Nov-97	<0.005	<0.05	<0.05

Appendix 3

TDP concentrations in samples from Teflon suction cups.

Event (sampling date)	Sampler ID	TDP (mg P/l)
BU1 (5th November 1997)	T1	0.05
	T2	0.05
	T3	<0.05
	T4	0.06
	5T	<0.05
	T6	<0.05
BU3 (18th November 1997)	T1	<0.05
	T2	<0.05
	T3	<0.05
	T4	0.05
	T5	<0.05
	T6	<0.05
BU5 (9th December 1997)	1T	0.10
	2T	0.10