Sediment Pick-Up in Combined Wave Current Flow

Data Report

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HR Wallingford

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This report describes measurements made by Miss P B Murray at HR Wallingford as part of her PhD requirements for the University of Wales, supported by a CASE studentship from the Natural Environment Research Council and HR. Her supervisor at HR was R L Soulsby, and at the University College of North Wales was Dr A G Davies. The involvement of R L Soulsby formed part of Contract No. CSA 1435 "Sediment transport by combined waves and currents - Phase II" funded by the Ministry of Agriculture Fisheries and Food. The nominated officer at MAFF was Mr A J Allison and at HR was Dr S W Huntington. The report was written by Dr P B Murray.

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Approved by R.L. Soulsby Group Manager

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Summary

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This report presents the experimental methods used in, and tabulates the data obtained from, experiments in the Pulsating Water Tunnel at HR. They were made over an immobile gravel rough bed, to investigate the hydrodynamics of wave-current boundary-layer interaction, and over a fine sand bed, to investigate the pick-up, suspension and transport of sediment by combined waves and currents.

Detailed tabulations of the data are obtainable from HR on diskette for a small handling charge.

Notation

A_0	Amplitude of near-bed oscillatory water motion
D	Grain diameter
E/ρ	Kinematic turbulent kinetic energy
k_s	Nikuradse equivalent roughness = $30z_0$
Re	Grain Reynolds number = u.D/v
RE	Wave Reynolds number = A_0U_0/ν
T	Wave period
U_0	Orbital velocity amplitude outside the wave boundary layer
x	Horizontal coordinate direction
y	Transverse coordinate direction
z	Vertical coordinate direction
z_0	Bed roughness length
μ	Coefficient of molecular viscosity
ν	Kinematic viscosity = μ/ρ
ρ	Water density

Velocity and sediment concentration

u	Instantaneous horizontal velocity
u'	Turbulent horizontal velocity
$\underline{U}$	Time-averaged (mean) horizontal velocity
U_a	Time-averaged (mean) horizontal velocity at height z=a
$\underline{U}$	Ensemble-averaged (mean) horizontal velocity, including the cycle-averaged component.
U_p	Ensemble-averaged (mean) horizontal velocity, having removed the cycle-averaged component.
<U>	Cycle-averaged (mean) horizontal velocity
$<U>_a$	Cycle-averaged (mean) horizontal velocity at height z=a
σ_U	(Italicised subscript) Ensemble-averaged horizontal turbulent velocity, that is, the standard deviation about the ensemble-averaged mean, $\sigma_U=\sqrt{\underline{u'^2}}$
σ_u	Time-averaged horizontal turbulent velocity, that is, the standard deviation about the time-averaged mean, $\sigma_u=\sqrt{(u'^2)}$

The same notation is applied for transverse (v) and vertical (w) components of velocity and sediment concentration (c).

Commonly used functions and symbols

$-u'w'$	Reynolds stress
$c'u'$	Horizontal Reynolds flux

Notation Continued

$c'v'$	Transverse Reynolds flux
$c'w'$	Vertical Reynolds flux

Overbar $\overline{x}$ denotes time-averaging.

Curly overbar $\tilde{x}$ denotes ensemble-averaging.

Angle brackets <x> denote cycle-averaging of the ensemble-averaged values.

σ_x denotes the standard deviation of the series x.

σ_X denotes the standard deviation of the series X, that is values of x at a particular phase.

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1 Introduction

A series of experiments was performed in the Pulsating Water Tunnel (PWT) at Hydraulics Research, Wallingford (Figure 1). The PWT comprises a closed horizontal loop made of aluminium sheets reinforced by a welded steel frame. The test section is 0.5m wide, 2.3m high and 9m long. A piston connected to a paddle produces the wave motion, while a pump connected across the piston chamber adds a steady current. For these experiments, the piston was driven by a BBC micro-computer programmed to generate nominally sinusoidal oscillations.

The experiments were divided into two phases. Firstly, the velocity field in isolation was investigated in current, wave and collinearly combined wave-current flow. Secondly, the combined velocity and sediment concentration fields were investigated in similar flow conditions.

Further details and interpretations of the data were given by Murray (1992).

2 Experimental set-up

Phase 1 : An artificial bed, comprising gravel glued onto plywood sheets, was installed along the length of the test-section, to generate rough-turbulent flow. The gravel had been sieved between 7.94mm and 12.7mm sieves. When attached to the sheets, the gravel tended to lie flat, and bed slightly into the glue. The heights of 495 grains above the plywood base were measured, and the average projection of the gravel above the plywood sheets, D=7.2mm, was taken as the appropriate bed reference level. The velocity field was measured using a Sensordata MINILAB ultrasonic current meter (USCM). This measures three components of velocity, u, v and w, in the x, y, and z directions. In measuring the horizontal velocities, acoustic signals are transmitted through a 60mm "v" shaped path, thereby averaging over 30mm in the appropriate horizontal direction and over 26mm in the vertical. The vertical velocity is derived via a direct 40mm path. The USCM was supported by a steel pole and aligned (by eye) in the PWT such that the x-axis is positive in the direction of the time-averaged bed shear stress or (for waves in isolation), along the direction of the maximum velocity amplitude. The z-axis is perpendicular to the bed, and the y-axis is orthogonal in a right-handed sense. A winch attached to the pole, enabled vertical movement of the instrument and determination of the height above the bed to an accuracy of 0.5mm.

At the beginning of each test, the USCM was lowered until the midpoint of the probe was 34.2mm above the plywood (measured using vernier callipers), that is 27mm above the bed reference level. This was the lowest measurement level; further measurements were obtained at higher levels. The levels were initially spaced 5mm apart, then at 10mm and finally at 50mm intervals (up to 627mm).

Phase 2 : A well sorted fine sand was used for the mobile bed tests. The bed material had a median diameter D_{50} = 0.145mm, and D_{35} = 0.128mm, D_{65} = 0.160mm. Pumped samples of the sand suspended by the combination of a large current and a large wave (see test parameters for mobile beds) exhibited similar grain size distributions at different heights above the bed (Figure 2). The median grain size D=0.124mm at a height of 5mm was taken

as representative of the suspended sediment. This grain size corresponds to a critical friction velocity, u_{*c}, equal to 12.2mms^{-1} (according to the Shields's curve modified by Miller *et al.*,1977) and to a settling velocity of 12mms^{-1} (Hallermeier,1981). Suspended sediment concentration was measured using an optical backscatter (OBS) probe (5cm length, 1.8cm width, and 1.5cm depth). The distance of the (mobile) bed from the instruments was recorded by a miniature ultra-sonic (US) acoustic transducer (2cm diameter x 1cm) to a resolution of 0.25mm.

The test section was covered in fine sand to a depth of 200mm. The instruments were supported by the pole used in Phase 1, but modified near the bed by an extension comprising two prongs. The USCM was attached to one prong and the OBS sediment probe and the US bed detector to the other. The support prongs were the same distance from each other as from the sidewalls. Flow disturbance involving one instrument interfering with the other, and also effects due to the sidewalls, were thus minimized. The USCM was aligned by eye, as in Phase 1, and the measurement face of the OBS probe was directed across the channel.

At the beginning of each experiment, the sand bed was smoothed by a few large amplitude wave oscillations and the mean bed level was noted. The wave and/or steady current flows were turned on to the test settings, and the bed allowed to develop into an equilibrium state. When ripples developed, they attained steady state three-dimensional forms after about one hour, while sheet flows moulded the bed in a matter of minutes. The instruments were then moved to each desired pole height, and time-series of velocities and sediment concentration were measured. In the case of rippled beds, instrument height was referred to the mean bed level that would have resulted from smoothing out the ripples. This could only be measured at the beginning and end of each test (after applying several large amplitude wave oscillations). Any variation in the mean bed level was assumed to have occurred linearly with time, and the instrument heights associated with each time-series were corrected accordingly.

Sheet flows were associated with flat beds or nearly flat beds (rolling grain ripples have heights of several millimetres). In such cases, the local bed level was the same as the mean bed level, thereby facilitating use of the ultra-sonic transducer. Clear detection of the bed occurred at least once every wave period during phases of low sediment concentration. A frequent correction of the bed position was particularly important in these tests because the sheet flows generated by wave-current combinations led to rapid erosion of the bed. (The PWT was unable to recirculate sediment because downstream of the test section, the larger cross-sectional area led to sediment deposition.) Finally, when the instruments were close to the bed, the OBS generated some bed scour. In these cases, the mean bed level was used as a reference and not the bottom of the scour pit.

The temperature at the top of the tunnel ranged from 13C to 16C with associated viscosities between 1.20 and 1.11mm^{2}s^{-1}. The mean values of 15C and 1.15mm^{2}s^{-1} were taken to apply throughout.

3 Data sampling and method of analysis

At each measurement level, the analogue velocity signals were sampled at 100 equally spaced phase-angles for 100 wave-cycles in the Phase 1 experiments and for 50 wave-cycles in Phase 2. Sampling was initiated in each wave-cycle by a +/- zero-crossing in the piston position. For current alone tests, sampling proceeded at 10Hz for 16.67 minutes. The signals were filtered at the Nyquist frequency, amplified to use the full range of the analogue-digital converter (preventing loss of precision), converted into a 12 bit digital number, and stored in a personal computer. The test parameters are shown in Tables 1 and 2.

The data was processed off line on a main frame computer. By applying a Reynolds decomposition, the steady flow velocity data was split into a time-averaged component (denoted by a capital letter with an overbar) and an instantaneous turbulent component (lower case letter primed) : $u=\bar{U}+u'$, $v=\bar{V}+v'$, $w=\bar{W}+w'$. Because the measurement axes were only approximately aligned, the data was then rotated such that u represented the velocity along the mean streamline, and $\bar{V}=\bar{W}=0$.

The mean quantities $\bar{U}$, $\bar{V}$, and $\bar{W}$, the turbulent variations σ_u, σ_v, and σ_w, where $\sigma_u=\sqrt{(u'^2)}$, the kinematic turbulent kinetic energy, $\bar{E}/\rho=\frac{1}{2}\left(\overline{u'^2}+\overline{v'^2}+\overline{w'^2}\right)$, and the kinematic Reynolds stresses $-\overline{u'w'}$, $-\overline{v'w'}$, $-\overline{u'v'}$ were derived.

The sediment concentration values were also split into a time-averaged mean and turbulent values, $c=\bar{C}+c'$. The turbulent variation, σ_c, and the Reynolds fluxes, $\overline{c'u'}$, $\overline{c'v'}$, $\overline{c'w'}$ were calculated.

Using the time-averaged concentration and velocity, the sediment flux $\bar{U}\bar{C}$ was then calculated.

When a wave was present (both in isolation and when combined with a current), the velocities were split into a periodic, ensemble-averaged component obtained at each phase-angle by averaging over 100 (or 50) wave-cycles (denoted by a capital letter), and an instantaneous turbulent component (denoted by a prime), such that $u=U+u'$, $v=V+v'$, $w=W+w'$. At each of the 100 phase-angles, the standard deviations σ_U, σ_V, σ_W, where, $\sigma_U=\sqrt{\widetilde{u'^2}}$, the kinematic turbulent kinetic energy, $E/\rho=\frac{1}{2}\left(\widetilde{u'^2}+\widetilde{v'^2}+\widetilde{w'^2}\right)$, and the Reynolds stresses, $-\widetilde{u'w'}$, $-\widetilde{v'w'}$, $-\widetilde{u'v'}$, were calculated.

In each case involving waves, parameters were further averaged over the 100 phase-angles, and such cycle-averaged values are denoted by angle brackets.

The same procedure has been followed for the sediment concentration data; here $c=C+c'$, where C is the ensemble-averaged mean sediment concentration. At each phase-angle, the turbulent concentration, σ_c, and Reynolds fluxes, $\widetilde{c'u'}$, $\widetilde{c'v'}$, $\widetilde{c'w'}$, were calculated. Cycle-averaged values were also calculated.

Sediment fluxes were calculated for the combined flow tests. Three fluxes were derived. Firstly, the "current flux" that arises from the product of the cycle-averaged velocity and cycle-averaged sediment concentration, that is

<U><C>. Secondly, the "total flux" due to the ensemble-averaged sediment and concentration variations, that is <UC>. Thirdly, the difference <U><C> - <UC> is the flux due to the periodic variations only and is termed the "wave-flux".

4 The organization of the data

All of the time-averaged (or cycle-averaged) data, and the ensemble-averaged data is available on four diskettes. For a test " ** ", the ten time-averaged (or cycle-averaged) flow parameters are contained in a single file named " **-cv.dat ". When measured, the five time-averaged (or cycle-averaged) sediment parameters are in a file " **-cc.dat " and the six time-averaged (or cycle-averaged) flux parameters are in a file " **-fl.dat ". Missing data items are indicated by 999.999. Ensemble-averaged values of each parameter at the highest eight vertical levels are contained in the following data files :

" **-u1.dat "	mean horizontal velocity component
" **-v1.dat "	mean transverse velocity component
" **-w1.dat "	mean vertical velocity component
" **-su1.dat "	turbulent horizontal velocity
" **-sv1.dat "	turbulent transverse velocity
" **-sw1.dat "	turbulent vertical velocity
" **-e1.dat "	kinematic turbulent kinetic energy
" **-uw1.dat "	kinematic Reynolds stress, $-\widetilde{u'w'}$
" **-vw1.dat "	kinematic Reynolds stress, $-\widetilde{v'w'}$
" **-uv1.dat "	kinematic Reynolds stress, $-\widetilde{u'v'}$

and when suspended sediments were measured :

" **-c1.dat "	mean suspended sediment
" **-sc1.dat "	turbulent suspended sediment
" **-cu1.dat "	horizontal Reynolds flux
" **-cv1.dat "	transverse Reynolds flux
" **-cw1.dat "	vertical Reynolds flux

Values at the lower levels are in data files, for example, " **-u2.dat ", " **-u3.dat " and " **-u4.dat ". In these files, missing data items are indicated by 9999.0.

Tables are presented of all of the time-averaged (or cycle-averaged) parameters, with an example of an ensemble-averaged data file. The phase 1 (fixed bed) tests are presented first starting with current alone tests, followed by the wave alone and the combined wave-current tests. Tables of the phase 2 (mobile bed tests) follow. Finally, the important derived parameters, that is z_0, u_*, and the vertical and cycle-averaged sediment fluxes, are summarized in a concluding table.

The data is also presented graphically. The phase 1 tests are shown first. Vertical profiles (Figures 3 to 7) of a selection of the time-averaged (or cycle-averaged) flow parameters and time-series of the ensemble-averaged properties (U, σ_u, E/ρ, and $-\widetilde{u'w'}$) are shown for all tests (Figures 8 to 17), followed by time-series of all the ensemble-averaged properties for an example test (Figures 18 to 20). The same information is shown for the Phase 2 experimental tests (Figures 21 to 45); in these cases time-averaged (or cycle-

averaged) mean sediment concentration profiles and time-series of the ensemble-averaged properties (C, σ_c, $\widetilde{c'u'}$ and $\widetilde{c'w'}$) are also shown.

5 Conclusions

Researchers wishing to use this data may take values from the printed tables or obtain it in digital form. Copies of the four 3¼" diskettes containing the tabulated data in ASCII format are available for a small handling charge from HR Wallingford. Contact R L Soulsby in the first instance. Further experimental details and interpretations were given by Murray (1992) and Murray et al (1991).

6 References

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Tables

Table 1 Test parameters for fixed bed experiments.

Test	$\overline{U}_{300}$ (mms^{-1})	T(s)	U_0 (mms^{-1})	A_0 (mm)	A_0/k_s	RE(or Re)
C1	167	-	-	-	-	(141.43)
C2	570	-	-	-	-	(203.99)
W1	-	10	366	583	31	1.86×10^5
W2	-	10	758	1206	64	7.95×10^5
W3	-	10	1127	1794	94	1.76×10^6
WC1	181	10	350	557	29	1.70×10^5
WC2	161	10	742	1181	62	7.62×10^5
WC3	140	10	1049	1670	88	1.52×10^5
WC4	603	10	366	583	31	1.86×10^5
WC5	618	10	726	1155	61	7.29×10^5
WC6	609	10	1140	1814	96	1.80×10^6
WC7	182	5	720	573	30	3.59×10^5

Note: For oscillatory flows, $k_s=30z_0$ where z_0, the bed roughness length, is 0.633mm. Here the intercept of the near-bed portion of instantaneous velocity profiles was calculated at phases in the wave-cycle that exhibited a well developed logarithmic layer, and the averaged value has been used for z_0. For a water temperature that was typically 15°, the kinematic viscosity, ν was taken equal to 1.15mm^{2}s^{-1}.

Table 2 Test parameters for mobile bed experiments.

Test	$\overline{U}_{300}$ (mms^{-1})	T(s)	U_0 (mms^{-1})	A_0 (mm)	A_0/k_s	RE (or Re)
CS1	159	-	-	-	-	(1.25)
CS2	386(σ_2=0.2)	-	-	-	-	(1.56)
WS1	-	10	411	654	8.96	2.34×10^5
WS2	-	10	1019	1622	22.50	1.44×10^6
WCS1	175(σ_2=0.3)	10	413	657	8.74	2.36×10^5
WCS2	189(σ_{10}=9.1)	10	1092	1738	17.96	1.65×10^6
WCS3	389(σ_{12}=7.9)	10	406	646	16.00	2.28×10^5
WCS4	380(σ_{40}=11.7)	10	1100	1751	10.41	1.67×10^6

Note: The relative roughness, A_0/k_s, was calculated using Grant and Madsen's (1982) formula for movable bed roughness. σ_n is the standard deviation of the current velocity, which arises from resetting the current n times, and ν=1.15mm^{2}s^{-1}.

Test	Bed Condition	Ripple wavelength (mm)	Ripple height (mm)
CS1	No sediment transport	-	-
CS2	3D ripples	100	15
WS1	3D ripples	100	15
WS2	Sheet flow over large-scale 2D ripples	1600	150-200
WSC1	3D ripples	100	15
WSC2	Sheet flow over flat bed	-	-
WSC3	Sheet flow over rolling-grain ripples	100	1-3
WSC4	Sheet flow over flat bed	-	-

$z_0 = \frac{25}{33}\frac{H^2}{\lambda}$ for rippled bed.

Table 3 Test C1 (small current in isolation): Time-averaged flow parameters

'c1-cv.dat'
TEST C1 - Fixed bed, small current
D50=7.2mm

$\bar{U}$ at 300mm above bed =167mm/s
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

TIME-AVERAGED VELOCITY DATA

z	$\bar{U}$	$\bar{V}$	$\bar{W}$	sigu	sigv	sigw	$\bar{E}$/rho	$-\overline{u'w'}$	$-\overline{v'w'}$	$-\overline{u'v'}$
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
627.0	176.79	0.00	0.00	15.61	20.82	12.11	411.83	27.20	10.23	78.48
327.0	167.40	0.00	0.00	13.20	10.64	11.38	208.51	-36.71	-4.60	32.72
277.0	181.84	0.00	0.00	12.85	12.20	10.78	215.09	-22.79	-12.22	38.97
227.0	184.94	0.00	0.00	12.28	23.82	9.71	406.26	-16.87	-14.36	3.70
177.0	189.86	0.00	0.00	10.42	20.74	7.88	300.45	-2.26	-23.89	19.55
127.0	191.48	0.00	0.00	9.89	21.06	6.36	290.95	6.36	-11.41	20.75
117.0	191.80	0.00	0.00	10.34	9.23	6.14	114.92	6.62	-5.08	23.87
107.0	191.36	0.00	0.00	10.38	8.85	5.99	111.01	8.89	-4.68	22.16
97.0	189.60	0.00	0.00	11.52	9.02	5.71	123.29	7.80	-2.62	26.69
87.0	190.02	0.00	0.00	12.73	10.74	5.23	152.44	10.53	-2.19	23.56
77.0	187.42	0.00	0.00	14.28	7.38	5.27	143.13	14.22	-2.48	22.64
72.0	187.78	0.00	0.00	13.73	7.81	5.18	138.18	14.13	-3.37	24.11
67.0	186.38	0.00	0.00	14.89	10.88	5.52	185.25	19.00	-7.46	28.59
62.0	186.01	0.00	0.00	14.62	8.71	5.47	159.84	11.31	-2.49	20.87
57.0	180.20	0.00	0.00	16.43	29.21	5.96	579.35	19.85	-18.46	49.53
52.0	177.39	0.00	0.00	15.99	28.74	5.78	557.55	18.92	-17.71	64.62
47.0	172.56	0.00	0.00	16.74	13.23	5.96	245.38	17.25	-12.90	41.29
42.0	167.02	0.00	0.00	16.14	9.33	5.95	191.50	18.31	-10.09	29.66
37.0	159.65	0.00	0.00	17.16	10.15	5.97	216.59	14.42	-14.98	32.62
32.0	148.78	0.00	0.00	16.53	9.56	6.05	200.67	14.53	-13.82	26.36
27.0	138.87	0.00	0.00	17.82	11.38	6.07	241.97	17.58	-18.06	18.41

Table 4 Test C2 (large current in isolation): Time-averaged flow parameters

'c2-cv.dat'
TEST C2 - Fixed bed, large current
D50=7.2mm

$\bar{U}$ at 300mm above bed =570mm/s
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

TIME-AVERAGED VELOCITY DATA

z	$\bar{U}$	$\bar{V}$	$\bar{W}$	sigu	sigv	sigw	$\bar{E}$/rho	$-\overline{u'w'}$	$-\overline{v'w'}$	$-\overline{u'v'}$
mm	mm/s	mm/s	mm/s	mm/s	mm/	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
327.0	572.21	-12.59	0.00	35.45	29.56	30.54	1531.27	-18.80	24.62	337.35
277.0	585.06	-18.38	0.00	32.38	23.39	28.54	1205.22	-10.11	-1.56	188.47
227.0	589.88	-19.57	0.00	27.87	28.17	25.78	1117.46	2.38	-83.36	97.44
177.0	598.09	-31.35	0.00	26.06	17.46	21.87	731.23	9.07	-47.85	95.71
127.0	603.11	-38.51	0.00	23.42	26.86	16.98	779.04	46.00	-44.97	103.72
117.0	601.95	-53.88	0.00	23.98	17.35	15.70	561.22	63.37	-11.87	93.28
107.0	598.09	-66.95	0.00	25.29	16.82	15.31	578.43	89.57	-27.14	102.09
97.0	594.76	-77.78	0.00	27.40	20.00	14.42	679.08	120.60	-12.39	87.10
87.0	586.06	-100.42	0.00	30.30	18.49	14.01	728.26	159.88	-15.07	94.23
77.0	576.45	-105.85	0.00	34.70	19.91	14.16	900.49	203.20	-23.05	93.74
72.0	570.89	-108.90	0.00	34.86	20.65	13.85	916.79	183.69	-28.78	120.89
67.0	567.52	-115.37	0.00	37.11	21.93	14.48	1033.64	224.96	-34.42	98.65
62.0	560.22	-127.63	0.00	38.64	27.47	14.30	1226.40	220.02	-50.21	83.23
57.0	555.28	-126.90	0.00	40.12	29.44	15.04	1351.22	223.17	-84.16	149.47
52.0	547.43	-122.23	0.00	42.48	27.39	15.00	1389.68	256.97	-76.61	105.41
47.0	538.89	-120.04	0.00	44.53	30.05	15.23	1559.19	261.66	-97.95	165.43
42.0	524.27	-80.28	0.00	45.70	27.10	16.02	1539.82	268.13	-77.19	153.67
37.0	518.43	-69.53	0.00	46.36	28.47	15.67	1602.60	242.26	-110.77	207.19
32.0	504.62	-60.38	0.00	46.47	29.04	15.87	1627.43	229.50	-136.32	168.82
27.0	491.87	-80.67	0.00	47.23	27.71	14.93	1610.66	145.79	-114.06	151.79

Table 5 Test W1 (small wave alone): Cycle-averaged flow parameters

'w1-cv.dat'
TEST W1 - Fixed bed, small wave
D50=7.2mm
T=10s, U0=366mm/s, A0=583mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
327.0	15.71	-2.92	2.64	5.34	3.65	3.03	26.34	1.56	-2.30	0.36
277.0	14.82	-4.22	2.00	5.51	3.97	2.79	27.85	1.01	-1.56	2.12
227.0	15.24	-1.77	1.43	5.43	3.78	2.84	26.99	0.79	-2.28	2.19
177.0	4.48	2.51	1.63	6.04	8.54	3.11	69.37	0.76	-3.11	1.36
127.0	3.42	0.49	1.31	6.24	4.72	3.39	38.64	0.07	-4.40	-1.69
117.0	4.71	1.43	1.80	6.48	7.32	3.38	60.66	0.72	-2.95	0.71
107.0	3.99	0.83	1.98	6.76	20.10	3.44	244.71	1.07	-5.36	4.22
97.0	3.84	-1.23	1.57	6.82	25.13	3.44	364.11	-0.50	-4.46	-0.32
87.0	3.80	0.26	1.20	7.21	27.04	3.54	419.48	-0.73	-7.50	4.28
77.0	4.16	-0.33	1.80	6.99	22.93	3.63	316.64	-0.46	-7.91	-4.95
72.0	3.75	0.49	2.51	6.88	18.78	3.60	222.79	1.15	-4.24	9.41
67.0	3.99	-0.68	2.38	7.12	27.19	3.73	412.99	-0.22	-7.81	4.27
62.0	3.41	0.34	1.90	7.07	12.17	3.79	111.27	0.76	-3.13	-1.10
57.0	3.82	1.63	2.08	7.68	11.80	3.97	111.32	0.75	-3.76	1.84
52.0	3.92	1.00	2.45	8.05	13.13	4.02	136.51	0.90	-5.36	5.28
47.0	4.75	1.54	2.16	9.43	11.94	4.45	130.78	0.01	-6.62	-4.40
42.0	4.18	1.08	2.11	9.94	5.69	4.73	81.08	3.51	-4.25	3.26
37.0	4.05	1.40	1.32	10.90	7.10	5.05	103.60	-0.73	-5.02	3.73
32.0	3.72	3.41	1.89	12.02	16.07	6.38	243.40	5.29	-7.38	11.84
27.0	4.43	3.46	0.28	12.96	13.10	5.98	211.10	-0.69	-3.67	3.92

Table 6 Test W2 (medium wave alone): Cycle-averaged flow parameters

'w2-cv.dat'
TEST W2 - Fixed bed, medium wave
D50=7.2mm
T=10s, U0=758mm/s, A0=1206mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
327.0	3.95	3.65	-11.09	8.33	5.87	4.18	68.41	0.00	-7.48	0.92
277.0	5.72	3.40	-12.33	8.68	5.71	4.27	71.27	-2.27	-5.56	3.18
227.0	7.31	2.52	-13.05	9.07	5.79	4.64	78.60	0.13	-7.28	4.94
177.0	16.46	9.97	-11.61	10.89	6.40	5.88	120.75	-14.72	-11.68	4.45
127.0	19.05	5.44	-9.17	11.62	22.15	6.79	359.08	-8.66	-31.35	-1.94
117.0	14.10	0.83	-8.26	12.28	7.45	7.17	145.33	-8.64	-13.88	-0.92
107.0	14.75	1.53	-7.18	13.58	7.71	7.53	168.77	3.26	-10.46	-4.62
97.0	15.28	2.29	-6.68	14.72	8.11	8.20	192.10	8.94	-12.27	-6.63
87.0	15.03	4.35	-5.42	16.80	8.18	8.59	232.86	20.78	-12.77	-2.64
77.0	16.11	4.45	-4.42	18.10	10.11	9.30	279.14	23.85	-16.34	-4.24
72.0	16.96	5.67	-4.04	19.78	11.23	9.88	330.42	27.78	-16.78	-1.43
67.0	17.62	7.23	-4.33	20.27	10.57	10.11	333.49	18.77	-17.34	-12.15
62.0	17.85	9.02	-3.90	21.35	11.01	10.66	369.83	30.23	-22.18	-2.58
57.0	18.19	10.12	-3.81	22.43	11.56	10.56	400.22	20.73	-19.77	-13.10
52.0	16.65	11.17	-4.16	23.54	11.96	10.74	438.48	37.12	-23.49	3.42
47.0	15.34	11.10	-4.22	26.76	12.94	11.23	562.48	46.32	-26.63	13.57
42.0	12.03	11.10	-3.77	26.52	13.44	11.61	565.87	29.57	-34.20	22.12
37.0	10.54	7.09	-3.79	27.83	48.16	11.94	1714.25	20.96	-60.80	29.46
32.0	2.58	1.43	-7.45	30.75	15.53	11.86	750.10	15.08	-44.90	11.03
27.0	0.14	1.04	-8.24	32.16	16.39	11.33	803.31	30.96	-39.54	32.93

Table 7 Test W3 (large wave alone): Cycle-averaged flow parameters

'w3-cv.dat'
TEST W3 - Fixed bed, large wave
D50=7.2mm
T=10s, U0=1127mm/s, A0=1794mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
326.8	9.08	-5.61	-23.94	12.90	32.31	9.55	727.25	5.13	-6.64	-49.90
276.7	8.56	-5.71	-23.46	14.03	33.61	9.56	780.92	9.79	-16.04	-75.70
226.7	7.35	-6.20	-23.58	15.15	15.71	9.79	327.36	10.88	-15.17	-15.09
177.0	3.54	-7.76	-20.15	15.41	15.84	10.30	326.33	12.72	-17.77	-3.80
127.0	1.34	-12.72	-15.76	18.87	16.82	12.37	414.59	20.23	-22.31	0.60
117.0	0.64	-10.48	-13.58	21.93	13.39	13.05	434.58	21.90	-18.58	-16.26
107.0	-1.07	-11.54	-11.76	22.23	13.12	13.78	450.93	36.94	-14.04	-11.15
97.0	0.71	-11.69	-10.69	23.93	15.78	14.42	548.99	38.74	-19.56	-15.35
87.0	0.44	-9.10	-9.02	26.51	14.44	15.67	626.27	46.07	-14.77	-17.48
77.0	0.31	-8.29	-8.82	28.43	16.22	16.98	754.01	21.41	-24.32	-2.28
72.0	-9.18	-10.49	-13.41	29.45	16.56	17.47	803.05	70.44	-46.21	2.60
67.0	-8.81	-11.70	-14.39	30.38	17.88	17.20	850.44	35.97	-46.75	7.73
62.0	-13.04	-17.99	-15.05	31.82	29.29	17.61	1205.77	51.46	-71.89	14.65
57.0	-15.53	-16.83	-15.49	34.34	29.20	17.91	1300.79	40.62	-79.90	40.01
52.0	-19.72	-13.57	-15.53	36.89	29.45	18.88	1444.72	46.33	-117.48	4.52
47.0	-22.33	-17.34	-16.94	38.51	47.88	18.32	2275.80	35.56	-122.47	0.97
42.0	-25.78	-9.29	-18.35	41.72	23.71	18.98	1479.56	34.65	-105.04	57.70
37.0	-29.39	-9.73	-19.55	43.13	43.94	19.47	2282.64	41.68	-220.86	139.42
32.0	-1.71	-9.26	-14.50	46.05	25.72	19.75	1788.75	38.90	-127.81	88.92
27.0	-6.36	-7.29	-16.81	46.77	25.68	19.13	1807.39	-17.66	-139.89	55.57

Table 8 Test WC1 (small current + small wave): Cycle-averaged flow parameters

'wc1-cv.dat'
TEST WC1 - Fixed bed, small current + small wave
D50=7.2mm
Time-av U (current only) at 300mm above bed =181mm/s
T=10s, U0=350mm/s, A0=557mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
627.0	198.71	36.40	0.00	13.99	12.14	10.46	235.78	0.30	0.22	76.06
327.0	199.93	9.68	0.00	13.90	13.67	9.16	243.16	-4.29	-9.11	76.08
277.0	199.95	34.73	0.00	13.00	9.88	8.89	181.14	-9.12	-11.52	54.34
227.0	202.22	33.10	0.00	12.60	9.08	8.26	162.71	-21.47	-6.60	39.07
177.0	203.26	36.16	0.00	11.90	17.77	8.03	280.91	-3.99	-14.14	26.25
127.0	196.01	62.61	0.00	13.99	43.00	8.40	1070.34	25.83	-24.57	92.81
117.0	193.45	45.34	0.00	14.72	38.31	8.40	895.46	32.67	-24.51	47.70
107.0	187.38	28.36	0.00	17.48	9.39	8.90	246.33	44.81	-14.41	39.74
97.0	180.90	62.58	0.00	17.67	78.24	9.23	3294.58	44.94	-46.72	193.17
87.0	175.51	36.45	0.00	18.42	49.74	9.23	1475.62	45.11	-59.24	120.88
77.0	167.42	24.88	0.00	19.67	41.90	9.65	1159.55	41.99	-65.09	109.40
72.0	161.08	22.87	0.00	21.24	35.76	9.48	949.82	54.46	-39.63	143.79
67.0	152.56	20.74	0.00	20.95	42.73	9.56	1216.24	40.60	-70.77	124.82
62.0	148.66	15.60	0.00	20.85	18.25	9.62	453.08	35.70	-38.03	75.36
57.0	143.03	19.09	0.00	20.86	44.87	9.42	1296.55	31.54	-80.68	129.79
52.0	135.05	17.10	0.00	21.64	59.98	9.52	2133.49	27.00	-125.31	189.81
47.0	129.97	12.02	0.00	22.47	38.79	9.30	1078.61	13.62	-77.26	163.65
42.0	124.04	10.33	0.00	22.05	26.00	8.93	651.07	12.89	-29.52	100.19
37.0	121.03	7.22	0.00	22.77	25.07	9.44	658.21	13.33	-40.70	115.74
32.0	119.23	6.51	0.00	22.15	17.23	8.86	472.79	-3.09	-32.99	78.08
27.0	113.16	6.80	0.00	22.52	14.80	8.63	440.14	-25.89	-24.04	65.89

Table 9 Test WC2 (small current + medium wave): Cycle-averaged flow parameters

'wc2-cv.dat'
TEST WC2 - Fixed bed, small current + medium wave
D50=7.2mm
Time-av U (current only) at 300mm above bed =161mm/s
T=10s, U0=742mm/s, A0=1181mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
627.0	207.65	0.00	0.00	12.73	14.31	11.83	266.78	-16.89	-10.12	50.65
327.0	219.21	0.00	0.00	15.49	12.88	12.30	292.94	10.41	-41.85	-3.06
277.0	206.96	23.48	0.00	14.69	14.45	11.69	295.42	5.44	-48.92	0.26
227.0	207.77	0.00	0.00	13.11	10.91	11.02	217.02	6.88	-52.76	20.83
177.0	202.60	0.00	0.00	14.79	11.75	11.30	253.93	19.24	-59.35	28.76
127.0	184.84	0.00	0.00	18.93	13.08	11.91	358.52	54.90	-62.76	63.23
117.0	181.38	0.00	0.00	20.61	13.82	12.46	414.06	70.30	-66.39	74.98
107.0	175.39	0.00	0.00	21.26	13.93	11.91	421.86	60.07	-58.45	95.52
97.0	166.73	20.78	0.00	22.76	18.27	12.37	543.62	86.47	-73.85	77.44
87.0	163.04	0.00	0.00	24.19	15.35	13.14	542.63	78.36	-76.78	87.81
77.0	153.93	0.00	0.00	23.57	15.82	13.05	536.76	75.75	-71.64	68.85
72.0	152.06	0.00	0.00	25.64	15.24	13.08	579.74	67.52	-73.51	64.36
67.0	150.57	0.00	0.00	24.55	16.08	12.48	554.92	50.10	-58.14	38.59
62.0	144.26	0.00	0.00	25.81	15.25	12.94	590.74	27.31	-60.29	77.77
57.0	143.64	0.00	0.00	27.02	15.42	12.88	631.74	22.67	-61.36	83.13
52.0	138.86	-0.54	0.00	28.84	60.60	13.01	2422.34	4.03	-154.15	101.39
47.0	132.73	0.00	0.00	31.13	16.38	13.51	819.01	-64.34	-50.86	70.25
42.0	129.26	-7.44	0.00	29.45	65.10	13.68	2786.11	-36.19	-197.72	123.60
37.0	123.72	-3.97	0.00	32.06	56.98	13.62	2366.29	-79.24	-177.90	73.76
32.0	116.62	-9.41	0.00	33.29	62.74	13.84	2765.83	-111.68	-174.18	109.79
27.0	105.58	-15.13	0.00	34.52	74.04	14.02	3671.12	-154.27	-241.78	95.21

Table 10 Test WC3 (small current + large wave): Cycle-averaged flow parameters

'wc3-cv.dat'
TEST WC3 - Fixed bed, small current + large wave
D50=7.2mm
Time-av U (current only) at 300mm above bed =140mm/s
T=10s, U0=1049mm/s, A0=1670mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
327.0	184.29	-1.08	0.00	31.77	42.87	29.22	2088.87	-60.50	-100.74	-139.99
277.0	172.36	-31.20	0.00	33.32	36.29	28.18	1766.75	-186.67	-159.34	-159.63
227.0	170.92	-41.77	0.00	32.09	33.93	26.96	1591.99	-75.04	-240.04	-272.28
177.0	164.71	-42.64	0.00	31.52	38.33	23.90	1684.90	-139.56	-416.00	-417.85
127.0	162.39	-40.85	0.00	31.58	37.01	21.47	1571.03	-49.67	-355.06	-327.38
117.0	160.59	-40.65	0.00	31.46	34.49	22.18	1479.69	-28.21	-344.11	-183.60
107.0	157.62	-33.40	0.00	32.84	34.94	20.47	1483.17	-13.35	-315.53	-89.90
97.0	153.87	-34.77	0.00	34.98	35.65	20.44	1621.68	-11.62	-314.81	-62.64
87.0	147.93	-12.78	0.00	38.93	33.90	19.64	1683.31	21.63	-177.61	57.86
77.0	157.79	-40.32	0.00	42.78	42.40	21.59	2355.08	-34.27	-363.27	265.77
72.0	151.24	-22.11	0.00	43.63	36.80	18.89	2045.30	41.38	-210.90	238.70
67.0	152.87	-18.60	0.00	43.80	37.63	19.22	2092.31	-39.71	-197.36	146.51
62.0	148.77	-20.02	0.00	46.82	36.41	20.80	2202.45	-12.55	-220.00	250.71
57.0	146.79	-15.53	0.00	47.95	35.95	20.20	2265.96	-92.55	-196.71	76.77
52.0	144.03	-17.07	0.00	48.01	33.83	19.83	2140.28	-71.77	-149.61	343.07
47.0	177.95	-58.13	0.00	45.71	35.82	21.66	2157.62	-245.71	-203.42	216.52
42.0	128.23	-6.08	0.00	51.54	33.72	21.29	2392.72	-202.62	-185.28	40.00
37.0	125.44	-8.73	0.00	55.21	35.99	21.85	2738.49	-279.82	-188.89	356.94
32.0	125.97	-12.90	0.00	54.90	39.26	20.60	2785.84	-261.44	-185.03	541.17
27.0	110.78	-5.72	0.00	54.98	36.99	20.91	2743.25	-363.98	-184.46	314.24

Table 11 Test WC4 (large current + small wave): Cycle-averaged flow parameters

'wc4-cv.dat'
TEST WC4 - Fixed bed, large current + small wave
D50=7.2mm
Time-av U (current only) at 300mm above bed =603mm/s
T=10s, U0=366mm/s, A0=583mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
627.0	653.64	0.00	0.00	48.67	39.10	34.55	2581.84	414.90	65.46	828.21
327.0	647.52	0.00	0.00	39.23	33.69	31.39	1877.57	-20.26	10.87	592.21
277.0	665.97	0.00	0.00	36.11	28.15	28.68	1506.49	-56.79	-19.81	388.63
227.0	672.78	0.00	0.00	31.56	24.54	26.79	1194.31	30.65	-33.24	274.89
177.0	683.70	14.53	0.00	29.59	49.25	23.26	1967.49	66.93	-102.04	354.90
127.0	678.73	0.00	0.00	30.31	24.20	20.07	1009.47	169.64	-51.89	211.95
117.0	678.51	0.00	0.00	31.43	25.60	19.39	1075.18	166.70	-37.46	222.76
107.0	670.71	0.00	0.00	35.45	25.65	19.23	1230.57	287.43	-47.62	185.79
97.0	664.26	0.00	0.00	38.18	25.27	19.07	1316.52	303.01	-49.27	199.03
87.0	658.91	0.00	0.00	39.26	26.86	19.60	1426.72	346.24	-77.60	221.37
77.0	645.56	0.00	0.00	44.13	28.91	19.29	1707.38	353.53	-76.69	286.47
72.0	636.52	0.00	0.00	46.30	29.92	19.83	1852.39	393.25	-107.61	296.34
67.0	627.64	8.27	0.00	48.88	47.78	19.95	2680.73	370.70	-183.11	452.71
62.0	622.03	0.00	0.00	49.44	28.11	19.97	1941.23	403.22	-121.96	275.87
57.0	604.92	5.28	0.00	51.51	59.50	20.18	3427.69	423.55	-257.85	640.96
52.0	601.24	0.00	0.00	53.50	33.17	20.16	2281.02	404.43	-159.51	362.45
47.0	583.82	0.00	0.00	57.97	32.24	21.00	2527.41	433.28	-180.84	328.41
42.0	576.40	0.00	0.00	61.02	30.62	20.84	2629.96	479.69	-177.46	544.31
37.0	563.03	0.00	0.00	61.70	31.65	20.80	2723.55	399.94	-208.13	452.07
32.0	538.68	0.00	0.00	62.56	32.83	20.33	2758.44	358.05	-200.41	431.00
27.0	518.83	0.00	0.00	63.42	35.40	19.65	2910.23	261.71	-224.83	369.73

Table 12 WC5 (large current + medium wave): Cycle-averaged flow parameters

'wc5-cv.dat'
TEST WC5 - Fixed bed, large current + medium wave
D50=7.2mm
Time-av U (current only) at 300mm above bed =618mm/s
T=10s, U0=726mm/s, A0=1155mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
627.0	651.46	0.00	0.00	42.10	37.52	30.88	2149.69	252.81	12.78	560.39
327.0	669.69	0.00	0.00	43.20	58.01	28.51	3134.03	74.91	-209.13	837.82
277.0	652.97	0.00	0.00	39.13	29.91	27.05	1663.33	63.64	-39.43	366.76
227.0	657.08	0.00	0.00	33.76	27.38	24.87	1294.00	81.76	-66.25	203.51
177.0	658.16	0.00	0.00	34.83	28.25	25.60	1418.56	211.17	-55.40	265.36
127.0	640.05	0.00	0.00	40.74	32.51	24.95	1810.12	415.08	-50.87	283.77
117.0	631.87	0.00	0.00	43.28	33.07	26.58	2048.66	480.22	-151.29	346.81
107.0	627.39	0.00	0.00	45.02	33.88	25.83	2118.72	540.76	-176.93	362.39
97.0	622.11	0.00	0.00	47.25	33.30	25.31	2194.00	523.35	-121.82	221.23
87.0	610.61	0.00	0.00	52.05	36.98	26.06	2676.09	516.48	-180.45	367.30
77.0	595.67	0.00	0.00	55.75	35.48	27.03	2875.39	653.81	-207.94	390.32
72.0	591.32	0.00	0.00	55.90	37.07	26.42	2872.09	620.81	-178.57	325.51
67.0	581.86	0.00	0.00	59.49	36.10	26.46	3050.36	599.39	-244.05	458.05
62.0	576.84	0.00	0.00	59.30	36.41	26.33	3068.30	668.67	-189.67	444.34
57.0	571.27	0.00	0.00	62.61	38.81	26.25	3406.51	619.51	-256.41	566.86
52.0	555.86	0.00	0.00	62.88	40.02	26.48	3494.65	600.96	-281.13	486.13
47.0	536.22	-38.61	0.00	62.18	67.68	26.13	4898.95	515.80	-493.72	866.46
42.0	525.77	-50.93	0.00	67.32	76.36	25.73	5956.25	549.12	-533.49	999.99
37.0	513.13	0.00	0.00	63.65	42.51	25.37	3559.09	446.67	-324.03	360.32
32.0	497.69	-48.16	0.00	64.72	86.87	24.86	6585.34	413.60	-663.09	999.99
27.0	472.48	-44.14	0.00	66.43	91.46	24.75	7163.06	360.43	-707.94	999.99

Table 13 WC6 (large current + large wave): Cycle-averaged flow parameters

'wc6-cv.dat'
TEST WC6 - Fixed bed, large current + large wave
D50=7.2mm
Time-av U (current only) at 300mm above bed =609mm/s
T=10s, U0=1140mm/s, A0=1814mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
627.0	648.97	0.00	0.00	41.80	46.72	40.58	2968.03	4.31	307.28	460.57
327.0	688.49	0.00	0.00	46.56	49.05	39.45	3356.67	148.17	-306.97	252.76
277.0	641.75	0.00	0.00	45.29	42.98	34.93	2763.81	120.72	-224.83	310.72
227.0	642.03	0.00	0.00	48.49	42.18	36.38	2968.45	266.03	-275.60	211.81
177.0	628.60	0.00	0.00	45.12	37.28	33.82	2449.32	400.67	-151.36	130.69
127.0	610.45	0.00	0.00	51.20	38.75	32.74	2906.62	700.40	-185.48	36.84
117.0	608.19	0.00	0.00	50.85	39.96	31.20	2852.67	538.47	-198.86	-12.59
107.0	598.04	0.00	0.00	56.26	42.27	31.55	3347.37	672.35	-273.60	31.38
97.0	584.80	0.00	0.00	53.42	42.53	31.74	3204.69	595.40	-263.79	-28.89
87.0	579.20	0.00	0.00	59.29	42.71	30.68	3582.44	731.95	-346.54	-59.38
77.0	562.74	0.00	0.00	63.25	46.37	30.78	4064.46	735.81	-324.70	-90.60
72.0	564.10	0.00	0.00	62.40	46.15	30.80	3964.06	715.42	-416.32	-131.83
67.0	554.39	0.00	0.00	61.73	46.48	30.00	3939.84	698.18	-381.69	-93.46
62.0	548.33	0.00	0.00	65.75	47.87	29.90	4382.74	664.62	-452.84	-135.54
57.0	536.54	0.00	0.00	69.51	50.85	29.05	4739.16	603.39	-421.50	-198.71
52.0	531.65	60.60	0.00	66.98	89.56	28.75	7450.73	535.92	-691.02	-656.34
47.0	514.10	56.15	0.00	69.57	83.87	29.10	7113.41	586.12	-639.41	-465.10
42.0	508.20	46.78	0.00	71.77	79.26	27.84	6869.05	432.25	-617.47	-295.52
37.0	488.93	55.62	0.00	72.03	87.86	27.65	7696.43	288.26	-871.78	-495.81
32.0	474.58	50.51	0.00	72.15	86.96	27.21	7587.48	250.54	-745.43	-482.77
27.0	455.22	0.00	0.00	77.74	54.02	25.89	5429.34	151.47	-550.01	115.98

Table 14 Test WC7 (small current + 5s wave): Cycle-averaged flow parameters

'wc7-cv.dat'
TEST WC7 - Fixed bed, small current + 5s wave
D50=7.2mm
Time-av U (current only) at 300mm above bed =182mm/s
T=5s, U0=720mm/s, A0=573mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
627.0	230.42	76.77	0.00	17.05	34.08	10.57	805.73	20.92	-93.96	283.10
327.0	232.86	2.73	0.00	16.24	12.06	9.67	263.55	5.46	-35.10	111.86
277.0	240.12	5.73	0.00	14.75	11.34	9.42	228.63	8.36	-34.27	84.77
227.0	239.11	10.86	0.00	13.86	14.73	8.11	251.19	15.22	-28.87	97.98
177.0	229.87	20.02	0.00	16.59	12.38	8.40	263.06	51.14	-29.22	90.64
127.0	224.94	26.14	0.00	16.40	11.02	8.45	242.29	48.54	-22.17	78.97
117.0	219.03	29.88	0.00	18.30	11.40	8.83	284.91	52.87	-25.50	87.71
107.0	210.48	34.75	0.00	20.61	12.04	9.32	344.83	61.09	-22.67	97.23
97.0	198.84	39.49	0.00	21.41	23.26	9.52	564.07	65.71	-39.60	113.29
87.0	188.24	40.25	0.00	23.01	16.28	9.65	463.38	70.30	-45.21	108.91
77.0	176.74	44.85	0.00	22.46	19.94	9.99	527.86	65.11	-47.80	118.65
72.0	173.22	45.86	0.00	22.20	18.93	10.10	516.69	61.21	-54.31	97.68
67.0	162.60	49.70	0.00	24.30	16.15	10.20	508.81	62.77	-61.10	116.46
62.0	155.23	69.15	0.00	24.07	37.42	10.11	1100.87	71.44	-112.61	224.68
57.0	151.33	86.69	0.00	25.05	53.50	10.17	1901.21	51.72	-134.71	367.84
52.0	139.85	73.09	0.00	24.39	29.96	9.85	842.72	50.22	-66.60	193.75
47.0	130.91	69.85	0.00	25.60	29.81	9.75	882.27	43.51	-74.32	182.39
42.0	123.92	64.12	0.00	26.24	36.68	10.23	1120.17	19.65	-69.75	212.41
37.0	114.48	63.57	0.00	27.14	25.99	9.33	801.94	22.68	-48.91	193.49
32.0	103.41	65.60	0.00	27.46	28.98	9.15	909.67	-24.52	-58.43	130.21

Table 15 Test W3 (large wave alone): An example of an ensemble-averaged data file

'w3-u1.dat'
TEST W3 - Fixed bed, large wave
D50=7.2mm
T=10s, U0=1127mm/s, A0=1794mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

ENSEMBLE-AVERAGED U-VELOCITY COMPONENT (mm/s)

phase in pi	z=326.8 z in mm	z=276.7	z=226.7	z=177.0	z=127.0	z=117.0	z=107.0	z= 97.0
0.02	228.65	212.02	153.76	129.24	102.84	90.86	60.82	53.98
0.04	314.04	304.91	244.99	226.54	200.92	186.05	155.65	151.64
0.06	386.99	382.24	324.34	309.49	287.46	271.48	241.44	239.55
0.08	458.66	450.82	396.18	384.55	366.14	349.63	323.11	317.55
0.10	528.06	517.82	466.43	451.82	438.08	422.42	401.53	389.29
0.12	591.33	581.57	535.34	516.47	502.18	483.72	472.20	456.48
0.14	656.88	651.75	609.06	585.04	570.23	547.08	540.30	523.33
0.16	725.25	721.96	682.83	660.27	642.60	618.46	615.34	596.41
0.18	793.48	791.63	758.43	735.40	722.37	697.93	693.52	674.19
0.20	858.94	859.95	833.11	815.11	803.39	780.28	777.53	754.99
0.22	918.67	924.27	895.29	886.27	876.27	860.38	855.96	835.51
0.24	966.52	975.95	945.64	940.34	935.94	926.10	920.74	899.48
0.26	1005.35	1016.70	989.12	986.28	983.83	979.23	972.43	957.74
0.28	1031.83	1049.15	1022.21	1023.66	1025.47	1021.03	1013.01	1005.46
0.30	1052.68	1076.62	1051.74	1056.40	1058.05	1054.38	1046.94	1041.40
0.32	1067.90	1096.35	1073.33	1079.36	1083.10	1080.77	1076.42	1069.16
0.34	1081.75	1107.60	1087.72	1099.15	1104.03	1102.18	1101.57	1093.38
0.36	1086.74	1113.48	1099.76	1115.53	1119.30	1117.40	1122.15	1114.54
0.38	1091.02	1121.83	1109.71	1127.37	1134.71	1134.32	1138.61	1135.72
0.40	1094.44	1128.79	1118.94	1136.31	1148.85	1151.39	1155.43	1150.83
0.42	1095.65	1136.37	1131.88	1146.88	1163.72	1172.21	1174.46	1168.77
0.44	1098.46	1142.45	1138.22	1155.74	1175.49	1188.35	1190.15	1187.85
0.46	1095.33	1144.28	1138.52	1166.00	1187.07	1201.42	1205.74	1204.90
0.48	1093.60	1139.05	1137.76	1170.48	1196.38	1212.84	1219.59	1218.12
0.50	1089.27	1133.48	1141.16	1173.99	1201.22	1222.69	1233.08	1227.53
0.52	1082.31	1128.05	1145.30	1176.54	1207.71	1224.74	1237.31	1234.03
0.54	1072.25	1125.68	1145.08	1174.68	1214.42	1225.69	1239.52	1238.85
0.56	1063.72	1123.74	1138.50	1163.43	1212.29	1221.40	1238.17	1238.20
0.58	1056.13	1113.06	1122.90	1146.08	1191.44	1200.10	1218.32	1225.12
0.60	1040.61	1087.08	1096.63	1118.26	1153.70	1166.19	1180.78	1190.27
0.62	1009.17	1055.25	1063.34	1084.15	1113.69	1127.58	1139.90	1147.28
0.64	974.94	1020.03	1027.68	1048.12	1073.49	1092.30	1102.04	1105.79
0.66	939.05	975.45	992.35	1014.13	1040.37	1055.49	1069.66	1072.97
0.68	885.39	926.81	950.55	975.76	1000.04	1015.30	1031.97	1037.74
0.70	819.99	874.14	897.04	931.32	953.83	971.42	989.06	1000.68
0.72	759.52	807.74	829.70	867.56	891.69	914.40	933.18	947.86
0.74	698.32	731.38	760.29	798.64	826.23	846.96	866.06	888.19
0.76	634.35	657.06	685.98	718.03	754.89	772.19	794.78	821.63
0.78	571.19	596.69	622.88	649.28	685.03	703.67	726.88	756.23
0.80	512.51	539.62	555.07	586.88	618.53	637.93	658.77	684.89
0.82	458.36	477.32	489.70	522.47	553.60	572.28	592.60	615.72
0.84	397.58	412.65	423.68	454.96	483.84	503.24	525.82	546.00
0.86	329.49	346.81	350.06	383.76	413.75	432.10	460.63	477.79
0.88	258.03	276.96	274.83	312.39	338.88	361.38	388.32	411.81
0.90	184.75	205.91	203.18	239.10	260.32	286.12	313.72	341.55
0.92	109.73	136.37	131.04	162.58	178.69	209.32	237.95	263.45
0.94	35.46	62.09	57.39	88.72	101.91	132.46	161.78	181.68
0.96	-34.87	-9.64	-16.40	15.50	32.09	58.63	86.98	101.96
0.98	-111.36	-88.72	-93.56	-57.78	-36.86	-11.75	16.40	29.09
1.00	-197.57	-177.61	-183.85	-148.13	-118.99	-97.21	-66.02	-51.33
1.02	-276.72	-254.94	-269.99	-234.39	-207.37	-186.28	-154.09	-141.34
1.04	-347.68	-330.90	-345.89	-314.16	-288.43	-269.57	-238.06	-225.22
1.06	-414.41	-394.54	-409.54	-383.85	-356.89	-337.71	-312.37	-295.39
1.08	-474.31	-454.42	-468.04	-449.90	-427.14	-401.72	-383.36	-360.97
1.10	-530.59	-513.03	-527.05	-512.89	-491.83	-463.64	-447.43	-421.54
1.12	-585.72	-573.16	-591.99	-580.82	-553.53	-530.93	-508.85	-483.03
1.14	-643.95	-633.70	-650.32	-640.24	-612.85	-601.90	-569.65	-546.60
1.16	-702.00	-694.68	-708.75	-699.98	-683.81	-670.45	-634.67	-611.55
1.18	-762.02	-757.14	-767.26	-760.32	-753.74	-735.85	-703.01	-687.67
1.20	-818.74	-817.03	-832.02	-827.21	-818.75	-800.57	-776.94	-765.16
1.22	-874.11	-868.47	-891.81	-884.07	-877.42	-862.08	-846.72	-834.65
1.24	-918.34	-913.39	-943.48	-930.28	-929.69	-916.63	-902.98	-889.48
1.26	-955.54	-955.35	-985.87	-973.23	-971.18	-960.14	-949.13	-935.70
1.28	-988.59	-989.67	-1020.62	-1009.57	-1006.10	-995.59	-985.33	-973.05
1.30	-1019.24	-1021.91	-1049.56	-1044.53	-1037.68	-1024.98	-1019.68	-1007.97
1.32	-1036.15	-1039.89	-1075.21	-1071.02	-1062.56	-1051.09	-1045.34	-1035.26
1.34	-1050.08	-1054.31	-1094.68	-1090.87	-1084.60	-1076.16	-1068.61	-1056.76

Table 15 Continued

1.36	-1057.48	-1063.91	-1109.63	-1105.99	-1103.50	-1094.54	-1088.01	-1075.53
1.38	-1070.00	-1077.20	-1123.13	-1125.16	-1119.59	-1116.10	-1110.20	-1097.54
1.40	-1080.46	-1092.73	-1139.89	-1141.02	-1142.17	-1136.42	-1133.40	-1121.89
1.42	-1098.53	-1112.07	-1158.06	-1167.80	-1167.76	-1166.11	-1159.08	-1152.72
1.44	-1102.18	-1126.61	-1179.08	-1192.62	-1187.23	-1188.47	-1182.63	-1179.02
1.46	-1111.98	-1136.79	-1199.64	-1211.88	-1206.78	-1210.43	-1205.07	-1198.03
1.48	-1116.92	-1143.50	-1206.33	-1217.13	-1219.61	-1223.26	-1218.74	-1215.81
1.50	-1114.24	-1146.40	-1206.75	-1220.38	-1226.07	-1228.77	-1227.22	-1225.59
1.52	-1106.32	-1139.93	-1196.84	-1214.44	-1222.16	-1228.54	-1229.27	-1228.88
1.54	-1094.76	-1127.46	-1184.02	-1206.29	-1214.94	-1221.82	-1223.67	-1223.55
1.56	-1077.18	-1108.29	-1168.16	-1191.16	-1197.96	-1208.80	-1214.43	-1213.98
1.58	-1051.90	-1089.51	-1150.03	-1175.92	-1184.06	-1196.56	-1203.05	-1200.83
1.60	-1033.35	-1068.37	-1130.58	-1154.91	-1163.20	-1179.93	-1186.97	-1187.19
1.62	-1009.17	-1046.26	-1106.15	-1124.90	-1144.09	-1158.95	-1167.35	-1168.13
1.64	-979.78	-1014.51	-1071.70	-1093.55	-1118.10	-1126.58	-1138.99	-1142.06
1.66	-948.70	-978.74	-1036.75	-1059.06	-1085.60	-1092.75	-1104.89	-1109.49
1.68	-909.84	-941.42	-1000.29	-1022.55	-1046.77	-1057.73	-1065.19	-1072.00
1.70	-861.76	-896.51	-954.68	-982.44	-1004.71	-1018.20	-1025.46	-1036.33
1.72	-802.27	-835.37	-901.74	-931.73	-955.44	-971.79	-982.23	-994.37
1.74	-740.32	-779.58	-852.05	-877.23	-904.57	-921.69	-932.25	-945.04
1.76	-676.93	-717.10	-797.66	-816.97	-849.88	-867.32	-873.42	-894.48
1.78	-622.77	-653.84	-741.47	-757.73	-792.45	-811.33	-816.62	-836.01
1.80	-569.32	-591.66	-677.13	-690.69	-724.23	-745.32	-751.43	-777.08
1.82	-508.58	-526.42	-605.99	-617.07	-654.62	-675.56	-688.71	-711.74
1.84	-438.02	-461.20	-531.16	-547.63	-577.01	-603.05	-618.58	-636.94
1.86	-372.27	-398.27	-461.19	-482.49	-504.91	-528.40	-546.53	-560.75
1.88	-305.69	-330.42	-391.65	-412.54	-439.17	-452.04	-472.72	-485.97
1.90	-235.62	-261.22	-315.65	-340.16	-366.26	-379.97	-399.23	-407.22
1.92	-163.05	-187.91	-239.64	-264.20	-290.78	-301.93	-324.66	-328.92
1.94	-96.12	-117.78	-165.95	-190.99	-217.62	-226.61	-253.26	-254.37
1.96	-27.74	-51.33	-96.57	-120.77	-147.29	-155.07	-179.29	-183.94
1.98	47.94	20.74	-22.72	-49.77	-74.78	-84.43	-107.65	-111.10
2.00	137.25	111.68	60.54	32.66	9.23	-2.80	-28.94	-31.44

Table 16 Test CS1 (small current alone): Time-averaged flow parameters

'cs1-cv.dat'
TEST CS1 - Mobile bed, small current
D50=0.124mm, no sediment transport

$\bar{U}$ at 300mm above bed =159mm/s
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	$\bar{U}$	$\bar{V}$	$\bar{W}$	sigu	sigv	sigw	$\bar{E}$/rho	$-\overline{u'w'}$	$-\overline{v'w'}$	$-\overline{u'v'}$
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
626.5	152.88	-0.42	0.37	3.77	3.95	4.07	360.91	63.98	-56.38	60.40
326.5	157.51	-0.23	0.44	3.61	3.47	3.87	270.16	8.80	-39.32	16.64
276.5	161.74	0.46	0.00	3.55	3.28	3.76	237.81	6.47	-38.84	16.72
226.5	165.66	-0.08	-0.06	3.43	3.31	3.67	219.59	-9.15	-32.03	1.59
176.5	171.31	0.09	-0.17	3.11	3.04	3.39	155.53	-3.17	-27.06	13.09
126.5	176.82	-0.25	0.00	3.14	2.86	3.17	132.26	-8.67	-17.33	12.35
116.5	181.37	-0.11	-0.05	2.91	2.78	3.02	107.54	-0.87	-9.81	9.93
106.5	179.72	0.04	0.05	3.05	2.89	3.11	125.13	-2.81	-10.98	12.44
96.5	174.61	0.06	0.03	2.90	2.84	2.96	106.24	-1.27	-10.59	6.97
86.5	181.79	0.30	0.04	2.98	2.72	2.77	96.34	4.18	-3.74	8.56
76.5	182.63	-0.20	-0.10	2.84	2.87	2.62	90.42	5.07	-3.83	6.53
71.5	184.38	0.07	0.10	2.85	2.75	2.56	83.05	1.90	-5.62	8.21
66.5	183.80	0.21	0.02	2.94	2.88	2.55	93.18	7.57	1.81	3.77
61.5	178.93	-0.12	0.19	3.00	2.85	2.53	93.58	8.83	-2.54	15.60
56.5	181.73	-0.20	-0.07	3.13	2.85	2.56	102.56	7.71	-1.00	10.84
51.5	160.82	-0.12	0.02	999.99	999.99	999.99	999.99	999.99	999.99	999.99
46.5	174.86	0.07	0.12	3.11	2.94	2.42	101.51	14.79	-4.22	19.62
41.5	173.36	0.12	-0.03	3.24	2.97	2.33	108.35	11.84	-5.15	22.87
36.5	171.58	-0.40	-0.04	3.31	2.85	2.31	107.30	14.89	-3.28	12.00
31.5	158.86	-0.37	0.20	3.80	2.96	2.21	154.92	11.40	2.31	-9.88
26.5	159.18	-0.09	-0.02	3.25	2.90	2.24	103.73	12.44	-2.74	1.72

Table 17 Test CS2 (large current alone): Time-averaged flow parameters

'cs2-cv.dat'
TEST CS2 - Mobile bed, large current
D50=0.124mm, ripple wavelength and height = 100mm x 15mm

$\bar{U}$ at 300mm above bed =386mm/s
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	$\bar{U}$	$\bar{V}$	$\bar{W}$	sigu	sigv	sigw	$\bar{E}$/rho	$-\overline{u'w'}$	$-\overline{v'w'}$	$-\overline{u'v'}$
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
315.5	384.61	-0.20	0.51	5.11	4.46	4.98	845.65	-25.28	-85.89	107.86
268.5	391.28	-0.06	-0.13	4.96	4.28	5.04	791.47	-2.04	-98.55	87.46
217.5	396.38	0.33	-0.55	4.56	4.04	4.63	578.63	2.61	-39.94	71.85
164.5	400.71	-0.41	0.22	4.22	3.87	4.24	432.16	-27.33	-29.82	54.58
113.5	399.33	-0.12	0.30	4.46	3.98	3.94	443.09	65.69	4.55	77.27
102.0	388.59	-0.38	0.44	5.23	4.13	3.98	645.30	192.59	-12.13	80.01
91.5	379.47	-0.22	-0.22	5.58	4.25	4.04	780.08	234.16	-19.63	84.58
80.5	368.53	0.10	-0.02	5.85	4.41	4.09	914.21	216.15	-28.60	129.83
69.5	365.45	-0.09	-0.10	5.92	4.48	4.06	952.29	235.56	-48.89	207.59
58.5	344.17	0.27	-0.14	5.89	4.66	4.01	967.10	195.69	-90.57	121.36
52.5	313.38	-0.36	0.18	6.10	4.87	4.21	1128.85	242.45	-123.75	81.31
46.5	297.44	0.47	0.56	5.83	4.90	4.23	1028.29	192.76	-144.12	189.75
41.0	297.51	0.36	0.17	5.79	4.96	4.15	1011.85	188.21	-151.04	258.93
35.0	309.73	-0.47	0.07	5.86	4.78	4.19	1006.44	141.14	-118.75	138.48
29.0	281.55	-0.51	-0.44	5.84	4.80	4.23	1007.27	118.42	-151.25	93.66
23.0	283.16	0.33	0.77	5.70	4.77	4.33	962.24	164.35	-168.08	-0.67
17.0	288.36	0.74	0.54	5.52	4.59	4.47	886.11	118.96	-189.91	83.91
11.5	274.86	-0.12	-0.41	5.72	4.67	4.29	940.38	112.66	-173.22	118.92

'cs2-cc.dat'
CYCLE-AVERAGED CONCENTRATION DATA

'cs2-fl.dat'
CYCLE-AVERAGED FLUX DATA

When tag=1, measurements were only made of sediment concentrations. Ensemble-averaged velocities were calculated at each phase, by assuming a logarithmic decay in velocity between the value at the lowest measurement level and zero velocity at z0.

z	C	sigC	c'u'	c'v'	c'w'	z	<U>	Tag	<C>	<U><C>	<UC>	<UC>-<U><C>
mm	kg/mE3	kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s	mm	m/s		kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
315.5	0.018	0.007	-0.018	0.003	0.007	315.5	0.38462	0	0.01800	0.00692	0.00000	0.00000
268.5	0.025	0.006	-0.017	-0.001	0.005	268.5	0.39128	0	0.02526	0.00988	0.00000	0.00000
217.5	0.023	0.006	-0.004	-0.001	0.006	217.5	0.39638	0	0.02338	0.00927	0.00000	0.00000
164.5	0.016	0.006	-0.010	-0.002	0.003	164.5	0.40071	0	0.01628	0.00652	0.00000	0.00000
113.5	0.020	0.012	0.001	0.010	0.003	113.5	0.39933	0	0.02022	0.00807	0.00000	0.00000
102.0	0.030	0.021	0.008	0.022	0.006	102.0	0.38859	0	0.02983	0.01159	0.00000	0.00000
91.5	0.045	0.033	0.013	0.072	0.003	91.5	0.37947	0	0.04489	0.01703	0.00000	0.00000
80.5	0.036	0.024	0.026	0.067	-0.017	80.5	0.36853	0	0.03599	0.01326	0.00000	0.00000
69.5	0.048	0.032	-0.106	0.136	0.003	69.5	0.36545	0	0.04783	0.01748	0.00000	0.00000
58.5	0.082	0.040	-0.003	0.143	0.031	58.5	0.34417	0	0.08245	0.02838	0.00000	0.00000
52.5	0.072	0.030	0.092	0.104	-0.017	52.5	0.31338	0	0.07243	0.02270	0.00000	0.00000
46.5	0.105	0.049	-0.024	0.078	0.006	46.5	0.29744	0	0.10486	0.03119	0.00000	0.00000
41.0	0.110	0.034	-0.034	0.110	0.008	41.0	0.29751	0	0.11017	0.03278	0.00000	0.00000
35.0	0.194	0.064	-0.085	0.157	0.038	35.0	0.30973	0	0.19384	0.06004	0.00000	0.00000
29.0	0.317	0.045	-0.072	0.042	0.007	29.0	0.28155	0	0.31690	0.08922	0.00000	0.00000
23.0	0.378	0.061	0.058	0.028	-0.025	23.0	0.28316	0	0.37785	0.10699	0.00000	0.00000
17.0	0.476	0.086	0.227	-0.055	-0.110	17.0	0.28836	0	0.47606	0.13727	0.00000	0.00000
11.5	0.715	0.099	-0.076	0.089	0.201	11.5	0.27486	0	0.71539	0.19663	0.00000	0.00000

Table 18 Test WS1 (small wave alone): Cycle-averaged flow parameters

TEST WS1 - Mobile bed, small wave
D50=0.124mm, ripple wavelength and height = 100mm x 15mm
T=10s, U0=411mm/s, A0=654mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
599.9	-5.28	2.82	0.59	9.25	8.21	8.69	121.74	5.45	10.03	-8.25
301.0	-5.04	-8.23	-2.38	6.41	5.95	6.62	65.22	2.35	-8.09	-0.04
257.6	-7.39	-8.00	-3.44	6.48	6.11	5.58	58.72	2.37	-7.56	-2.26
208.6	-3.19	-7.46	-4.50	14.97	6.07	5.90	163.33	-12.34	-6.14	-4.24
159.7	1.29	-7.09	-3.80	6.54	5.85	5.57	57.58	-0.08	-4.52	7.38
111.9	5.03	-4.82	-5.69	9.13	7.33	7.02	98.58	1.26	-4.05	-2.73
102.9	3.96	-6.52	-4.20	10.42	8.34	7.56	125.29	5.24	-0.19	-2.58
93.9	3.33	-5.20	-4.69	10.34	7.99	7.81	123.27	-5.01	-4.61	-8.12
85.0	2.14	-4.65	-4.54	9.79	7.58	7.41	107.39	-1.73	-2.08	-1.21
76.0	-1.39	-3.29	-6.44	8.83	7.30	7.42	96.13	-1.93	-3.96	1.12
67.1	-6.79	-1.61	-5.85	9.56	7.34	6.70	99.57	-1.79	-4.62	-0.10
60.8	7.65	-3.37	-9.39	12.65	10.85	10.36	205.87	-6.13	-4.68	2.52
54.4	-13.21	-0.58	-10.20	14.65	10.22	9.82	224.91	9.58	2.98	-5.82
46.9	-3.35	-0.29	-5.18	14.17	10.44	9.07	215.28	3.53	-9.81	-2.37
43.3	-14.26	3.35	-18.61	16.05	11.65	11.02	277.44	-10.40	-9.20	34.22
35.2	-1.71	-0.71	-7.27	15.33	10.59	9.97	242.82	6.97	-10.46	30.23
32.2	-6.18	6.02	-19.80	16.88	11.23	11.49	289.91	-16.81	-15.77	17.72
25.7	-8.55	4.67	-12.03	15.44	11.28	10.23	259.27	35.58	-21.96	10.04
18.6	-1.40	5.41	-5.10	22.80	17.26	14.43	567.53	26.75	-28.15	-30.47
13.5	18.85	5.17	-13.22	23.50	16.87	14.23	564.65	24.54	-36.81	1.86
7.4	-0.73	1.77	-15.73	23.86	15.90	11.62	517.27	-38.43	-37.02	-36.91

'ws1-cc.dat'
CYCLE-AVERAGED CONCENTRATION DATA

z	<C>	<sigC>	<c'u'>	<c'v'>	<c'w'>
mm	kg/mE3	kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
599.9	0.002	0.003	0.001	0.000	0.001
301.0	0.008	0.004	0.001	0.001	-0.002
257.6	0.010	0.005	0.003	0.005	0.001
208.6	0.017	0.008	0.002	0.003	0.002
159.7	0.047	0.025	-0.009	0.003	0.006
111.9	0.155	0.081	0.016	0.001	0.014
102.9	0.147	0.072	0.003	-0.037	0.027
93.9	0.173	0.085	0.020	0.030	0.023
85.0	0.156	0.069	-0.002	0.006	0.011
76.0	0.185	0.079	0.009	0.047	-0.031
67.1	0.206	0.074	0.017	0.020	-0.009
60.8	0.612	0.201	-0.027	0.005	-0.229
54.4	0.415	0.195	0.033	0.000	-0.111
46.9	0.585	0.217	-0.010	0.057	-0.061
43.3	0.552	0.229	0.197	-0.021	0.087
35.2	0.625	0.247	-0.143	0.003	0.050
32.2	0.748	0.323	0.129	0.106	-0.281
25.7	0.765	0.250	0.136	-0.004	0.006
18.6	1.221	0.370	0.087	0.292	-0.038
13.5	1.677	0.510	1.022	0.128	-0.339
7.4	2.120	0.382	1.018	0.488	-0.198

Table 19 Test WS2 (large wave alone): Cycle-averaged flow parameters

'ws2-cv.dat'
TEST WS2 - Mobile bed, large wave
D50=0.124mm, sheet flow above ripples of wavelength approximately 1600mm and height 150-200mm
T=10s, U0=1019mm/s, A0=1622mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
609.5	-11.70	69.70	-31.19	14.53	11.38	11.07	267.99	20.76	-23.84	-27.19
318.5	-11.92	63.58	-33.92	12.45	10.05	10.38	202.16	6.49	-29.56	-7.98
219.5	-15.91	63.94	-32.42	12.60	9.82	9.45	190.01	5.59	-25.39	-11.77
170.5	-13.91	65.72	-30.43	13.42	10.08	9.91	205.50	-0.90	-32.66	-19.55
122.0	-14.11	68.46	-30.01	15.03	10.58	9.17	222.85	1.28	-19.14	-17.27
114.9	-13.85	67.61	-29.91	14.43	10.39	8.81	210.99	3.89	-24.37	-7.17
108.9	-16.84	68.81	-29.59	14.92	10.75	9.36	229.50	1.75	-24.86	-21.85
98.5	-15.59	71.02	-29.64	16.54	11.19	8.87	257.85	-8.77	-25.12	-22.99
85.7	-13.93	70.39	-30.43	15.44	11.28	8.39	235.32	6.90	-29.07	-27.01
76.3	-14.15	70.87	-29.29	15.98	10.58	8.09	236.22	-8.11	-27.60	-18.13
70.6	-12.01	71.25	-28.52	17.15	11.12	7.81	263.63	-15.43	-23.66	-28.84
68.3	-4.00	71.79	-27.68	18.19	10.98	7.90	282.37	-6.34	-25.70	-26.05
59.4	1.11	71.38	-27.54	18.17	10.70	7.83	270.54	-7.76	-20.82	-19.59
54.1	2.85	73.20	-25.23	18.44	10.49	7.45	280.08	-1.35	-19.31	-13.35
50.4	2.33	73.14	-25.08	19.79	10.75	7.40	306.16	-17.37	-15.36	-18.74
44.5	10.18	74.72	-24.14	18.52	10.66	7.78	281.59	-1.48	-17.70	-19.54
38.1	21.23	78.43	-23.69	19.23	10.13	6.87	272.54	-9.52	-15.24	-4.61
32.5	9.20	75.79	-23.60	18.69	9.89	6.92	266.94	-13.72	-12.95	-24.68
28.6	12.63	76.26	-24.35	19.90	10.81	7.00	305.84	-9.85	-15.27	-34.90
24.8	14.70	79.01	-25.61	19.28	10.29	6.37	269.29	0.06	-6.66	-22.09
21.3	10.78	78.40	-27.15	20.35	10.25	7.52	316.93	-32.29	-8.90	-34.53
20.7	900.00	900.00	900.00	900.00	900.00	900.00	900.00	999.99	999.99	999.99
15.0	9.01	74.17	-32.52	20.55	11.38	6.65	319.29	0.01	-7.93	-29.28
13.3	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
9.0	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
4.3	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99

'ws2-cc.dat'
CYCLE-AVERAGED CONCENTRATION DATA

z	<C>	<sigC>	<c'u'>	<c'v'>	<c'w'>
mm	kg/mE3	kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
609.5	0.120	0.021	0.000	0.008	-0.016
318.5	0.162	0.035	-0.042	0.022	0.025
219.5	0.255	0.057	-0.007	0.005	0.023
170.5	0.336	0.085	0.032	0.052	-0.001
122.0	0.573	0.157	0.021	0.173	0.005
114.9	0.595	0.155	0.034	0.151	-0.037
108.9	0.603	0.175	0.012	0.204	0.143
98.5	0.778	0.220	0.235	0.057	0.114
85.7	0.845	0.227	0.220	0.225	0.104
76.3	0.873	0.236	-0.051	0.231	0.086
70.6	0.909	0.259	-0.082	0.229	-0.057
68.3	1.042	0.263	0.292	0.144	0.032
59.4	1.204	0.294	0.183	0.295	0.120
54.1	1.341	0.338	0.509	0.201	0.188
50.4	1.498	0.369	-0.099	0.152	-0.044
44.5	1.599	0.396	0.330	0.375	0.101
38.1	1.990	0.481	0.264	-0.116	0.003
32.5	2.329	0.547	0.069	0.117	0.214
28.6	2.752	0.616	0.146	-0.007	0.103
24.8	3.156	0.669	-0.022	0.416	0.029
21.3	3.114	0.674	0.342	0.333	-0.012
20.7	2.871	0.654	999.990	999.990	999.990
15.0	3.842	0.735	0.057	0.053	-0.527
13.3	4.333	0.823	999.990	999.990	999.990
9.0	4.778	0.851	999.990	999.990	999.990
4.3	6.839	1.132	999.990	999.990	999.990

WCS1 (small current + small wave):

Table 20 Test ~~WS2 (large wave alone):~~ Cycle-averaged flow parameters

'wcs1-cv.dat'
TEST WCS1 - Mobile bed, small current + small wave
D50=0.124mm, ripple wavelength and height = 100mm x 15mm
Time-av U (current only) at 300mm above bed =175mm/s
T=10s, U0=413mm/s, A0=657mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
597.4	188.09	-0.10	0.57	13.65	12.24	16.29	309.94	3.01	-63.04	1.66
299.8	210.04	0.79	-0.08	13.47	12.13	14.34	280.62	-50.66	-60.22	-4.13
252.2	215.68	0.23	-0.52	13.10	10.24	12.59	229.54	-40.07	-35.33	-8.84
204.5	220.94	-0.19	0.49	12.60	10.82	12.40	230.22	-21.21	-37.75	-11.84
156.9	221.80	-0.03	0.21	12.75	10.35	10.89	204.27	2.15	-27.78	6.77
109.3	210.40	-0.08	0.05	15.55	12.40	11.64	277.27	28.78	-29.84	50.13
101.6	196.11	-0.40	0.50	21.13	13.68	13.24	425.62	58.80	-22.48	68.86
94.0	195.42	-0.14	-0.05	22.38	14.82	14.26	479.58	62.66	-4.10	16.82
86.4	188.07	-0.32	0.46	21.37	14.15	13.13	432.21	53.05	-29.38	29.33
78.8	175.88	-0.44	-0.23	22.72	15.15	12.96	473.47	57.25	-52.88	60.36
71.1	167.85	-0.32	-0.28	20.81	15.40	12.34	434.75	61.41	-25.09	54.53
69.6	144.50	0.02	-0.17	22.98	15.50	12.28	478.71	44.01	-27.31	16.85
63.7	138.48	-0.74	0.05	23.15	16.29	13.00	506.98	14.17	-27.11	47.69
63.6	151.91	0.33	0.43	22.76	16.34	13.25	510.38	46.33	-59.16	36.45
63.5	158.90	-0.45	0.37	24.16	16.41	13.71	541.88	31.87	-72.79	30.00
59.5	142.12	-0.35	-0.11	24.56	16.28	15.44	585.13	50.62	-52.79	24.86
57.8	139.73	0.29	-0.02	23.28	15.10	12.64	492.74	34.41	-17.96	80.66
51.8	132.81	-0.58	-0.17	22.46	15.53	13.07	478.01	23.16	-39.87	55.32
45.9	137.84	-0.39	0.67	23.70	15.30	14.56	543.24	17.17	-25.51	77.22
40.0	119.19	-0.36	0.59	22.31	15.74	13.18	489.12	28.82	-55.08	37.46
35.1	144.64	-0.17	-0.24	26.64	17.20	14.52	653.05	30.56	-40.62	86.07
34.1	119.33	0.06	-0.17	24.92	15.63	13.49	553.34	24.16	-38.90	44.67
28.2	121.96	-0.58	-0.19	21.90	15.49	14.72	497.26	29.02	-48.88	30.98
22.3	107.91	-0.06	-0.81	24.75	15.96	14.39	558.38	-15.35	-44.67	11.54
16.4	87.86	-0.14	-1.10	27.50	19.17	16.52	747.51	-48.33	-80.35	-31.57

'wcs1-cc.dat'
CYCLE-AVERAGED CONCENTRATION DATA

z	<C>	<sigC>	<c'u'>	<c'v'>	<c'w'>
mm	kg/mE3	kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
597.4	-0.001	0.004	-0.001	0.002	0.008
299.8	0.000	0.005	0.003	-0.001	0.011
252.2	-0.002	0.004	0.006	0.001	0.008
204.5	-0.003	0.005	0.003	0.002	0.004
156.9	0.002	0.010	0.010	0.011	0.000
109.3	0.054	0.062	0.059	0.025	0.033
101.6	0.039	0.057	0.050	0.088	0.023
94.0	0.087	0.092	0.071	0.206	-0.084
86.4	0.062	0.075	-0.089	-0.066	-0.098
78.8	0.133	0.109	0.060	0.168	0.020
71.1	0.144	0.107	0.084	0.079	-0.033
69.6	0.198	0.123	0.265	0.187	0.080
63.7	0.227	0.129	0.148	0.097	-0.095
63.6	0.359	0.183	-0.148	0.374	-0.026
63.5	0.258	0.165	-0.116	-0.028	0.097
59.5	0.346	0.178	0.836	-0.029	0.086
57.8	0.301	0.175	-0.380	0.279	-0.002
51.8	0.426	0.238	0.008	0.139	0.143
45.9	0.396	0.199	0.449	0.309	-0.097
40.0	0.305	0.128	0.097	0.215	0.000
35.1	0.740	0.328	1.033	0.145	-0.112
34.1	0.420	0.179	0.313	0.319	0.145
28.2	0.576	0.231	0.085	-0.166	-0.430
22.3	0.646	0.269	0.106	0.016	0.419
16.4	0.859	0.312	0.576	0.713	0.294

'wcs1-fl.dat'
CYCLE-AVERAGED FLUX DATA

When tag=1, measurements were only made of sediment concentrations. Ensemble-averaged velocities were calculated at each phase, by assuming a logarithmic decay in velocity between the value at the lowest measurement level and zero velocity at z0.

z	<U>	Tag	<C>	<U><C>	<UC>	<UC>-<U><C>
mm	m/s		kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
597.4	0.18809	0	-0.00097	-0.00018	-0.00014	0.00004
299.8	0.21004	0	-0.00048	-0.00010	-0.00024	-0.00013
252.2	0.21568	0	-0.00155	-0.00033	-0.00032	0.00001
204.5	0.22094	0	-0.00274	-0.00061	-0.00066	-0.00005
156.9	0.22180	0	0.00240	0.00053	0.00065	0.00012
109.3	0.21040	0	0.05443	0.01145	0.00588	-0.00557
101.6	0.19611	0	0.03855	0.00756	0.00258	-0.00499
94.0	0.19542	0	0.08685	0.01697	0.00645	-0.01053
86.4	0.18807	0	0.06169	0.01160	0.00097	-0.01064
78.8	0.17588	0	0.13268	0.02334	0.00135	-0.02198
71.1	0.16785	0	0.14375	0.02413	0.00189	-0.02224
69.6	0.14450	0	0.19823	0.02864	0.00349	-0.02516
63.7	0.13848	0	0.22661	0.03138	0.00244	-0.02894
63.6	0.15191	0	0.35931	0.05458	0.01227	-0.04231
63.5	0.15890	0	0.25791	0.04098	0.00136	-0.03962
59.5	0.14212	0	0.34623	0.04921	0.02262	-0.02659
57.8	0.13973	0	0.30096	0.04205	0.01303	-0.02902
51.8	0.13281	0	0.42560	0.05652	0.01561	-0.04091
45.9	0.13784	0	0.39592	0.05457	0.00673	-0.04785
40.0	0.11919	0	0.30520	0.03638	0.00905	-0.02733
35.1	0.14464	0	0.73970	0.10699	0.04476	-0.06223
34.1	0.11933	0	0.41994	0.05011	0.01709	-0.03302
28.2	0.12196	0	0.57640	0.07030	0.02510	-0.04520
22.3	0.10791	0	0.64588	0.06969	0.03309	-0.03660
16.4	0.08786	0	0.85945	0.07551	0.03156	-0.04395

Table 21 Test WCS2 (small current + large wave): Cycle-averaged flow parameters

'wcs2-cv.dat'
TEST WCS2 - Mobile bed, small current + large wave
D50=0.124mm, sheet flow above rolling grain ripples
Time-av U (current only) at 300mm above bed =189mm/s
T=10s, U0=1092mm/s, A0=1738mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
607.5	205.13	0.41	1.10	28.94	21.76	31.55	1215.63	-207.31	20.15	79.50
318.5	222.38	0.02	0.97	25.14	22.64	24.31	925.07	-103.53	-114.09	-117.44
271.7	224.55	0.82	0.41	22.95	19.75	24.39	803.20	-151.23	-96.11	-92.14
222.7	229.03	-1.07	-0.94	20.48	17.54	20.01	603.26	-102.12	-47.60	-25.00
174.0	230.90	-0.93	-0.79	18.94	20.28	17.73	568.64	-63.72	-89.92	-37.18
132.1	235.47	0.96	-1.43	21.98	22.34	19.14	710.24	-103.08	58.87	23.46
122.8	233.38	-0.43	-0.46	24.07	20.95	15.92	676.04	-70.51	-38.12	-85.30
114.0	230.43	-0.23	0.55	21.01	18.93	14.73	542.38	-30.83	-20.10	-24.92
99.6	221.48	0.35	0.13	27.99	20.46	15.35	753.35	-81.47	-45.93	-81.76
87.7	211.56	6.65	0.23	21.77	17.07	13.03	499.07	-29.02	-20.63	-39.21
76.6	209.25	-0.78	0.23	25.16	20.08	11.98	614.34	-3.13	-42.94	-169.47
70.2	220.62	0.05	-0.29	20.61	17.02	10.23	438.35	-26.70	-44.87	-64.96
66.7	222.20	-0.05	-1.44	20.62	20.24	9.05	474.51	-14.98	-25.21	-86.15
61.5	201.21	0.84	-2.19	22.09	16.04	11.59	457.80	-23.06	0.64	-52.21
51.9	195.70	-0.21	-0.08	23.47	16.94	9.38	491.48	8.64	-22.22	-103.02
46.9	184.27	-0.58	0.50	22.80	15.57	9.59	468.72	-14.39	-18.47	-50.57
41.4	164.28	3.07	0.21	21.83	15.89	7.85	423.53	-38.46	-27.07	-50.21
36.7	174.22	0.11	-0.14	24.58	17.09	8.09	507.67	5.53	11.59	-37.07
28.3	155.54	0.05	-1.33	22.79	23.07	8.10	586.40	-83.72	38.34	-35.16
24.2	142.69	0.65	-2.64	24.07	23.14	27.87	1071.16	-96.50	-300.79	48.61
12.7	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
10.0	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
5.9	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
3.0	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
0.5	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99

'wcs2-cc.dat'
CYCLE-AVERAGED CONCENTRATION DATA

z	<C>	<sigC>	<c'u'>	<c'v'>	<c'w'>
mm	kg/mE3	kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
607.5	0.398	0.127	0.720	0.063	1.364
318.5	0.438	0.095	0.001	0.420	0.350
271.7	0.491	0.118	-0.151	0.499	0.247
222.7	0.620	0.116	0.058	0.410	-0.228
174.0	0.680	0.155	-0.019	0.672	-0.195
132.1	0.537	0.187	0.259	1.077	-0.170
122.8	0.594	0.214	0.125	0.753	0.257
114.0	0.695	0.243	0.025	1.076	0.031
99.6	0.802	0.329	0.398	2.070	-0.043
87.7	0.966	0.299	1.253	1.387	0.155
76.6	1.061	0.386	2.126	2.519	-0.091
70.2	1.476	0.389	1.783	2.240	0.146
66.7	1.933	0.527	1.679	2.025	-0.029
61.5	1.512	0.390	1.736	0.873	0.086
51.9	1.596	0.574	2.969	1.278	0.371
46.9	1.754	0.617	3.183	0.123	0.067
41.4	2.030	0.663	1.532	1.501	0.474
36.7	2.521	0.786	2.332	1.332	0.300
28.3	3.773	1.010	4.484	2.851	0.851
24.2	4.313	1.135	0.741	0.074	-1.053
12.7	7.896	2.813	999.990	999.990	999.990
10.0	6.728	1.332	999.990	999.990	999.990
5.9	8.754	1.797	999.990	999.990	999.990
3.0	10.338	1.828	999.990	999.990	999.990
0.5	14.952	2.180	999.990	999.990	999.990

'wcs2-fl.dat'
CYCLE-AVERAGED FLUX DATA

When tag=1, measurements were only made of sediment concentrations. Ensemble-averaged velocities were calculated at each phase, by assuming a logarithmic decay in velocity between the value at the lowest measurement level and zero velocity at z0.

z	<U>	Tag	<C>	<U><C>	<UC>	<UC>-<U><C>
mm	m/s		kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
607.5	0.20513	0	0.39786	0.08161	0.09058	0.00897
318.5	0.22238	0	0.43843	0.09750	0.09925	0.00175
271.7	0.22456	0	0.49113	0.11029	0.11083	0.00055
222.7	0.22903	0	0.61964	0.14191	0.14347	0.00156
174.0	0.23090	0	0.67966	0.15693	0.15957	0.00264
132.1	0.23547	0	0.53659	0.12635	0.13189	0.00554
122.8	0.23338	0	0.59364	0.13854	0.14507	0.00652
114.0	0.23043	0	0.69546	0.16025	0.17428	0.01402
99.6	0.22148	0	0.80184	0.17759	0.19443	0.01684
87.7	0.21156	0	0.96615	0.20440	0.23272	0.02832
76.6	0.20925	0	1.06114	0.22205	0.21261	-0.00943
70.2	0.22062	0	1.47616	0.32568	0.32209	-0.00358
66.7	0.22220	0	1.93344	0.42961	0.39544	-0.03417
61.5	0.20121	0	1.51178	0.30418	0.26431	-0.03986
51.9	0.19570	0	1.59630	0.31240	0.13186	-0.18054
46.9	0.18427	0	1.75398	0.32320	0.07224	-0.25096
41.4	0.16428	0	2.03004	0.33349	0.03527	-0.29822
36.7	0.17422	0	2.52137	0.43928	0.06235	-0.37693
28.3	0.15554	0	3.77279	0.58680	-0.01585	-0.60265
24.2	0.14269	0	4.31260	0.61535	0.04096	-0.57438
12.7	0.12183	1	7.89649	0.96204	0.64329	-0.31875
10.0	0.11411	1	6.72784	0.76773	0.56528	-0.20244
5.9	0.09704	1	8.75408	0.84946	0.88320	0.03374
3.0	0.07502	1	10.33792	0.77560	0.95138	0.17578
0.5	0.01796	1	14.95168	0.26853	0.40145	0.13292

Table 22 Test WCS3 (large current + small wave): Cycle-averaged flow parameters

'wcs3-cv.dat'
TEST WCS3 - Mobile bed, large current + small wave
D50=0.124mm, sheet flow above a flat bed
Time-av U (current only) at 300mm above bed =389mm/s
T=10s, U0=406mm/s, A0=646mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
620.0	393.30	0.75	0.08	28.27	27.16	29.43	1243.76	80.12	-71.53	289.77
322.5	420.25	0.40	0.69	25.92	20.05	25.66	883.32	31.83	-172.56	95.73
271.3	429.98	0.24	-0.41	22.82	19.15	23.02	722.17	44.94	-75.77	118.18
218.8	442.41	-0.20	-0.03	21.10	17.39	22.99	661.19	23.30	-106.99	100.74
165.8	438.42	-0.39	-0.09	18.89	16.24	20.17	524.45	37.98	-49.22	68.04
118.5	443.44	-0.07	0.09	16.90	15.33	15.92	396.05	19.12	6.94	66.40
111.5	438.01	0.08	0.47	16.29	14.97	16.67	393.22	16.18	-22.07	61.98
97.1	446.25	0.31	0.18	16.21	15.47	15.25	379.01	53.50	-7.09	58.29
88.8	443.22	0.70	-0.99	17.43	15.29	14.52	385.60	37.14	-4.89	55.74
75.8	446.76	0.22	0.18	16.71	15.07	13.71	358.63	26.64	-5.57	46.71
71.4	442.15	-0.68	0.39	17.63	15.36	13.14	374.62	42.41	-11.65	60.32
64.7	450.03	-0.11	0.06	19.25	16.16	12.71	416.69	66.28	6.28	52.41
58.2	441.45	-0.01	-0.01	21.34	16.94	12.63	471.26	54.36	-0.21	57.81
52.5	434.41	-0.02	0.14	20.22	17.11	12.40	456.52	48.09	16.16	74.46
48.5	430.05	0.08	-0.16	20.10	16.64	11.71	425.62	43.97	12.51	65.13
43.1	431.54	1.01	-0.23	25.70	18.53	11.88	612.63	95.06	-2.75	129.27
34.3	398.92	-0.01	-0.17	28.68	20.39	12.07	716.53	86.03	12.30	157.51
30.9	373.59	0.51	-0.02	30.78	21.70	13.36	842.43	85.92	-18.45	119.08
27.8	407.54	-0.93	-0.39	28.83	20.63	11.57	740.37	63.29	-16.61	211.49
22.3	356.90	0.17	0.32	35.27	20.03	13.31	963.17	29.41	-20.88	210.98
18.4	367.48	-1.10	-0.02	30.06	20.70	11.31	772.10	20.35	-23.69	165.44
16.4	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
15.3	352.39	1.44	1.50	31.11	20.86	22.60	1010.87	-68.90	43.60	120.21
11.3	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
9.3	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99

'wcs3-cc.dat'
CYCLE-AVERAGED CONCENTRATION DATA

z	<C>	<sigC>	<c'u'>	<c'v'>	<c'w'>
mm	kg/mE3	kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
620.0	0.037	0.012	-0.027	0.039	0.069
322.5	0.046	0.020	-0.057	0.032	0.026
271.3	0.073	0.041	-0.062	0.021	0.015
218.8	0.046	0.025	-0.064	0.021	0.009
165.8	0.062	0.035	0.004	0.029	0.016
118.5	0.036	0.016	-0.005	0.024	-0.010
111.5	0.052	0.014	-0.021	0.015	-0.014
97.1	0.055	0.012	-0.015	0.018	-0.001
88.8	0.111	0.061	0.127	0.044	-0.046
75.8	0.122	0.042	-0.027	0.060	-0.002
71.4	0.115	0.030	0.045	0.009	0.001
64.7	0.130	0.036	-0.031	0.055	-0.024
58.2	0.138	0.043	-0.023	0.058	-0.006
52.5	0.142	0.060	0.069	0.009	0.056
48.5	0.214	0.041	-0.057	0.145	-0.046
43.1	0.270	0.051	-0.018	0.254	0.006
34.3	0.344	0.053	0.042	0.265	-0.055
30.9	0.366	0.078	-0.021	0.273	-0.126
27.8	0.431	0.066	-0.123	0.313	-0.047
22.3	0.569	0.131	-1.100	0.279	-0.043
18.4	0.576	0.076	-0.012	0.154	-0.062
16.4	0.911	0.223	999.990	999.990	999.990
15.3	0.770	0.112	-0.040	0.372	-0.402
11.3	1.306	0.541	999.990	999.990	999.990
9.3	1.517	0.206	999.990	999.990	999.990

'wcs3-fl.dat'
CYCLE-AVERAGED FLUX DATA

When tag=1, measurements were only made of sediment concentrations. Ensemble-averaged velocities were calculated at each phase, by assuming a logarithmic decay in velocity between the value at the lowest measurement level and zero velocity at z0.

z	<U>	Tag	<C>	<U><C>	<UC>	<UC>-<U><C>
mm	m/s		kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
620.0	0.39330	0	0.03745	0.01473	0.01444	-0.00029
322.5	0.42025	0	0.04622	0.01942	0.01929	-0.00014
271.3	0.42998	0	0.07273	0.03127	0.03112	-0.00015
218.8	0.44241	0	0.04581	0.02027	0.01936	-0.00090
165.8	0.43842	0	0.06213	0.02724	0.02697	-0.00027
118.5	0.44344	0	0.03599	0.01596	0.01558	-0.00038
111.5	0.43801	0	0.05179	0.02268	0.02244	-0.00024
97.1	0.44625	0	0.05502	0.02455	0.02420	-0.00035
88.8	0.44322	0	0.11112	0.04925	0.04857	-0.00068
75.8	0.44676	0	0.12236	0.05466	0.05422	-0.00044
71.4	0.44215	0	0.11451	0.05063	0.04926	-0.00137
64.7	0.45003	0	0.13034	0.05866	0.05684	-0.00182
58.2	0.44145	0	0.13790	0.06087	0.05990	-0.00098
52.5	0.43441	0	0.14198	0.06168	0.05994	-0.00174
48.5	0.43005	0	0.21432	0.09217	0.09033	-0.00183
43.1	0.43154	0	0.26985	0.11645	0.11290	-0.00354
34.3	0.39892	0	0.34428	0.13734	0.13495	-0.00239
30.9	0.37359	0	0.36556	0.13657	0.13072	-0.00585
27.8	0.40754	0	0.43080	0.17557	0.16995	-0.00562
22.3	0.35690	0	0.56853	0.20291	0.19360	-0.00931
18.4	0.36748	0	0.57633	0.21179	0.20888	-0.00291
16.4	0.35811	1	0.91121	0.32631	0.29054	-0.03577
15.3	0.35239	0	0.77010	0.27138	0.26337	-0.00800
11.3	0.32744	1	1.30617	0.42769	0.40286	-0.02482
9.3	0.31139	1	1.51668	0.47228	0.46926	-0.00303

Table 23 Test WCS4 (large current + large wave): Cycle-averaged flow parameters

'wcs4-cv.dat'
TEST WCS4 - Mobile bed, large current + large wave
D50=0.124mm, sheet flow above a flat bed
Time-av U (current only) at 300mm above bed =380mm/s
T=10s, U0=1100mm/s, A0=1751mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

CYCLE-AVERAGED VELOCITY DATA

z	<U>	<V>	<W>	<sigU>	<sigV>	<sigW>	<E/rho>	<-u'w'>	<-v'w'>	<-u'v'>
mm	mm/s	mm/s	mm/s	mm/s	mm/s	mm/s	(mm/s)E2	(mm/s)E2	(mm/s)E2	(mm/s)E2
611.5	452.70	0.41	1.10	31.16	25.15	31.99	1394.40	-167.53	-133.84	65.40
316.5	470.50	0.02	0.97	26.19	25.78	26.67	1156.22	-53.75	-143.54	8.09
264.5	469.39	0.82	0.41	30.07	23.18	26.28	1183.27	-134.91	-82.21	7.56
221.5	466.36	-1.07	-0.94	26.43	24.52	24.93	1051.05	-58.69	-10.39	51.81
171.5	471.53	-0.93	-0.79	27.26	22.70	23.45	977.87	31.15	-92.89	25.06
133.5	441.09	0.96	-1.43	28.61	23.12	20.53	995.23	-25.28	-17.39	84.23
120.0	450.63	-0.43	-0.46	25.37	20.69	20.71	812.97	-40.97	-62.60	15.41
108.5	451.97	-0.23	0.55	27.09	25.57	20.16	958.84	-65.78	-12.05	51.72
97.0	454.75	0.35	0.13	31.30	22.14	21.03	1027.01	43.22	-55.70	40.23
85.4	449.48	6.65	0.23	27.38	36.17	19.03	1295.85	-13.43	-176.68	162.19
73.3	430.50	-0.78	0.23	27.88	28.03	16.58	966.63	90.02	-25.22	3.77
68.8	430.54	0.05	-0.29	28.70	21.61	16.76	851.81	104.48	-96.13	77.96
62.4	437.69	-0.05	-1.44	31.16	24.78	18.44	1014.86	210.04	3.48	-33.04
57.5	428.67	0.84	-2.19	28.29	25.09	17.59	910.44	5.20	-5.40	0.98
50.0	409.59	-0.21	-0.08	29.43	23.28	13.80	858.46	34.58	-96.20	-10.12
47.0	406.53	-0.58	0.50	30.30	23.80	13.12	877.52	46.27	-36.49	18.91
38.4	385.13	3.07	0.21	34.08	28.72	15.00	1178.83	107.60	-98.57	346.92
33.6	383.62	0.11	-0.14	30.64	23.94	13.65	899.46	5.28	10.74	68.94
29.4	380.62	0.05	-1.33	31.56	21.18	13.75	881.30	-10.41	-27.60	-10.27
23.2	341.77	0.65	-2.64	35.53	22.70	13.98	1057.92	-6.74	17.23	158.26
18.3	320.00	4.62	-5.97	36.20	27.07	24.70	1587.27	-208.40	354.33	289.30
12.2	303.65	13.76	-42.85	999.99	999.99	999.99	999.99	999.99	999.99	999.99
11.9	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
6.7	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99
0.5	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99	999.99

'wcs4-cc.dat'
CYCLE-AVERAGED CONCENTRATION DATA

'wcs4-fl.dat'
CYCLE-AVERAGED FLUX DATA

When tag=1, measurements were only made of sediment concentrations. Ensemble-averaged velocities were calculated at each phase, by assuming a logarithmic decay in velocity between the value at the lowest measurement level and zero velocity at z0.

z	<C>	<sigC>	<c'u'>	<c'v'>	<c'w'>	z	<U>	Tag	<C>	<U><C>	<UC>	<UC>-<U><C>
mm	kg/mE3	kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s	mm	m/s		kg/mE3	kg/mE2s	kg/mE2s	kg/mE2s
611.5	0.644	0.121	-0.572	0.577	0.301	611.5	0.45270	0	0.64378	0.29144	0.27648	-0.01495
316.5	0.675	0.120	-0.103	0.428	0.323	316.5	0.47050	0	0.67474	0.31747	0.29205	-0.02541
264.5	0.680	0.161	-0.145	0.295	0.398	264.5	0.46939	0	0.67995	0.31916	0.30015	-0.01901
221.5	0.769	0.143	-0.629	0.310	0.411	221.5	0.46636	0	0.76854	0.35841	0.34469	-0.01372
171.5	0.917	0.206	-0.793	0.719	0.392	171.5	0.47153	0	0.91679	0.43229	0.42153	-0.01076
133.5	0.875	0.237	-1.189	1.176	-0.217	133.5	0.44109	0	0.87488	0.38591	0.40172	0.01581
120.0	1.153	0.288	-1.294	1.122	-0.224	120.0	0.45063	0	1.15256	0.51938	0.52849	0.00911
108.5	1.035	0.369	-0.700	2.125	-0.324	108.5	0.45198	0	1.03523	0.46790	0.48186	0.01396
97.0	1.206	0.409	-0.958	1.877	-0.239	97.0	0.45475	0	1.20639	0.54860	0.54047	-0.00813
85.4	1.511	0.489	-0.767	0.479	-1.087	85.4	0.44948	0	1.51134	0.67932	0.61094	-0.06838
73.3	1.671	0.609	0.320	2.866	-0.090	73.3	0.43050	0	1.67053	0.71917	0.57106	-0.14811
68.8	1.726	0.682	0.991	3.121	0.297	68.8	0.43054	0	1.72631	0.74324	0.54412	-0.19912
62.4	1.887	0.737	-0.523	1.336	0.610	62.4	0.43769	0	1.88716	0.82599	0.57921	-0.24678
57.5	2.027	0.774	-0.171	2.748	-0.055	57.5	0.42867	0	2.02656	0.86874	0.52190	-0.34683
50.0	3.359	1.229	1.120	1.093	0.091	50.0	0.40959	0	3.35906	1.37584	0.80323	-0.57262
47.0	2.976	1.109	2.482	3.634	-0.093	47.0	0.40653	0	2.97557	1.20967	0.55159	-0.65808
38.4	3.228	1.093	0.337	2.550	1.301	38.4	0.38513	0	3.22799	1.24321	0.44973	-0.79348
33.6	3.682	1.221	-0.674	1.010	-0.345	33.6	0.38362	0	3.68193	1.41247	0.43973	-0.97274
29.4	4.938	1.472	3.478	1.718	-0.381	29.4	0.38062	0	4.93829	1.87959	0.71686	-1.16273
23.2	5.783	1.648	0.499	6.229	-1.005	23.2	0.34177	0	5.78308	1.97645	0.65545	-1.32101
18.3	7.063	2.048	1.651	9.524	0.819	18.3	0.32000	0	7.06348	2.26029	1.07148	-1.18881
12.2	8.428	2.329	999.990	999.990	999.990	12.2	0.30365	0	8.42758	2.55907	1.45548	-1.10359
11.9	8.302	2.227	999.990	999.990	999.990	11.9	0.30164	1	8.30237	2.50433	1.53136	-0.97296
6.7	9.387	2.304	999.990	999.990	999.990	6.7	0.25529	1	9.38683	2.39633	2.00503	-0.39129
0.5	16.378	7.760	999.990	999.990	999.990	0.5	0.04520	1	16.37781	0.74020	1.07625	0.33606

Table 24 Test WCS2 (small current + large wave): An example of an ensemble-averaged data file

'wcs4-u3.dat'
TEST WCS4 - Mobile bed, large current + large wave
D50=0.124mm, sheet flow above a flat bed
Time-av U (current only) at 300mm above bed =380mm/s
T=10s, U0=1100mm/s, A0=1751mm
Water temp. =15 degrees, kinematic viscosity =1.15mmE2/s

ENSEMBLE-AVERAGED U-VELOCITY COMPONENT (mm/s)

phase in pi	z= 38.4 z in mm	z= 33.6	z= 29.4	z= 23.2	z= 18.3	z= 12.2	z= 11.9	z= 6.7
0.02	343.89	354.09	357.12	354.75	341.20	344.12	9999.00	9999.00
0.04	416.69	431.57	437.95	433.58	424.28	423.16	9999.00	9999.00
0.06	489.10	506.98	519.18	510.90	504.55	499.51	9999.00	9999.00
0.08	570.97	587.42	605.19	593.52	587.55	581.10	9999.00	9999.00
0.10	646.83	664.74	683.69	668.52	666.73	657.50	9999.00	9999.00
0.12	724.99	742.08	758.29	743.08	741.91	731.45	9999.00	9999.00
0.14	797.19	806.73	824.85	808.39	806.02	798.14	9999.00	9999.00
0.16	859.85	868.27	889.47	869.05	867.71	859.40	9999.00	9999.00
0.18	917.81	924.83	947.76	924.44	922.61	914.92	9999.00	9999.00
0.20	971.90	978.88	1001.98	977.52	976.61	968.38	9999.00	9999.00
0.22	1021.05	1030.04	1057.86	1029.91	1031.36	1023.29	9999.00	9999.00
0.24	1073.73	1084.46	1117.78	1085.54	1092.31	1077.93	9999.00	9999.00
0.26	1128.16	1142.48	1177.39	1141.31	1151.37	1130.29	9999.00	9999.00
0.28	1185.12	1199.25	1237.37	1199.70	1207.55	1179.93	9999.00	9999.00
0.30	1238.27	1251.15	1294.01	1255.62	1261.48	1225.64	9999.00	9999.00
0.32	1291.69	1297.67	1346.35	1308.27	1310.34	1264.89	9999.00	9999.00
0.34	1343.66	1344.11	1391.33	1352.72	1350.44	1299.17	9999.00	9999.00
0.36	1392.18	1393.42	1431.43	1393.61	1390.24	1335.13	9999.00	9999.00
0.38	1436.29	1441.50	1470.05	1435.63	1429.11	1370.76	9999.00	9999.00
0.40	1473.37	1484.02	1504.22	1468.93	1460.71	1403.99	9999.00	9999.00
0.42	1503.97	1514.10	1536.29	1492.78	1483.96	1422.84	9999.00	9999.00
0.44	1526.69	1534.24	1560.40	1510.81	1498.91	1432.93	9999.00	9999.00
0.46	1539.56	1548.86	1574.19	1523.76	1504.34	1442.32	9999.00	9999.00
0.48	1542.78	1555.42	1581.56	1530.25	1505.59	1451.84	9999.00	9999.00
0.50	1542.22	1552.39	1584.60	1529.30	1501.76	1436.45	9999.00	9999.00
0.52	1540.07	1545.57	1582.84	1524.07	1491.66	1430.08	9999.00	9999.00
0.54	1535.38	1542.58	1579.36	1515.33	1478.30	1428.58	9999.00	9999.00
0.56	1528.15	1536.33	1571.95	1502.00	1460.46	1375.33	9999.00	9999.00
0.58	1516.10	1523.63	1561.87	1488.42	1440.95	1418.08	9999.00	9999.00
0.60	1507.56	1512.85	1551.54	1475.33	1416.62	1367.55	9999.00	9999.00
0.62	1491.08	1499.31	1533.62	1453.48	1393.87	1348.25	9999.00	9999.00
0.64	1467.31	1478.13	1506.86	1425.01	1359.03	1330.64	9999.00	9999.00
0.66	1427.47	1448.66	1470.29	1383.03	1313.53	1398.52	9999.00	9999.00
0.68	1384.78	1409.26	1427.18	1335.05	1269.79	1335.87	9999.00	9999.00
0.70	1333.37	1353.81	1369.93	1274.73	1220.51	1220.36	9999.00	9999.00
0.72	1279.28	1301.06	1311.63	1216.20	1167.34	1152.50	9999.00	9999.00
0.74	1219.60	1236.43	1245.96	1157.01	1113.53	1110.09	9999.00	9999.00
0.76	1166.67	1172.80	1185.55	1106.64	1060.73	1053.97	9999.00	9999.00
0.78	1110.75	1113.19	1126.88	1050.52	1017.41	927.37	9999.00	9999.00
0.80	1058.23	1058.35	1073.69	1000.47	971.77	947.37	9999.00	9999.00
0.82	1009.15	1010.53	1018.87	950.43	930.88	929.52	9999.00	9999.00
0.84	962.77	963.24	964.94	897.83	880.44	848.91	9999.00	9999.00
0.86	912.87	913.57	908.94	842.67	819.50	768.03	9999.00	9999.00
0.88	856.65	857.90	851.29	780.40	735.53	669.49	9999.00	9999.00
0.90	794.80	796.12	785.89	712.95	676.98	620.01	9999.00	9999.00
0.92	729.62	729.55	714.77	645.68	604.06	516.93	9999.00	9999.00
0.94	654.82	648.58	634.14	570.29	538.06	433.56	9999.00	9999.00
0.96	573.53	572.50	557.95	503.15	467.43	374.84	9999.00	9999.00
0.98	492.43	500.57	483.60	431.95	397.64	316.28	9999.00	9999.00
1.00	418.78	425.21	407.61	357.59	330.71	275.45	9999.00	9999.00
1.02	349.47	353.49	341.20	291.50	271.73	203.51	9999.00	9999.00
1.04	286.57	286.38	267.60	226.06	216.26	161.02	9999.00	9999.00
1.06	223.87	223.10	203.43	164.67	150.08	99.13	9999.00	9999.00
1.08	161.39	162.41	143.99	103.82	90.29	52.83	9999.00	9999.00
1.10	102.55	100.96	82.74	44.06	29.36	5.22	9999.00	9999.00
1.12	43.52	39.08	17.81	-17.48	-43.48	-85.93	9999.00	9999.00
1.14	-17.10	-23.81	-54.87	-90.93	-110.41	-151.04	9999.00	9999.00
1.16	-77.94	-87.29	-129.08	-169.02	-183.24	-206.32	9999.00	9999.00
1.18	-141.50	-152.78	-195.56	-243.01	-259.70	-281.71	9999.00	9999.00
1.20	-206.50	-217.45	-265.45	-310.56	-329.86	-343.51	9999.00	9999.00
1.22	-259.09	-279.67	-329.19	-373.84	-389.60	-407.74	9999.00	9999.00
1.24	-310.40	-337.57	-381.39	-432.54	-447.05	-465.70	9999.00	9999.00
1.26	-359.33	-393.97	-437.75	-481.79	-494.75	-515.33	9999.00	9999.00
1.28	-402.35	-440.16	-482.55	-528.04	-537.55	-556.68	9999.00	9999.00
1.30	-443.95	-478.08	-519.77	-569.02	-582.76	-591.73	9999.00	9999.00
1.32	-487.34	-514.62	-558.93	-596.47	-624.50	-618.72	9999.00	9999.00

Table 24 Continued

1.34	-528.42	-551.58	-596.43	-623.35	-654.52	-649.16	9999.00	9999.00
1.36	-566.29	-588.18	-632.61	-655.86	-684.68	-679.93	9999.00	9999.00
1.38	-607.09	-627.82	-664.60	-688.23	-720.26	-706.06	9999.00	9999.00
1.40	-634.96	-657.87	-695.30	-713.93	-747.38	-726.68	9999.00	9999.00
1.42	-663.38	-679.88	-723.72	-736.95	-773.85	-746.49	9999.00	9999.00
1.44	-688.14	-704.29	-740.73	-754.52	-791.93	-763.01	9999.00	9999.00
1.46	-703.67	-724.55	-752.65	-769.71	-803.13	-776.38	9999.00	9999.00
1.48	-716.69	-735.50	-758.62	-778.66	-810.09	-784.29	9999.00	9999.00
1.50	-723.42	-742.89	-766.30	-788.99	-812.48	-790.19	9999.00	9999.00
1.52	-724.07	-739.81	-764.95	-789.31	-811.05	-789.38	9999.00	9999.00
1.54	-726.78	-739.48	-760.64	-788.47	-809.60	-787.45	9999.00	9999.00
1.56	-723.14	-736.26	-755.55	-779.61	-803.25	-781.13	9999.00	9999.00
1.58	-722.39	-735.70	-754.40	-773.20	-802.10	-778.28	9999.00	9999.00
1.60	-713.77	-727.38	-743.86	-763.43	-788.00	-769.23	9999.00	9999.00
1.62	-700.91	-714.83	-733.09	-753.04	-771.69	-755.50	9999.00	9999.00
1.64	-677.85	-688.42	-711.31	-730.15	-746.03	-727.36	9999.00	9999.00
1.66	-651.24	-659.56	-682.23	-703.32	-720.03	-702.59	9999.00	9999.00
1.68	-617.28	-621.65	-645.86	-664.95	-686.39	-667.74	9999.00	9999.00
1.70	-574.79	-580.71	-608.36	-624.32	-649.41	-627.68	9999.00	9999.00
1.72	-526.60	-535.74	-559.94	-573.87	-603.13	-581.29	9999.00	9999.00
1.74	-478.37	-492.33	-514.25	-526.84	-554.25	-533.84	9999.00	9999.00
1.76	-429.48	-443.99	-461.86	-475.25	-495.41	-480.46	9999.00	9999.00
1.78	-381.00	-394.95	-407.63	-423.14	-441.62	-427.92	9999.00	9999.00
1.80	-329.83	-337.18	-348.54	-364.67	-382.62	-370.94	9999.00	9999.00
1.82	-274.06	-280.77	-290.98	-307.29	-321.82	-313.77	9999.00	9999.00
1.84	-213.72	-220.73	-230.81	-246.42	-259.17	-251.16	9999.00	9999.00
1.86	-160.41	-164.57	-173.20	-189.88	-203.41	-195.51	9999.00	9999.00
1.88	-102.44	-106.03	-114.22	-129.35	-144.48	-138.50	9999.00	9999.00
1.90	-49.25	-53.16	-59.36	-75.09	-90.48	-83.92	9999.00	9999.00
1.92	10.11	8.76	0.11	-19.96	-32.95	-26.52	9999.00	9999.00
1.94	76.94	74.69	66.52	43.11	31.25	38.42	9999.00	9999.00
1.96	143.69	143.45	138.47	118.31	108.41	114.30	9999.00	9999.00
1.98	206.99	210.46	207.90	192.67	183.05	188.84	9999.00	9999.00
2.00	273.93	282.23	280.77	274.64	261.99	266.31	9999.00	9999.00

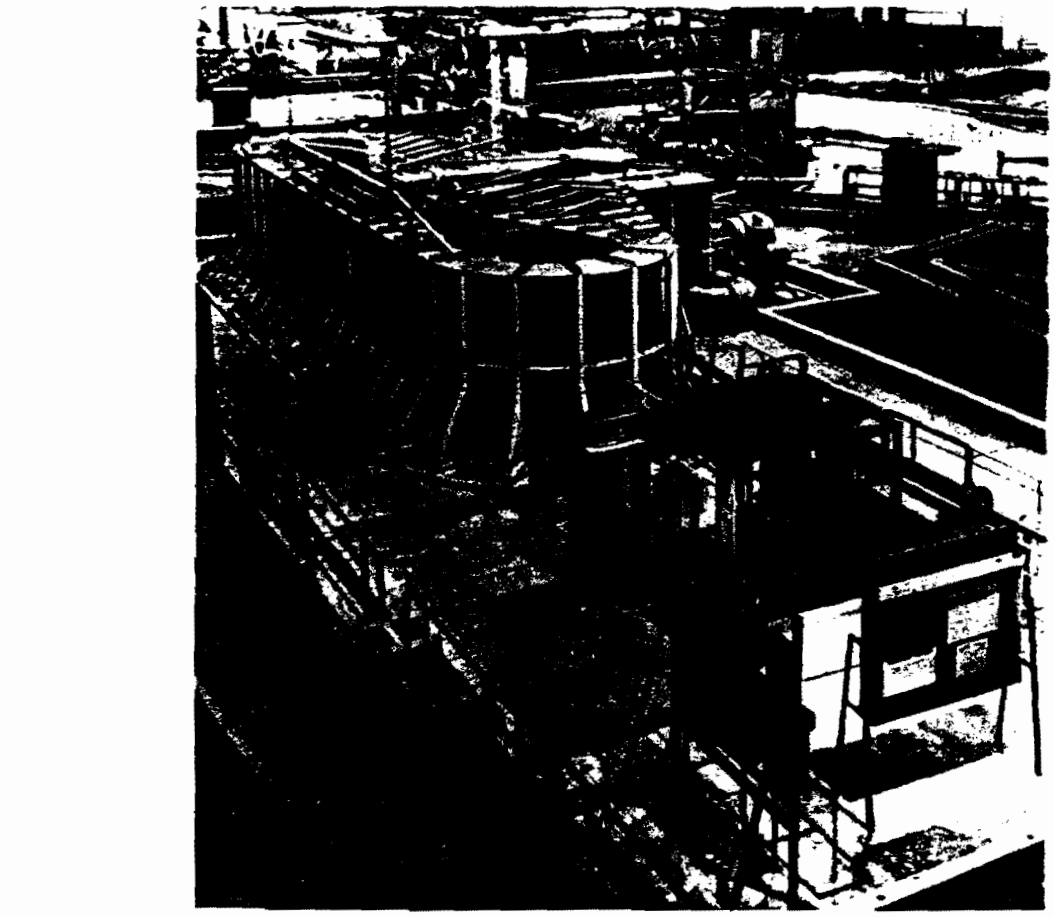
Table 25 Derived parameters from selected tests

'dparams.dat'
IMPORTANT DERIVED PARAMETERS

Values of z0 and time-av(u*) are derived from a logarithmic fit to the cycle-averaged velocity data. Where the cycle-averaged velocities exhibit a segmented profile (due to the presence of ripples), values are derived for the near-bed region, (a), and the overlying region, (b).
The cycle-averaged fluxes integrated through the bottom 300mm of the flow, Q, are shown.

Test	z0 mm	time-av(u*) mm/s	Q(current) ~~kg~~/ms	Q(periodic) ~~kg~~/ms	Q(net) ~~kg~~/ms
C1	2.26	22.59			
C2	0.05	31.28			
CS1	0.112	11.55	0.0	0.0	0.0
WCS1(a)	3.123	20.58			
WCS1(b)	14.677	41.86	4.458	-3.017	1.441
WCS3	0.212	31.78	17.326	-0.442	16.883
CS2(a)	0.008	14.50	6.986	0.0	6.986
CS2(b)	3.310	46.08			
WCS2	1.792	22.28	70.372	-16.479	53.893
WCS4	0.286	31.74	202.715	-52.534	150.181

Figures



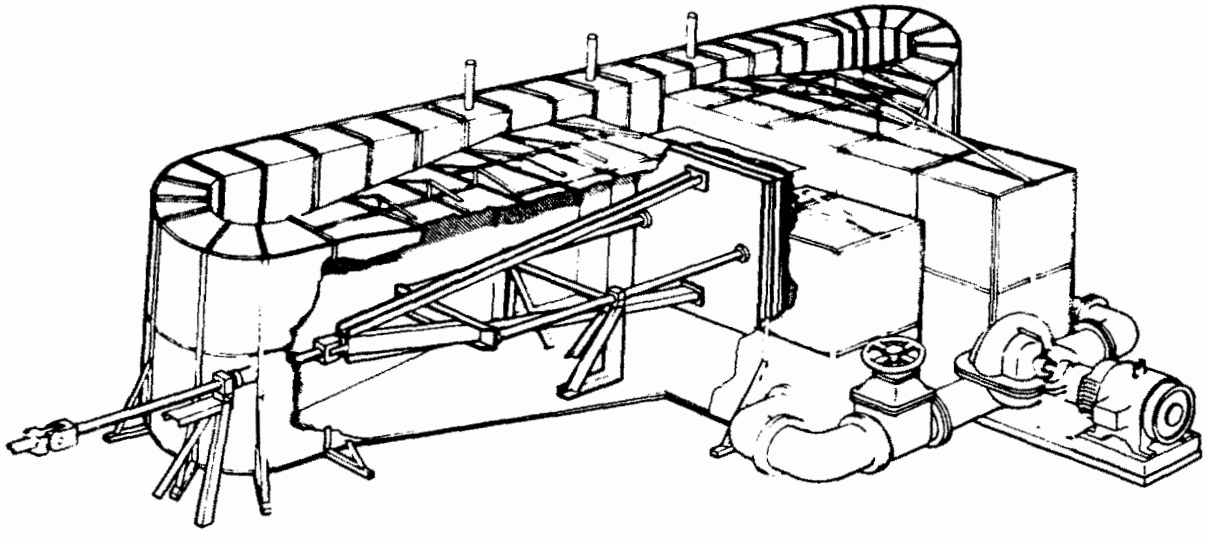


Fig 1 **Photograph and schematic diagram of the Pulsating Water Tunnel at Hydraulics Research, Wallingford.**

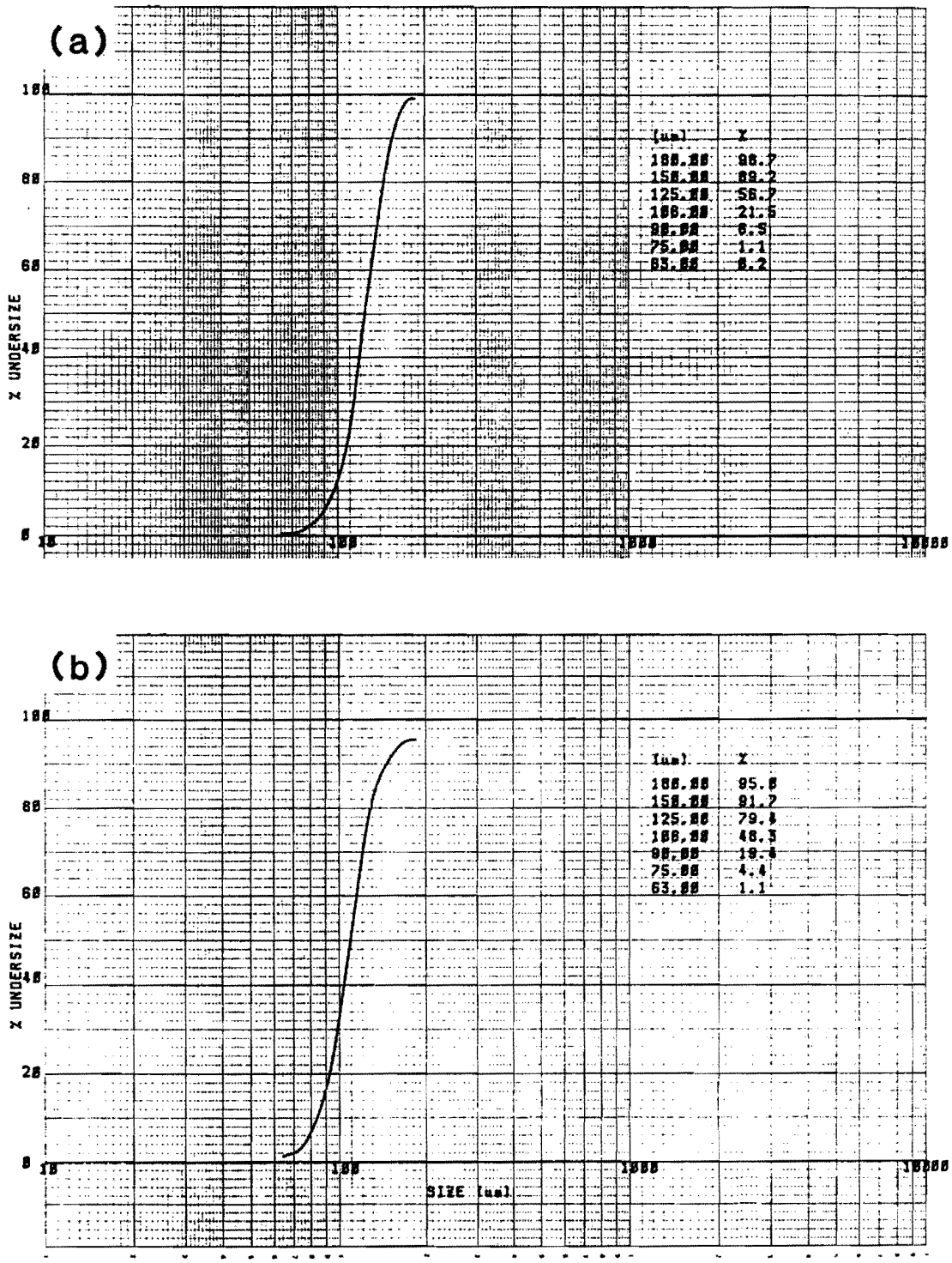


Fig 2 **The grain size distributions of pumped samples suspended by the combination of a large current and large wave, extracted at heights of (a) 5mm and (b) 55mm above the bed.**

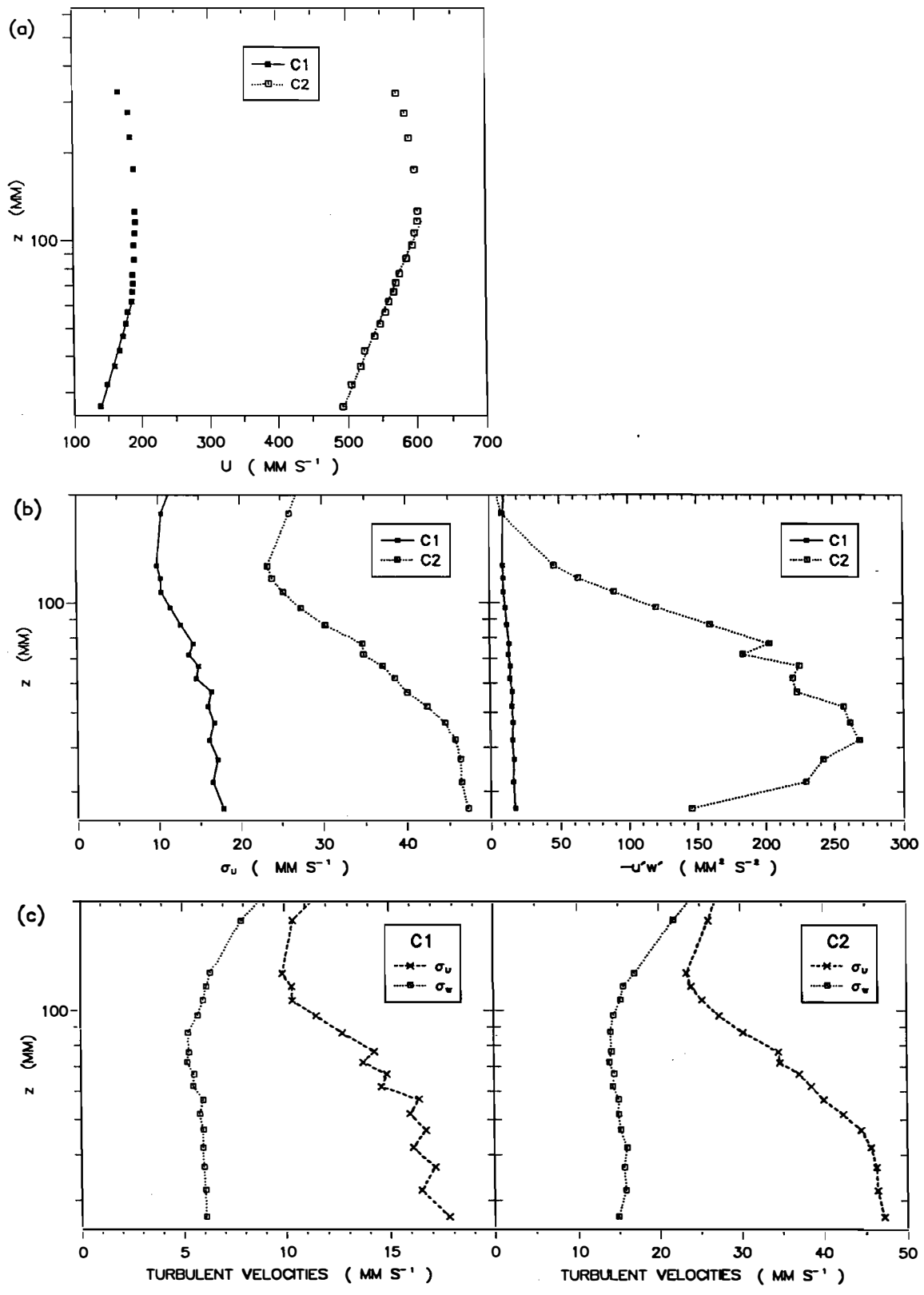


Fig 3 **Vertical profiles of the time-averaged flow parameters for the current alone tests : (a) velocity, (b) σ_v and Reynolds stress, and (c) turbulent velocites.**

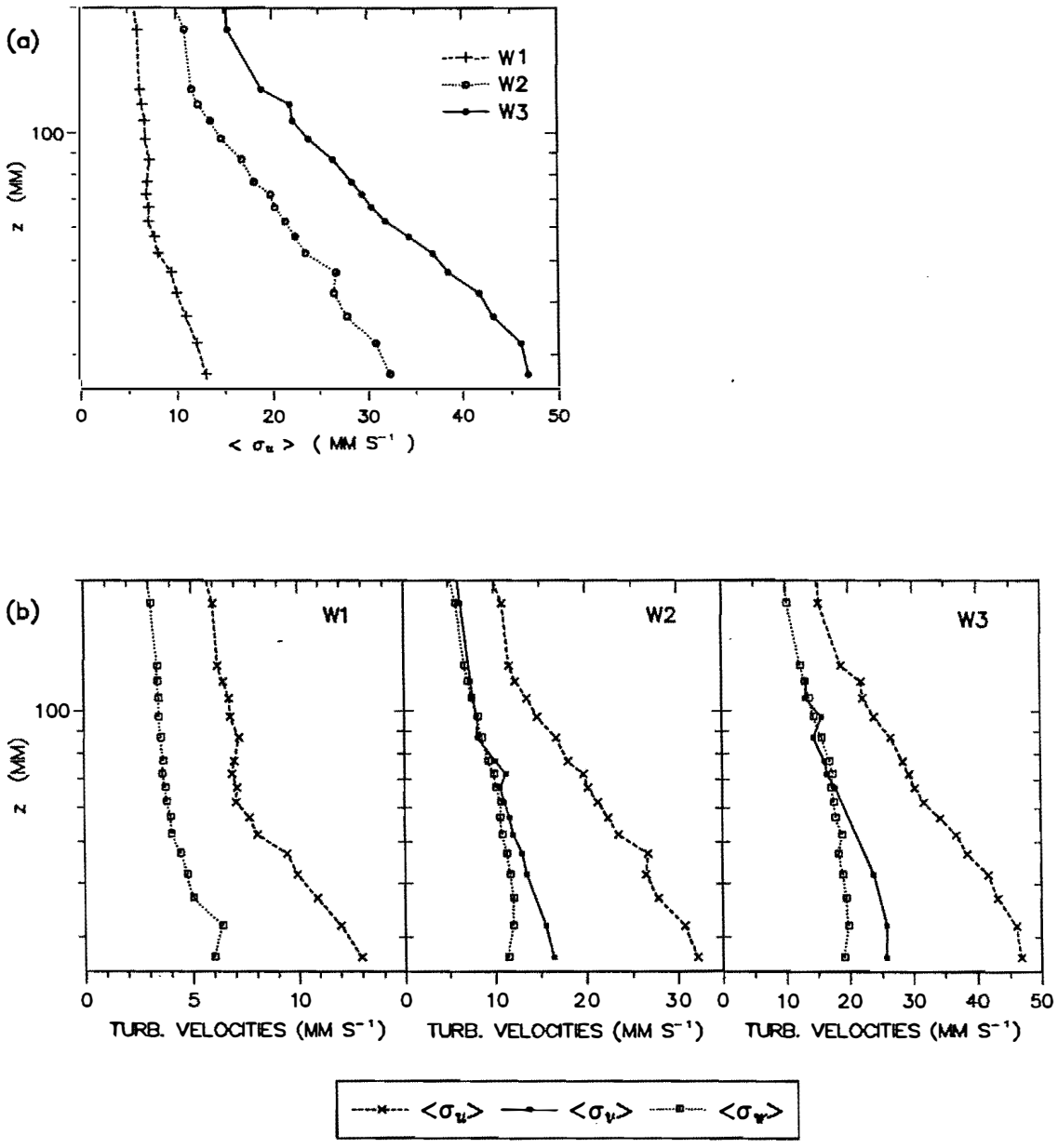


Fig 4 **Vertical profiles of (a) the cycle-averaged turbulent component, $\langle\sigma_U\rangle$, and (b) the component turbulent velocities for waves alone.**

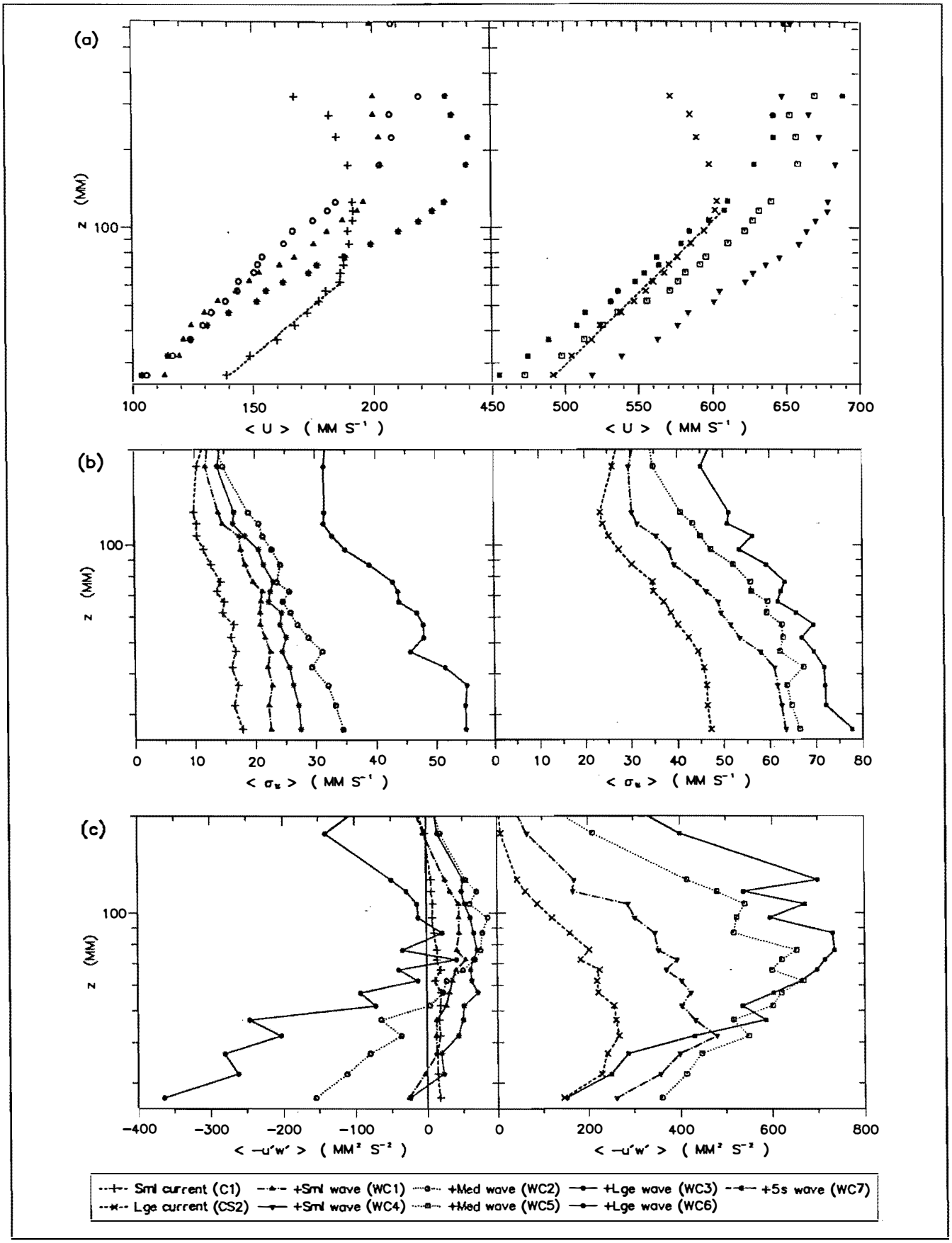


Fig 5 **The effect on the flow of adding waves onto steady currents as indicated by vertical profiles of (a) <U>, (b) $<\sigma_U>$, and (c) $<-u'w'>$.**

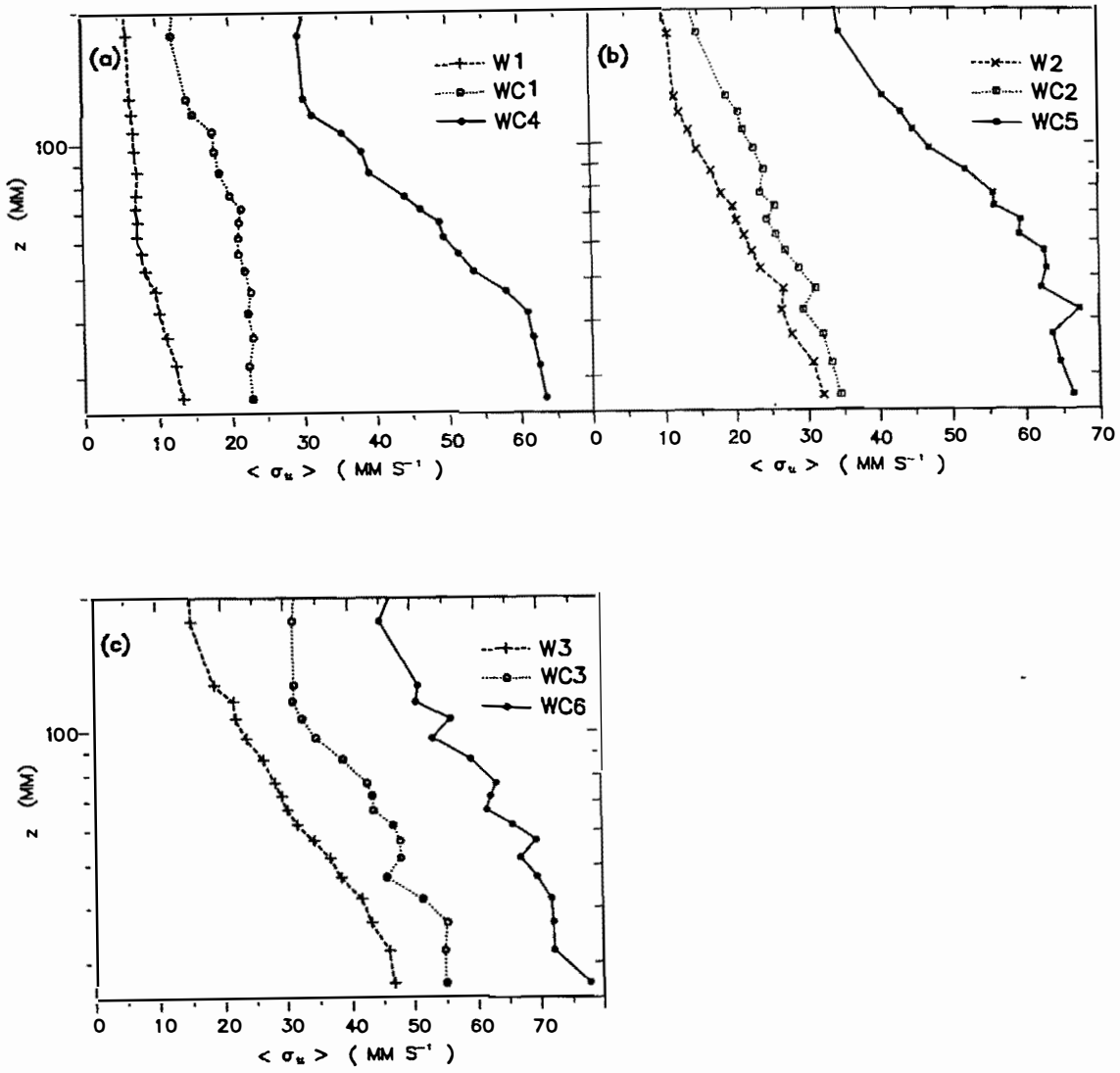


Fig 6 **The effect on the flow of adding currents onto (a) the small wave, (b) the medium wave, and (c) the large wave, as indicated by vertical profiles of $<\sigma_U>$.**

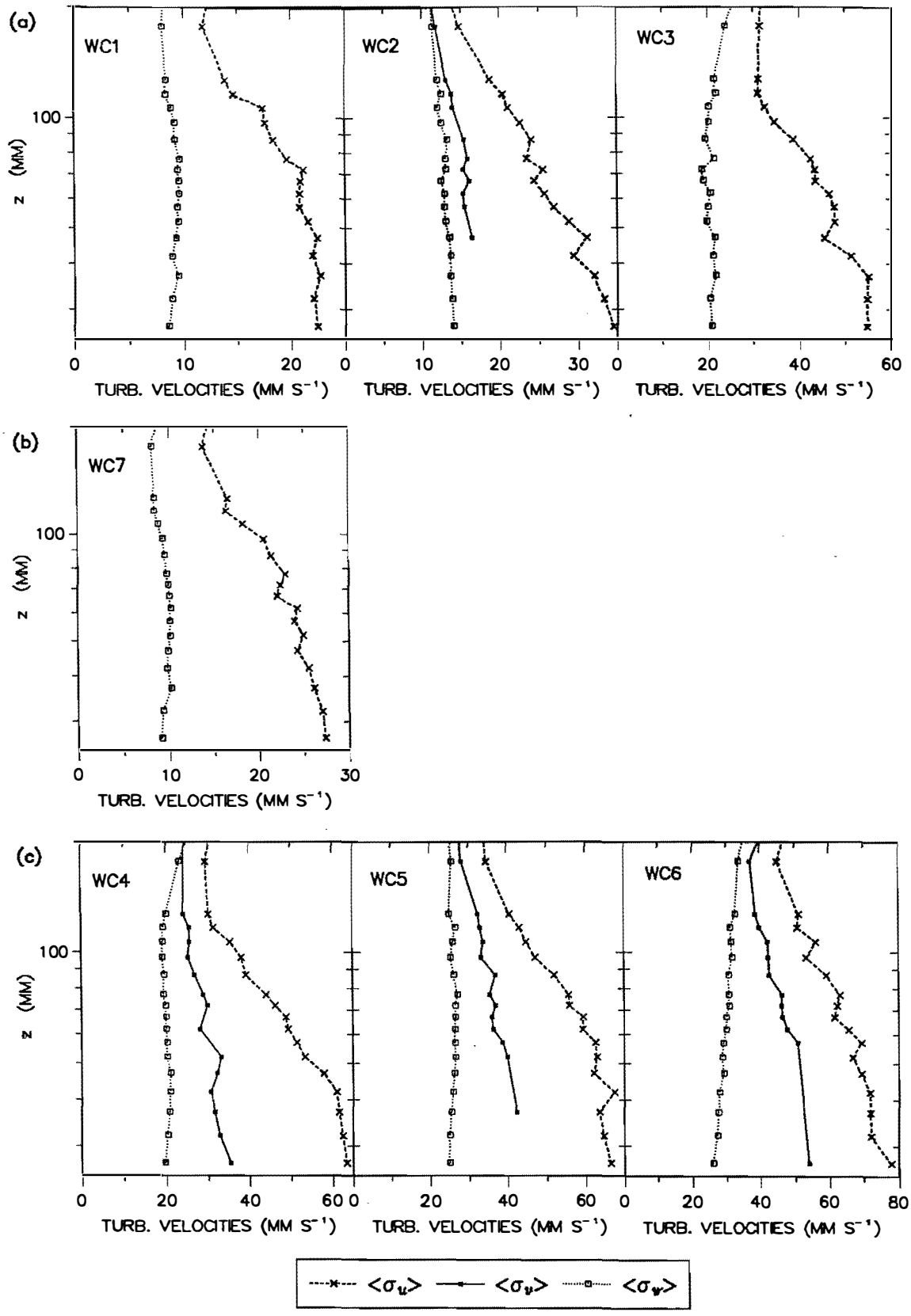


Fig 7 **Vertical profiles of the cycle-averaged turbulent velocites for tests (a) WC1, WC2, and WC3, (b) WC7, and (c) WC4, WC5, and WC6.**

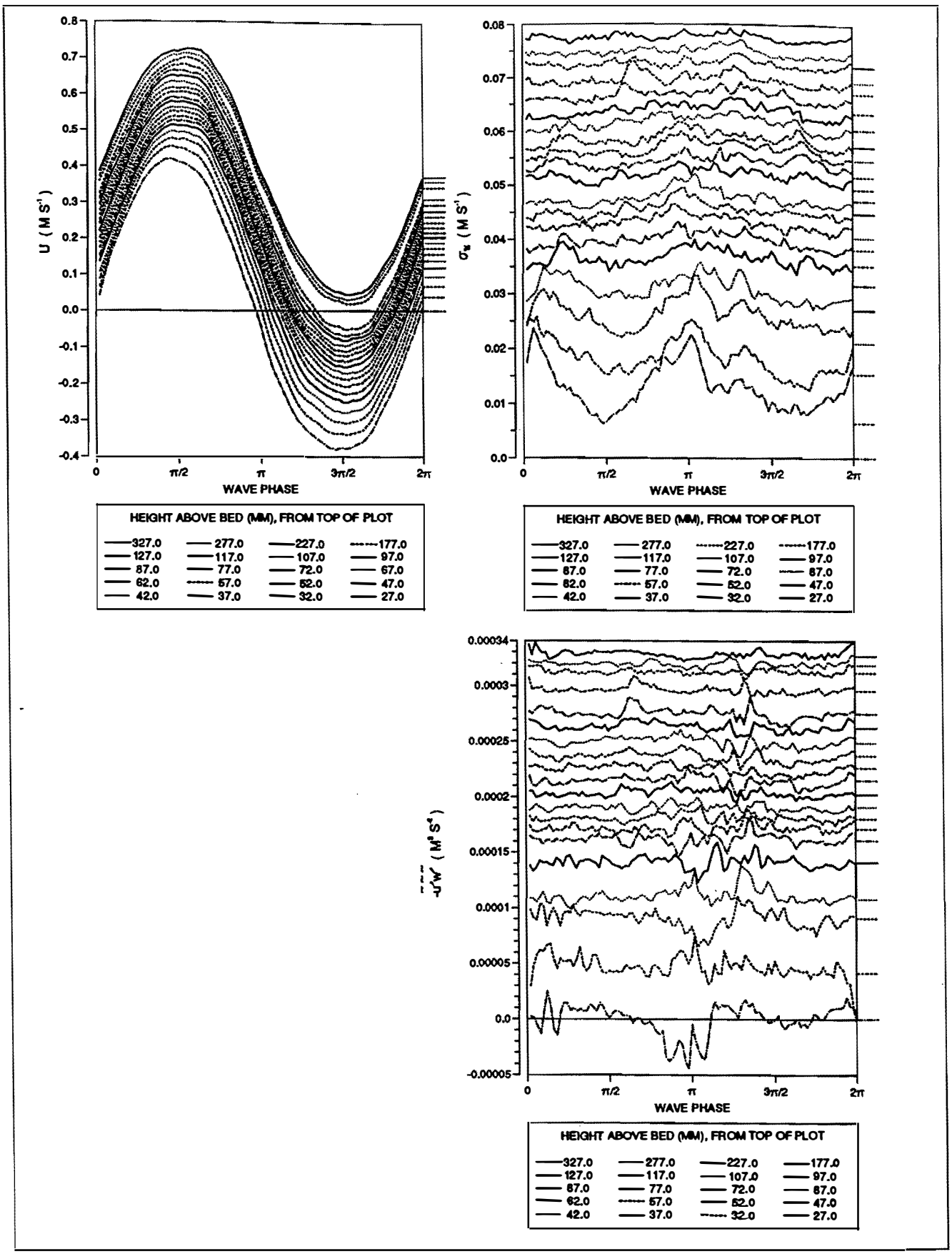


Fig 8 Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, and $-\overline{u'w'}$) for test W1 (U_0=366mms^{-1}) at different heights above the bed. In each plot, the origin for the lowest height is the zero velocity line, with all the higher levels relating to a displaced origin indicated to the right in a corresponding line type.

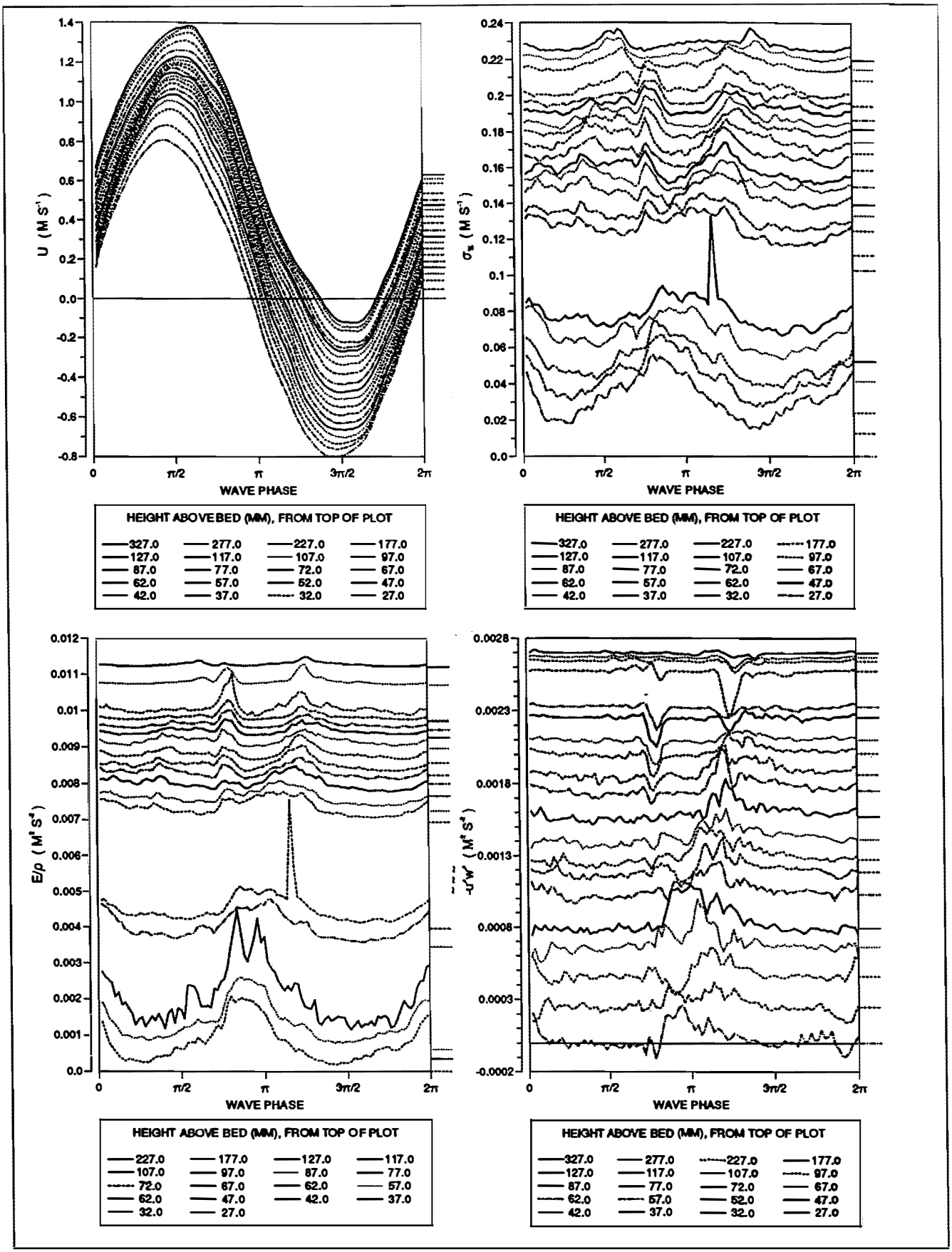


Fig 9 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_u, E/ρ and $-\overline{u'w'}$) for test W2 (U_0=758mms^{-1}) at different heights above the bed. See caption for Fig 8.**

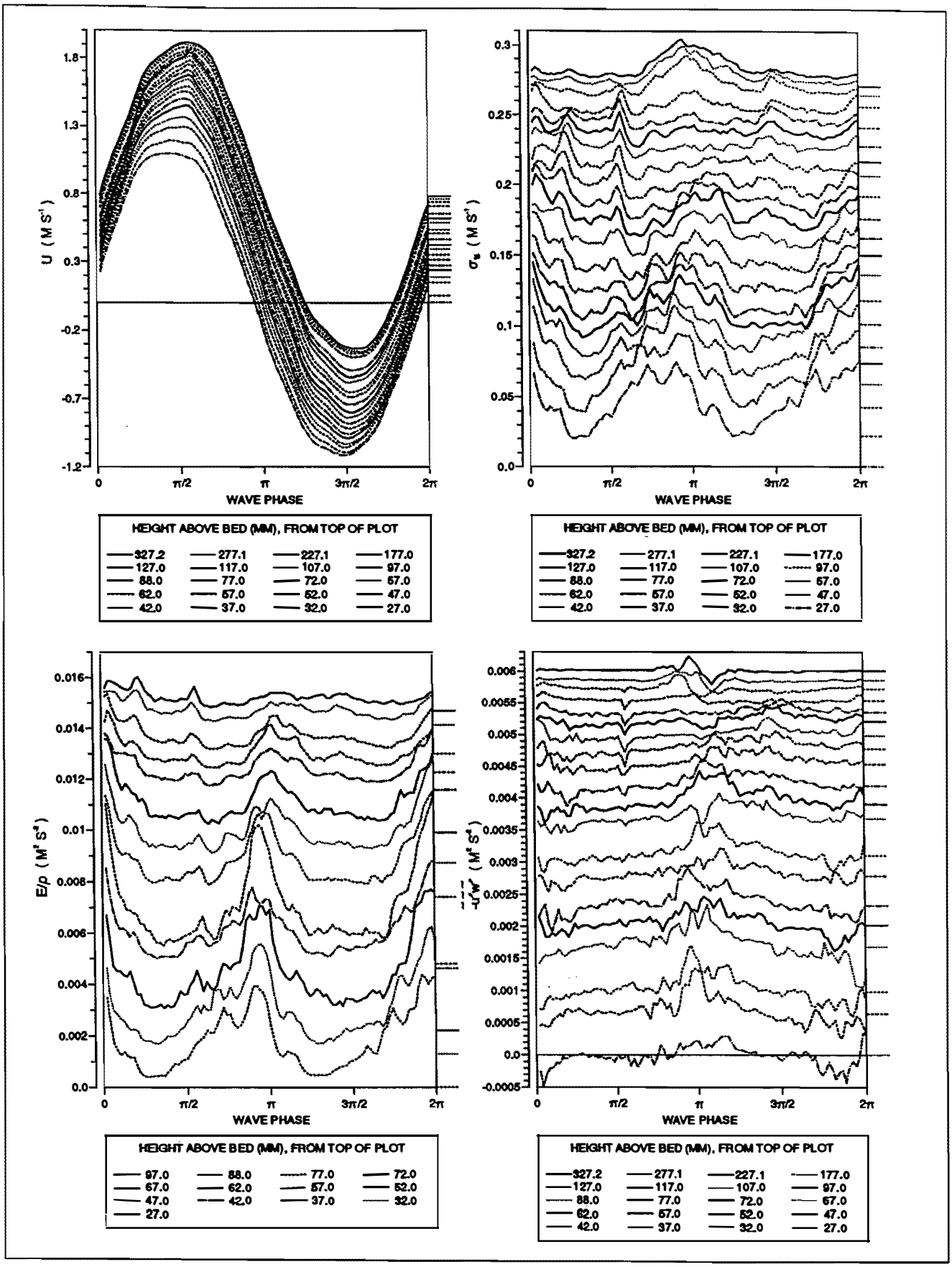


Fig 10 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test W3 (U_0=1127mms^{-1}) at different heights above the bed. See caption for Fig 8.**

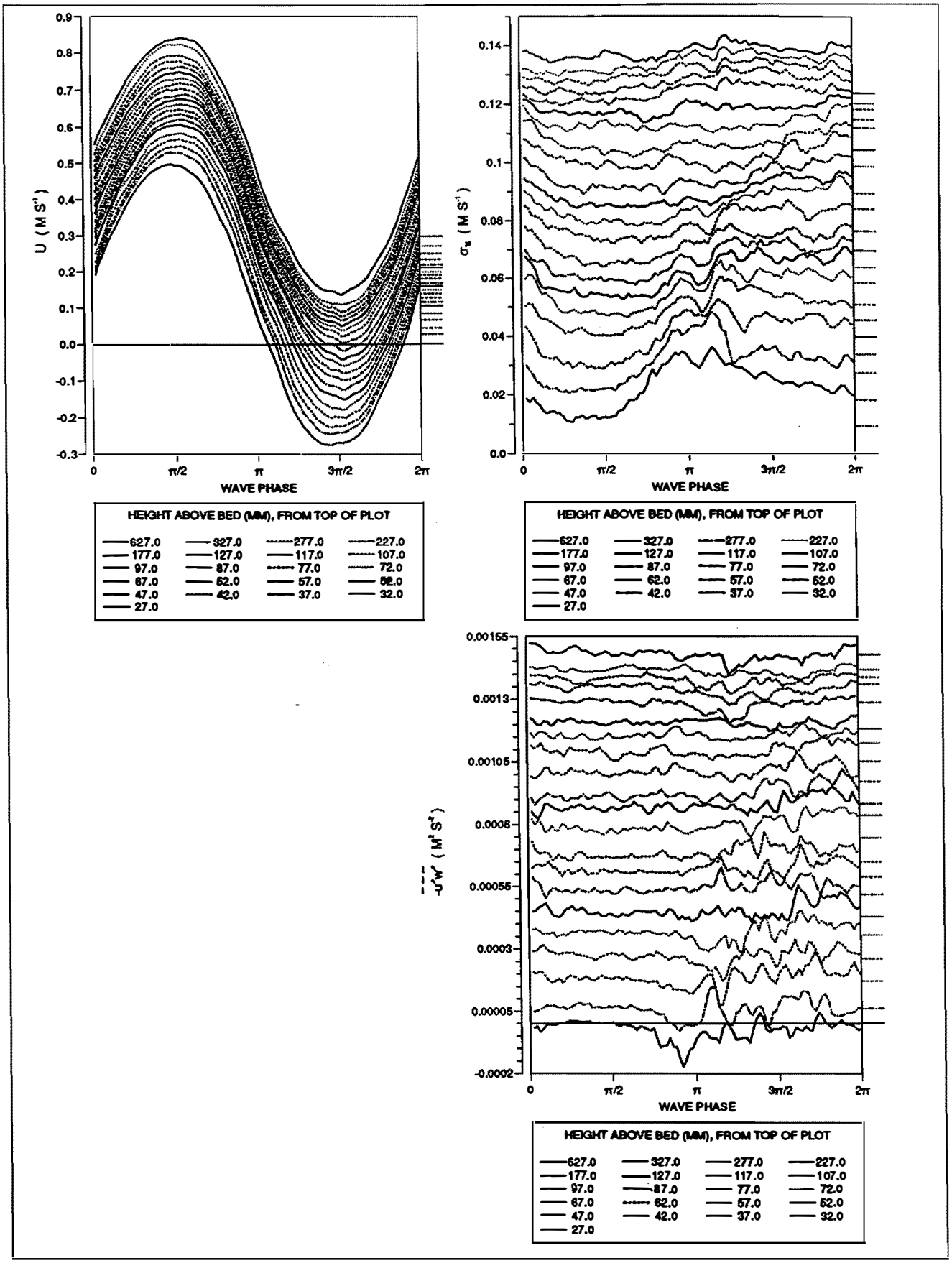


Fig 11 Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, and $-\widetilde{u'w'}$) for test WC1 (U_0=350mms^{-1}, $\bar{U}$=181mms^{-1}) at different heights above the bed. See caption for Fig 8.

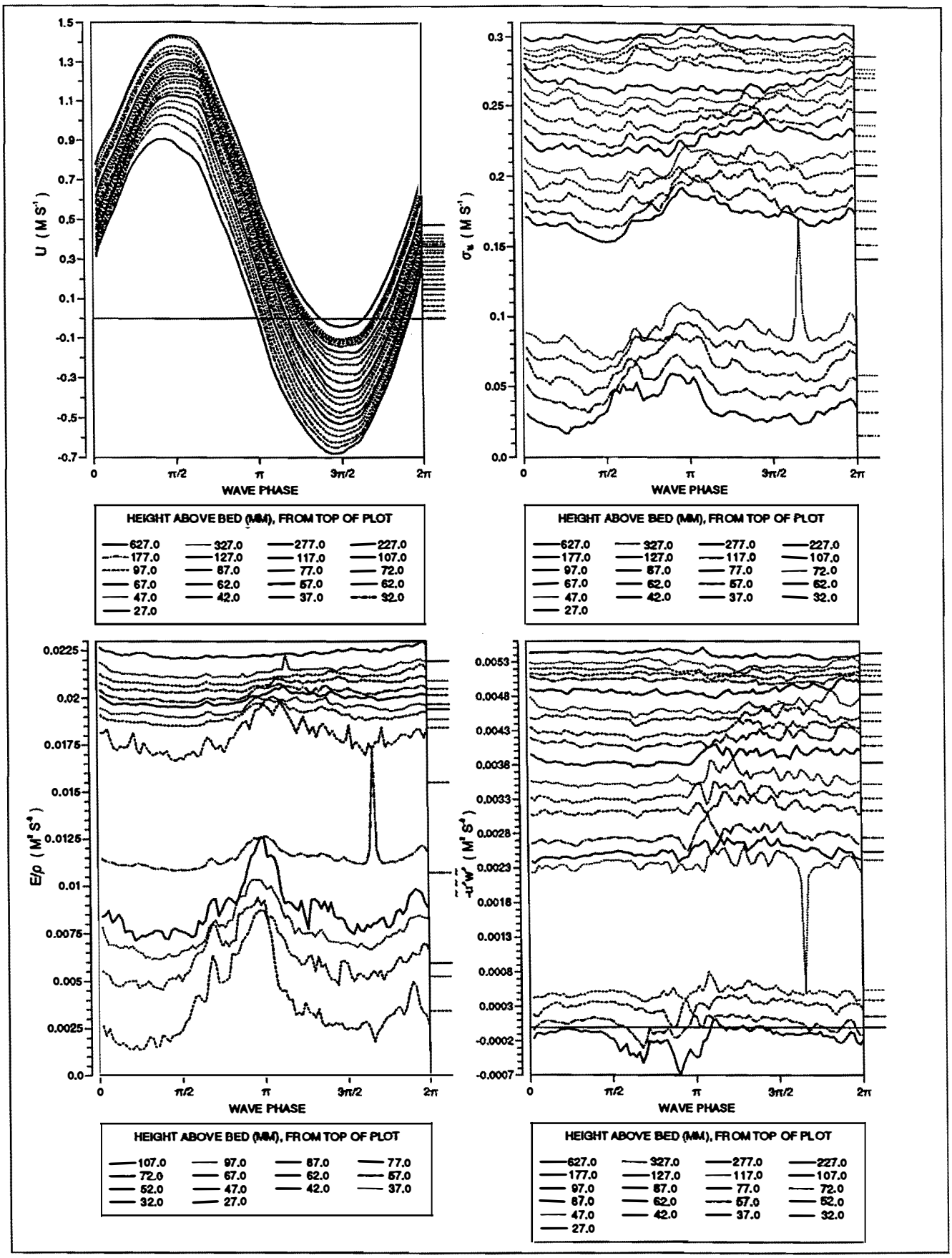


Fig 12 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test WC2 (U_0=742mms^{-1}, $\bar{U}$=161mms^{-1}) at different heights above the bed. See caption for Fig 8.**

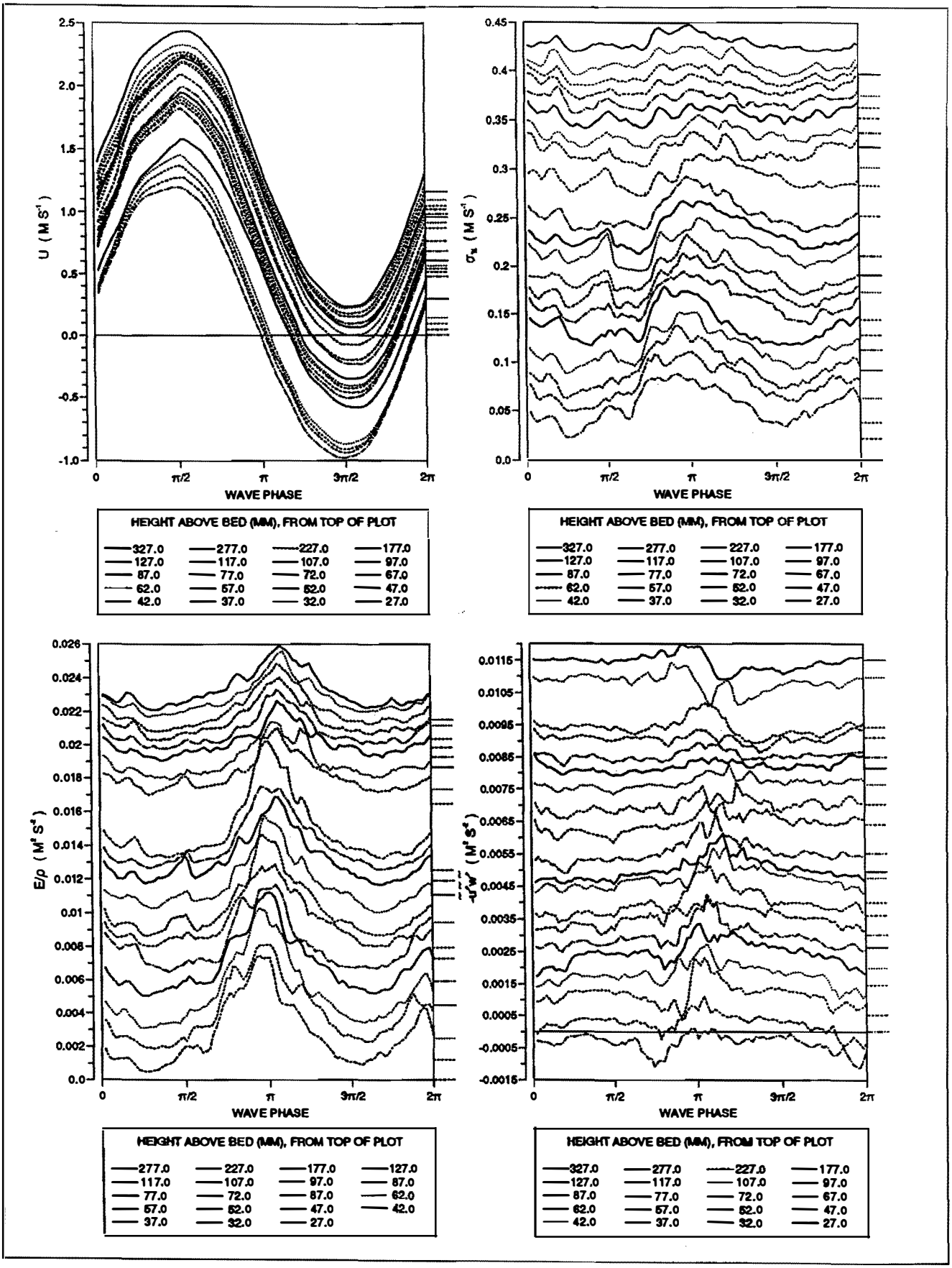


Fig 13 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test WC3 (U_0=1049mms^{-1}, $\bar{U}$=140mms^{-1}) at different heights above the bed. See caption for Fig 8.**

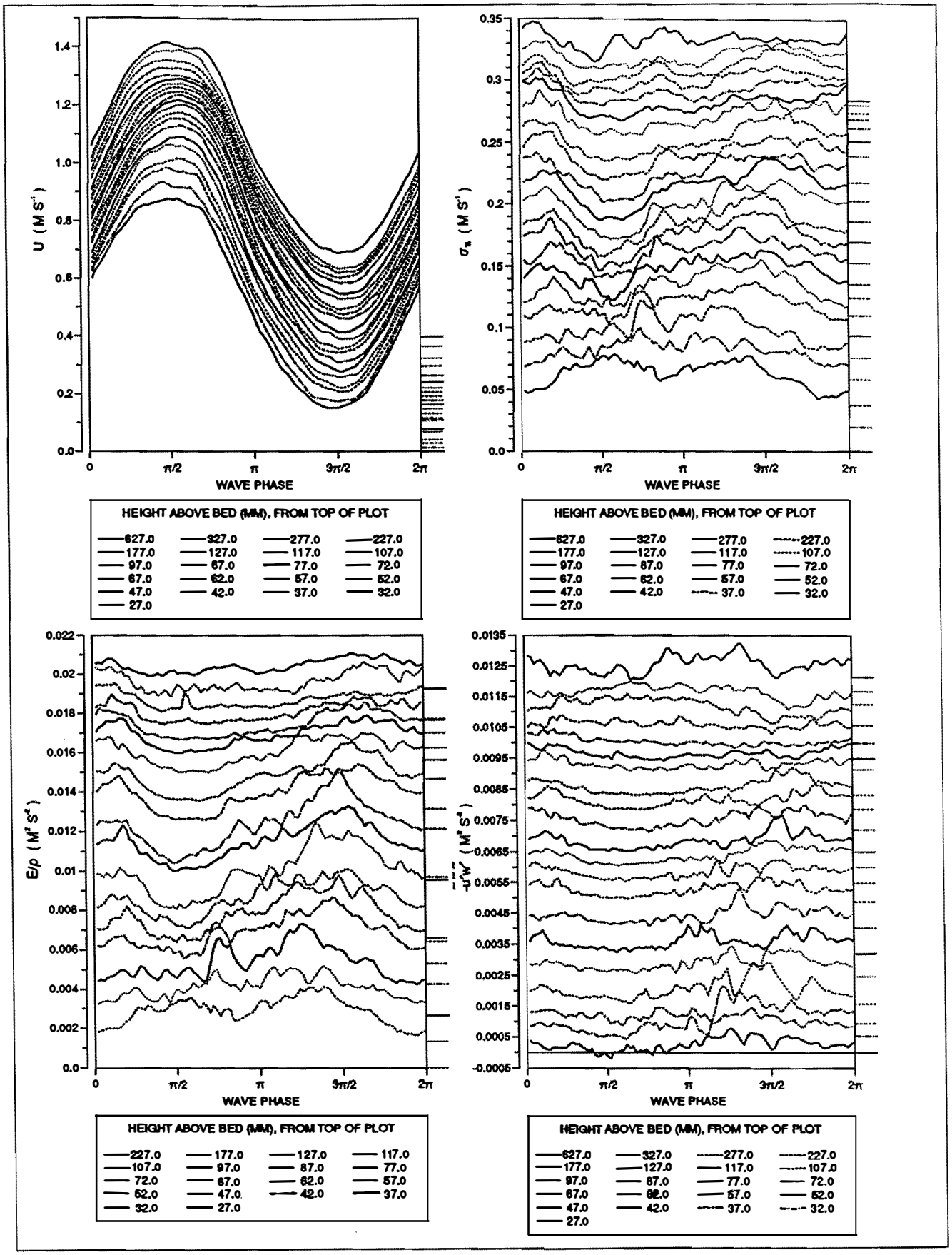


Fig 14 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test WC4 (U_0=366mms^{-1}, $\bar{U}$=603mms^{-1}) at different heights above the bed. See caption for Fig 8.**

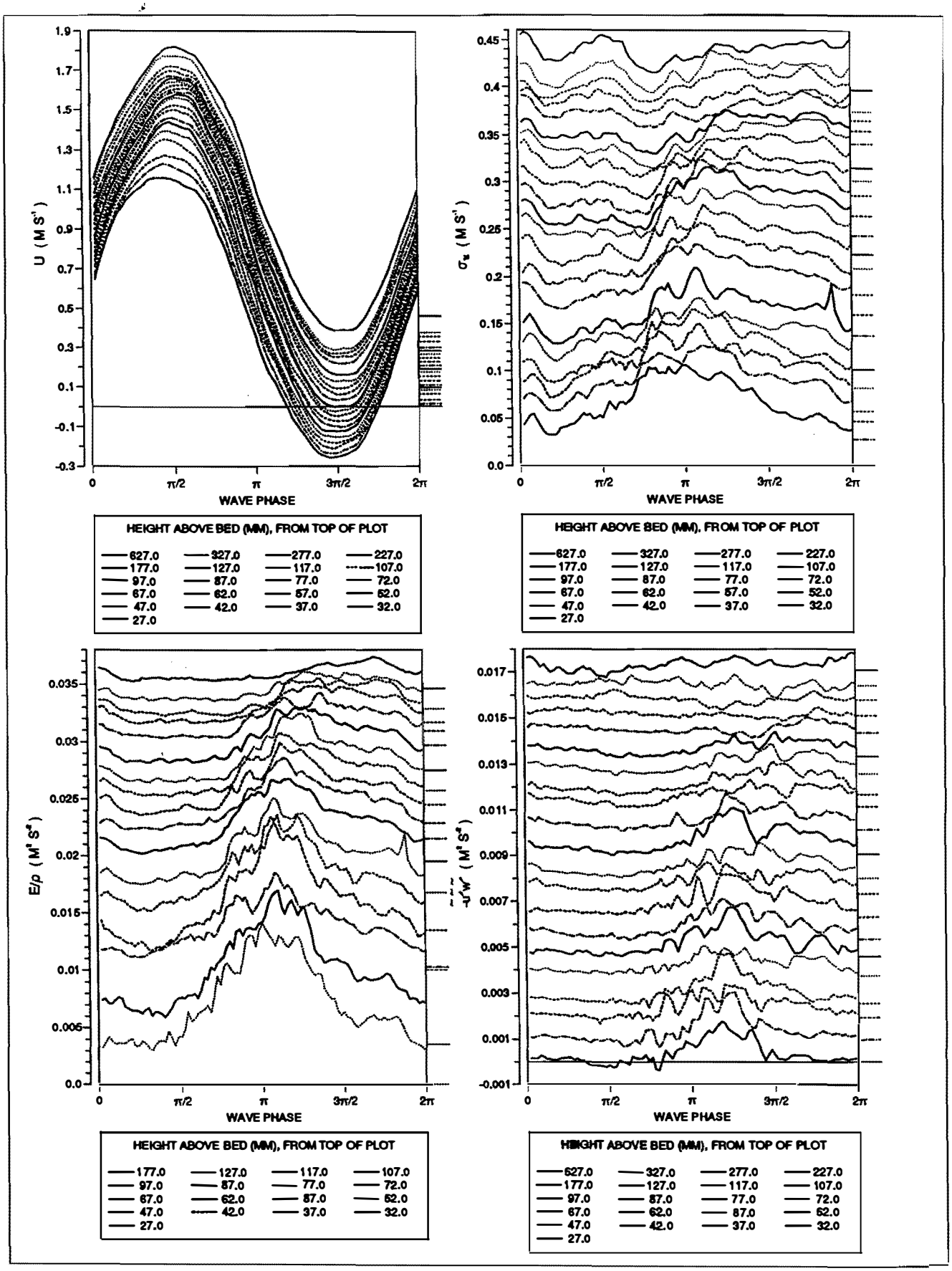


Fig 15 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test WC5 (U_0=726mms^{-1}, $\bar{U}$=618mms^{-1}) at different heights above the bed. See caption for Fig 8.**

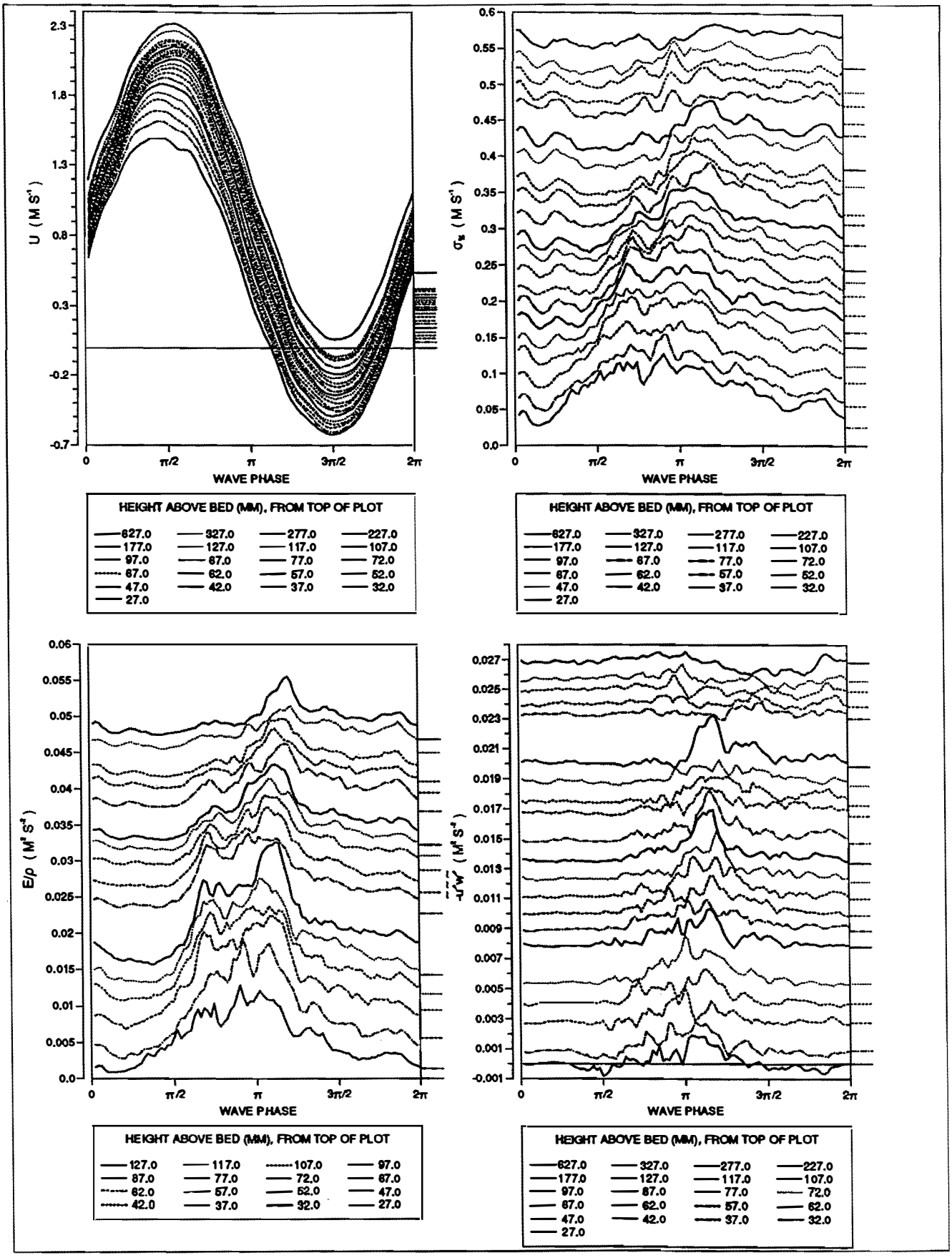


Fig 16 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test WC6 (U_0=1140mms^{-1}, $\bar{U}$=609mms^{-1}) at different heights above the bed. See caption for Fig 8.**

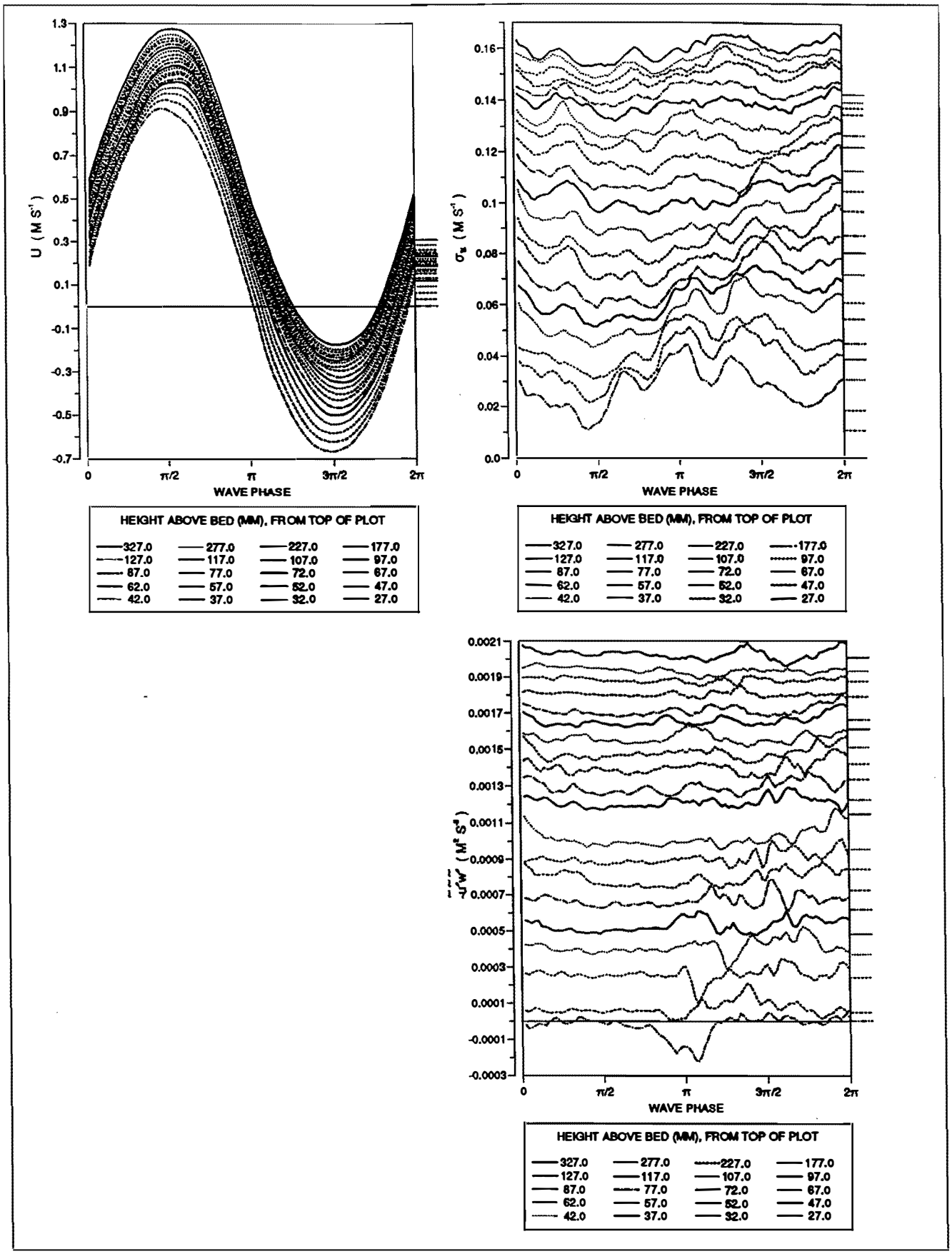


Fig 17 Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, and $-\overline{u'w'}$) for test WC7 (U_0=720mms^{-1}, $\bar{U}$=182mms^{-1}) at different heights above the bed. See caption for Fig 8.

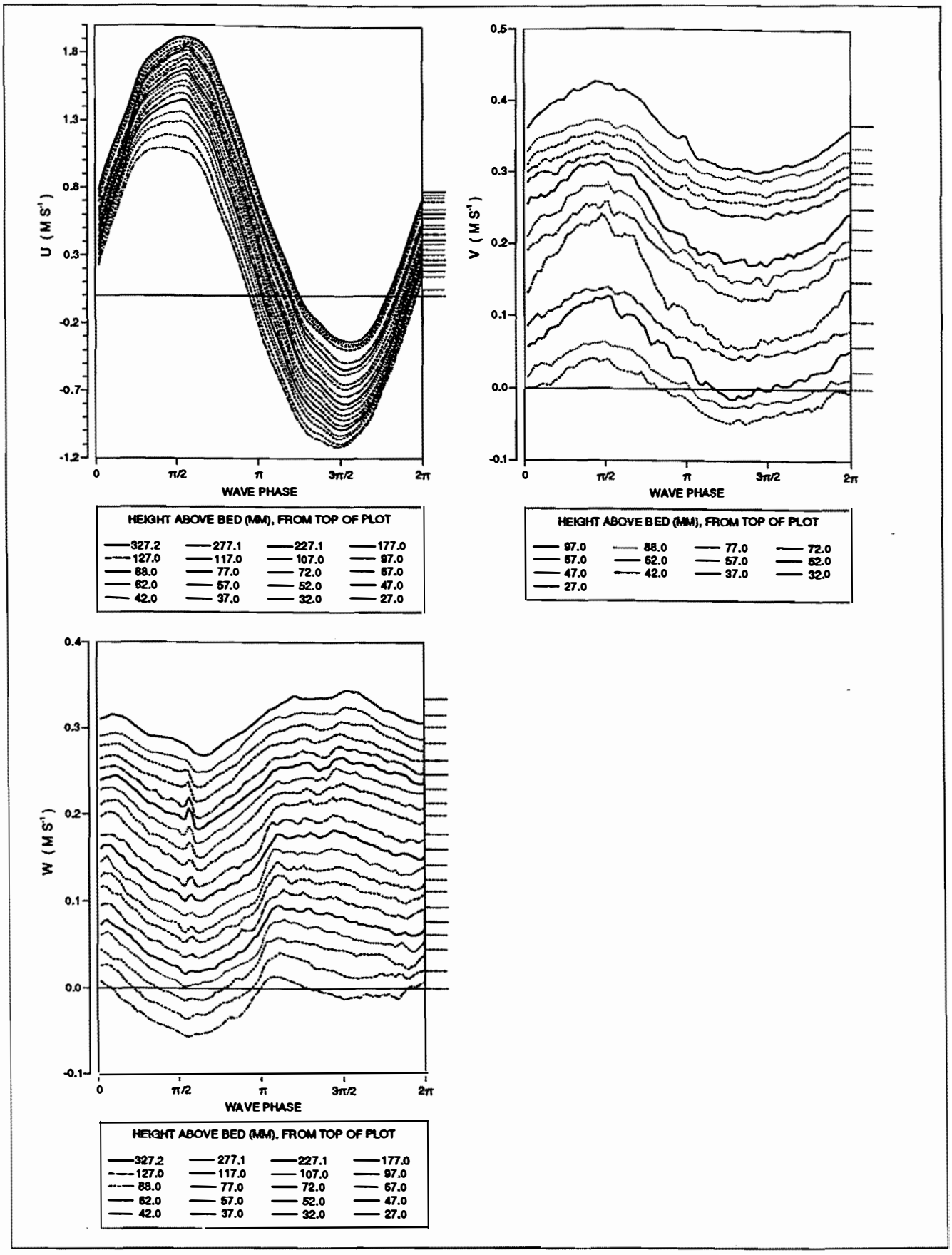


Fig 18 **Time-series of the ensemble-averaged mean velocities (U, V, and W) for a selected test (W3 : U_0=1127mms^{-1}) at different heights above the bed. See caption for Fig 8.**

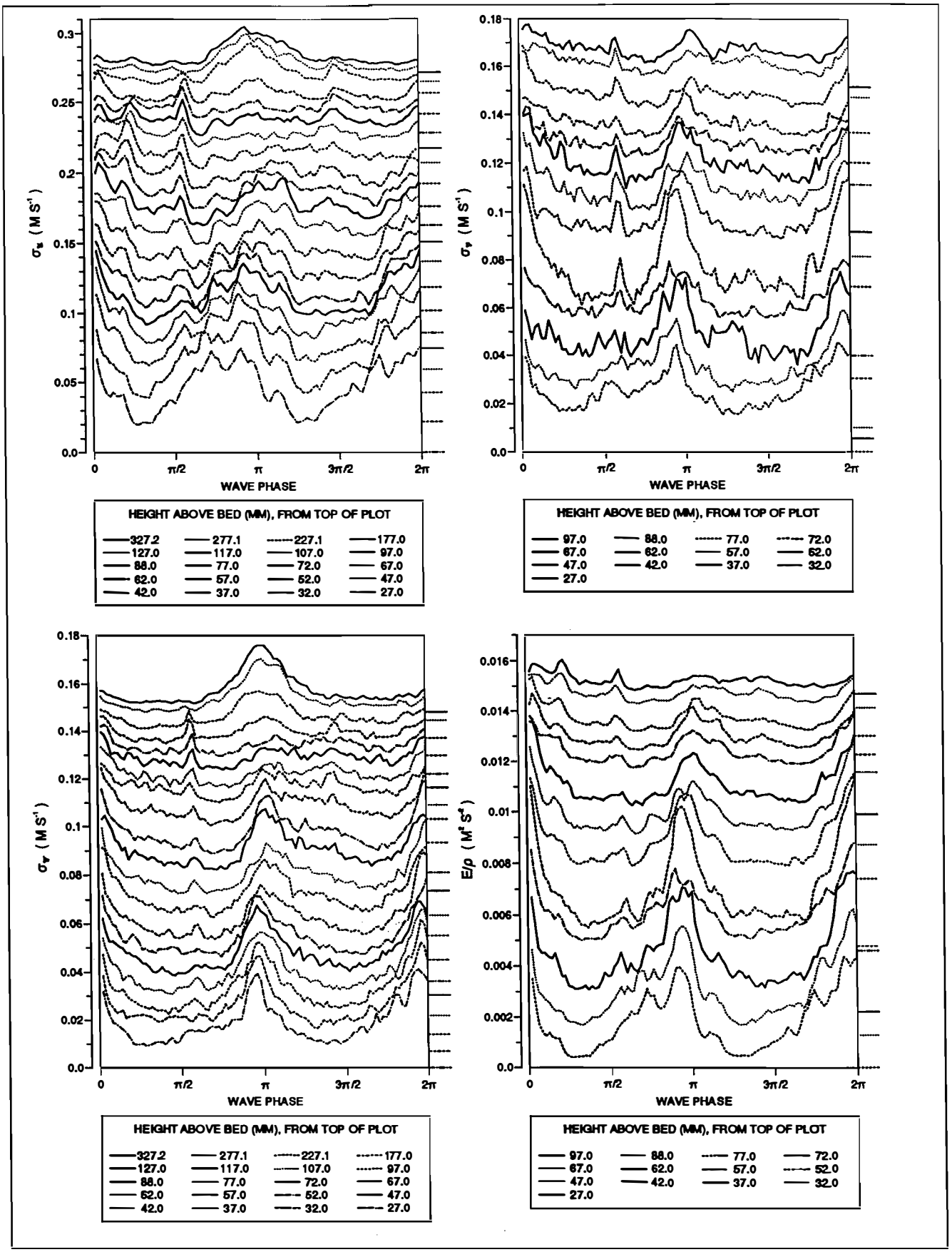


Fig 19 **Time-series of the ensemble-averaged kinematic Energy and turbulent velocities (E/ρ, σ_U, σ_V, and σ_W) for a selected test (W3 : U_0=1127mms^{-1}) at different heights above the bed. See caption for Fig 8.**

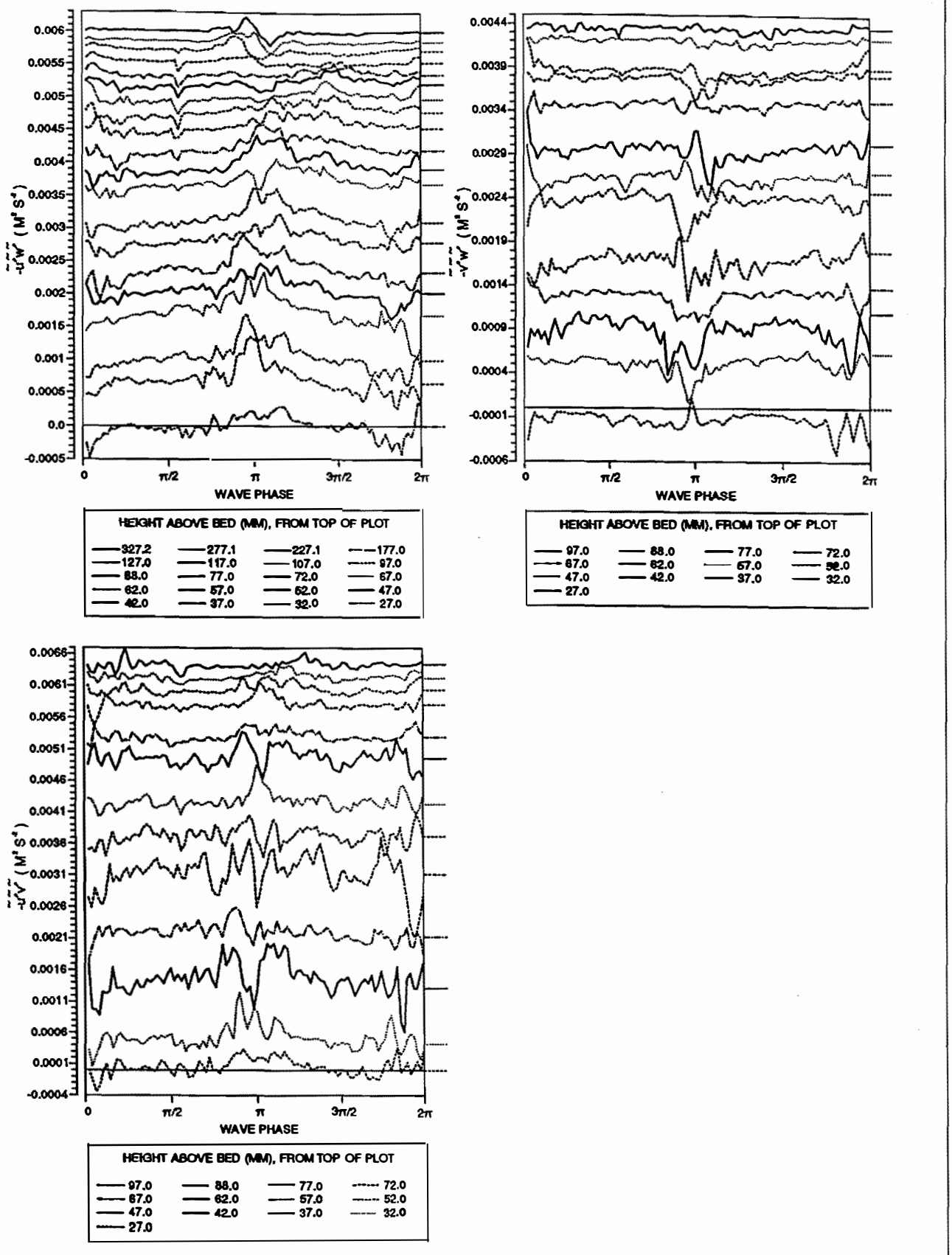


Fig 20 Time-series of the ensemble-averaged Reynolds stresses ($-\overline{u'w'}$, $-\overline{v'w'}$, $-\overline{u'v'}$) for a selected test ; W3 (U_0=1127mms^{-1}) at different heights above the bed. See caption for Fig 8.

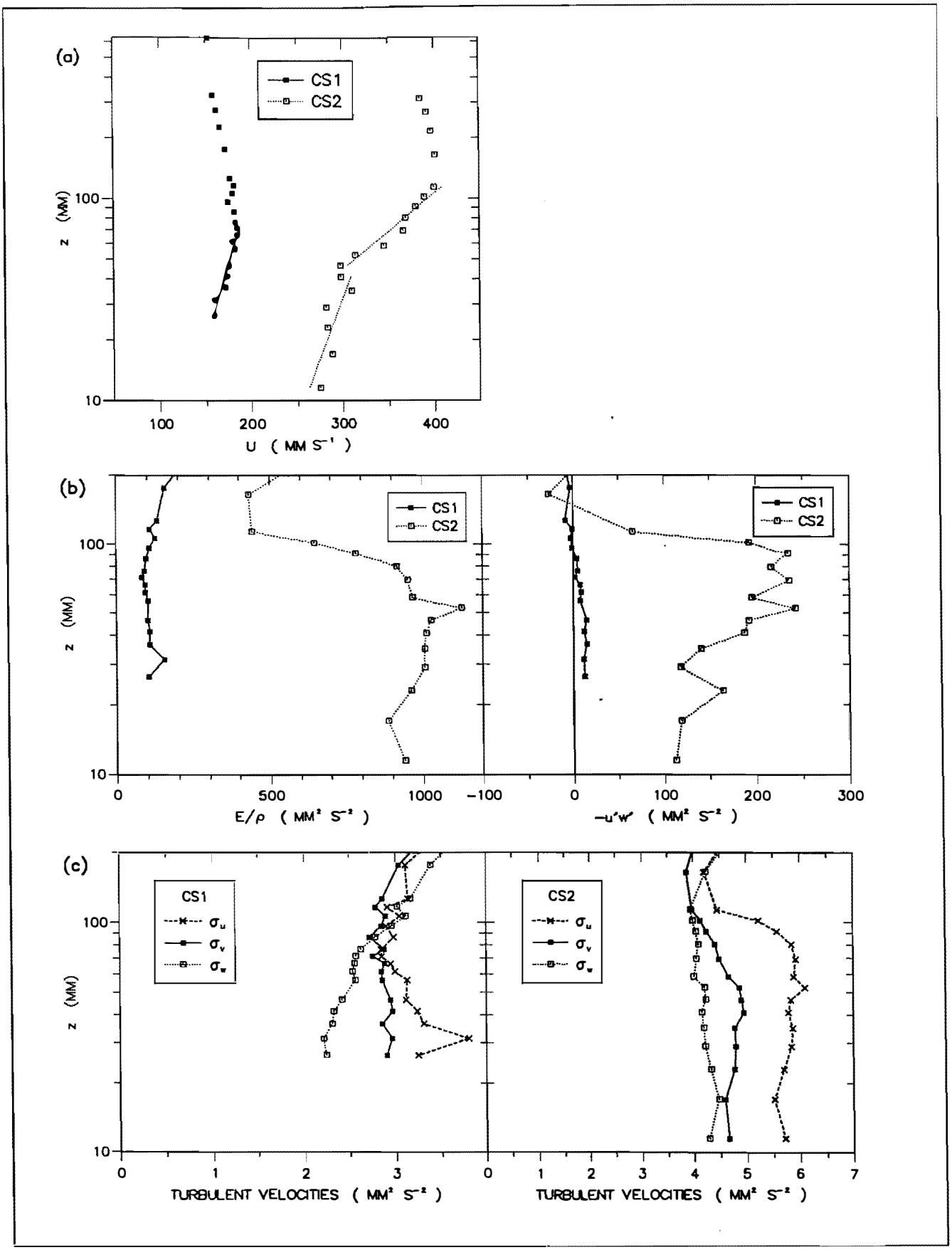


Fig 21 **Vertical profiles of the time-averaged flow parameters for the current alone tests : (a) velocity, (b) energy and Reynolds stress, and (c) turbulent velocites.**

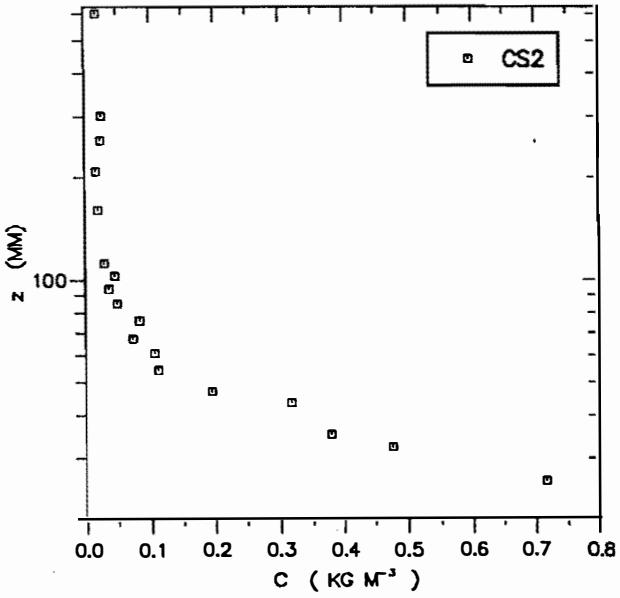
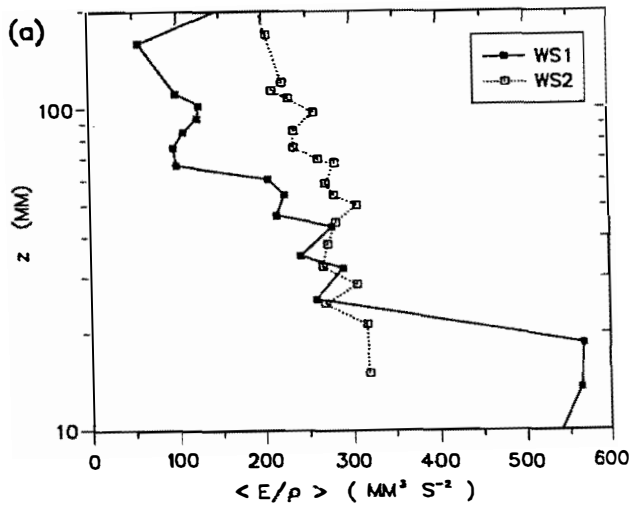


Fig 22 **Vertical profile of the time-averaged mean sediment concentration for current CS2. In CS1, no sediment entrainment occurred.**



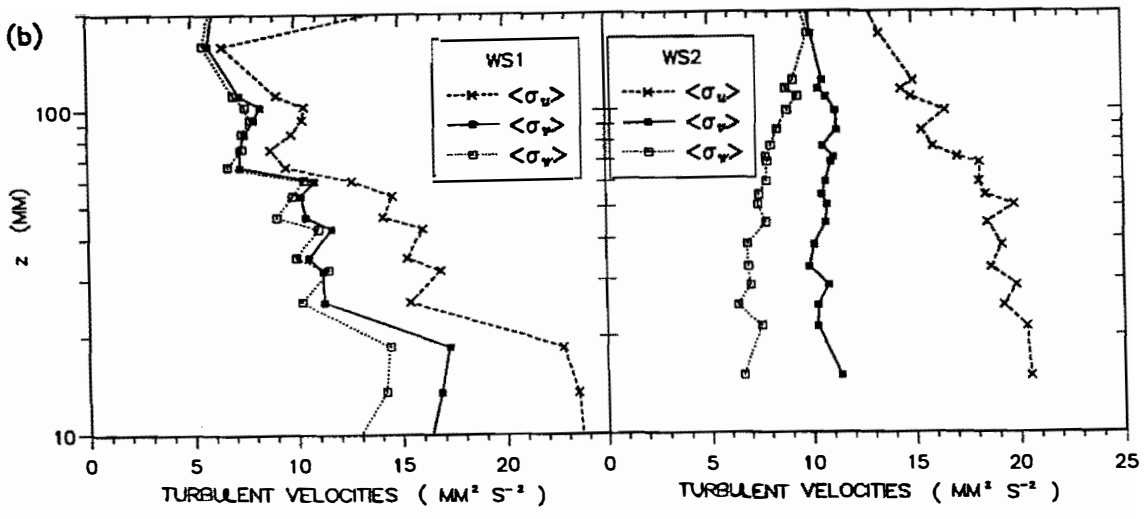


Fig 23 **Vertical profiles of (a) the cycle-averaged energy, and (b) the component turbulent velocities, for waves alone.**

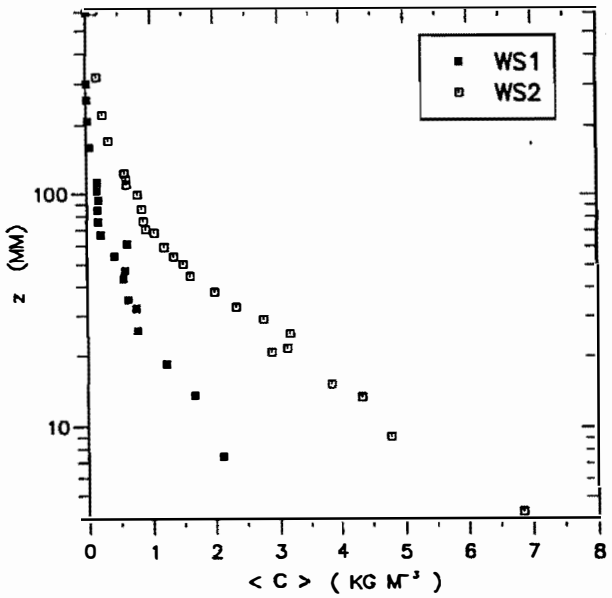


Fig 24 **Vertical profiles of the cycle-averaged sediment concentration for waves.**

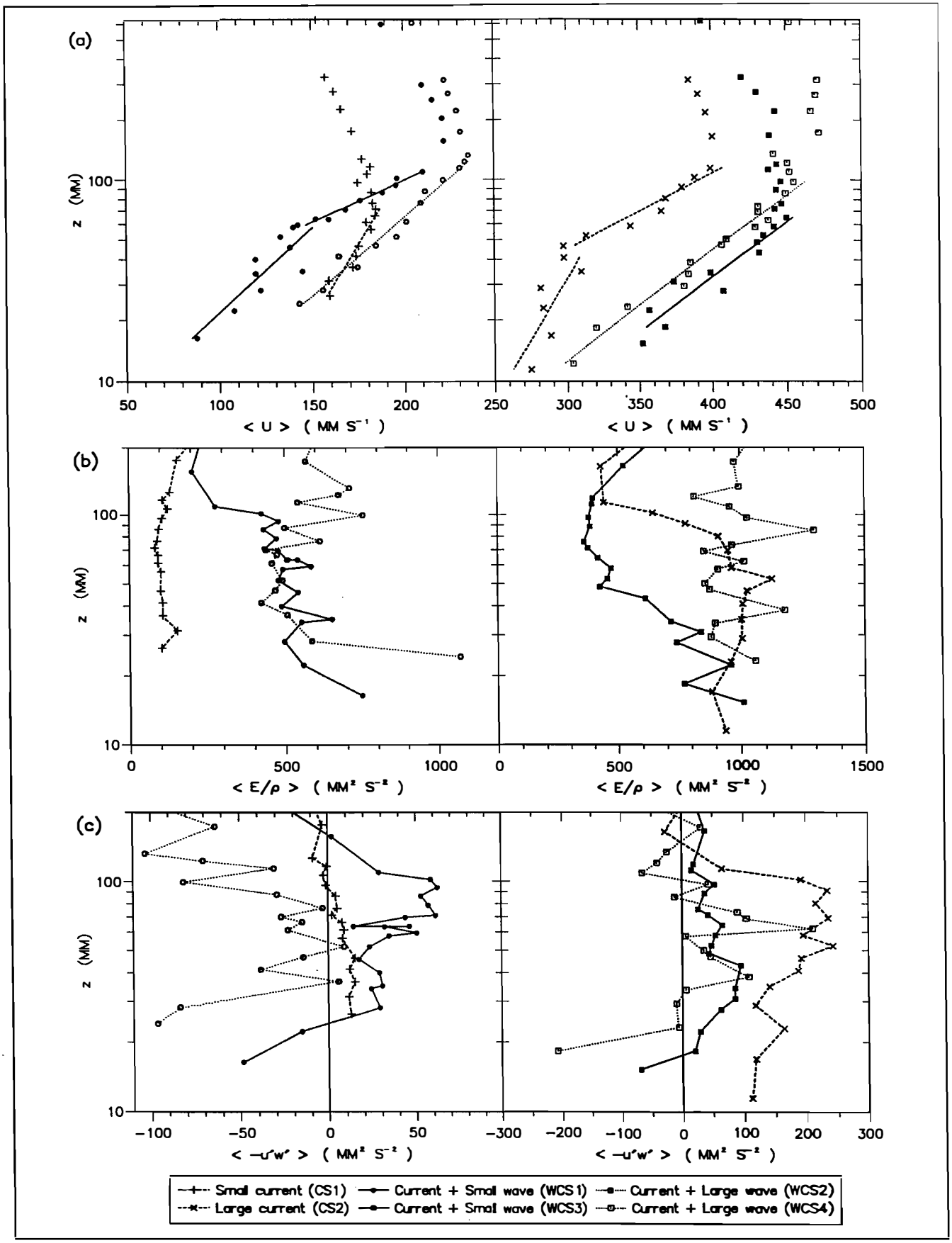


Fig 25 The effect on the flow of adding waves onto steady currents as Indicated by vertical profiles of (a) <U>, (b) <E/ρ>, and (c) $< -u'w' >$.

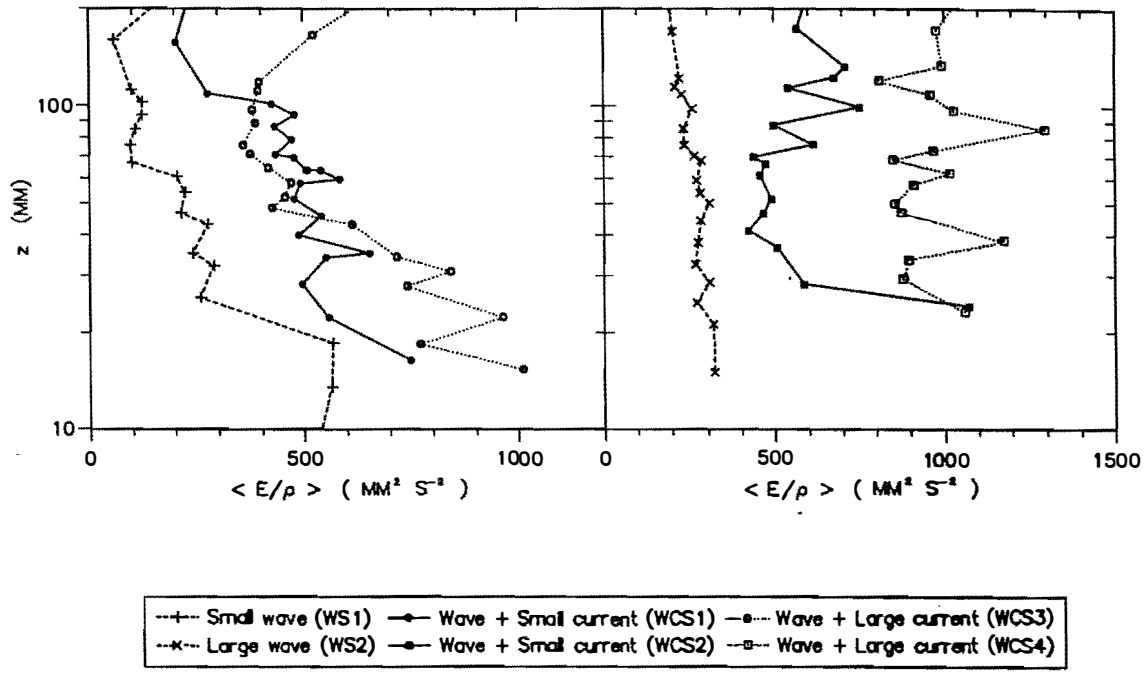


Fig 26 **The effect on the flow of adding currents onto waves, as indicated by vertical porfiles of <E/ρ>.**

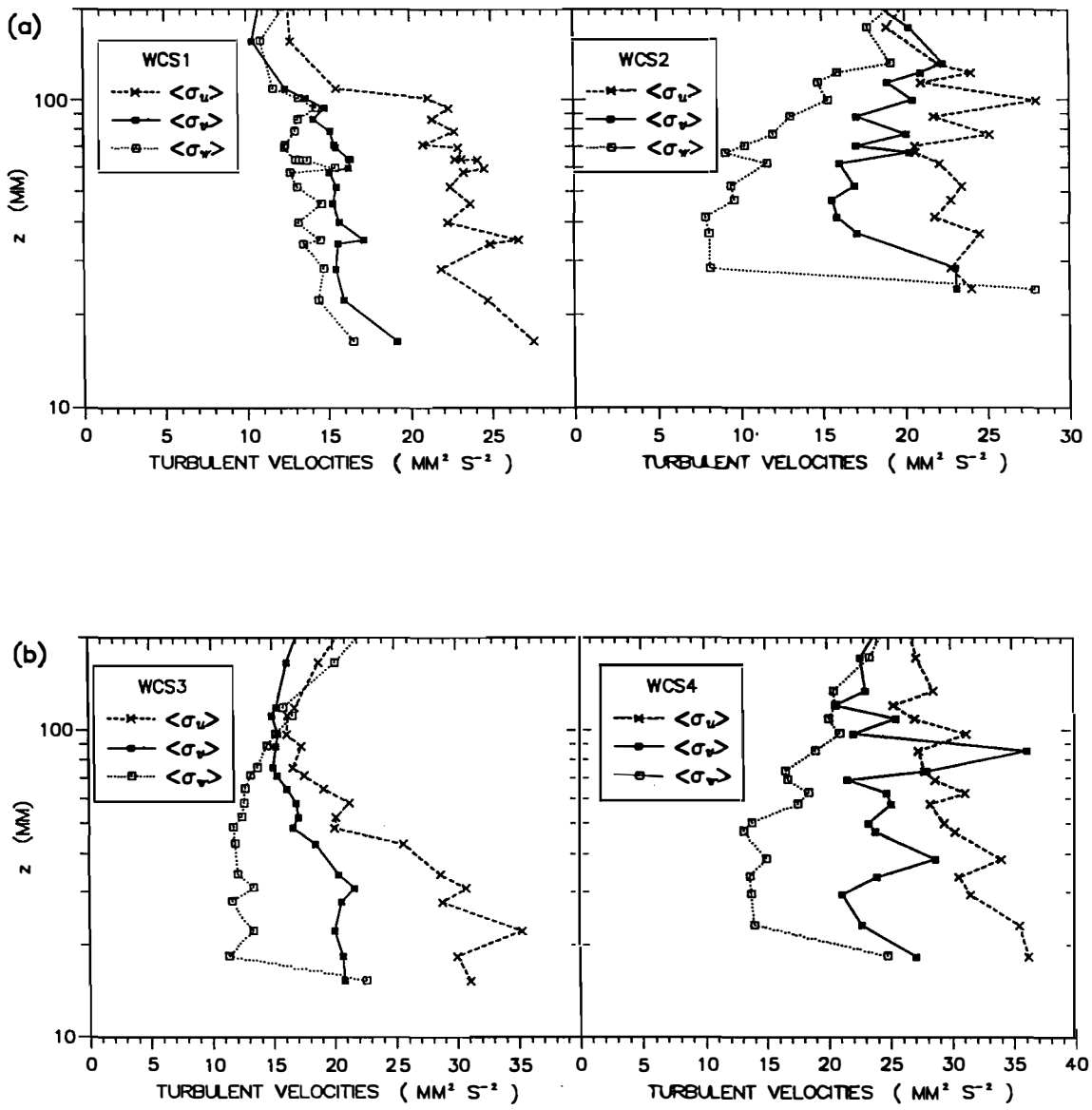


Fig 27 **Vertical profiles of the cycle-averaged turbulent velocites for tests (a) WCS1, (b) WCS2, (c) WCS3, and (d) WCS4.**

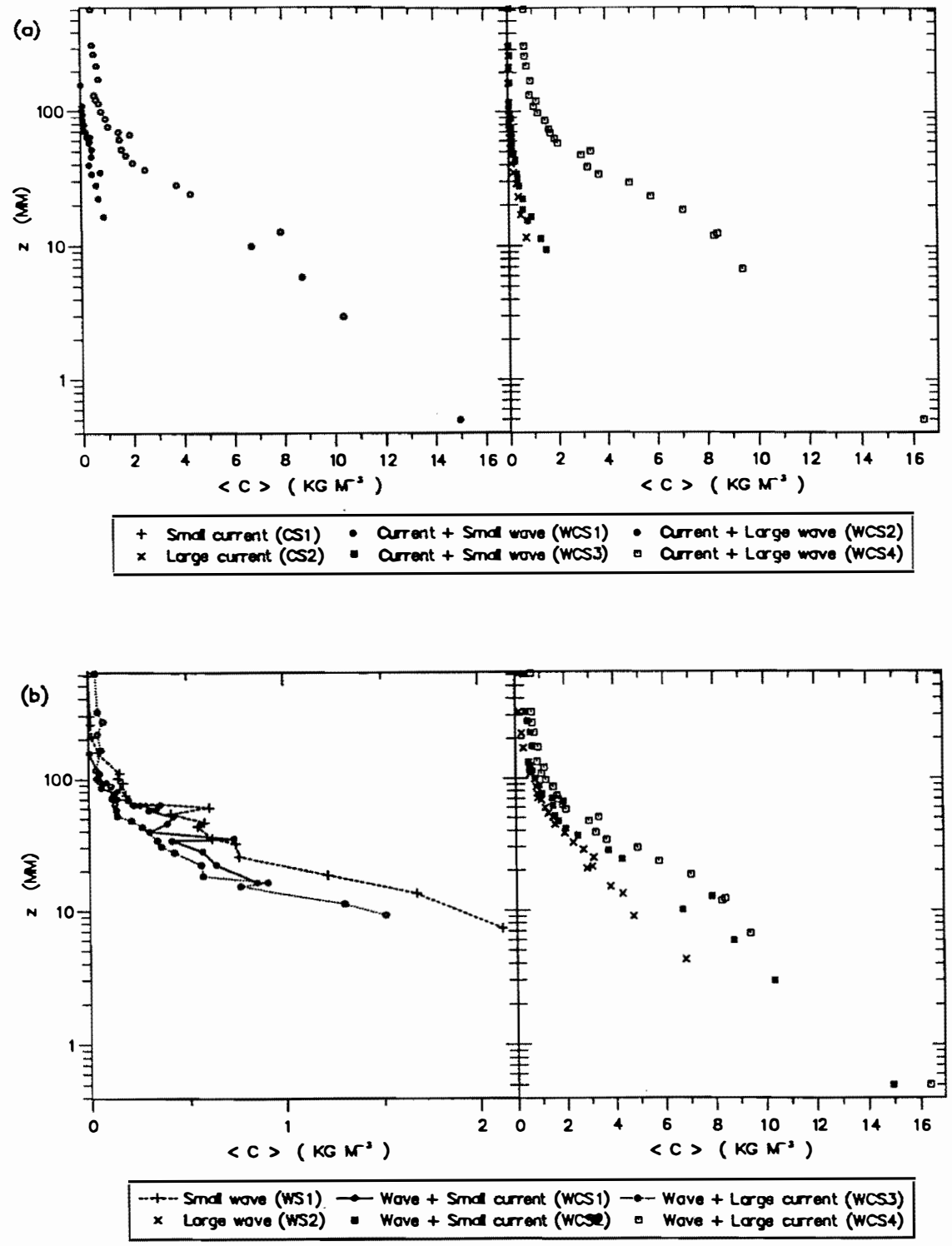


Fig 28 **The effect on vertical profiles of <C> of (a) adding waves onto steady currents, and (b) adding steady currents onto waves.**

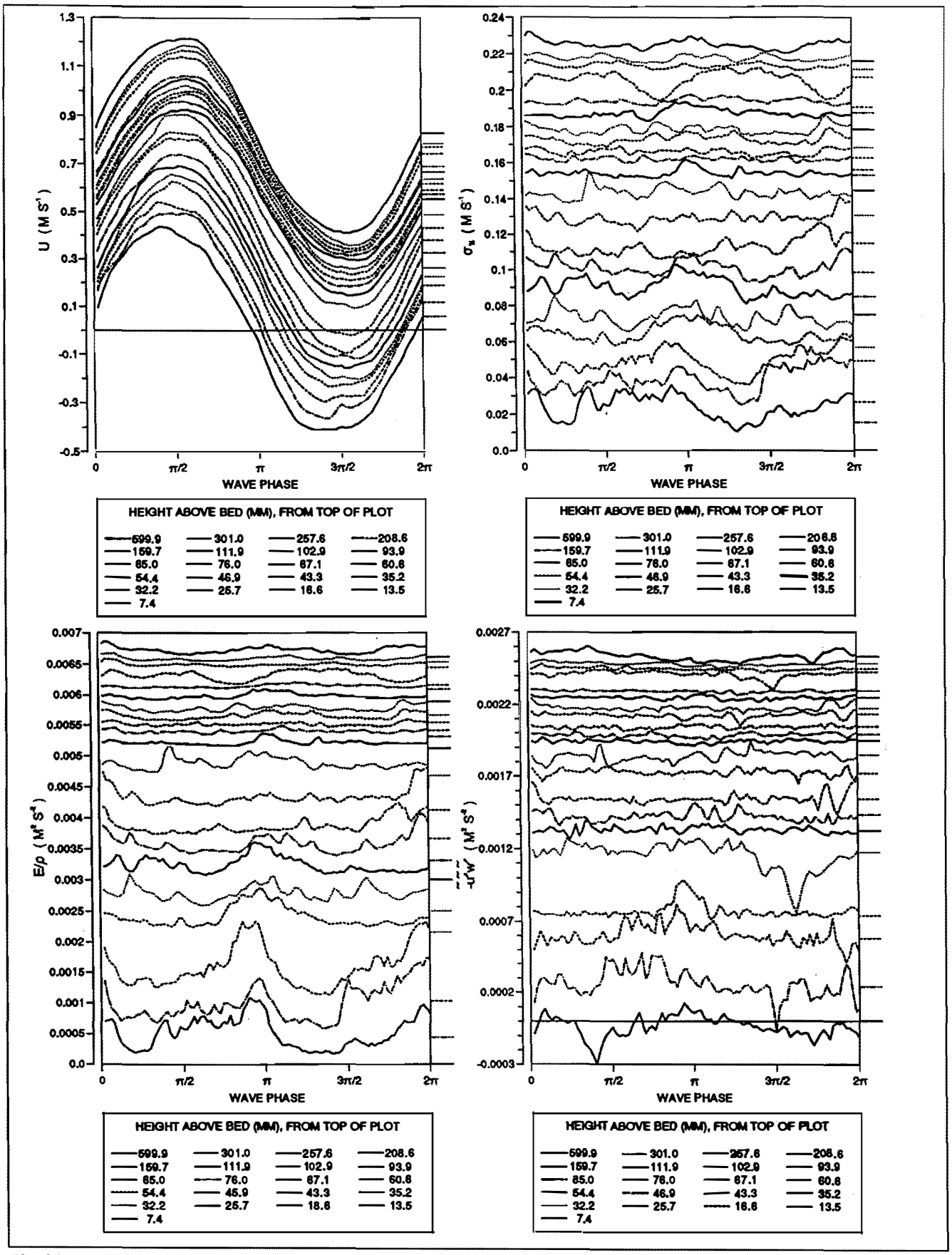


Fig 29 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_u, E/ρ and $-\overline{u'w'}$) for test WS1 (U_0=411mms^{-1}) at different heights above the bed. In each plot, the origin for the lowest height is the zero velocity line, with all the higher levels relating to a displaced origin indicated to the right in a corresponding line type.**

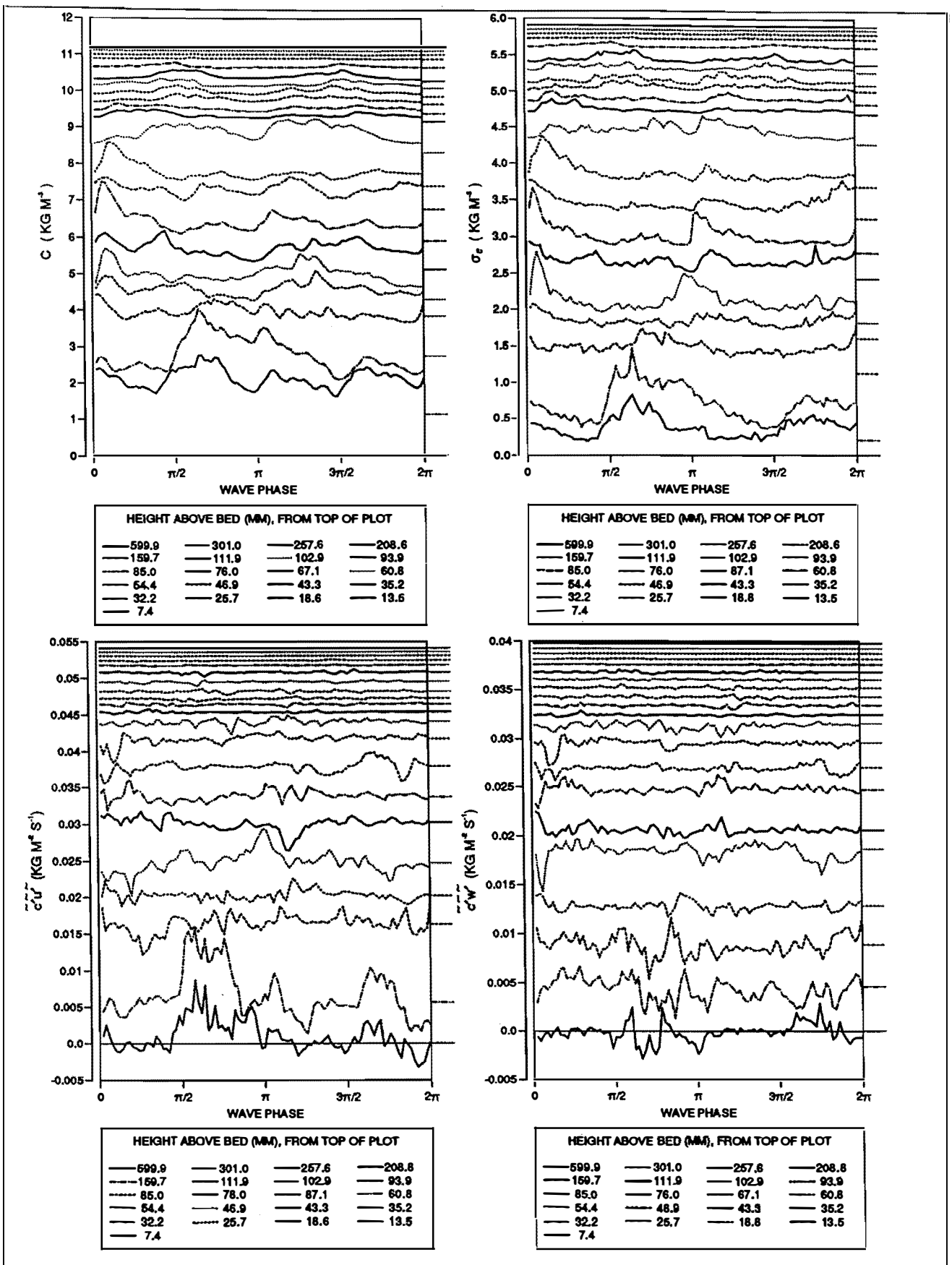


Fig 30 Time-series of a selection of the ensemble-averaged sediment parameters (C, σ_c, $\overline{c'u'}$ and $\overline{c'w'}$) for test WS1 (U_0=411mms^{-1}) at different heights above the bed. In each plot, the origin for the lowest height is the base line (or line of zero flux), with all the higher levels relating to a displaced origin indicated to the right in a corresponding line type.

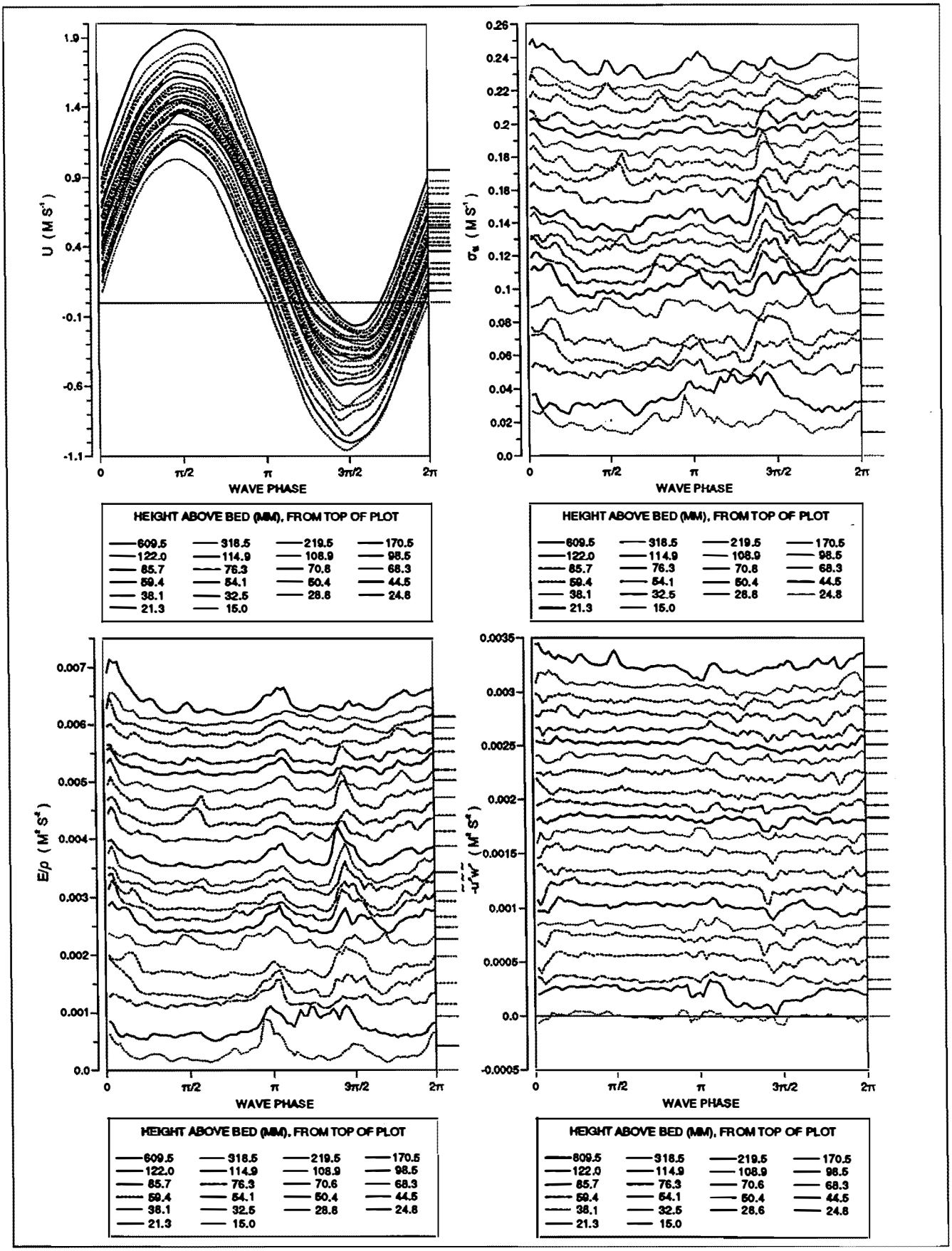


Fig 31 Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test WS2 (U_0=1019mms^{-1}) at different heights above the bed. See caption for Fig 29.

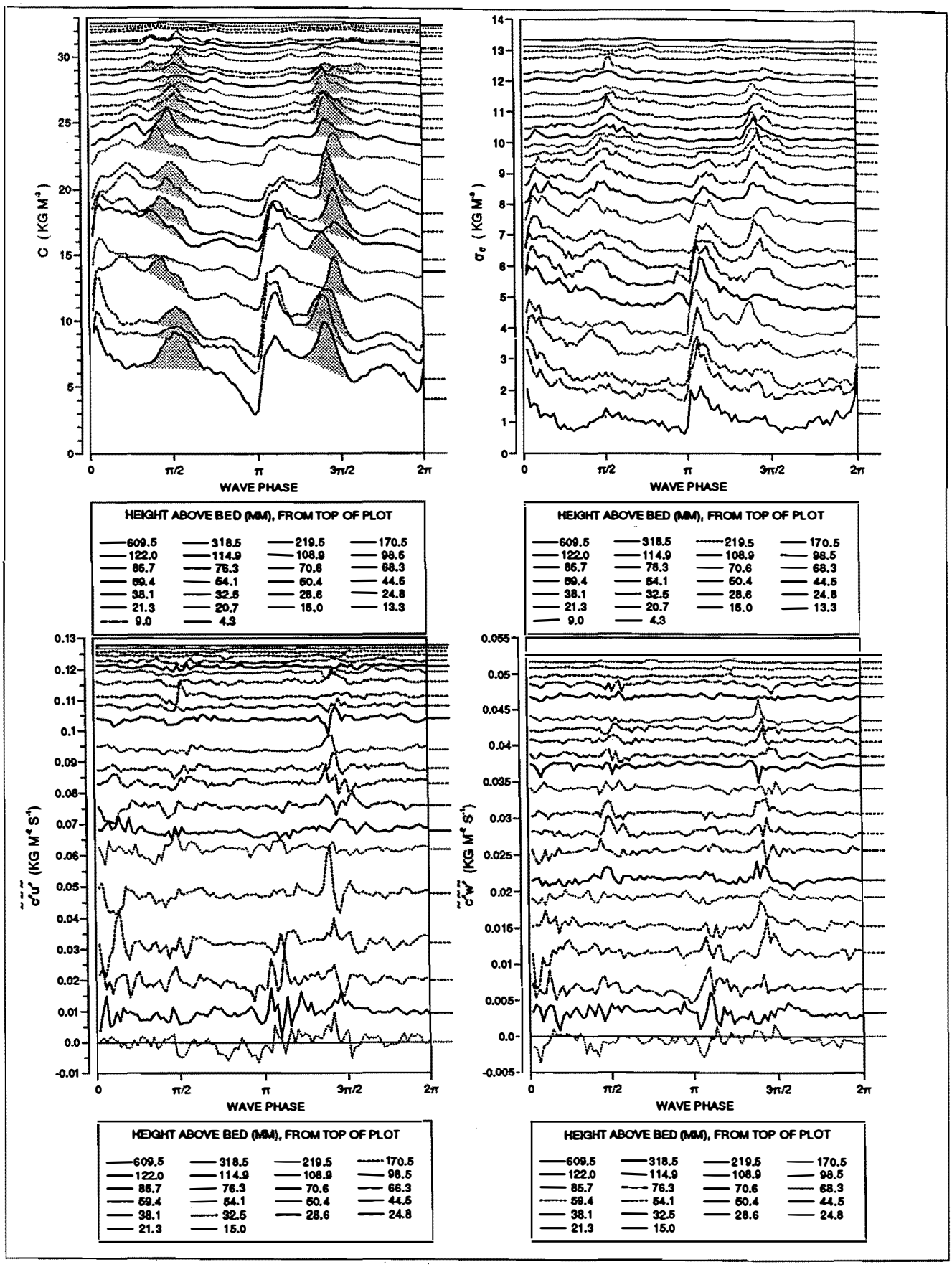


Fig 32 **Time-series of a selection of the ensemble-averaged sediment parameters (C, σ_c, $\overline{c'u'}$ and $\overline{c'w'}$) for test WS1 (U_0=1019mms^{-1}) at different heights above the bed. See caption for Fig 30.**

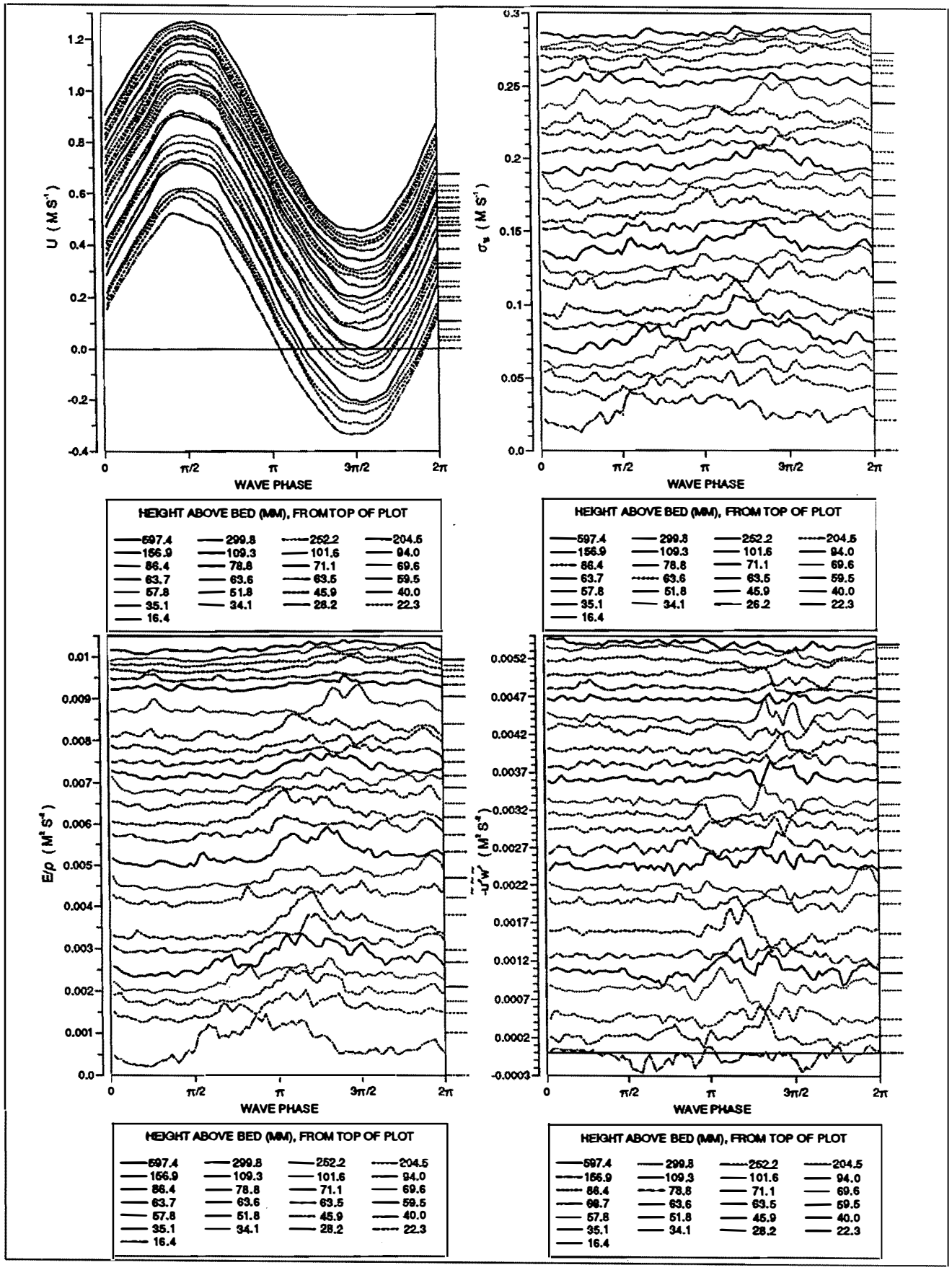


Fig 33 Time-series of a selection of the ensemble-averaged flow parameters (U, σ_u, E/ρ and $-\widetilde{u'w'}$) for test WCS1 (U_0=413mms^{-1}, $\bar{U}$=175mms^{-1}) at different heights above the bed. See caption for Fig 29.

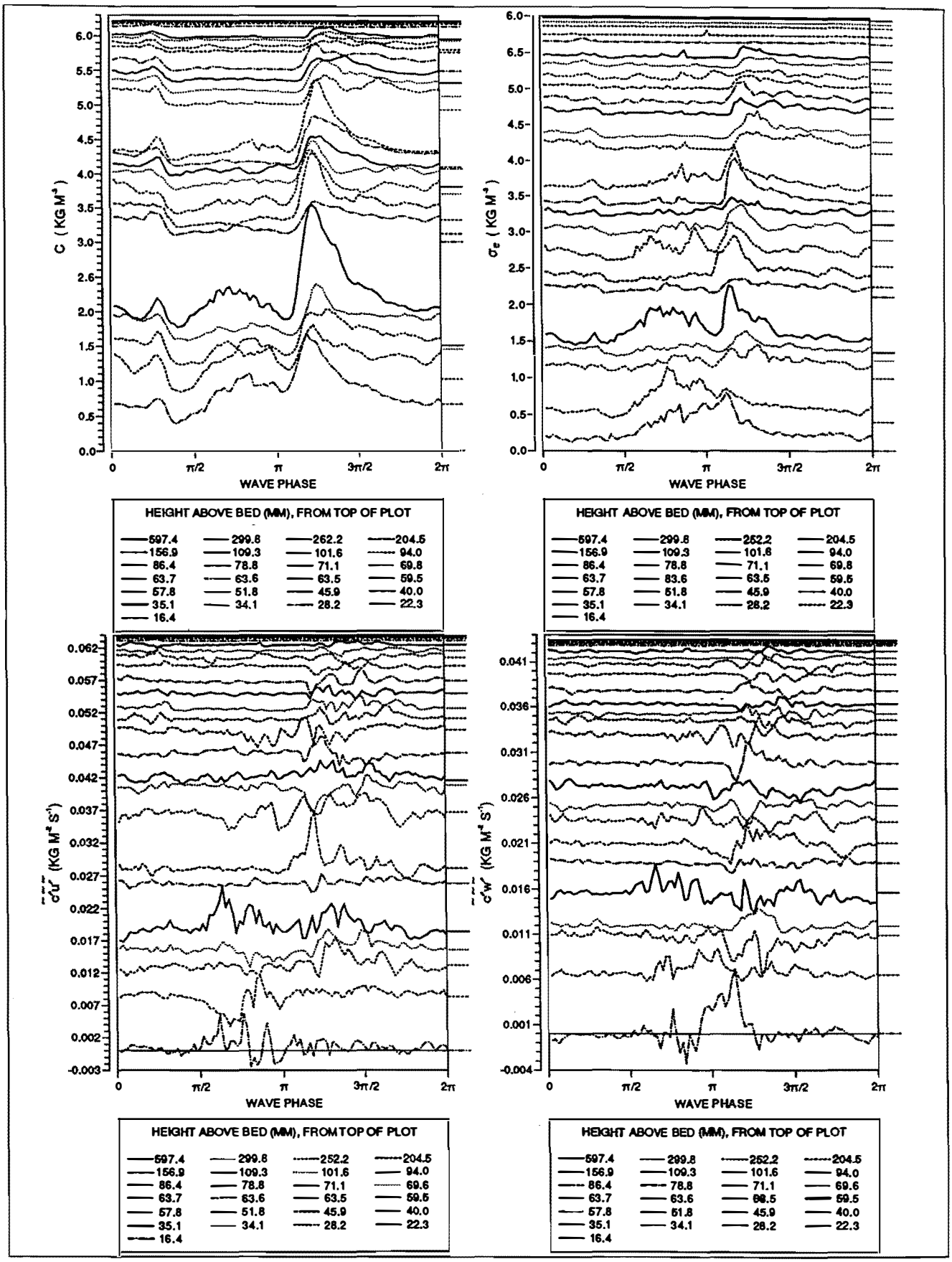


Fig 34 **Time-series of a selection of the ensemble-averaged sediment parameters (C, σ_c, $\overline{c'u'}$ and $\overline{c'w'}$) for test WCS1 (U_0=413mms^{-1}, $\bar{U}$=175mms^{-1}) at different heights above the bed. See caption for Fig 30.**

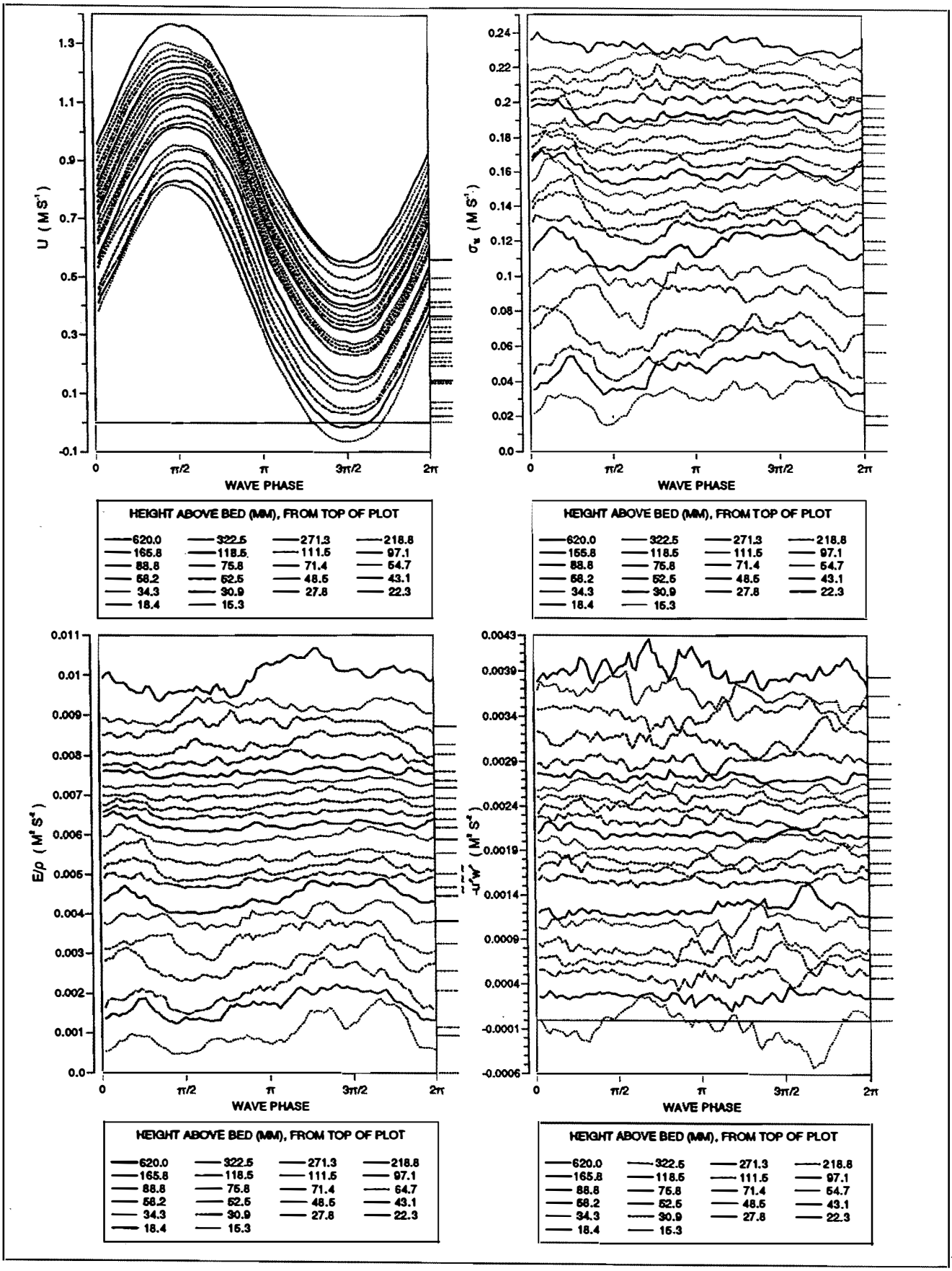


Fig 35 Time-series of a selection of the ensemble-averaged flow parameters (U, σ_u, E/ρ and $-\overline{u'w'}$) for test WCS2 (U_0=1092mms^{-1}, $\bar{U}$=189mms^{-1}) at different heights above the bed. See caption for Fig 29.

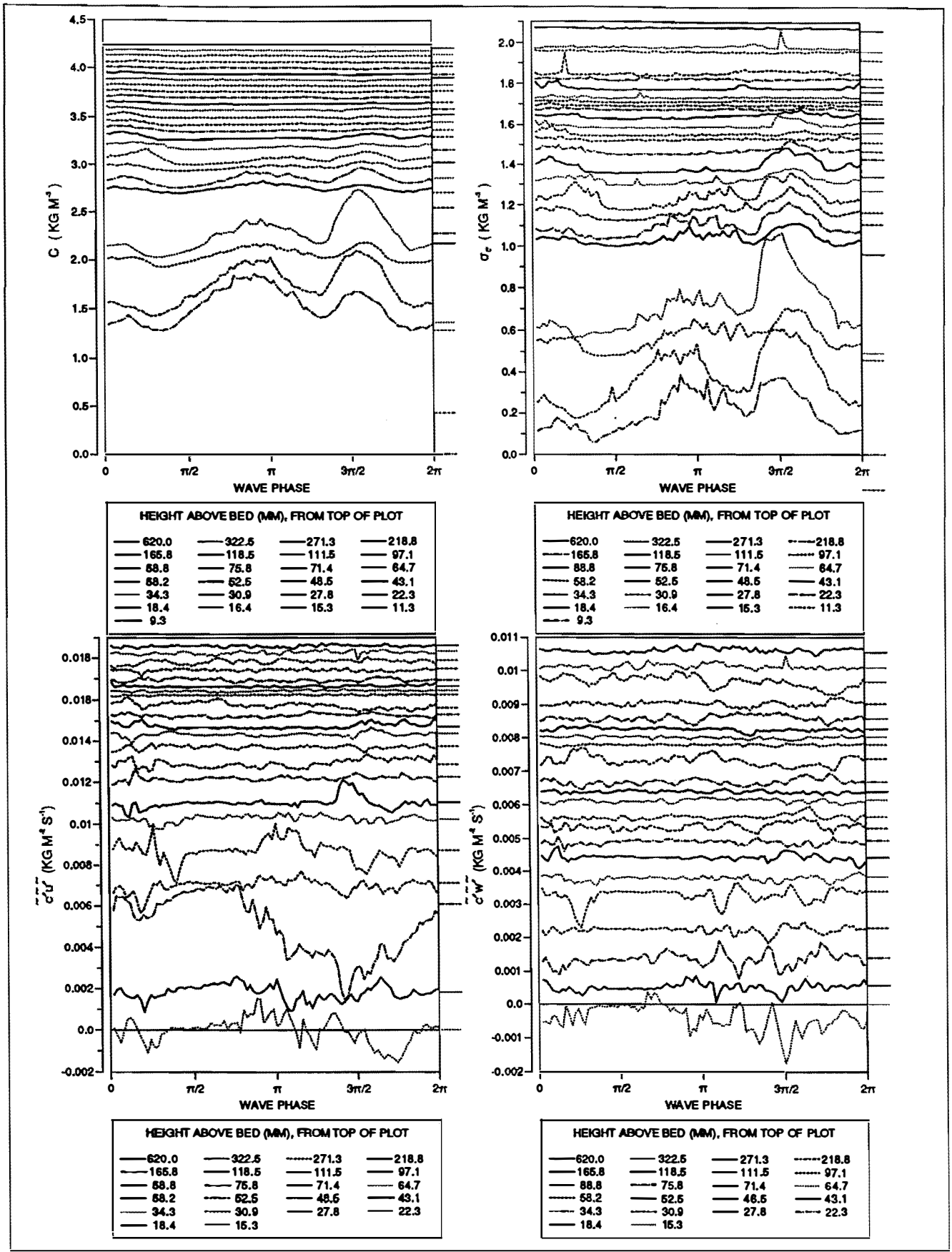


Fig 36 **Time-series of a selection of the ensemble-averaged sediment parameters (C, σ_c, $\overline{c'u'}$ and $\overline{c'w'}$) for test WCS2 (U_0=1092mms^{-1}, $\bar{U}$=189mms^{-1}) at different heights above the bed. See caption for Fig 30.**

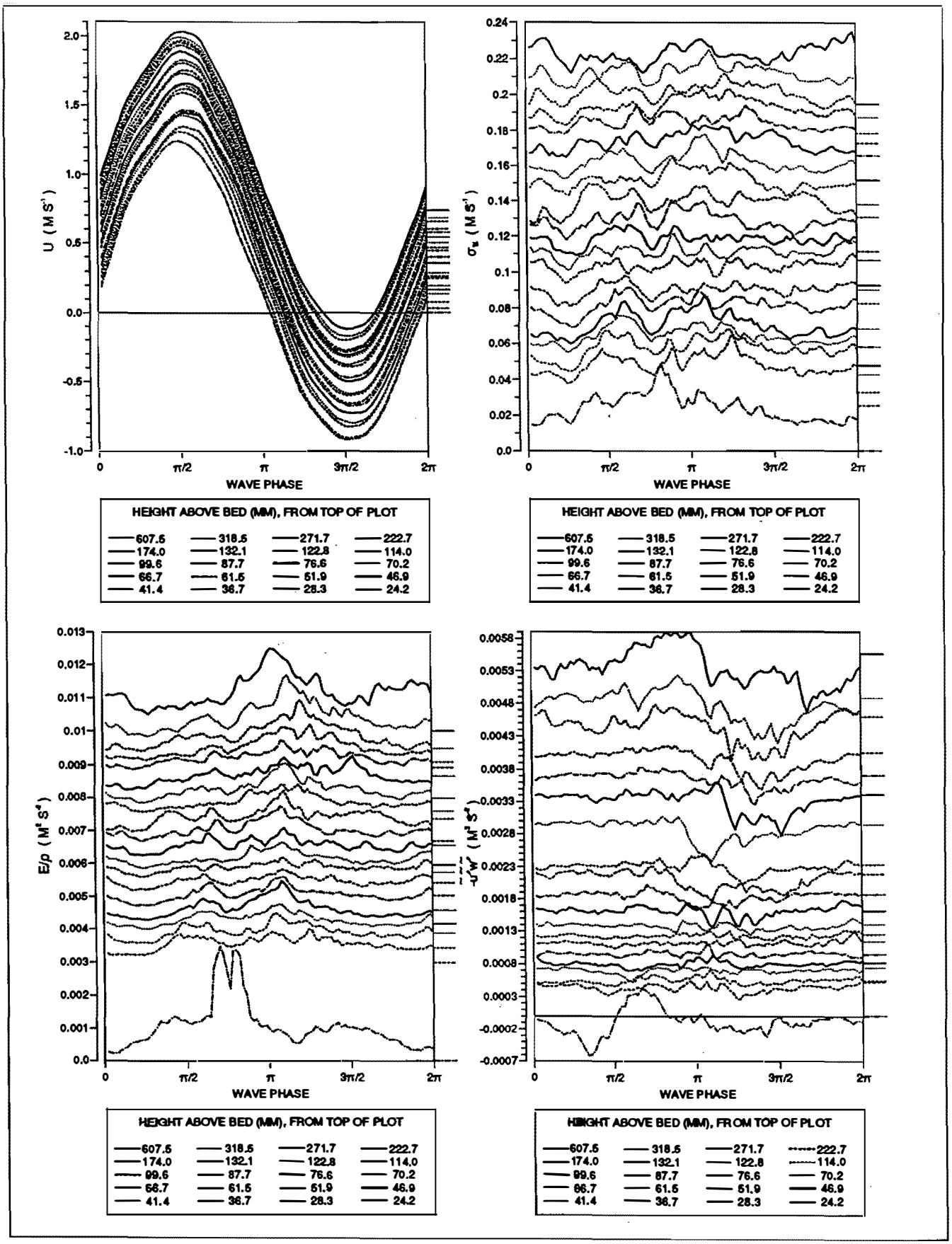


Fig 37 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test WCS3 (U_0=406mms^{-1}, $\bar{U}$=389mms^{-1}) at different heights above the bed. See caption for Fig 29.**

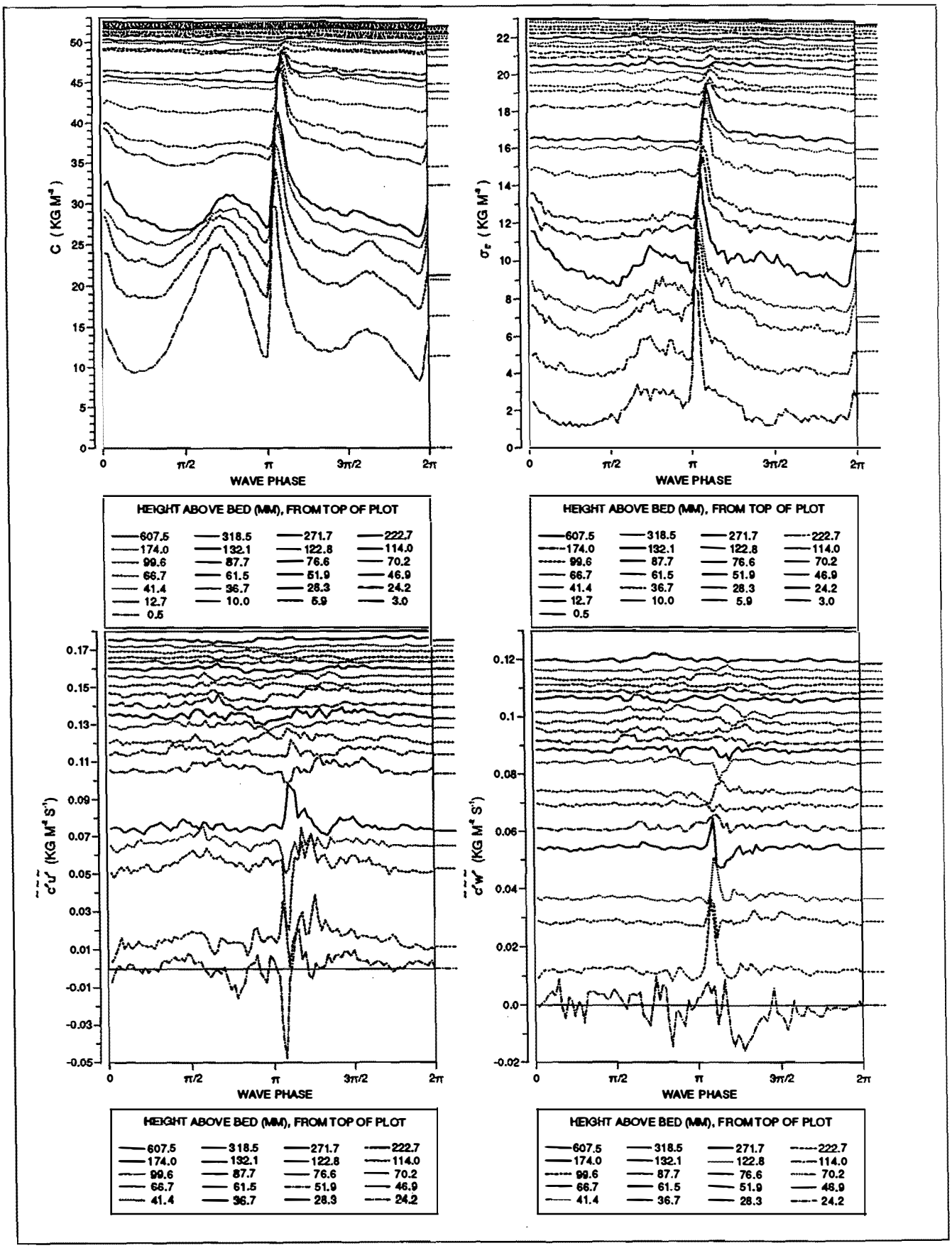


Fig 38 Time-series of a selection of the ensemble-averaged sediment parameters (C, σ_c, $\overline{c'u'}$ and $\overline{c'w'}$) for test WCS3 (U_0=406mms^{-1}, $\bar{U}$=389mms^{-1}) at different heights above the bed. See caption for Fig 30.

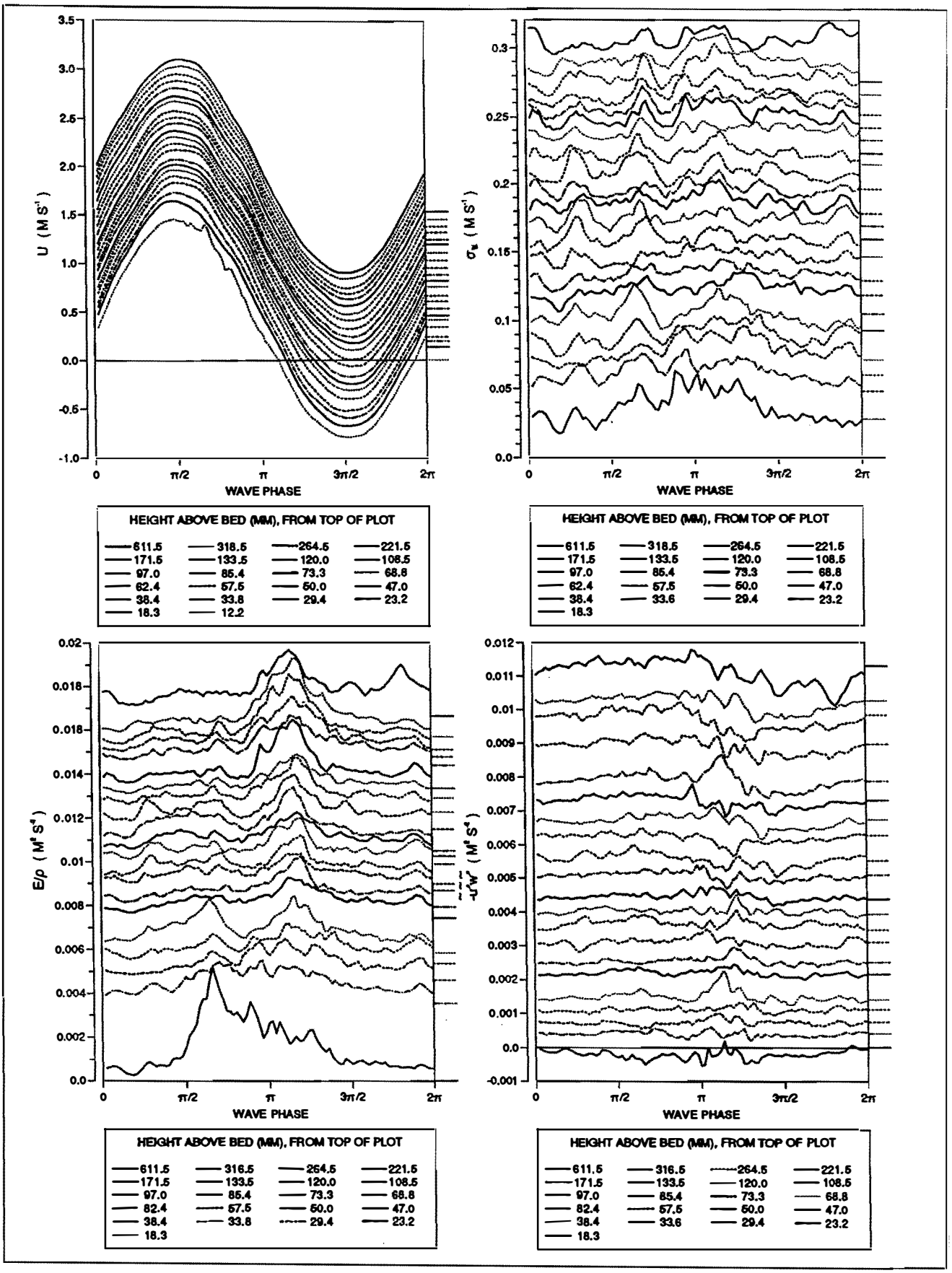


Fig 39 **Time-series of a selection of the ensemble-averaged flow parameters (U, σ_U, E/ρ and $-\overline{u'w'}$) for test WCS4 (U_0=1100mms^{-1}, $\bar{U}$=380mms^{-1}) at different heights above the bed. See caption for Fig 29.**

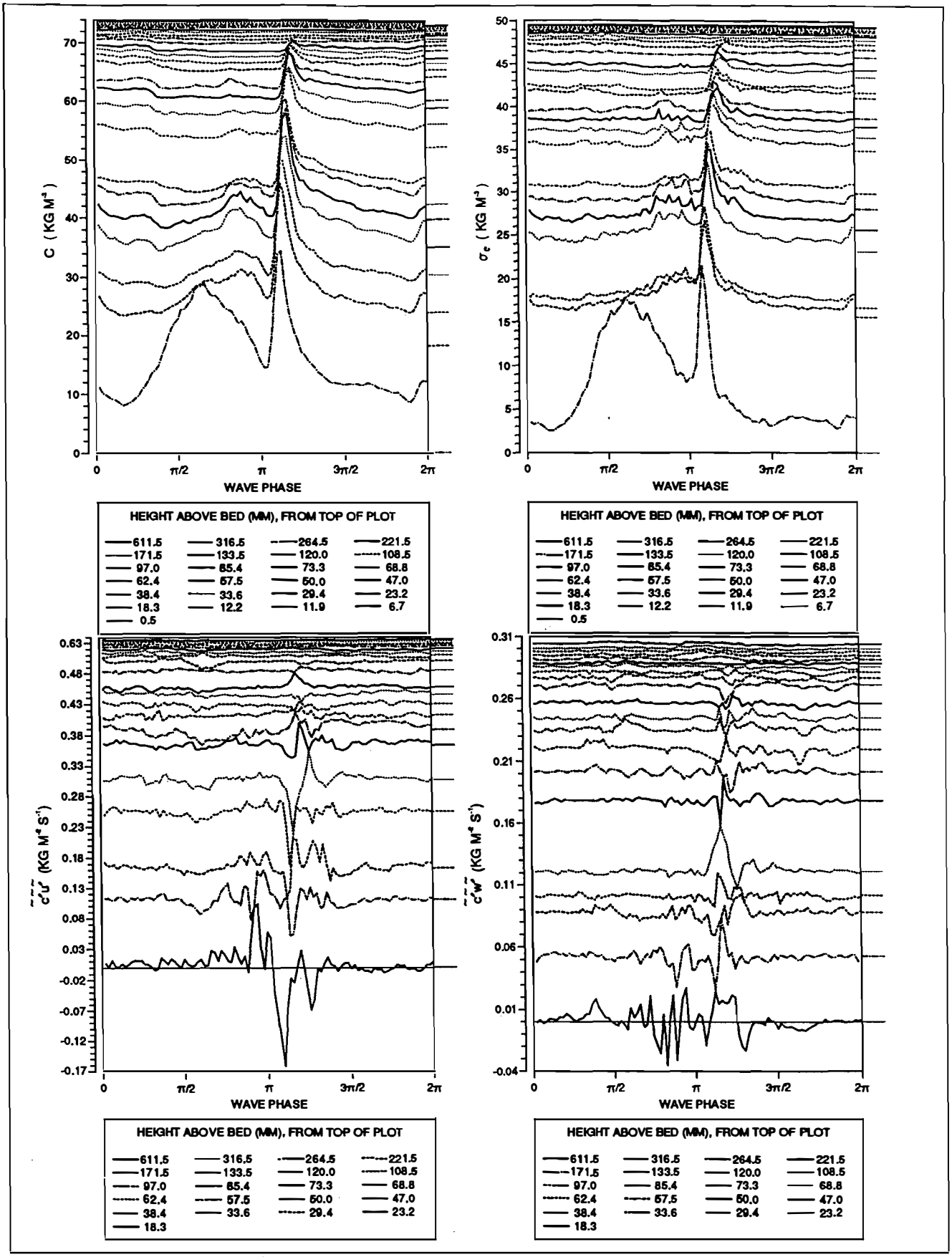


Fig 40 Time-series of a selection of the ensemble-averaged sediment parameters (C, σ_c, $\overline{c'u'}$ and $\overline{c'w'}$) for test WCS4 (U_0=1100mms^{-1}, $\bar{U}$=380mms^{-1}) at different heights above the bed. See caption for Fig 30.

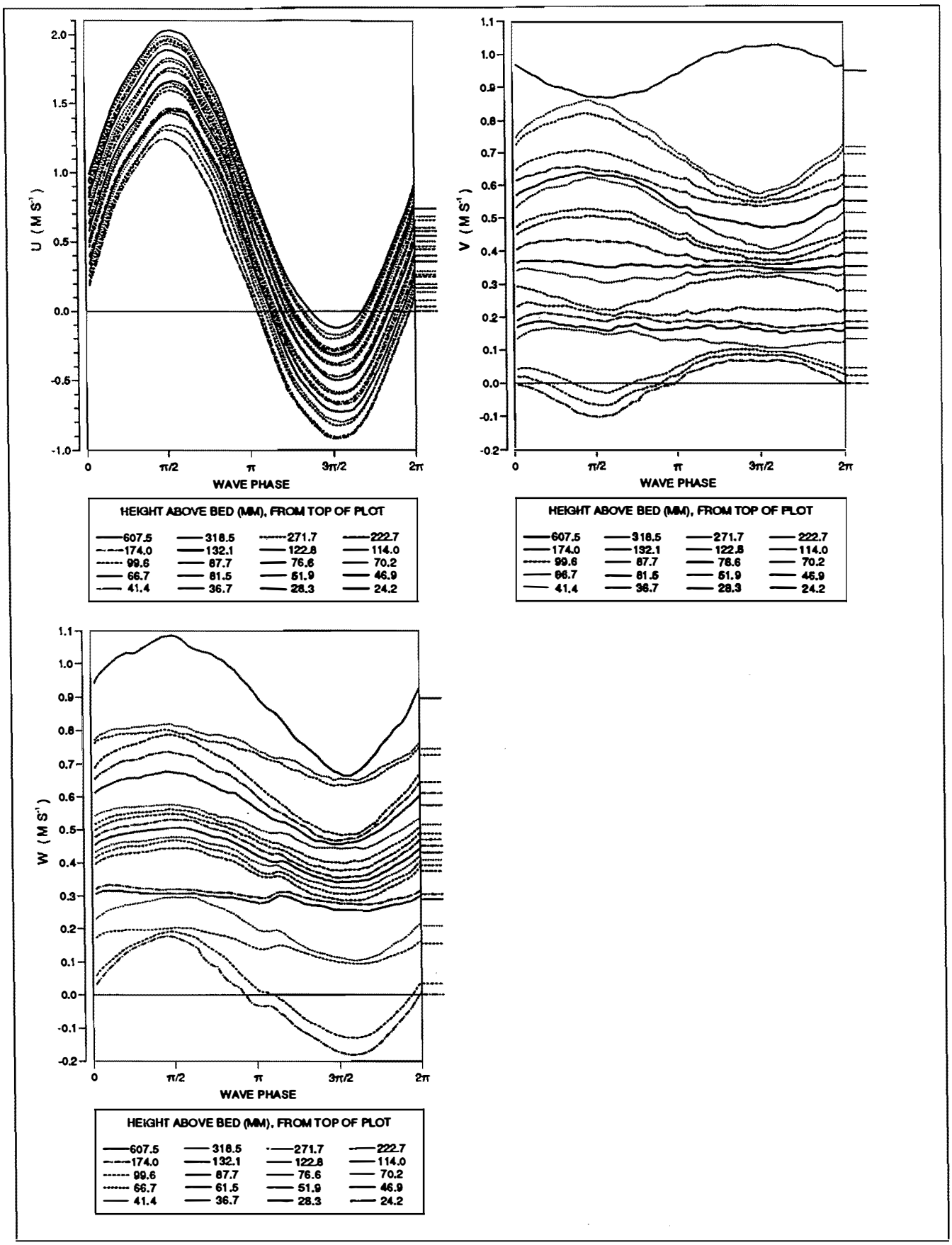


Fig 41 **Time-series of the ensemble-averaged mean velocities (U, V, and W) for a selected test (WCS2 : U_0=1092mms^{-1}, U=189mms^{-1}) at different heights above the bed. See caption for Fig 29.**

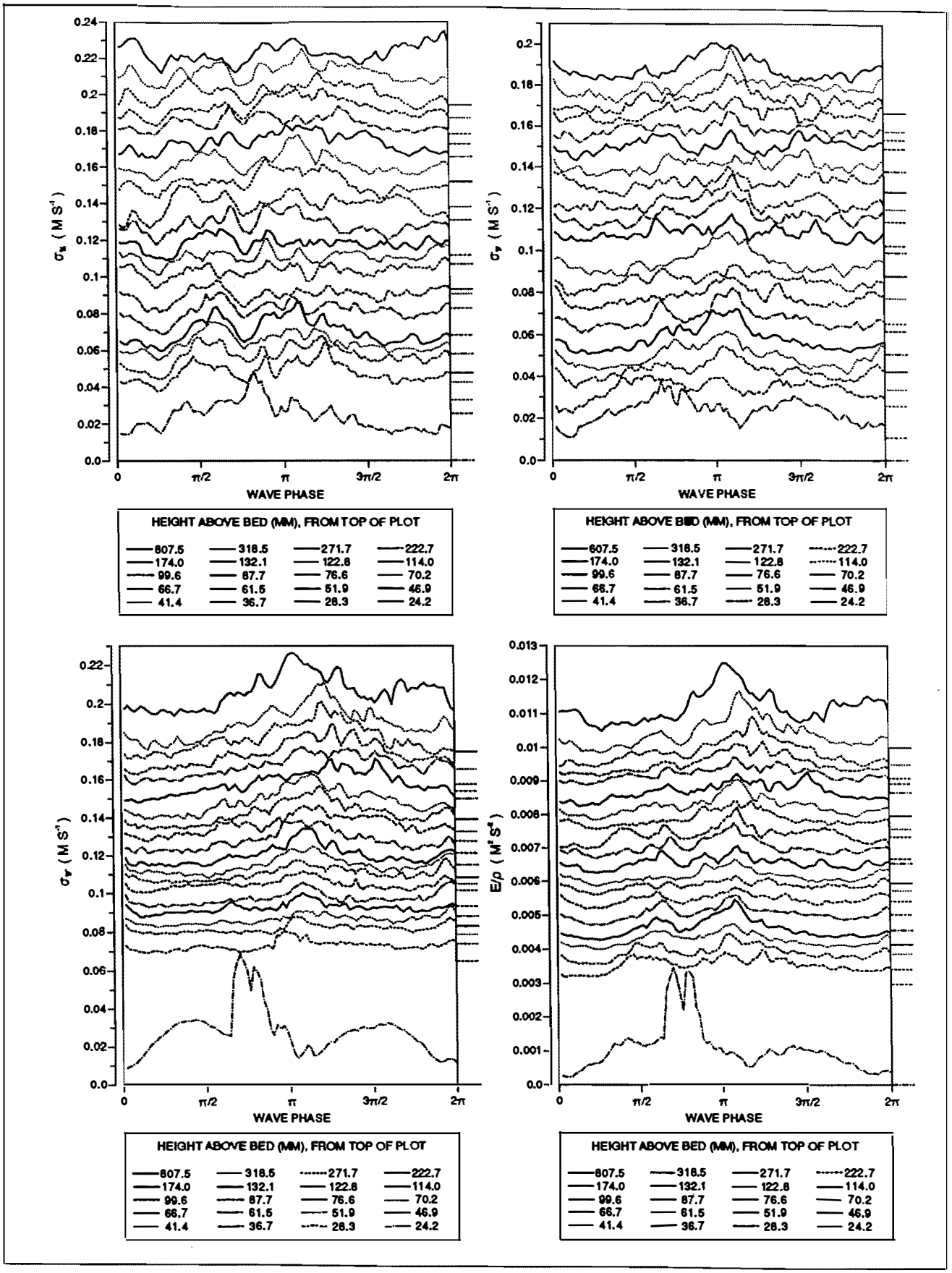


Fig 42 **Time-series of the ensemble-averaged kinematic Energy and turbulent velocities (E/ρ, σ_U, σ_V, and σ_W) for a selected test (WCS2 : U_0=1092mms^{-1}, U=189mms^{-1}) at different heights above the bed. See caption for Fig 29.**

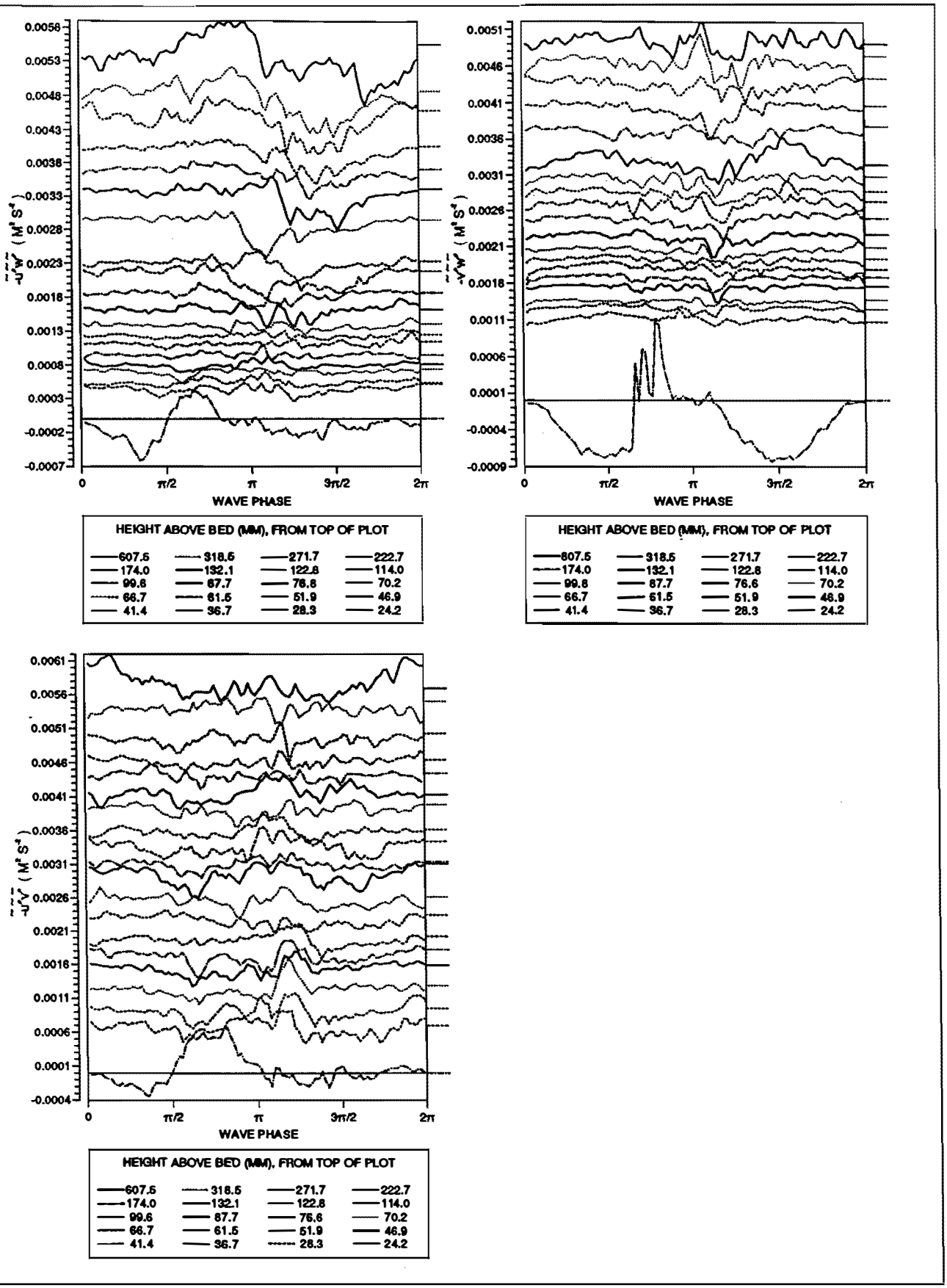


Fig 43 **Time-series of the ensemble-averaged Reynolds stresses ($-\overline{u'w'}$, $-\overline{v'w'}$, $-\overline{u'v'}$) for a selected test (WCS2 : U_0=1092mms^{-1}, $\bar{U}$=189mms^{-1}) at different heights above the bed. See caption for Fig 29.**

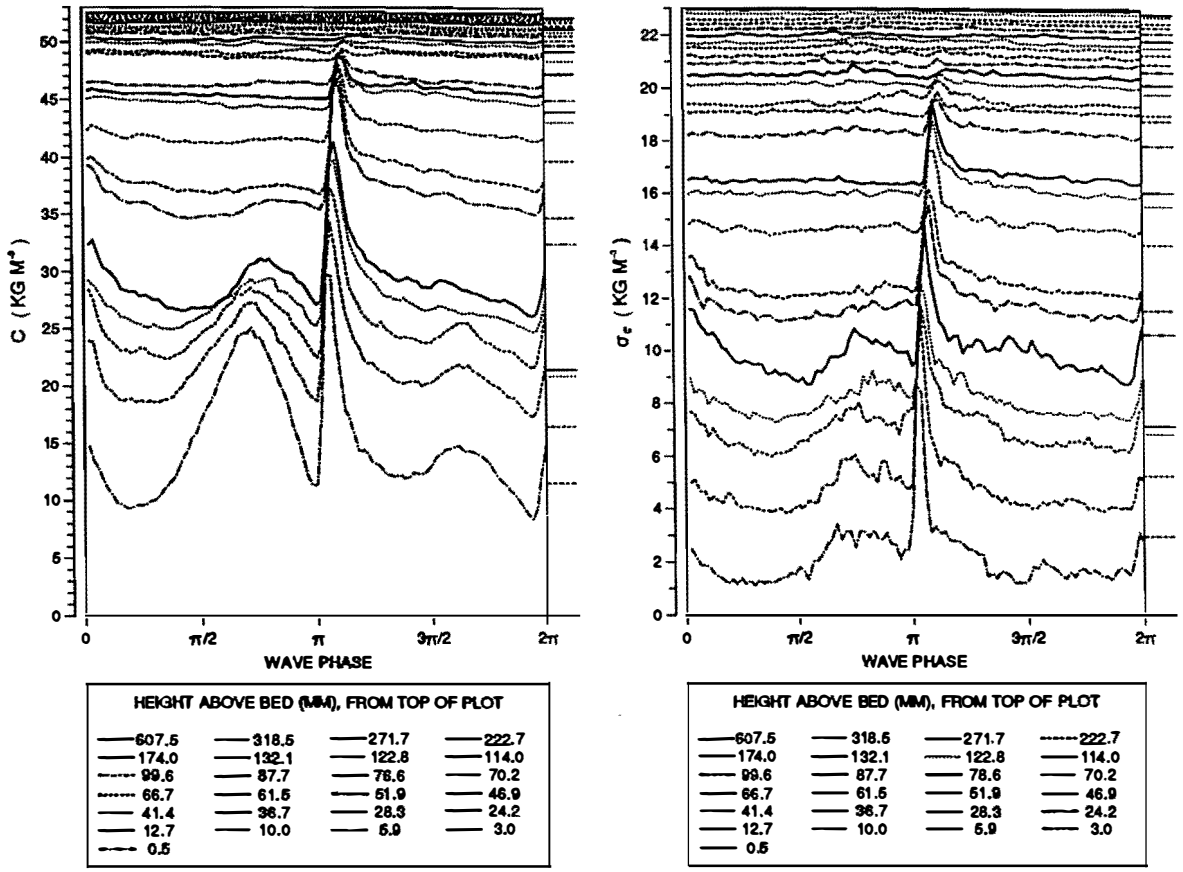


Fig 44 **Time-series of the ensemble-averaged sediment concentration parameters (C, and σ_C) for a selected test (WCS2 : U_0=1092mms^{-1}, U=189mms^{-1}) at different heights above the bed. See caption for Fig 30.**

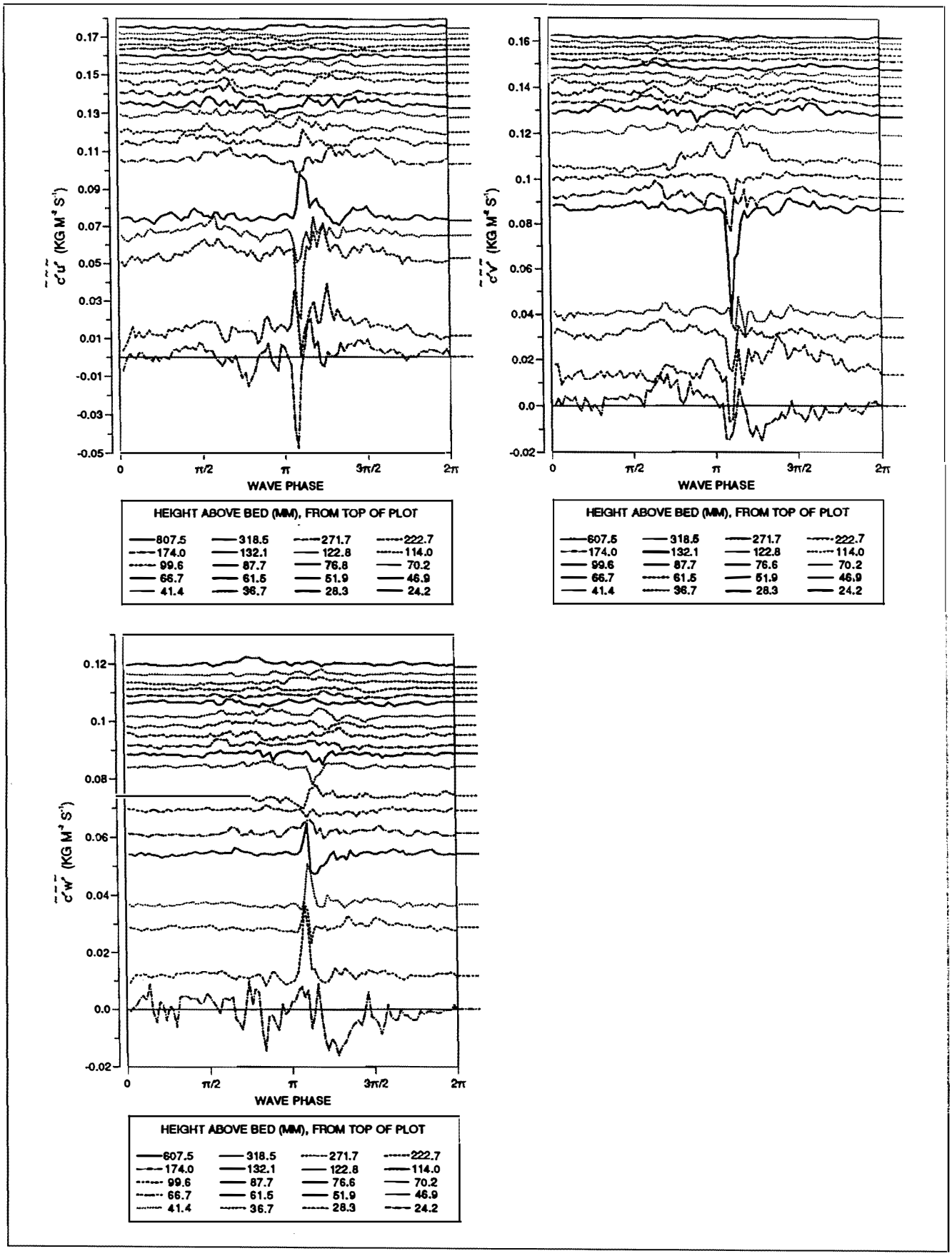


Fig 45 **Time-series of the ensemble-averaged Reynolds fluxes ($\overline{c'u'}$, $\overline{c'v'}$ and $\overline{c'w'}$) for test WCS3 (U_0=406mms^{-1}, $\bar{U}$=389mms^{-1}) at different heights above the bed. See caption for Fig 30.**