Ting Kau and Sham Tseng Sewerage Scheme

Environmental Impact Assessment Study

Agreement No. CE 35/94

Final Report

Volume 2 of 2

20 October 1995

Mott Connell Limited

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TING KAU AND SHAM TSENG SEWERAGE SCHEME

ENVIRONMENTAL IMPACT ASSESSMENT STUDY
AGREEMENT NUMBER CE 35/94

PROJECT NUMBER T399

FINAL REPORT

Appendices

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Date	14-11-95	Date	14/11/95

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Appendix A

The Study Brief

Agreement No. CE 35/94

Ting Kau and Sham Tseng Sewerage Scheme
Environmental Impact Assessment Study

BRIEF

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A

Agreement No. CE 35/94

Ting Kau and Sham Tseng Sewerage Scheme
Environmental Impact Assessment Study

BRIEF

1. Introduction

This Brief is to be read in conjunction with the Memorandum of Agreement, the General Conditions of Employment for a Feasibility Assignment, the Special Conditions of Employment and the Schedule of Fees.

2. Description of the Project

2.1 The Tsuen Wan, Kwai Chung and Tsing Yi Sewerage Master Plan Study commissioned in 1989 recommended, among others, the provision of a comprehensive sewerage system and a centralized sewage treatment plant with submarine outfall to serve the Ting Kau / Sham Tseng coastal area which stretches from Approach Beach in the east to Tsing Lung Tau in the west. The sewage treatment plant was proposed to be built on an area reclaimed for that purpose.

2.2 The Ting Kau and Sham Tseng sewerage scheme forms part of the implementation of the aforementioned Sewerage Master Plan Study and comprises two Public Works Programme items, namely, 52DS - Ting Kau Sewerage and Pumping Stations, and 126DS - Sham Tseng Sewerage, Sewage Treatment Works and Disposal Facilities, (hereinafter referred to as "the Project"). It consists of

(a) sewer reticulation and pumping stations in the Ting Kau, Sham Tseng and Tsing Lung Tau areas;
(b) trunk sewers to convey the sewage from the coastal area to Sham Tseng;
(c) reclamation at Sham Tseng; and
(d) a sewage treatment works and a submarine outfall at Sham Tseng.

A drawing numbered DDN 8370A showing the general layout of the whole sewerage scheme, and a layout plan of the reclamation are included in this Brief as Appendix I.

2.3 The estimated maximum flow to the Sham Tseng sewage treatment works is about 22000 m^3/day. The major requirements with respect to effluent discharge from the sewage treatment works are given in Appendix II.

3. Objectives of the Assignment

The objectives of this Environmental Impact Assessment Study are as follows:

(i) to describe the proposed Project and associated works together with the requirements for carrying out the proposed Project as a design-and-build package;

(ii) to review the proposed sewage treatment scheme of the Project, identify, evaluate and agree with the Director's Representative suitable sewage treatment options conforming with the specified effluent standards and the available site area for further study;

(iii) to identify and describe the elements of the community and environment likely to be affected by the proposed Project, and/or likely to cause adverse impacts upon the proposed Project, including both the natural and the man-made environment;

(iv) to identify and quantify emission sources and determine the significance of impacts on sensitive receivers and potential affected uses;

(v) to propose the provision of infrastructure or mitigation measures so as to minimize pollution, environmental disturbance and nuisance during construction and operation of the Project;

(vi) to identify, predict and evaluate the residual (i.e. after practicable mitigation) environmental impacts and cumulative effects expected to arise during the construction and operation phases of the Project in relation to the sensitive receivers and potential affected uses;

(vii) to identify, assess and specify methods, measures and standards, to be included in the detailed design, construction and operation of the Project which are necessary to mitigate these impacts and reduce them to acceptable levels;

(viii) to design and specify the environmental monitoring and audit requirements necessary for monitoring the effectiveness of the environmental protection and pollution control measures adopted;

(ix) to investigate the extent of side-effects of proposed mitigation measures that may lead to other forms of impacts;

(x) to identify constraints associated with the mitigation measures recommended in the study; and

(xi) to identify any additional studies necessary to fulfil the objectives to the requirements of this Study or for the completion of the Project.

4. Description of the Assignment

4.1 An environmental review was carried out under the Tsuen Wan, Kwai Chung and Tsing Yi Sewerage Master Plan Study described in Section 2. In 1992 another study - Sham Tseng Sewerage and Sewage Treatment: Underground Cavern Options - was commissioned. A preliminary environmental review was also carried out under this study, and a number of potential environmental issues were identified which would require further investigations. This Study is a follow up on these two environmental reviews.

4.2 The purpose of this Environmental Impact Assessment Study is to provide information on the nature and extent of environmental impacts arising from the construction and operation of the Ting Kau and Sham Tseng Sewerage Scheme described in Section 2 above and all related activities taking place concurrently. The information will contribute to decisions on:

(i) the selection of the treatment process for the Sham Tseng sewage treatment works;

(ii) the conditions and requirements for the detailed design, construction and operation of the proposed Project; and

(iii) the acceptability of residual impacts after the proposed mitigation measures are implemented.

5. Deliverables

5.1 Within two weeks of the commencement of the Assignment, 30 copies of a Draft Inception Report shall be submitted to the Director's Representative for his approval. The Inception Report shall include:

(i) an inventory of all the identified environmental issues and other issues which are considered necessary for the purpose of this study;

(ii) a works programme which identifies and clearly describes the major tasks and critical activities of the Study; and

(iii) a schedule for the submission of reports, working papers and technical notes necessary to fulfil the requirements of this Study.

5.2 Within 6 weeks from the commencement of the Assignment, 30 copies of a Draft Interim Report on Sewage Treatment Options embracing the identification, evaluation and recommendation of sewage treatment and disposal options for the Sham Tseng sewage treatment works shall be submitted to the Directors Representative. The Draft Interim Report shall enumerate for each option details including in particular

(i) a preliminary assessment of environmental impacts associated with the option;

(ii) the cost of works taking into account the cost of environmental impact mitigation measures and recurrent running costs; and

(iii) programming and a preliminary layout plan of the sewage treatment works under the particular sewage treatment option considered.

5.3 Within 25 weeks from commencement of the Assignment, 30 copies each of the Draft Final Report and Draft Executive Summary shall be submitted to the Director's Representative. This Report shall contain all materials specified under this Study, as well as other information as may be required by the Director's Representative. A period of 3 weeks shall then be allowed for circulation of the Report for comments.

5.4 Within 27 weeks from commencement of the Assignment, 30 copies of the Draft Environmental Monitoring and Audit Manual shall be submitted to the Director's Representative. The Manual shall contain all materials specified in Section 6.3 (vii) (c) and elsewhere of this Brief, as well as other information as may be required by the Director' Representative. A period of 3 weeks shall then be allowed for circulation of the Draft Environmental Monitoring and Audit Manual for comments.

5.5 80 copies of the Final Report together with the Consultants' responses to comments on the Draft Final Report, and 150 copies of Executive Summary (in separate Chinese and English versions) shall be submitted to the Director's Representative within 4 weeks of the receipt of comments on the Draft Final Report. The Final Report shall

(i) fully satisfy the requirements of this brief in respect of the identification, evaluation and recommendation of the sewage treatment process options and the prediction and assessment of impacts, the identification of environmental impact mitigation measures and the associated residual impacts;

(ii) describe the agreed schedules and programmes for monitoring and audit requirements;

(iii) prescribe the specification for detailed design, construction and operation requirements of the proposed Project; and

(iv) provide the impacts summary, the study findings, conclusions, recommendations and a mechanism for implementation.

The Executive Summary shall highlight the sewage treatment options recommended, the issues of concern to the community, the acceptability of residual environmental impacts and cumulative effects, requirements for implementation of the Project, and the basis for and implications of those requirements. It is intended that the information contained therein would assist the Government in undertaking public consultations with the Advisory Committee on the Environment, the District Boards and other parties.

5.6 All reports, technical notes, working papers shall first be issued in drafts. Unless specified otherwise, within 3 weeks of the receipt of comments, the revised version with the incorporation of comments where appropriate and written responses to comments as appendix shall be issued by the Consultants and submitted to the Director's Representative.

5.7 Unless specified otherwise, the Consultants shall supply the Director's Representative with 30 copies of every report, technical note, working paper, written responses and other written documents as may be required under the Study, and 80 copies of technical notes and working papers in the revised form.

5.8 The Consultants shall also supply the Government with appropriate copies of such reports, technical notes, working papers, briefs, supporting documents and other relevant inputs as may be required during the Environmental Impact Assessment Study or any public consultation exercise.

5.9 The requirements in the Planning, Environment and Lands Branch General Circular 2/94 on Public Access to Environmental Impact Assessment Reports shall be complied with. The Final Report and the Executive Summary will be made available to the public according to the provisions in the circular. The Environmental Impact Assessment Study findings may be presented to the Advisory Committee on the Environment.

5.10 Within 15 weeks from the commencement of the Assignment, the Consultants shall supply to the Director's Representative 5 copies in writing and 1 copy on computer disk in WordPerfect format of a draft brief for a follow-up consultancy to execute the Project through a design-and-build package.

6. Services to be provided by the Consultants

6.1 The Consultants shall review the sewage flow and the proposed sewage treatment scheme of the Project, identify, evaluate and agree with the Director's Representative suitable sewage treatment options conforming with the effluent standards as specified in Appendix II and the available site area, enumerating for each option details which shall include a preliminary assessment of associated environmental impacts, programming and the costs of the works taking into account the cost of environmental impact mitigation measures and recurrent running costs; recommend and agree with the Director's Representative not more than two preferred options and carry out detailed environmental impact assessment for them together with other elements of the proposed Project.

6.2 The Consultants shall consider all aspects of the activities arising from the Project in any stage / phase of implementation, and, observe the following guidelines in addition to the Hong Kong Planning Standards and Guidelines (HKPSG) as well as other statutory requirements during the Environmental Impact Assessment Study.

(i) Sensitive Uses

Due consideration should be given to existing and committed future land uses and sensitive receivers in the study area must be identified. Future land uses should include those that will be occupied during the construction and operation phases of the proposed Project.

(ii) Mitigation Measures

Effective mitigation measures should be proposed to reduce impacts to acceptable levels and to minimize the probability, occurrence and consequences of predicted impacts in terms of the layout and design of the Project, the duration of pollution activities, construction methods and equipment, operational procedures and administrative controls.

(iii) Residual Impacts

Residual environmental impacts shall be identified and quantified and their acceptability should be determined against the Environmental Chapter of the Hong Kong Planning Standards and Guidelines and other statutory requirements as stated in Section 11.3.

6.3 The Environmental Impact Assessment shall include, but not be limited to, the tasks stated in the following.

(i) Noise Impact Study

The Consultants shall,

(a) assess the construction noise impacts on existing noise-sensitive receivers due to the construction of the sewerage, the sewage treatment works (including reclamation) and the submarine outfall; propose mitigation measures of such forms suitable to be included in the construction contracts;

(b) assess the operation noise impacts of the pumping stations along the sewerage route on existing and planned noise-sensitive receivers; propose mitigation measures to be included in the design of the pumping stations; and

(c) assess the operation noise impacts of the Sham Tseng sewage treatment works on existing and planned noise-sensitive receivers; and propose mitigation measures to be included in the design and operation of the sewage treatment works and assess the extent of buffer zone required.

(ii) Air Pollution Impact Study

(a) Construction Phase Assessment

The Consultants shall,

(1) consider the existing and future land uses in the Study area and prepare plans identifying representative receptors in the vicinity of the proposed Project, the locations of the representative receptors to be agreed with the Director of Environmental Protection;

(2) from a knowledge of the likely type, sequence and duration of construction activities required for the implementation of the Project, identify those construction activities likely to cause air pollutant problems to the receptors, including borrowing activities for the reclamation works;

(3) assess and evaluate the net and cumulative air pollution impacts (dust and odour) of the proposed Project to receptors by dispersion modelling with reference to Hong Kong Air Quality Objectives (HKAQO); provide detailed methodology statement and key assumptions of the selected dispersion model such as emission factors and other input parameters etc. to the Director of Environmental Protection for comment and consent before the commencement of the study; and evaluate the dust impact from the construction activities, with the use of a Fugitive Dust Model (FDM) being preferred; and

(4) recommend appropriate air pollution control measures (including odour) for inclusion into the contract documents; propose compliance monitoring where appropriate.

(b) Operation Phase Assessment

The Consultants shall,

(1) from a consideration of the existing and future land uses in the Study area, prepare plans identifying representative receptors that would likely be affected by air pollution (including odour) impact; and agree with the Director of Environmental Protection the locations of the receptors;

(2) establish the background air pollution levels at the Study area for the assessment of cumulative air impacts in (3) below;

(3) assess the net and cumulative air pollution impacts (including odour) of the proposed Project to receptors by dispersion modelling; provide detailed methodology statement and key assumptions of the selected model such as emission factors and other input parameters etc. to the Director of Environmental Protection for comment and consent before the commencement of the study. For odour prediction at the receptor, the predicted odour level should not exceed 5 odour units based on a prediction averaging time of 5 seconds. For odour measurement or monitoring, the odour level should not exceed 2 odour units as measured at the site boundary of the sewage treatment works and pumping stations.

The report should contain sample calculation and input parameters used in the modelling.

The pollution isopleths should be produced as an output of the Study.

(4) The Consultants shall propose cost effective amelioration measures in situations where the predicted cumulative air pollution levels exceed the Hong Kong Air Quality Objectives (HKAQO) or the predicted odour level at the receptor exceed 5 odour units based on a prediction averaging time of 5 seconds. For air pollutants not included in the list of HKAQO, the Consultants should propose air quality standards based on established international standards with justification and seek prior agreement from the Director of Environmental Protection for use of the standards.

(iii) Water Quality Impact Study

The Consultant shall,

(a) identify all sensitive receivers that could potentially be affected during the construction and operational phases, including, but not be restricted to, bathing beaches, recreational facilities, mariculture activities and water intakes;

(b) determine the water quality requirements of the sensitive receivers identified in Section 6.1 (iii) (a) above;

(c) assess the impacts of construction activities including dredging of contaminated and uncontaminated sediments, land reclamation, site formation, building works and outfall construction; propose mitigation measures, spoil disposal method and monitoring requirements (baseline and during construction) to minimise the impacts of construction phase activities; and

(d) quantitatively assess the impacts of effluent discharge from the Sham Tseng sewage treatment works under the proposed reclamation configuration using mathematical modelling techniques to the satisfaction of Director of Environmental Protection; propose the location, orientation and form of the outfall including the diffuser with reference to the water quality requirements of the identified sensitive receivers for compliance with the relevant gazetted Water Quality Objectives.

(iv) <u>Solid Waste Pollution Study</u>

Solid waste assessment shall focus on:

(a) identification of the quantity and quality of contaminated spoil/dredged material generated as a result of dredging and reclamation;

(b) recommendation of suitable handling and disposal measures for any spoils/mud (contaminated and/or uncontaminated) as a result of dredging and reclamation, attention to be paid to the licensing requirements under the Work Branch Technical Circular No. 22/92 'Marine Disposal of Dredged Mud';

(c) identification of the sources of solid waste with details of the waste generation, waste characterization and waste separation;

(d) the issue of sludge disposal during the operation stage which should be fully addressed;

(e) investigation on any secondary impacts such as, odour, gas emission, noxious leachate;

(f) evaluation of the proposed waste management strategy, waste handling, treatment and disposal methods; and

(g) incorporation of waste reduction / reuse / recycling by any practical means.

(v) Visual Impact Study

The Consultant shall assess the visual impacts of the Sham Tseng sewage treatment works and the various pumping stations, and propose outline landscaping proposals and building design to minimise the visual impacts. The building design proposal shall consider, amongst others, a fully enclosed, a partially enclosed and a sunken sewage treatment works. A complete 'Visual Impact Assessment Report' shall consist of the following major elements:

(a) identification of visual envelope and sensitive receivers (or 'potential receptors') or viewpoints;

(b) illustrations of the proposed Project by photomontage and/or scale models (N.B. The directions in which various views are being taken should be incorporated into a map for illustration);

(c) assessment of the visual impacts of the proposed structures to individual receptors and identification of the most affected views; and

(d) proposals of mitigation measures required for the affected views.

(vi) Traffic Impacts Study

The Consultants shall, in respect of traffic impacts,

(a) assess the impacts on the traffic on Castle Peak Road arising from the sewerage works, as well as the construction vehicles especially during reclamation of the site; liaise with the Highways Department for the programme and details of the Castle Peak Road widening project which is scheduled to be carried out at about the same time with the sewerage works; and assess the cumulative impacts of the two projects and propose mitigation measures in terms of the interfacing of the projects;

(b) assess the traffic impacts arising from the borrowing activities and propose mitigation measures; and

(c) assess the impacts on marine traffic arising from the reclamation works and outfall construction, and propose mitigation measures.

(vii) Environmental Monitoring and Audit (EM&A) Requirements

(a) Environmental Monitoring

The Consultants shall identify and recommend environmental monitoring requirements for all construction, post-project and operational phases of the development. These requirements shall include but not be limited to the identification of sensitive receivers, monitoring locations, monitoring parameters and frequencies, monitoring equipment to be used, and any other necessary programmes for baseline monitoring, impact and compliance monitoring, and data management of monitoring results.

(b) Environmental Audit

The Consultants shall identify and recommend environmental audit requirements for all construction, post-project and operational phases of the development. These requirements shall include but not be limited to:

(1) organisation and management structure, and procedures for auditing of the implementation of respective environmental mitigation measures recommended for the detailed design, contract document preparation, construction, post-project operation stages of the development;

(2) environmental quality performance limits for compliance auditing for each of the recommended monitoring parameters to ensure compliance with relevant environmental quality objectives, statutory or planning standards, or acceptance criteria recommended by the Environmental Impact Assessment, such limits being that they shall give indication of a deteriorating environmental quality and shall allow proactive responses to be taken (the commonly used approach is a set of trigger, action and target levels);

(3) organisation and management structure, and procedures for reviewing the monitoring results and auditing the compliance of the monitoring data with the environmental quality performance limits (point (2) above), project contractual and regulatory requirements, and environmental policies and standards;

(4) event / action plans for impact and compliance

- monitoring;

(5) complaints handling, liaison and consultation procedures; and

(6) reporting procedures, report formats and reporting frequency including periodical reports and annual reviews to cover all construction and post-project / operational phases of the development.

(c) The Consultants shall prepare an Environmental Monitoring and Audit Manual which shall cover the requirements and recommendations in (a) and (b) above. The Manual shall also contain a summary list of recommended environmental mitigation measures. This Manual shall be used as a guideline for environmental monitoring and audit during the construction and post-project operational phases. This Manual shall be a stand-alone document and form part of the Final Report.

6.4 The Consultants shall meet the objectives listed in Section 3 above by:

(i) carrying out the necessary background studies to identify, collect and analyze existing information relevant to the Environmental Impact Assessment Study;

(ii) carrying out any necessary environmental survey, site investigations and baseline monitoring work to achieve the objectives;

(iii) quantifying, by use of models or other predictive methods, the residual and cumulative environmental impacts (specifying whether these are transient, long term and/or irreversible) arising from the construction and operation of the Project;

(iv) proposing practicable, effective and enforceable methods, measures and standards to effectively mitigate any significant environmental impacts in the short and long term; and

(v) outlining a programme by which the environmental impacts of the Project can be assessed, monitored and audited.

In further defining the scope of the Environmental Impact Assessment Study, consideration should be given to beneficial and adverse effects, short and long term effects, secondary and induced effects, cumulative effects, synergistic effects and transboundary effects.

6.5 The Consultants shall take into account, where available, the findings of all previous and current studies relevant to this Environmental Impact Assessment Study, including in particular the following:

(i) Tsuen Wan, Kwai Chung and Tsing Yi Sewerage Master Plan Study;
(ii) Sham Tseng Sewerage and Sewage Treatment - Underground Cavern Options;
(iii) Castle Peak Road Improvement between Area 2 and Ka Loon Tsuen, Tsuen Wan - Feasibility Study;
(iv) Reclamation and Servicing of Tuen Mun Area 38 for Special Industries - Environmental Impact Assessment Study.

6.6 The use of models, survey protocols and analytical methods (including laboratory techniques) in the Study shall be agreed and approved by the Director's Representative, prior to commencement of detailed studies. In connection with the modelling work, the Consultants are required to undertake the following:

(i) elaboration of background assumptions;

(ii) confirmation with data validation;

(iii) calibration of model;

(iv) prescription of tool application (such as, questionnaire, numerical/stochastic algorithm); and

(v) presentation of scenario projection and interpretation of results.

6.7 To assess the water quality impacts of the Project, the Consultants shall make use of models approved by the Director's Representative pursuant to Section 6.6, and shall agree with the Director's Representative on the extent and the programme of modelling. The Consultants may make use of the hydrodynamic and water quality data available in the Environmental Protection Department. Where available, the model data may be supplied on tapes while most of the field data will be in hard copies. A minimum of 3 weeks' notice shall be given in requesting for such data.

6.8 The Consultants shall liaise with relevant Government departments and agencies, and all other parties involved in this and any other projects or developments likely to be affected by the Project. Any correspondence, notes or minutes arising from such liaison shall be copied to the Director's Representative.

6.9 The Study should be carried out with due regard to the information, policies, regulations and procedures contained in the following:

(i) All anti-pollution Ordinances, Technical Memoranda, advisory booklets *et al*;

(ii) Works Branch Technical Circular 14/92, April 1992: Environmental impact assessment of major development projects;

(iii) Planning, Environment and Lands Branch General Circular 2/94, May 1994: Public access to EIA reports;

(iv) Environment Hong Kong (Annual review of 1992), Environmental Protection Department, 1993;

(v) The Hong Kong Environment: a green challenge for the community, Planning, Environment and Lands Branch, 1993;

(vi) Environmental Protection Department Technical Circular 15-2-94, February 1993: Consultancy documents submitted to EPD - working greener.

7. Response to Queries

The Consultants shall respond to queries under Clause 20 of the General Conditions of Employment raised prior to a date six months after the final submission of the Deliverables required under the Agreement. Such date shall be confirmed in writing to the Consultants by the Director's Representative.

8. Programme of Implementation

8.1 The date for commencement of the Agreement is 9 September 1994.

8.2 The study shall be completed within 32 weeks, working to an agreed Programme. The Draft Final Report shall be completed within 25 weeks.

The Consultants shall produce the programme referred to in Clause 26 of the General Conditions of Employment in draft form within the first 2 weeks of the Assignment detailing the main streams of the study, target dates for particular tasks and any decision dates that may be required for the uninterrupted progress of the Assignment. The Consultants shall discuss with the Director's Representative during this period to agree the timing of submissions of reports and plans for each of the main elements of the Assignment, for inclusion in the draft programme.

The Consultants shall endeavour to ensure that the Assignment is carried out in accordance with the Programme and shall submit regular programme reviews as part of the progress reports referred to in Clause 9 of this Brief.

9. Progress Reports

The Consultants shall submit to the Director's Representative progress reports at monthly intervals on all aspects of the Services relating progress to the Programme referred to in clause 8 of this Brief. The reports shall include a list of those parts of the Services the execution of which is behind the Programme, together with proposals to expedite progress, so as to complete the work on time. The reports shall also include updated expenditure forecasts in accordance with Clause 10 of this Brief.

10. Financial Management

At monthly intervals or at such other intervals as the Director's Representative may require, the Consultants shall submit a report on the current and forecast expenditure on the Assignment and the fees due to the Consultants, in a form to be agreed by the Director's Representative.

11. Standards and Specifications

11.1 The Consultants shall adopt such technical and design standards and specifications as are in current use by the Government department(s) or, if non-existent, British Standard Codes of Practice and Specifications. Should instances arise for which suitable standards or specifications do not exist or for which the current standards or specifications appear to require modification or if by the adoption of current standards the Consultants would incur additional expenses not within reasonable contemplation, the Consultants shall submit recommendations on appropriate alternatives to the Director's Representative for agreement.

11.2 In assessing and quantifying residual environmental impacts, if there are emissions of non-criterion pollutants with health implications, the Consultants should review relevant standards of other countries and international bodies, such as the World Health Organization (WHO), the International Agency for Research on Cancer, the US Environmental Protection Agency (USEPA), and the US National Research Council (USNRC), and propose for agreement with the Director's Representative on the appropriate reference criteria.

11.3 The Consultants shall comply with and observe all Ordinances, bye-laws, regulations and rules for the time being in force in Hong Kong governing the control of any form of pollution for environmental protection.

12. Director's Representative

The Director's Representative as defined in the General Conditions of Employment shall be Assistant Director/Projects and Development, Drainage Services Department or such other person as may be authorised by the Director in writing and notified to the Consultants. The Director's Representative may delegate any of the powers and functions vested in him to other officers. If the Consultants are dissatisfied with a decision or instruction of any such officer the matter shall be referred to the Director's Representative for a ruling.

13. Control of the Project and Assignment

13.1 The Environmental Impact Assessment Study will be managed by a Study Management Group formed within the Government. This shall be the forum for liaison with Government departments and agencies, providing guidance to the study consultant, and for comment and review on the work and outputs of the study. All secretarial services will be provided by the Consultants.

13.2 The Consultants should make themselves available to be present in the Advisory Committee on the Environment, District Boards (DB's) (e.g. Tsuen Wan DB and its sub-committees) and/or any public consultation meetings to brief their case against the relevant environmental impacts generated.

14. Information and Facilities Provided by the Employer

All available information relevant to the Assignment will be provided to the Consultants. Relevant documents including reports, drawings and other background materials are listed in Sections 2 and 6 of this Brief. The Consultants shall indicate for guidance those documents which they currently hold and those of which a copy may be needed, should the Assignment be awarded to them. A copy of each of the documents indicated as needed will be supplied free of charge by the Director's Representative on request from the Consultants, except those currently available from the Sales section of the Information Services Department. In the case of plans and drawings, one transparency and two prints of each plan or drawing shall be provided free of charge if requested by the Consultants.

15. Consultants' Office and Staffing

The Consultants shall maintain for the duration of this Agreement an office in Hong Kong under the control of the Project Director of the Consultants who shall be responsible for the Study. He shall have adequate authority and sufficient professional, technical and administrative support staff in all relevant disciplines to ensure progress to the satisfaction of the Director's Representative.

16. Specialist and Sub-consultant Services

The Consultants shall provide all specialist and sub-consultant services required for the satisfactory completion of the Assignment. No additional fees or expenses for the provision of such services rendered locally or overseas shall be payable by the Employer except as otherwise provided for in the Schedule of Fees.

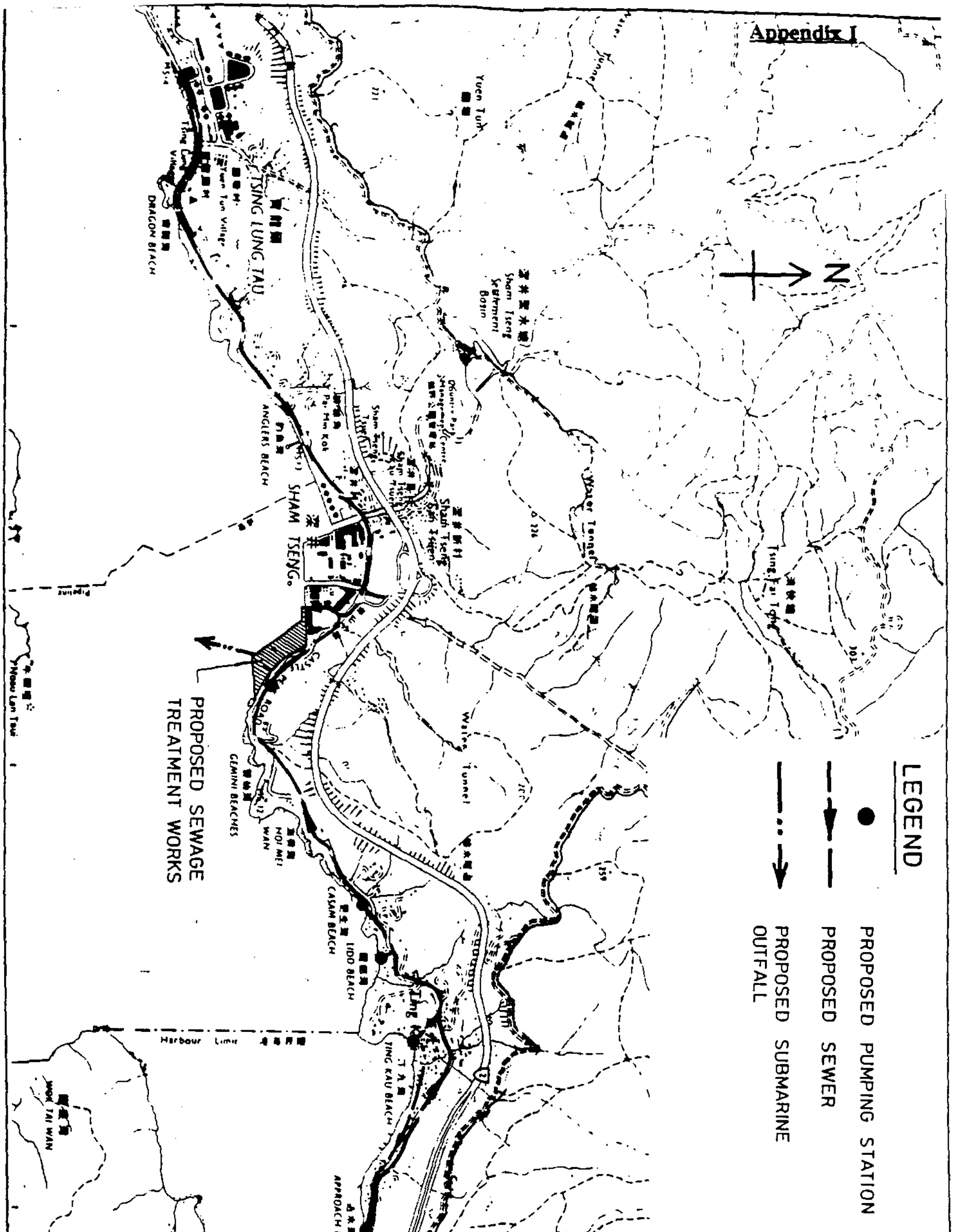
17. Surveys

One velograph and two prints of topographical mapping at 1:20,000, 1:5,000 and 1:1,000 scales prepared by the Survey and Mapping Office of the Buildings and Lands Department, where available for the area covered by the Project for which the Assignment forms a part, can be obtained free of charge on application to the Director's Representative. All field survey work required for the proper execution of the Assignment shall unless otherwise provided for in the Agreement, be the duty of the Consultants. A copy of field notes, field data and resultant plans arising from these surveys shall be handed over to the Director's Representative upon completion of the Assignment. The accuracy as well as presentation of these surveys shall be of a standard agreed by the Director's Representative.

18. Insurance

The amount of insurance cover to be maintained in accordance with sub-clause (A) of Clause 47 of the General Conditions of Employment shall be HONG KONG Dollars 3,000,000.

Appendix I

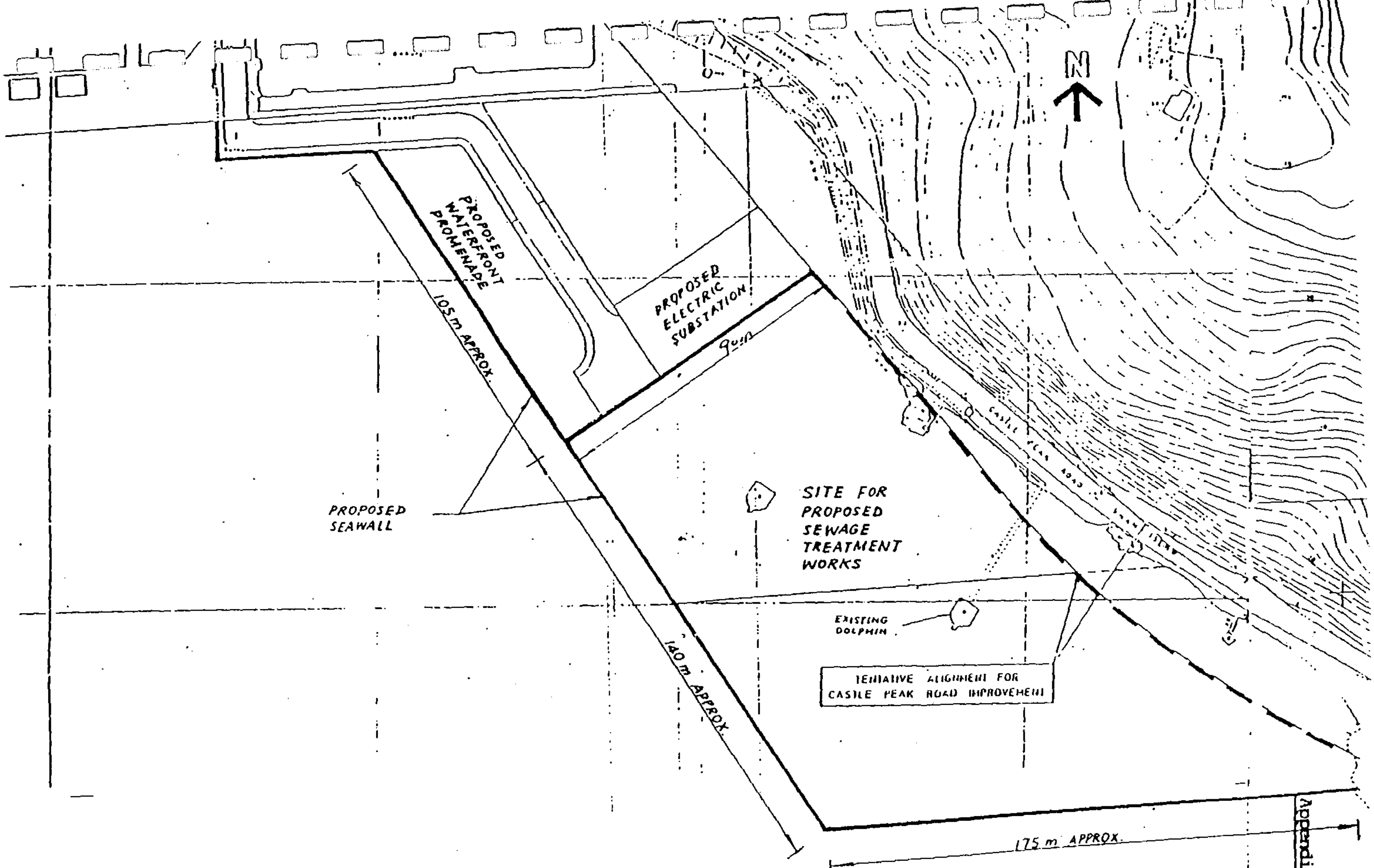


A	8.7.94	GENERAL REVISION	
no	date	description	initial

title	drawn by	date	drawing no.	scale
SHAM TSENG SEWERAGE, SEWAGE TREATMENT AND SUBMARINE OUTFALL —SITE INVESTIGATION AND ENVIRONMENTAL IMPACT ASSESSMENT STUDY	S. H. CHAN	14.1.94	DDN 8370 A	1:20 000
	approved: T. C. LAU	17.1.94	DRAINAGE SERVICES DEPARTMENT HONG KONG	
	office: DESIGN DIVISION			

GF 507

Appendix I



Proposed Reclamation for the Sham Tseng Sewage Treatment Works

Appendix B

Marine Site Investigations

Ting Kau and Sham Tseng Sewerage Scheme
Factual Fieldwork Report

Marine Site Investigations

CONTRACT No. GE/93/11
W.O. No.: GE/93/11.13
SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL
FACTUAL FIELDWORK REPORT

CIVIL ENGINEERING DEPARTMENT CONTRACT No. GE/93/11
GROUND INVESTIGATION - MARINE WORKS
(TERM CONTRACT)

CONTRACTOR

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February 1995

BACHY SOLETANCHE

BACHY SOLETANCHE GROUP

SOIL & FOUNDATIONS SPECIALISTS

Contract Data Summary

Project Name: SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL	Site Name:	Date: 27/11/93 to 27/11/95 Official only
G.I. Contractor: BACHY SOLETANCHE GROUP	Client: DRAINAGE SERVICES DEPARTMENT	G.E.O. Data Bank No.
Contract No.: GE/93/11	W.O. No.: GE/93/11.13	File Ref.:

Field Work Summary

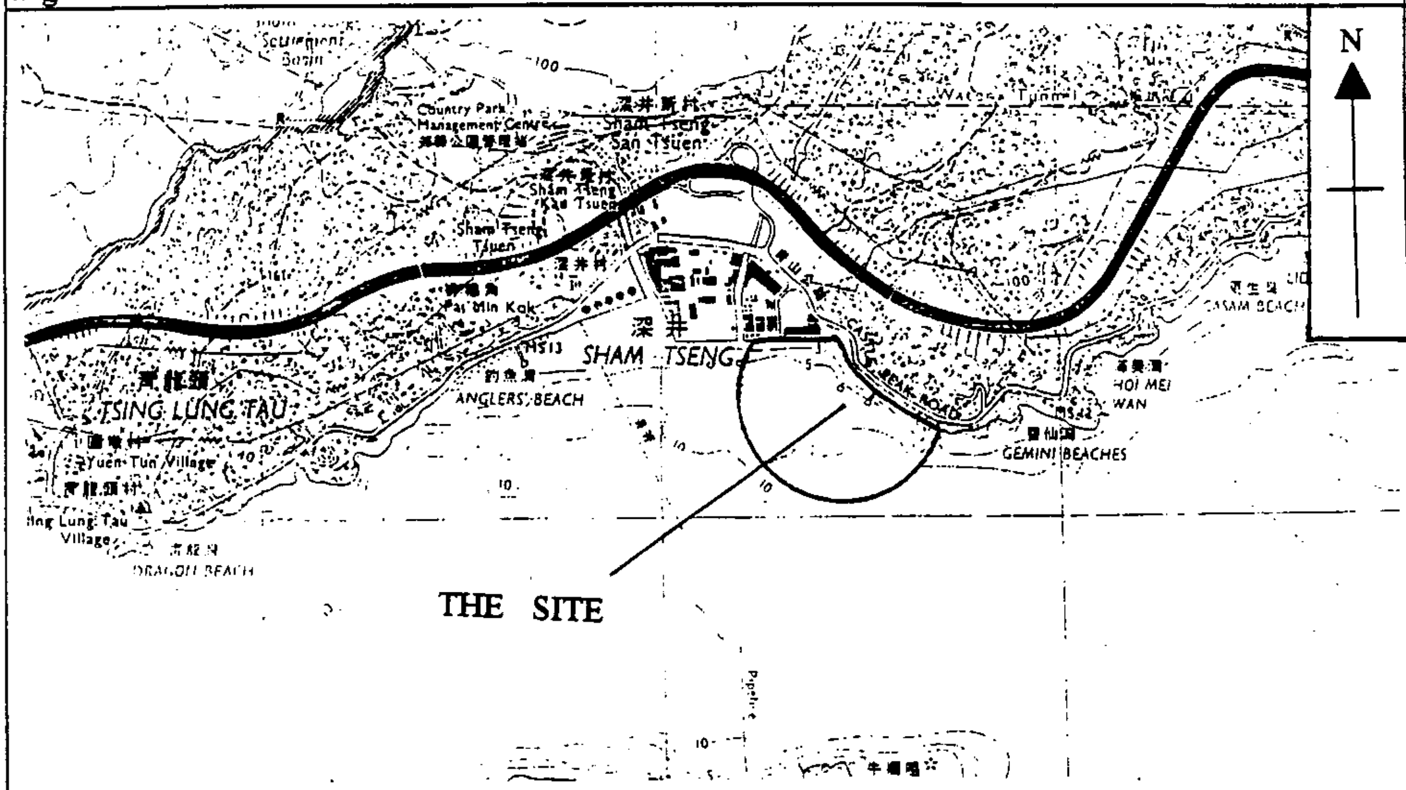
Drillholes Total No.:	11	Method: ROTARY	Date: 10/11/94 to 01/12/94
Pits / Trenches / Caissons: No.:	NIL		
Probes: No.:	NIL		
Piezometers: No.:	NIL		
Insitu Tests: No.:	NIL	Types:	
Geophysics: Traverses:	NIL	Type:	

Laboratory Testing Summary

Total No. of Tests:		NIL	Date:			
Soil	Physical Properties	LL	PL	Grading	M/C	
	Strength Tests	SG	Tm/Td			
	Compaction & CBR Tests	CU	CD	UU	Shear Box CD	
	Oedometer & Perm. Tests	Standard	Modified			
	Others	Cv	k			
Rock	T					

Location Plan Scale: 1 : 20 000 Derived from: 20 000 Sheet

Figure 1



	G.I.	Laboratory
Contractor	BACHY SOLETANCHE GROUP	
Works Order No.	GE/93/11.13	

GEOTECHNICAL ENGINEERING OFFICE

CIVIL ENGINEERING DEPARTMENT HONG KONG

BACHY SOLETANCHE

CIVIL ENGINEERING DEPARTMENT CONTRACT No. GE/93/11
GROUND INVESTIGATION - MARINE WORKS
(TERM CONTRACT)

W.O. No.: GE/93/11.13

SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL

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1. INTRODUCTION

In November 1993, Bachy Soletanche Group was awarded a two year Term Contract to carry out marine ground investigations for the Geotechnical Engineering Office (G.E.O) of the Civil Engineering Department. The Contract Area for the Works consists of the Hong Kong Territorial Waters, including the near shore areas where the water depth exceeds one metre during high tide.

This report details the fieldwork carried out for Works Order No. GE/93/11.13 issued under the Contract. The instructed fieldwork consisted of eleven drillholes at locations immediately offshore south-east of Sham Tseng. The fieldwork was undertaken between 10th November and 1st December, 1994.

2. THE SITE

The site is located immediately offshore south-east of Sham Tseng. (see Fig. 1 in Contract Data Summary Sheet). The drillholes are located within the site area bounded by co-ordinates of :

- 824550E and 825150N
- 824670E and 824890N
- 824900E and 824890N
- 824910E and 824970N

3. GEOLOGY

According to the 1:20 000 HGM 20 series geological maps of Hong Kong Sheet 6 (Yuen Long) - Edition 1, 1988, the site is underlain by marine deposits of the Hang Hau Formation. Rock outcrops onshore comprise fine to medium grained granites.

The findings of the ground investigation are in general accordance with the geological map and the sequence of strata encountered may be summarised as follows:

- Fill
- Marine Deposit (Hang Hau Formation)
- Colluvium (Chek Lap Kok Formation)
- Grade VI / V rock
- Rock, consisting of basalt and medium grained granite.

In this report, the term 'rock' is used as recommended in the Geoguide 3, i.e. a material which has not weathered in situ to the condition of a soil and which cannot be broken by hand into its constituent grains. The material is equivalent to weathering grades I to IV (fresh rock to highly decomposed rock)

Detailed descriptions of each stratum are given in the drillhole logs presented in Appendix I. When the formation name or geological origin of a material could not be clearly determined, a '?' has been incorporated into the description.

The depth and thickness of each strata are given in Table 1.

Fill was encountered in drillhole BH06 only and constists of :

- Grey, angular COBBLES and coarse GRAVEL of various rock types.

Marine Deposit (Hang Hau Formation) was encountered in drillholes BH02, BH04, BH07, BH09A, BH10 and BH10A (see Table 1) and generally consists of either :

- Medium dense, grey to yellowish brown, slightly silty / clayey, fine to coarse SAND with occasional to some shell fragments and some subangular, fine quartz gravel or,
- Soft, olive grey to grey, very sandy silty CLAY with occasional angular, coarse quartz gravel.

Alluvium was encountered in the drillhole BH09A only (see Table 1) and consists of :

- Grey to brown, angular to subrounded COBBLES and coarse GRAVEL of granite.

The degree of decomposition of rock varies from one drillhole to another and is dependent on the orientation and spacing of discontinuities, groundwater flow paths and removal of overburden by erosion. The material attributed to weathering grades V and VI (i.e. essentially a soil), generally ranges in grain size in its remoulded condition from a soft clay to a sand with some rock fragments.

Rock, consisting of medium grained GRANITE and very fine grained BASALT.

4. FIELDWORK

4.1 Setting out

Drillhole locations were set out in accordance with the co-ordinates given on Works Drawing Number DCM 1097 and by site instruction. Drillhole locations were positioned using conventional surveying techniques. The 'as-drilled' positions of drillhole locations are shown on Drawing BSG /11.13/1 enclosed in this report. Seabed levels were determined by relating the sounding results to the tide gauge reading. Survey positions and seabed levels are summarised in Table 2.

4.2 Drilling

All drilling was carried out by rotary equipment which was established on-board an anchored barge. The drilling technique employed utilises a power pack remote from the drilling platform to drive a power swivel system that provides roatation when coupled to the drill rods. The power swivel is fixed either side of the drilling position by two guide wires which restricts rotation in the horizontal plane, but allows vertcal movement through the guide wires such that motion of the platform or the barge is not transferred to the swivel or to the drill string. Using this technique ensures that the drill bit stays in constant contact with the base of the drillhole and is therefore not subject to wave and tidal action.

Drillholes were advanced by rotating SX and HX drill casings using sea water as a flushing medium. Cable tool boring methods were generally employed in materials other than rock.

Sampling (U76, maziers and SPT liners) and testing (SPT) was carried out in drillholes in accordance with the requirements given in the Works Order. All sampling is reported at the relevant depth on the drillhole log; undisturbed sample depths refer to the base of samples and small disturbed samples refer to the middle of the depth range.

4.3 Sample Description

Soils have been described in accordance with the general principles given in Geoguide 3 - Guide to Rock and Soil Descriptions (GCO, 1988) with the exception of the use of Munsell Soil Colour Charts and the descriptive terms for the additional constituents in composite soil types. As instructed, the terms used are as follows:

- 'with occasional' for less than 5% additional materials
- 'with some' for between 5% and 20% additional materials
- 'with much' for between 20% and 50% additional materials

Drillhole logs are presented in Appendix I. Sample descriptions given on the logs have been amended to incorporate comments provided by the Client and the G.E.O. Soil descriptions and delineation of strata have been based primarily on the examination of samples obtained from the ends of U76, mazier, SPT liner samples and, to a lesser degree, on the daily site records

4.4 Drillhole Photography

Photographs of the samples recovered from drillhole locations which have been used for log production are provided in Appendix II. The reference board shown in the photograph gives details of the samples.

5. DIGITAL RECORDS

5.1 Method

Both the preliminary and final drillhole logs have been produced using gINT, a commercially available software package capable of providing the ground investigation data in ASCII digital format. The data is provided in uncompressed form on the 3.5" disk (formatted to MS-DOS Version 6.0) submitted with the Final Fieldwork Report. The data file format complies with Appendix 1 of the latest edition of the Association of Geotechnical Specialists (AGS) publication "Electronic Transfer of Geotechnical Data from Ground Investigations". The data dictionary used for data field headings are in accordance with that recommended by the AGS with local variations as instructed by the G.E.O.

5.2 Data Index

The media index record and the data disk are included in the Mastercopy of the Final Fieldwork Report.

H.T.Burbidge

Geotechnical Engineer

M.P.Chan

Drilling Department Manager

REFERENCES

GCO (1986). Map HGM 20, Sheet 7: Solid and Superficial Geology (1:20 000 map)

GCO (1989). Map HGM 20, Sheet 16: Solid and Superficial Geology (1:200 000 map)

GCO (1988). Guide to Rock and Soil Descriptions (Geoguide 3). Geotechnical Control Office, Hong Kong.

AGS (1992). Electronic Transfer of Geotechnical Data from Ground Investigations. Association of Geotechnical Specialists.

Macbeth (1992). Munsell Soil Colour Charts

TABLES

Table 1. Summary of Strata Depths and Thicknesses

Hole Number	Seabed Level (mPD)	FILL		HANG HAU FORMATION		CHEK LAP KOK FORMATION		ROCK - GRADE VI to I	Hole Depth (m)
		Base Depth (m)	Thick-ness (m)	Base Depth (m)	Thick-ness (m)	Base Depth (m)	Thick-ness (m)	Penetrated thickness (m)	
BH01	-11.30	-	-	-	-	-	-	4.60	4.60
BH02	-14.90	-	-	0.90	0.90	-	-	9.80	10.70
BH03	-12.80	-	-	-	-	-	-	12.02	12.02
BH04	-16.60	-	-	2.00	2.00	-	-	5.38	7.38
BH05	-15.40	-	-	-	-	-	-	7.67	7.67
BH06	-18.30	1.00	1.00	-	-	-	-	11.96	12.96
BH07	-18.30	-	-	2.90	2.90	-	-	7.16	10.06
BH08	-17.80	-	-	-	-	-	-	7.00	7.00
BH09A	-16.90	-	-	1.90	1.90	3.60	1.70	9.20	12.80
BH10	-18.10	-	-	1.80	1.80	-	-	2.55	4.35
BH10A	-18.10	-	-	1.70	1.70	-	-	2.52	4.22

Table 2. Drillhole Location Co-ordinates and Seabed Levels

Hole Number	Easting Co-ordinates	Northing Co-ordinates	Seabed Level (mPD)
BH01	824637.56	825077.64	-11.30
BH02	824676.92	825014.38	-14.90
BH03	824752.38	825017.59	-12.80
BH04	824677.33	824972.83	-16.60
BH05	824793.36	824976.89	-15.40
BH06	824725.31	824939.56	-18.30
BH07	824782.55	824941.35	-18.30
BH08	824828.17	824943.86	-17.80
BH09A	824735.25	824974.91	-16.90
BH10	824680.60	824940.52	-18.10
BH10A	824680.23	824940.20	-18.10

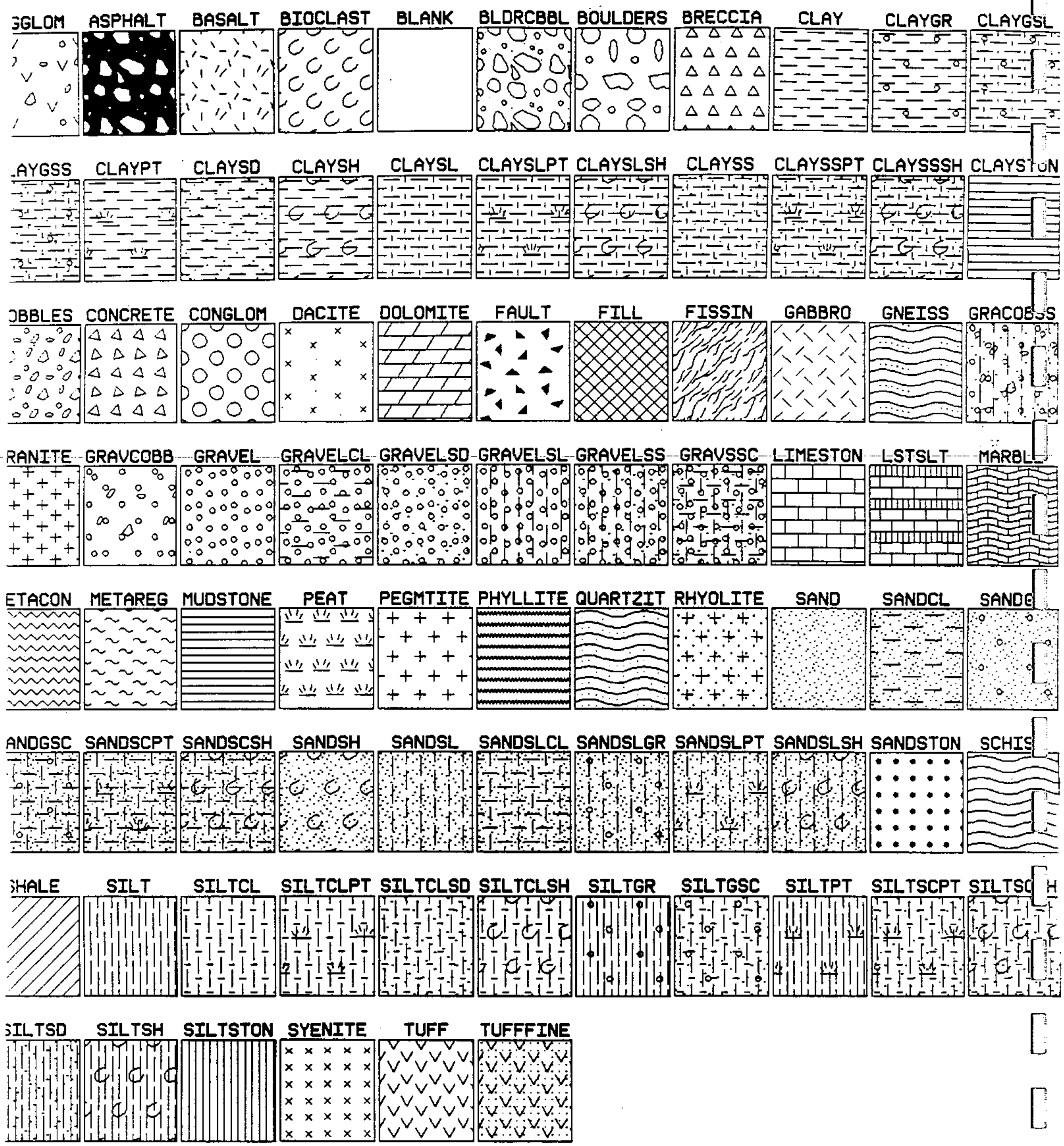
DRAWINGS

APPENDIX I

List of Material Codes for the Log Legend

Material Code	Description
AGGLOM	Pyroclastic Breccia (volcanic ash, agglomerate)
ASPHALT	Asphalt
BASALT	Basalt
BIOCLAST	Shells, Bioclastic Remains
BLANK	Void or Core loss
BLDRCBBL	Boulders and Cobbles
BOULDERS	Boulders
BRECCIA	Sedimentary Breccia
CLAY	Clay
CLAYGR	Gravelly Clay
CLAYGSL	Silty clay with gravel
CLAYGSS	Sandy silty Clay with gravel
CLAYPT	Organic Clay
CLAYSD	Sandy Clay
CLAYSH	Shelly Clay
CLAYSL	Silty Clay
CLAYSLPT	Silty Clay with organics
CLAYSLSH	Silty Clay with shells
CLAYSS	Sandy silty Clay
CLAYSSPT	Sandy silty Clay with organics
CLAYSSSH	Sandy silty Clay with shells
CLAYSTON	Claystone
COBBLES	Cobbles
CONCRETE	Concrete
CONGLOM	Conglomerate
DACITE	Dacite, Latite, Andesite, Trachyte, Trachyandesite
DOLOMITE	Dolomitic Limestone
FAULT	Fault Breccia
FILL	Artificial fill; includes landfill, rock fill, masonry wall
FISSIN	Fissure Infill
GABBRO	Gabbro, Lamprophyre
GNEISS	Gneiss, Coarse-grained metamorphic rock
GRACOBSS	Silty sandy Gravel and Cobbles
GRANITE	Granite, Coarse-grained Acid Igneous Rock
GRAVCOBB	Gravel and Cobbles
GRAVEL	Gravel
GRAVELCL	Clayey Gravel
GRAVELSD	Sandy Gravel
GRAVELSL	Silty Gravel
GRAVELSS	Silty Sandy Gravel
GRAVSSC	Clayey Silty Sandy Gravel
LIMESTON	Limestone
LSTSLT	Interbedded Limestone and Siltstone
MARBLE	Yuen Long Marble

METACON	Contact Metamorphic Rock
METAREG	Regional Metamorphic Rock
MUDSTONE	Mudstone
PEAT	Peat
PEGMTITE	Very coarse-grained Igneous Rock
PHYLLITE	Phyllite, Mylonite (fine grained metamorphic rock)
QUARTZIT	Quartzite, Coarse-grained Metamorphic Rock
RHYOLITE	Rhyolite, fine grained acid igneous rock
SAND	Sand
SANDCL	Clayey Sand
SANDGR	Gravelly Sand
SANDGSC	Silty clayey Sand with gravel
SANDSCPT	Silty clayey Sand with organics
SANDSCSH	Silty clayey Sandy with shells
SANDSH	Shelly Sand
SANDSL	Silty Sand
SANDSLCL	Silty clayey Sand
SANDSLGR	Silty Sand with gravel
SANDSLPT	Silty Sand with organics
SANDSLSH	Silty Sand with shells
SANDSTON	Sandstone
SCHIST	Schist (medium grained Metamorphic Rock)
SHALE	Shale, Fissile Mudstone
SILT	Silt
SILTCL	Clayey Silt
SILTCLPT	Clayey Silt with organics
SILTCLSD	Sandy clayey Silt
SILTCLSH	Clayey Silt with shells
SILTGR	Gravelly Silt
SILTGSC	Sandy clayey Silt with gravel
SILTPT	Organic Silt
SILTSCPT	Sandy clayey Silt with organics
SILTSCSH	Sandy clayey Silt with shells
SILTSD	Sandy Silt
SILTSH	Shelly Silt
SILTSTON	Siltstone
SYENITE	Granodiorite, Syenite, Quartz Syenite, Monzonite
TUFF	Coarse Ash Tuff, Lapilli Tuff, Eutaxite
TUFFFINE	Fine Ash Tuff


GGLOM
ASPHALT
BASALT
BIOCLAST
BLANK
BLDRCBBL
BOULDERS
BRECCIA
CLAY
CLAYGR
CLAYGSL
LAYGSS
CLAYPT
CLAYSD
CLAYSH
CLAYSL
CLAYSLPT
CLAYSLSH
CLAYSS
CLAYSSPT
CLAYSSSH
CLAYSTON
OBBLES
CONCRETE
CONGLOM
DACITE
DOLOMITE
FAULT
FILL
FISSIN
GABBRO
GNEISS
GRACOBSS
RANITE
GRAVCOBB
GRAVEL
GRAVELCL
GRAVELSD
GRAVELSL
GRAVELSS
GRAVSSC
LIMESTON
LSTSLT
MARBL
ETACON
METAREG
MUDSTONE
PEAT
PEGMTITE
PHYLLITE
QUARTZIT
RHYOLITE
SAND
SANDCL
SANDG
ANDGSC
SANDSCPT
SANDSCSH
SANDSH
SANDSL
SANDSLCL
SANDSLGR
SANDSLPT
SANDSLSH
SANDSTON
SCHIS
SHALE
SILT
SILTCL
SILTCLPT
SILTCLSD
SILTCLSH
SILTGR
SILTGSC
SILTPT
SILTSCPT
SILTSCSH
SILTSD
SILTSH
SILTSTON
SYENITE
TUFF
TUFFFINE

BACHY SOLETANCHE

BACHY SOLETANCHE GROUP

SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO. 8H01

SHEET 1 of 1

PROJECT **SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL**

METHOD ROTARY	CO-ORDINATES E 824637.56 N 825077.64	W.O. GE/93/11.13	
MACHINE & No. HELEN		DATE from 11/11/94	to 11/11/94
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND-LEVEL -11.30 mPD	

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
11/11/94	SX		100				B=14	1, 2		0.35		V	Extremely weak, yellow to light yellowish brown, spotted olive and white, completely decomposed GRANITE. (Silty clayey, silty fine to coarse SAND with some cobble sized granite fragments below 2.90m.)
							(2, 3, 3, 4, 4, 5) N=16	3		0.90			
			100					4, 5		1.90			
										2.00			
							(3, 5, 5, 3, 4, 5) N=17	6		2.45			
	SX 2.90m									2.90			
	HX 3.20m		20					7	-14.50	3.20			
			100	63	40			T2-101		3.60		III	Moderately weak, light yellowish brown, spotted black and olive, equigranular, moderately decomposed medium gravel GRANITE, locally highly fractured.
			100	62	35	>20		T2-101	-15.90	4.60			Joints closely spaced, rough planar, limonite stained and kaolinite coated, dipping 40° to 45° and subvertical from 3.20m to 3.45m, 3.60m to 4.45m.
													End of hole at 4.60m

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Key	
SMALL DISTURBED SAMPLE	WATER SAMPLE
LARGE DISTURBED SAMPLE	PIEZOMETER TIP
SPT LINER SAMPLE	STANDPIPE
U76 UNDISTURBED SAMPLE	STANDARD PENETRATION TEST
U100 UNDISTURBED SAMPLE	PERMEABILITY TEST
MAZIER SAMPLE (70mm)	IN-SITU VANE SHEAR TEST
PISTON SAMPLE	

LOGGED R. T. WU

DATE 12/11/94

CHECKED H.BURBIDGE

DATE 12/12/94

REMARKS

Hole termination depth at 4.60m
B = Number of Blows

BACHY SOLETANCHE — BACHY SOLETANCHE GROUP — SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT	GE/93/11	HOLE NO.	BH02
SHEET	1 of 2		
PROJECT	SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL		
METHOD	ROTARY	W.O.	GE/93/11.13
MACHINE & No.	HELEN	DATE from	12/11/94 to 12/11/94
CO-ORDINATES	E 824676.92 N 825014.38		
FLUSHING MEDIUM	WATER	ORIENTATION	Vertical
GROUND-LEVEL	-14.90 mPD		

Drilling Progress: 12/11/94. Casing size: SX to 2.90m; HX to 9.30m. Water level (m) Shift start/end: 15.80m at 08:00.

Depth (m)	Reduced Level	Samples	Tests	Grade	Description
0.35, 0.45, 0.90	-15.80	1, 2, 3	B=8; (2, 3, 4, 5, 5, 7) N=21		Medium dense, grey (N4/), slightly clayey silty fine to coarse SAND with some shell fragments and occasional rounded fine to coarse quartz gravel. (MARINE DEPOSIT) (HANG HAU FORMATION) Some completely decomposed granite presents below 0.80m
1.90, 2.00, 2.45, 2.90	-17.80	4, 5, 6	(4, 5, 5, 6, 6, 7) N=24	V	Extremely weak, yellowish brown, mottled white, completely decomposed GRANITE. (Firm, very sandy clayey SILT with occasional angular, fine gravel sized granite fragments)
3.90, 4.12	-19.02	7, 8, 9		V	Extremely weak, light brownish grey, spotted white and grey, completely decomposed GRANITE. (Clayey silty fine to coarse SAND with some angular fine to medium gravel sized granite fragments)
4.90, 6.00	-20.90	10, 11	(35, 105 / 45mm) 140 / 120mm	V	Extremely weak, brown, spotted white and grey, completely decomposed GRANITE. (Firm, very sandy, clayey SILT with some angular medium to coarse gravel sized granite fragments)
7.10	-22.00	12, 13		V	Extremely weak, light brownish grey, spotted white and grey, completely decomposed GRANITE. (Clayey silty, fine to coarse SAND with many angular, medium to coarse gravel sized granite fragments)
7.55, 8.00, 9.00, 9.10, 9.30	-24.20	14, 15, 16, 17	(10, 13, 21, 28, 36, 63) N=148	V	Extremely weak, brown to brownish grey, spotted white and dark grey, completely decomposed GRANITE. (Firm, very sandy, clayey SILT with some angular cobble sized granite fragments below 9.10m)
10.00			T2-101	III/II	Moderately strong to strong, yellowish brown to light pink, spotted black, equigranular,

Total core recovery % (runs, top to bottom): 100, 100, 100, 60, 90, 50, 10, 100. Solid core recovery %: 86 (last run). R.Q.D.: 71 (last run).

LOGGED R. T. WU — DATE 12/11/94

APPROVED H.BURBIDGE — DATE 12/12/94

REMARKS

Hole termination depth at 10.70m
B = Number of Blows

Key: SMALL DISTURBED SAMPLE; LARGE DISTURBED SAMPLE; SPT LINER SAMPLE; U76 UNDISTURBED SAMPLE; U100 UNDISTURBED SAMPLE; MAZIER SAMPLE (70mm); PISTON SAMPLE; WATER SAMPLE; PIEZOMETER TIP; STANDPIPE; STANDARD PENETRATION TEST; PERMEABILITY TEST; V IN-SITU VANE SHEAR TEST

BACHY SOLETANCHE

BACHY SOLETANCHE GROUP

SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO. 8H02

SHEET 2 of 2

PROJECT **SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL**

METHOD ROTARY	CO-ORDINATES E 824676.92 N 825014.38	W.O. GE/93/11.13	
MACHINE & No. HELEN		DATE from 12/11/94	to 12/11/94
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND-LEVEL	-14.90 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
12/11			100	100	100	4.3		T2-101	-25.60	10.70	+ + +		moderately to slightly decomposed medium grained GRANITE. Joints closely to medium spaced, smooth planar and stepped limonite stained, dipping 50° to 55°.
11													End of hole at 10.70m.
12													
13													
14													
15													
16													
17													
18													
19													
20													

SMALL DISTURBED SAMPLE
LARGE DISTURBED SAMPLE
SPT LINER SAMPLE
U76 UNDISTURBED SAMPLE
U100 UNDISTURBED SAMPLE
MAZIER SAMPLE (70mm)
PISTON SAMPLE
WATER SAMPLE
PIEZOMETER TIP
STANDPIPE
STANDARD PENETRATION TEST
PERMEABILITY TEST
IN-SITU VANE SHEAR TEST

LOGGED R. T. WU

DATE 12/11/94

CHECKED H.BURBIDGE

DATE 12/12/94

REMARKS

BACHY SOLETANCHE BACHY SOLETANCHE GROUP

SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO.	BH03
SHEET	1 of 2

PROJECT **SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL**

METHOD	ROTARY	CO-ORDINATES E 824752.38 N 825017.59	W.O. GE/93/11.13
MACHINE & No.	HELEN		DATE from 22/11/94 to 23/11/94
FLUSHING MEDIUM	WATER	ORIENTATION Vertical	GROUND-LEVEL -12.80 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
22/11/94	SX	16.20m at 07:30	100				B = 13	1, 2		0.35, 0.45		V	Extremely weak, olive grey (5Y) to yellowish brown (10YR), spotted white and dark brown, completely decomposed GRANITE. (Firm, sandy clayey SILT with some angular fine quartz gravel)
							(2, 3, 4, 4, 4, 5) N = 17	3, 4		0.90			
	SX 2.00m		85					5		1.90, 2.00			
	HX						(3, 3, 4, 4, 5, 5) N = 18	6	-15.25	2.45			
			100					7		2.90		V	Extremely weak, yellowish brown (10YR), spotted white and black, completely decomposed GRANITE. (Clayey silty, fine to coarse SAND with some medium gravel sized rock fragments below 6.45m)
		13.00m at 07:30					(3, 4, 5, 6, 6, 8) N = 25	8, 9		3.90, 4.00, 4.45			
23/11/94			80					10		4.90			
							(8, 12, 14, 16, 17, 20) N = 67	11, 12		5.90, 6.00, 6.45			
			44					13, 14	-20.70	6.90, 7.90			
			42	26	17	N.A.		T2-101	-21.08	8.28		IV/III	Weak to moderately strong, brown, spotted black, equigranular, highly to moderately decomposed, medium grained GRANITE, highly fractured. (CORESTONE)
						N.R.			-21.60	8.80		V	No recovery assumed to be completely decomposed granite.
			67	40	0	N.A.		T2-101	-21.80	9.00, 9.10		IV/III	
			68	34	26	N.R.			-22.06	9.26		V	
						N.A.		T2-101		9.60		IV/III	
			44	40	0			T2-101	-22.62	9.82			

• SMALL DISTURBED SAMPLE	△ WATER SAMPLE
LARGE DISTURBED SAMPLE	PIEZOMETER TIP
SPT LINER SAMPLE	STANDPIPE
U76 UNDISTURBED SAMPLE	STANDARD PENETRATION TEST
U100 UNDISTURBED SAMPLE	PERMEABILITY TEST
MAZIER SAMPLE (70mm)	IN-SITU VANE SHEAR TEST
PISTON SAMPLE	

LOGGED R. T. WU

DATE 30/11/94

CHECKED H.BURBIDGE

DATE 05/12/94

REMARKS

Hole termination depth at 12.02m
B = Number of Blows
N.A. = Not Applicable
N.R. = No Recovery

BACHY SOLETANCHE — BACHY SOLETANCHE GROUP — SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

HOLE NO. BH03	SHEET 2 of 2	CONTRACT GE/93/11	
PROJECT	SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL		
METHOD	ROTARY	CO-ORDINATES E 824752.38 N 825017.59	W.O. GE/93/11.13
MACHINE & No.	HELEN		DATE from 22/11/94 to 23/11/94
FLUSHING MEDIUM	WATER	ORIENTATION Vertical	GROUND-LEVEL -12.80 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
	HX 10.40m					N.R.		T2-101	-22.90	10.10		V	
			0					15	-23.20	10.40		V	Extremely weak, brown, spotted black, completely decomposed GRANITE. (Fine to coarse SAND with some coarse gravel sized rock fragments.)
23/11/94			92	46	28	N.I.		T2-101		10.64		IV/III	
									-23.80	11.00			Weak to moderately strong, brown, spotted black and white, equigranular, highly to moderately decomposed, medium grained GRANITE, highly fractured. Joints closely spaced, rough undulating, limonite stained, dipping 10°, 25° and subvertical from 10.64m to 11.00m.
			100	100	100	7.2		T2-101	-24.82	12.02		III	Moderately strong, yellowish brown to brown, spotted black, equigranular, moderately decomposed, medium grained GRANITE. Joints closely spaced, rough planar, limonite stained, dipping 15° to 25° and subvertical from 11.56m to 11.82m.

End of hole at 12.02m.

Depth scale: 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

• SMALL DISTURBED SAMPLE	△ WATER SAMPLE
LARGE DISTURBED SAMPLE	PIEZOMETER TIP
SPT LINER SAMPLE	STANDPIPE
U76 UNDISTURBED SAMPLE	STANDARD PENETRATION TEST
U100 UNDISTURBED SAMPLE	PERMEABILITY TEST
MAZIER SAMPLE (70mm)	V IN-SITU VANE SHEAR TEST
PISTON SAMPLE	

LOGGED	R. T. WU
DATE	30/11/94
CHECKED	H.BURBIDGE
DATE	05/12/94

REMARKS

BACHY SOLETANCHE BACHY SOLETANCHE GROUP
SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO. BH04

SHEET 1 of 1

PROJECT **SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL**

METHOD **ROTARY**	CO-ORDINATES E 824677.33 N 824972.83	W.O. **GE/93/11.13**	
MACHINE & No. **HELEN**		DATE from **14/11/94** to **14/11/94**	
FLUSHING MEDIUM **WATER**	ORIENTATION **Vertical**	GROUND-LEVEL **-16.60 mPD**	

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
14/11/94	SX	17.80m at 10:00	100				B=12; (2, 2, 3, 2, 3, 3) N=11	1, 2, 3		0.35, 0.45, 0.90			Medium dense, yellowish brown to grey (10YR), clayey silty, fine to coarse SAND with some shell fragments. (MARINE DEPOSIT) (HANG HAU FORMATION) A cobble of completely decomposed basalt above 0.45m.
									-18.60	2.00			
	SX 2.45m; HX		100				B=5; (2, 3, 2, 3, 3, 4) N=12	4, 5, 6, 7		2.35, 2.45, 2.90		V	Extremely weak, yellowish brown to grey (10YR), completely decomposed BASALT. (Firm, silty CLAY)
			100				(3, 4, 5, 7, 10, 15) N=37	8, 9		3.90, 4.00, 4.45, 4.90			
	HX 6.00m		95					10, 11	-22.60	6.00			
			100	56	45	9.4	T2-101		-22.90	6.30		IV/III	Moderately weak to moderately strong, grey, highly to moderately decomposed, very fine grained BASALT, highly fractured.
			100	100	75		T2-101		-23.98	6.62, 7.38		III	Moderately strong, brown, spotted black, equigranular, moderately decomposed, medium grained GRANITE. Joints medium spaced, smooth planar, limonite stained, dipping 45° and 60°.

End of hole at 7.38m.

Key	
• SMALL DISTURBED SAMPLE	△ WATER SAMPLE
LARGE DISTURBED SAMPLE	PIEZOMETER TIP
SPT LINER SAMPLE	STANDPIPE
U76 UNDISTURBED SAMPLE	STANDARD PENETRATION TEST
U100 UNDISTURBED SAMPLE	PERMEABILITY TEST
MAZIER SAMPLE (70mm)	V IN-SITU VANE SHEAR TEST
PISTON SAMPLE	

LOGGED R. T. WU
DATE 17/11/94
CHECKED H.BURBIDGE
DATE 01/12/94

REMARKS
Hole termination depth at 7.38m
B = Number of Blows

BACHY SOLETANCHE

BACHY SOLETANCHE GROUP

SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO. BH05

SHEET 1 of 1

PROJECT **SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL**

METHOD **ROTARY**	CO-ORDINATES	W.O. GE/93/11.13	
MACHINE & No. HELEN	E 824793.36 N 824976.89	DATE from 21/11/94	to 22/11/94
FLUSHING MEDIUM **WATER**	ORIENTATION **Vertical**	GROUND-LEVEL	-15.40 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
21/11/94	SX	16.80m at 08:00	100				B=10	1, 2		0.45		V	Extremely weak, yellowish brown (10YR), spotted white and black, completely decomposed GRANITE. (Clayey silty fine to coarse SAND with occasional angular, fine quartz gravel.)
	SX 0.90m						(3, 3, 4, 4, 5, 7) N=20	3		0.90			
	HX		100					4, 5		1.90			
										2.00			
							(5, 6, 7, 10, 15, 17) N=49	6		2.45			
										2.90			
			85					7, 8		3.90			
										4.00			
							(8, 10, 13, 15, 17, 20) N=65	9		4.45			
	HX 4.85m								-20.25	4.85			
			53	16	0	N.A.		T2-101	-20.73	5.33		IV/III	Weak to moderately strong, brown, spotted black and white, equigranular, highly to moderately decomposed medium grained GRANITE, highly fractured.
						N.R.			-21.15	5.75		V	
			49	26	0	N.A.		T2-101	-21.57	6.17		IV/III	No recovery assumed to be completely decomposed granite. (CORESTONE)
						N.R.			-22.00	6.60		V	
			100	85	65	7.5		T2-101		7.22		III	Moderately strong, yellowish brown, spotted black, equigranular, moderately decomposed medium grained GRANITE.
22/11			100	100	67			T2-101	-23.07	7.67			Joints closely spaced, rough planar, limonite stained dipping 25°, 65° and subvertical from 6.70m to 6.87m, 6.90m to 7.22m.

End of hole at 7.67m.

• SMALL DISTURBED SAMPLE	△ WATER SAMPLE
LARGE DISTURBED SAMPLE	PIEZOMETER TIP
SPT LINER SAMPLE	STANDPIPE
U76 UNDISTURBED SAMPLE	STANDARD PENETRATION TEST
U100 UNDISTURBED SAMPLE	PERMEABILITY TEST
MAZIER SAMPLE (70mm)	IN-SITU VANE SHEAR TEST
PISTON SAMPLE	

LOGGED R. T. WU

DATE 29/11/94

CHECKED H.BURBIDGE

DATE 05/12/94

REMARKS

Hole termination depth at 7.67m
B = Number of Blows
N.A. = Not Applicable
N.R. = No Recovery

BACHY SOLETANCHE — BACHY SOLETANCHE GROUP — SOIL & FOUNDATIONS SPECIALISTS	DRILLHOLE RECORD	HOLE NO. BH06
	CONTRACT GE/93/11	SHEET 1 of 2

PROJECT	SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL
METHOD	ROTARY
MACHINE & No.	HELEN
FLUSHING MEDIUM	WATER
CO-ORDINATES	E 824725.31 N 824939.56
ORIENTATION	Vertical
W.O.	GE/93/11.13
DATE from	15/11/94 to 16/11/94
GROUND-LEVEL	-18.30 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
15/11/94	SX	19.60m at 12:00	0				B=17	1		0.35 0.45			Grey (N5/), angular COBBLES and coarse GRAVEL of various rock types. (FILL)
			55					HX	-19.30	1.00			
			100				B=8	2, 3		1.35 1.45		V	Extremely weak, yellowish brown (10YR), spotted black and white, completely decomposed GRANITE. (Slightly clayey, silty, fine to coarse SAND with some fine quartz gravel and cobble sized rock fragments.)
	SX 1.90m HX						(2, 3, 4, 4, 5, 5) N=18	4		1.90			
			0					5, 6		2.90 3.00			
			60					7		4.00 4.10			
			0					T2-101		5.00			
							(10, 13, 14, 19, 25, 45) N=103	8		5.45			
										6.00			
			60					9, 10		7.00 7.10			
			70					11, 12	-26.30	8.00			
16/11/94			39	9	0	N.A.		T2-101	-26.61	8.31		IV/III	Weak to moderately strong, brown, spotted white and black, equigranular, highly to moderately decomposed, medium grained GRANITE, highly fractured. (CORESTONES)
						N.R.			-27.10	8.80		V	No recovery assumed to be completely decomposed granite.
			82	37	20	N.A.		T2-101	-27.59	9.29		IV/III	
						N.R.			-27.70	9.40		V	
			65	37	37	N.A.		T2-101	-28.12	9.82		IV/III	

Key:
- • SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE (70mm)
- PISTON SAMPLE
- △ WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- V IN-SITU VANE SHEAR TEST

LOGGED R. T. WU
DATE 21/11/94
CHECKED H.BURBIDGE
DATE 05/12/94

REMARKS

Hole termination depth at 12.96m
B = Number of Blows
N.A. = Not Applicable
N.R. = No Recovery
HX = "H" Casing Coring

BACHY SOLETANCHE — BACHY SOLETANCHE GROUP — SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

HOLE NO. BH06	SHEET 2 of 2	CONTRACT GE/93/11	
PROJECT	SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL		
METHOD ROTARY	CO-ORDINATES E 824725.31 N 824939.56	W.O. GE/93/11.13	
MACHINE & No. HELEN		DATE from 15/11/94 to 16/11/94	
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND-LEVEL -18.30 mPD	

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
						N.R.			-28.35	10.05	+ +	V	
			44	9	0	N.A.		T2-101	-28.79	10.49	+ +	IV/III	
						N.R.						V	
11	HX 11.05m								-29.35	11.05			
16/11/94			100	89	70			T2-101		11.76	+ +	III	Moderately strong, brown, spotted black and white, equigranular, moderately decomposed, medium grained GRANITE.
12			100	100	68	8.4		T2-101	-31.26	12.96	+ +		Joints closely spaced, rough planar and undulating, limonite stained, dipping 10°, 40°, 60° and subvertical from 11.60m to 11.76m.
13													End of hole at 12.96m.
14													
15													
16													
17													
18													
19													
20													

SMALL DISTURBED SAMPLE
LARGE DISTURBED SAMPLE
SPT LINER SAMPLE
U76 UNDISTURBED SAMPLE
U100 UNDISTURBED SAMPLE
MAZIER SAMPLE (70mm)
PISTON SAMPLE
WATER SAMPLE
PIEZOMETER TIP
STANDPIPE
STANDARD PENETRATION TEST
PERMEABILITY TEST
IN-SITU VANE SHEAR TEST

LOGGED R. T. WU
DATE 21/11/94
CHECKED H.BURBIDGE
DATE 06/12/94

REMARKS

BACHY SOLETANCHE GROUP
SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO. BH07

SHEET 1 of 2

PROJECT SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL

METHOD ROTARY	CO-ORDINATES E 824782.55 N 824941.35	W.O. GE/93/11.13
MACHINE & No. HELEN		DATE from 17/11/94 to 17/11/94
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND-LEVEL -18.30 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
17/11/94	SX	19.70m at 08:00	100				B=7 (3, 3, 4, 6, 8, 10) N=28	1, 2, 3		0.35, 0.45, 0.90			Medium dense to very dense, p[…] yellow to dark brown (10YR), fi[…] coarse SAND with much subang[…] fine to coarse gravel of quartz and of granite. (MARINE DEPOSIT) (HANG HAU FORMATION)
			100				B=8 (9, 10, 13, 17, 18, 25) N=73	4, 5, 6	-21.20	2.00, 2.35, 2.45, 2.90			
												V	Extremely weak, reddish grey to grey (5YR), spotted black and white, completely decomposed GRANITE. (Firm, sandy clayey SILT)
	SX 4.00m HX		100				B= (3, 7, 8, 8, 9, 13) N=38	7, 8, 9, 10		4.00, 4.35, 4.45, 4.90			
			80				(4, 7, 9, 10, 10, 13) N=42	11, 12		5.90, 6.00, 6.45			
	HX 8.00m		100					13, 14	-26.30	6.90, 8.00			Below 6.90m with some coarse gravel sized granite fragments.
			67	62	43	N.A.	T2-101		-26.70	8.40		IV/III	Weak to moderately strong, pale red, spotted black, equigranular, highly to moderately decomposed medium grained GRANITE. (CORESTONE)
						N.R.			-26.90	8.60		V	No recovery assumed to be completely decomposed granite.
			100	100	44	10	T2-101			9.40		III	
			100	97	97		T2-101						Moderately strong, brown, spotted black, equigranular, moderately

KEY:
- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE (70mm)
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IN-SITU VANE SHEAR TEST

LOGGED R. T. WU
DATE 21/11/94
CHECKED H.BURBIDGE
DATE 05/12/94

REMARKS

Hole termination depth at 10.06m
B = Number of Blows
N.A. = Not Applicable
N.R. = No Recovery

BACHY SOLETANCHE BACHY SOLETANCHE GROUP SOIL & FOUNDATIONS SPECIALISTS	DRILLHOLE RECORD CONTRACT GE/93/11	HOLE NO. BH07 SHEET 2 of 2

PROJECT SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL		
METHOD ROTARY	CO-ORDINATES E 824782.55 N 824941.35	W.O. GE/93/11.13
MACHINE & No. HELEN		DATE from 17/11/94 to 17/11/94
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND-LEVEL -18.30 mPD

Drilling Progress	Casing size	Water level (m) Shift start/ end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
									-28.36	10.06			decomposed medium grained GRANITE. Joints closely spaced, smooth and rough planar, limonite stained, dipping 40° to 45°, 60° and subvertical from 8.60m to 9.80m.
													End of hole at 10.06m.

Depth scale: 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Key	
SMALL DISTURBED SAMPLE	WATER SAMPLE
LARGE DISTURBED SAMPLE	PIEZOMETER TIP
SPT LINER SAMPLE	STANDPIPE
U76 UNDISTURBED SAMPLE	STANDARD PENETRATION TEST
U100 UNDISTURBED SAMPLE	PERMEABILITY TEST
MAZIER SAMPLE (70mm)	IN-SITU VANE SHEAR TEST
PISTON SAMPLE	

LOGGED R. T. WU

DATE 21/11/94

CHECKED H.BURBIDGE

DATE 05/12/94

REMARKS

BACHY SOLETANCHE — BACHY SOLETANCHE GROUP — SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO. BH08

SHEET 1 of 1

PROJECT SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL

METHOD ROTARY	CO-ORDINATES E 824828.17 N 824943.86	W.O. GE/93/11.13	
MACHINE & No. HELEN		DATE from 19/11/94	to 19/11/94
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND-LEVEL	-17.80 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Grade	Description
19/11/94	SX	19.10m at 08:00	100				B=6	1, 2		0.35, 0.45	V	Extremely weak, yellowish brown to pinkish grey (7.5YR), spotted black and white, completely decomposed GRANITE. (Clayey silty fine to coarse SAND with medium to coarse gravel sized granite fragments below 4.00m)
							(2, 2, 3, 2, 3, 4) N=12	3, 4		0.90		
			90					5		1.90, 2.00		
							(3, 7, 8, 8, 9, 13) N=38	6		2.45		
								7		2.90		
	SX 4.00m		55					8		3.90, 4.00		
	HX		0					9	-22.00	4.20		
	HX 4.95m		91	69	53	9.0	T2-101		-22.75	4.95	IV/III	Weak to moderately strong, brown, spotted black, equigranular, highly to moderately decomposed medium grained GRANITE.
			100	96	64		T2-101			5.65	III	Joints recovery assumed to be completely decomposed granite.
			100	98	74	6.7	T2-101		-24.80	7.00		Moderately strong, brown, spotted black, equigranular, moderately decomposed medium grained GRANITE. Joints closely spaced, rough planar and undulating limonite stained, dipping 10° to 15°, 45° and 65°.
												End of hole at 7.00m.

Key:
- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE (70mm)
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IN-SITU VANE SHEAR TEST

LOGGED R. T. WU
DATE 29/11/94
CHECKED H.BURBIDGE
DATE 05/12/94

REMARKS

Hole termination depth at 7.00m
B = Number of Blows

BACHY SOLETANCHE — BACHY SOLETANCHE GROUP — SOIL & FOUNDATIONS SPECIALISTS	**DRILLHOLE RECORD** CONTRACT GE/93/11	HOLE NO. **BH09A** SHEET 1 of 2

PROJECT **SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL**		
METHOD **ROTARY**	CO-ORDINATES E 824735.25 N 824974.91	W.O. **GE/93/11.13**
MACHINE & No. **HELEN**		DATE from **29/11/94** to **30/11/94**
FLUSHING MEDIUM **WATER**	ORIENTATION **Vertical**	GROUND-LEVEL -16.90 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
29/11/94	SX 0.45m HX	18.90m at 10:00	100				B = 10	1, 2		0.35, 0.45			Soft, olive grey (5Y) to grey (N5/), very sandy silty CLAY with occasional angular, coarse quartz gravel. (MARINE DEPOSIT) (HANG HAU FORMATION)
							(4, 3, 3, 2, 3, 3) N = 11	3		0.90			
									-18.80	1.90			
			37					T2-101		2.60			Grey to brown (10YR), angular to subrounded, COBBLES and coarse GRAVEL of granite. (COLLUVIUM?) (CHEK LAP KOK FORMATION?)
			38					T2-101		3.10			No recovery assumed to be finer soil washed out by flushing medium.
			30					T2-101	-20.50	3.60			
			0					4		4.60, 4.70		V	Extremely weak, yellowish brown to olive grey, spotted white, completely decomposed GRANITE. (Firm, very sandy clayey SILT with some angular, fine to coarse gravel sized granite fragments)
			100					5, 6		5.70, 5.80			
30/11/94		18.60m at 07:30					(7, 10, 13, 16, 17, 20) N = 66	7		6.25			
										6.70			
			80					8, 9		7.70, 7.80			
							(8, 10, 14, 17, 19, 21) N = 71	10		8.25			
										8.70			
			100					11, 12		9.70, 9.80			
							(20, 25,						

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

• SMALL DISTURBED SAMPLE	△ WATER SAMPLE
LARGE DISTURBED SAMPLE	PIEZOMETER TIP
SPT LINER SAMPLE	STANDPIPE
U76 UNDISTURBED SAMPLE	STANDARD PENETRATION TEST
U100 UNDISTURBED SAMPLE	PERMEABILITY TEST
MAZIER SAMPLE (70mm)	V IN-SITU VANE SHEAR TEST
PISTON SAMPLE	

LOGGED **R. T. WU**

DATE **02/12/94**

CHECKED **H.BURBIDGE**

DATE **12/12/94**

REMARKS

Hole termination depth at 12.80m

B = Number of Blows

BACHY SOLETANCHE — BACHY SOLETANCHE GROUP, SOIL & FOUNDATIONS SPECIALISTS	DRILLHOLE RECORD	HOLE NO. BH09A
	CONTRACT GE/93/11	SHEET 2 of 2

PROJECT SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL

METHOD ROTARY	CO-ORDINATES E 824735.25 N 824974.91	W.O. GE/93/11.13
MACHINE & No. HELEN		DATE from 29/11/94 to 30/11/94
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND-LEVEL -16.90 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
							52, 40, 55, 65) N=192	13		10.25			
										10.70			
11	HX 11.20m		75					14, 15	-28.10	11.20			
30/11/94			92	24	0	N.I.		T2-101		11.45		III	Moderately strong, brown, spotted black, equigranular, moderately decomposed medium grained GRANITE, locally highly fractured.
12			100	96	81			T2-101		12.13			Joints closely spaced rough undulating, limonite stained, dipping 10°, 25°, 50° and subvertical from 12.03m to 12.16m.
			100	100	69	6.7		T2-101	-29.70	12.80			End of hole at 12.80m.
13													
14													
15													
16													
17													
18													
19													
20													

Key		Key	
•	SMALL DISTURBED SAMPLE	△	WATER SAMPLE
	LARGE DISTURBED SAMPLE		PIEZOMETER TIP
	SPT LINER SAMPLE		STANDPIPE
	U76 UNDISTURBED SAMPLE		STANDARD PENETRATION TEST
	U100 UNDISTURBED SAMPLE		PERMEABILITY TEST
	MAZIER SAMPLE (70mm)	V	IN-SITU VANE SHEAR TEST
	PISTON SAMPLE		

LOGGED R. T. WU

DATE 02/12/94

CHECKED H.BURBIDGE

DATE 12/12/94

REMARKS

BACHY SOLETANCHE

BACHY SOLETANCHE GROUP

SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO. BH10

SHEET 1 of 1

PROJECT SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL

METHOD ROTARY	CO-ORDINATES E 824680.60 N 824940.52	W.O. GE/93/11.13	
MACHINE & No. HELEN		DATE from 24/11/94 to 25/11/94	
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND-LEVEL -18.10 mPD	

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
24/11/94	SX		100				B=13 (3, 3, 4, 4, 5, 5) N=18	1, 2, 3		0.35, 0.45, 0.90	Sand		Medium dense, brown (10YR), fine to coarse SAND with some subangular fine quartz gravel and occasional shell fragments. (MARINE DEPOSIT) (HANG HAU FORMATION)
	SX 1.80m								-19.90	1.80			
			100	85	77	7.8		T2-101	-20.80	2.70	Granite	III	Moderately strong, brown, spotted black and white, equigranular, moderately decomposed, medium grained GRANITE. Joints closely spaced, rough planar, limonite stained, dipping 25° and 40°.
25/11/94		18.60m at 07:30	100	53	26	>20		T2-101		2.90	Granite	IV/III	Weak to moderately strong, brown, spotted black and white, equigranular, highly to moderately decomposed, medium grained GRANITE, highly fractured. Joints closely spaced, rough planar and undulating limonite stained and chlorite coated, dipping 15° to 20° and subvertical from 2.70m to 4.35m.
			100	79	65			T2-101	-22.45	3.28, 4.35			End of hole at 4.35m.

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Key:
- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE (70mm)
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IN-SITU VANE SHEAR TEST

LOGGED R. T. WU

DATE 26/11/94

CHECKED H.BURBIDGE

DATE 12/12/94

REMARKS

Hole termination depth at 4.35m
B = Number of Blows

BACHY SOLETANCHE

BACHY SOLETANCHE GROUP

SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD

CONTRACT GE/93/11

HOLE NO. BH10A

SHEET 1 of 1

PROJECT **SHAM TSENG SEWAGE TREATMENT WORKS AND OUTFALL**

METHOD **ROTARY**

MACHINE & No. **HELEN**

FLUSHING MEDIUM **WATER**

CO-ORDINATES
E 824680.23
N 824940.20

ORIENTATION **Vertical**

W.O. GE/93/11.13

DATE from 28/11/94 to 28/11/94

GROUND-LEVEL -18.10 mPD

Drilling Progress	Casing size	Water level (m) Shift start/end	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
28/11/94	SX	19.00m at 07:30	100				B = 12 (3, 4, 4, 5, 5, 6) N = 20	1, 2, 3		0.35			Medium dense, brown (10YR), fine to coarse SAND with occasional shell fragments and some subangular, fine quartz gravel. (MARINE DEPOSIT) (HANG HAU FORMATION)
										0.45			
										0.90			
	SX 1.70m								-19.80	1.70			
			100	100	93	8.8		T2-101		2.39		III	Moderately strong, brown, spotted black, equigranular, moderately decomposed, medium grained GRANITE, locally highly fractured.
			100	69	55			T2-101		2.94			Joints closely spaced, rough planar, limonite stained, dipping 15° to 25°, 40° and subvertical from 3.35m to 3.60m, 3.95m to 4.22m.
			100	100	94	13		T2-101		3.30			
										3.76			
			100	100	74			T2-101	-22.32	4.22			
													End of hole at 4.22m.

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Key:
- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE (70mm)
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IN-SITU VANE SHEAR TEST

LOGGED R. T. WU

DATE 02/12/94

CHECKED H.BURBIDGE

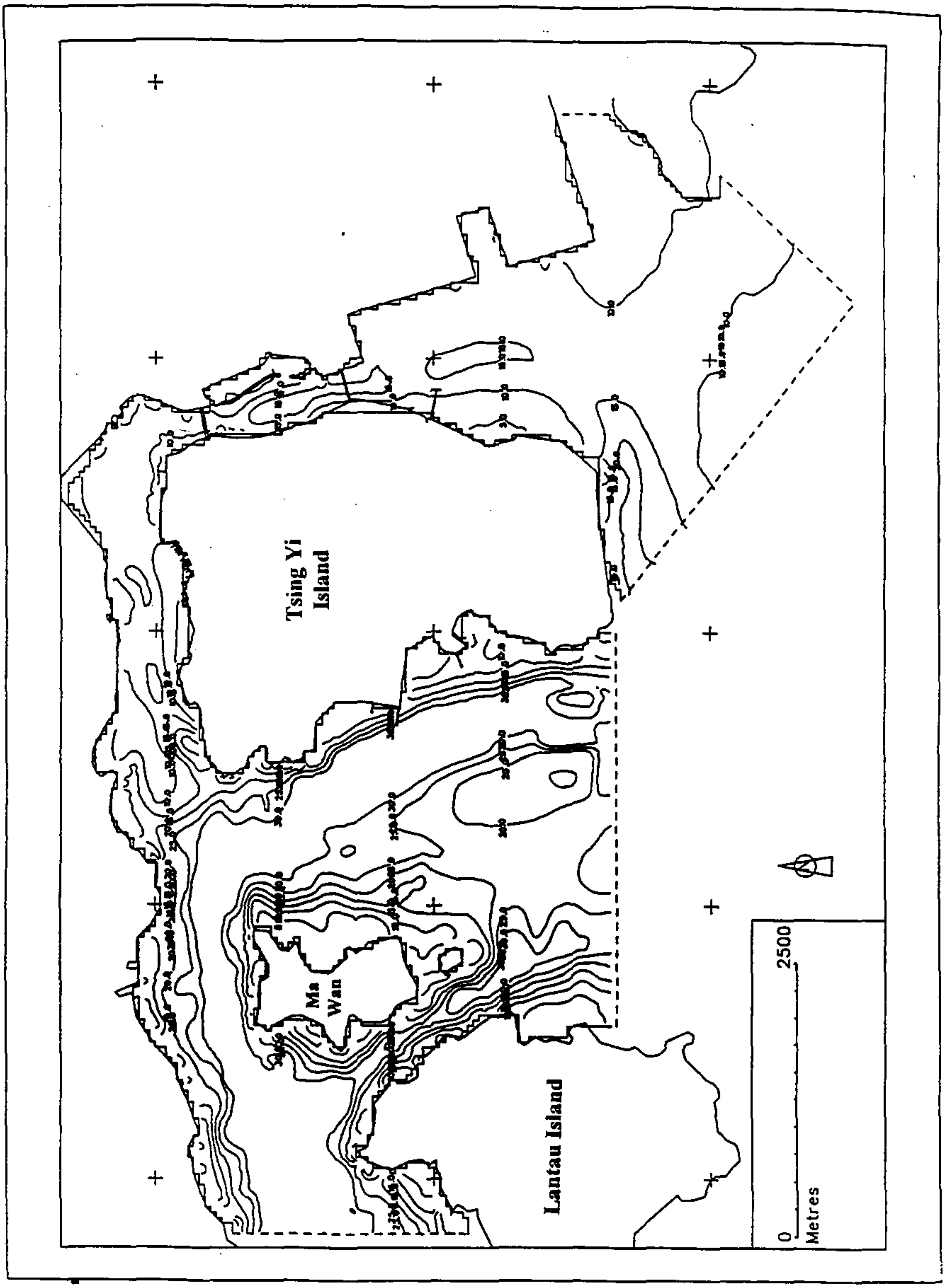
DATE 12/12/94

REMARKS

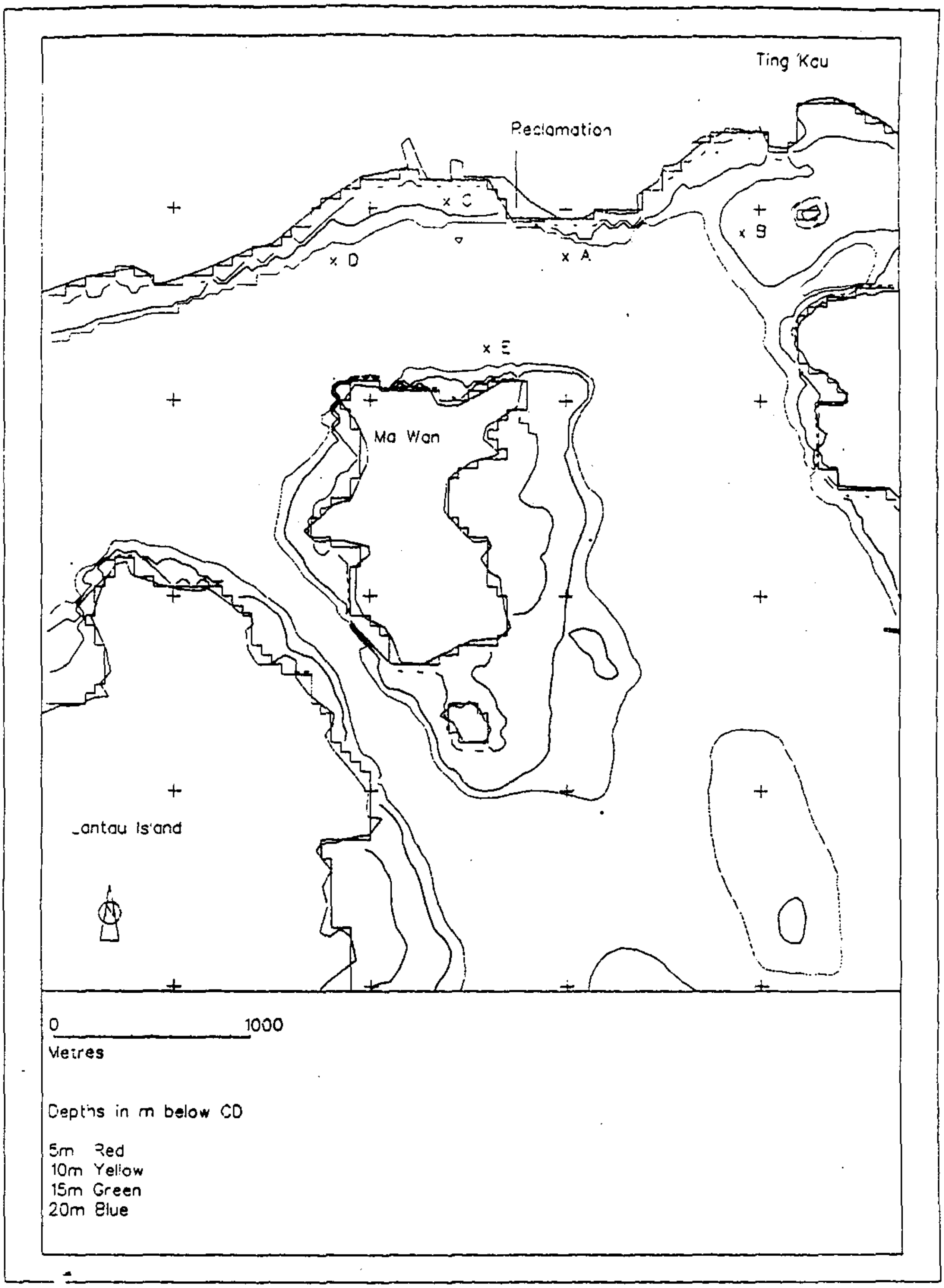
Hole termination depth at 4.22m
B = Number of Blows

Appendix C

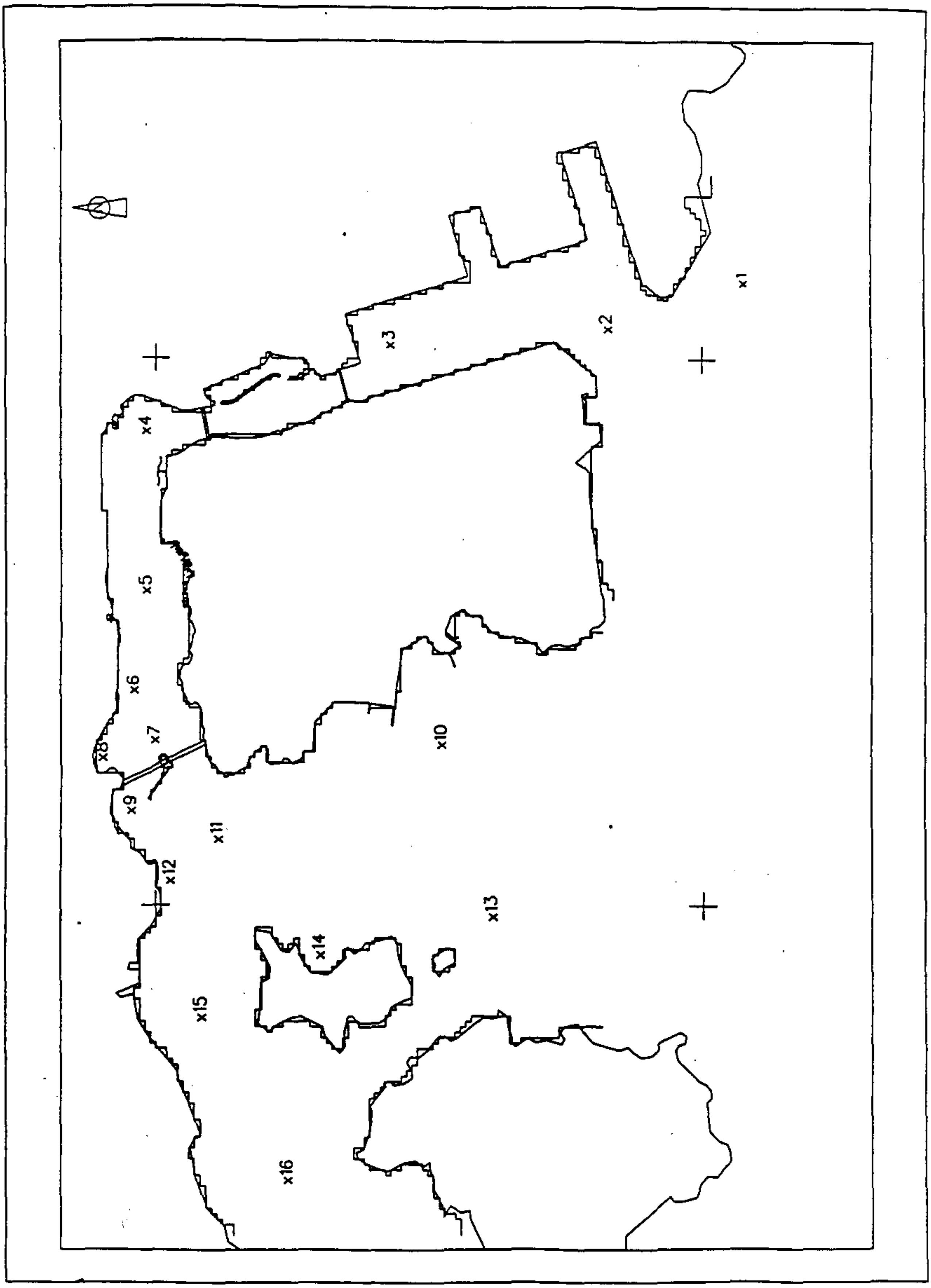
Layout and Bathymetry of the Area Covered by the Model



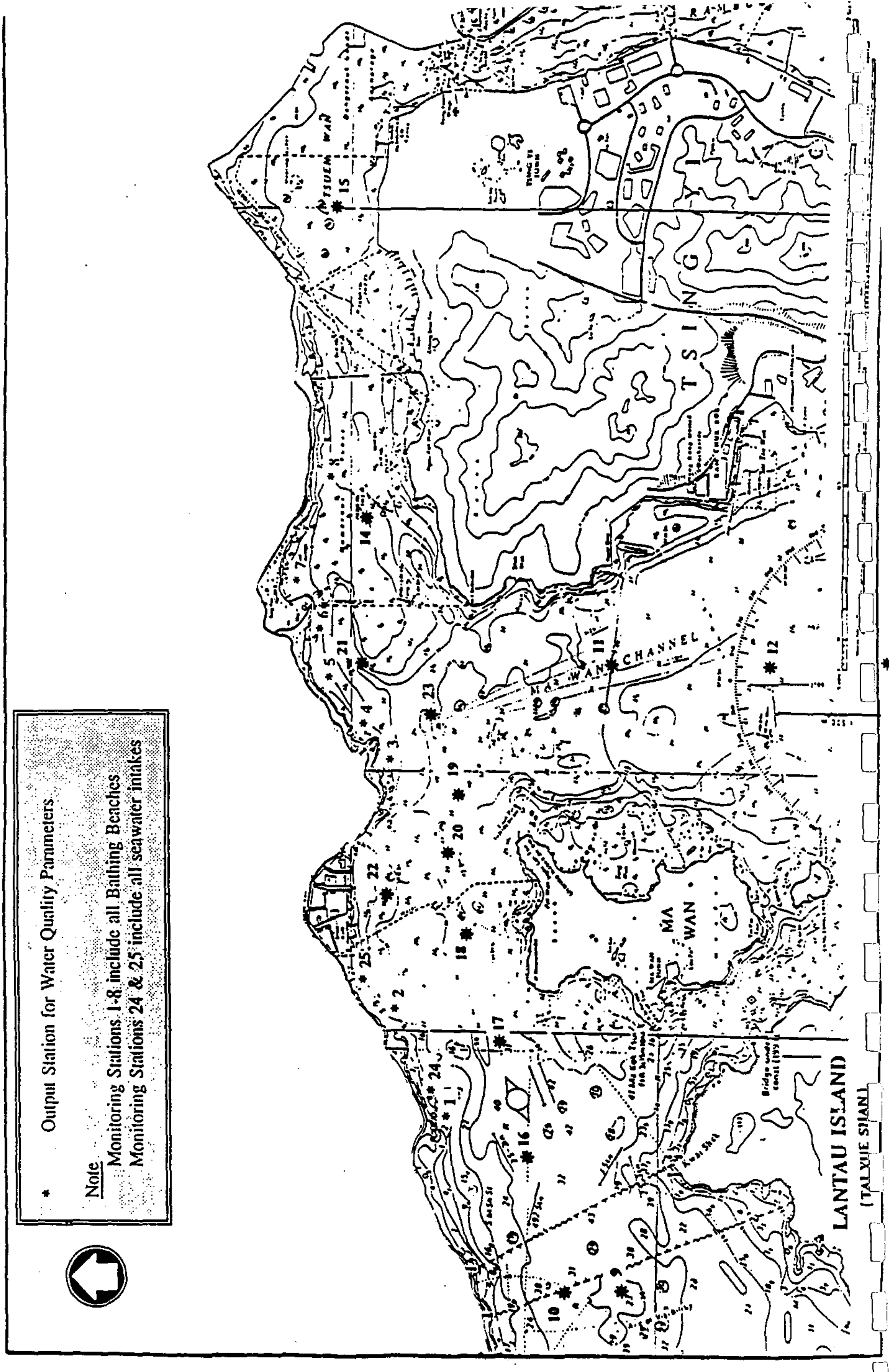
1a Model Location Plan



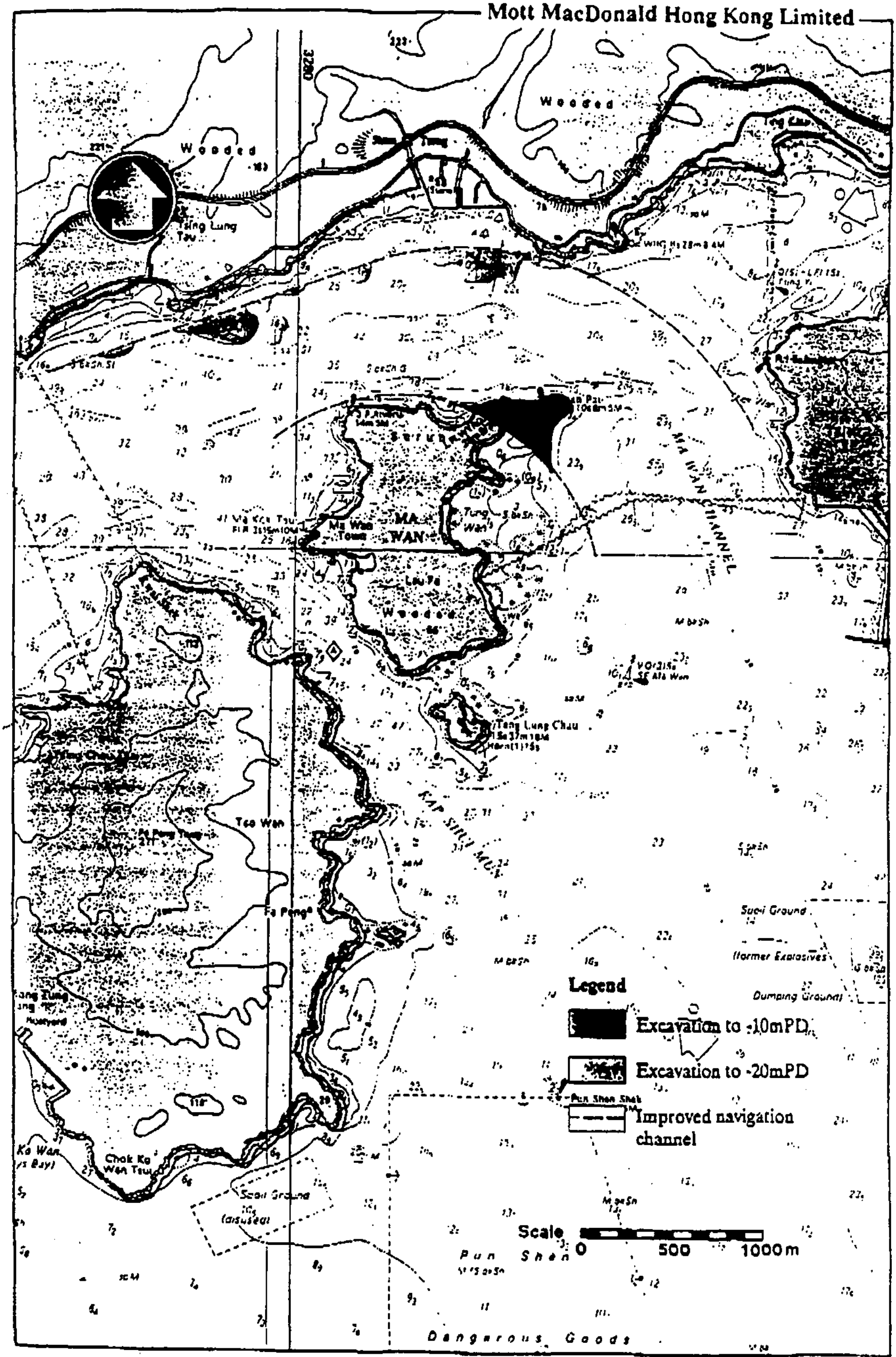
1b Model Bathymetry and Location of Water Velocity Stations A-E



1c Location of Water velocity Stations 1-16



1d Location of Water Quality Monitoring Stations 1-25

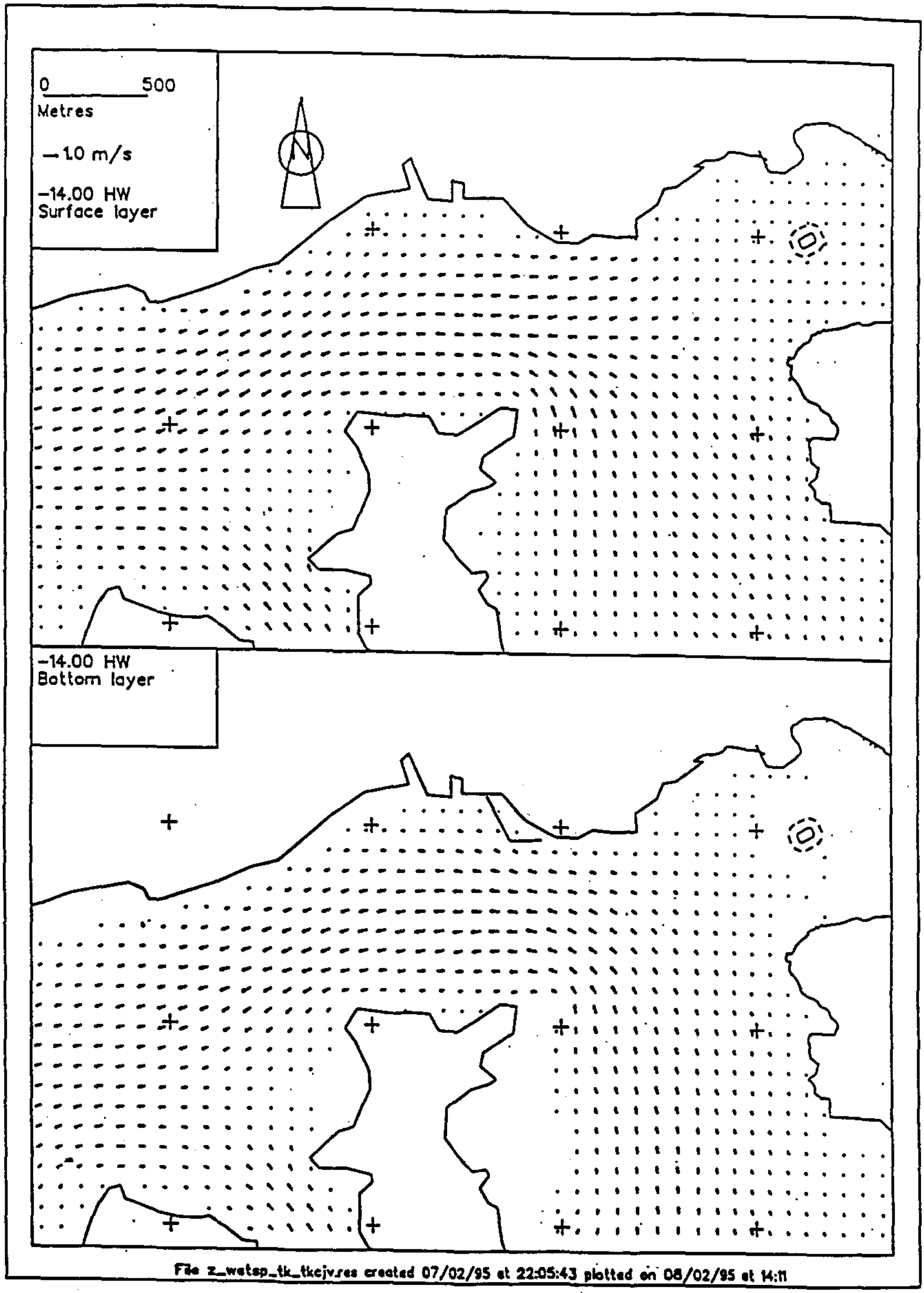


Recommended Scope of Improvements

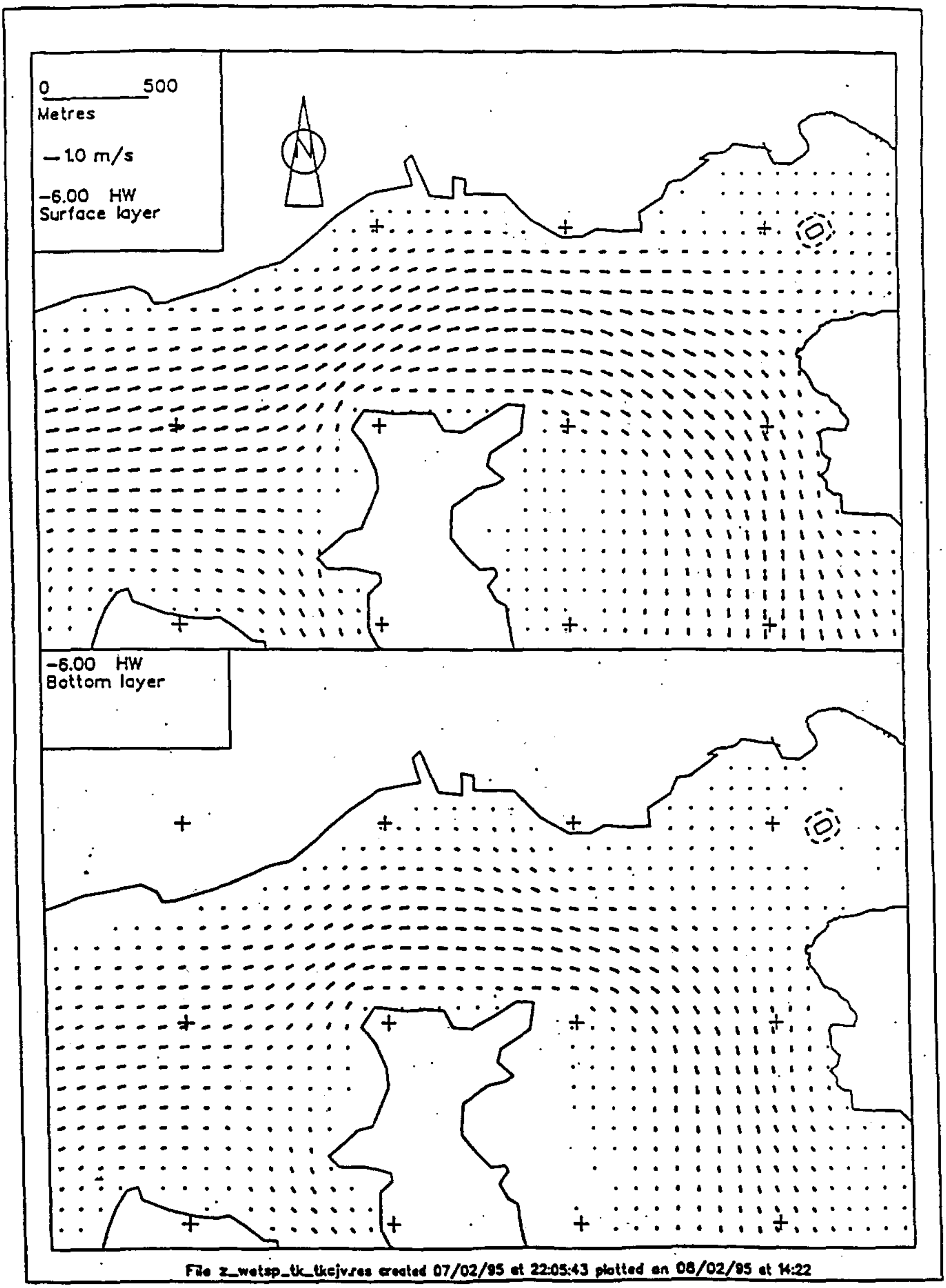
2 Ma Wan Improvement Scheme Dredging

Appendix D

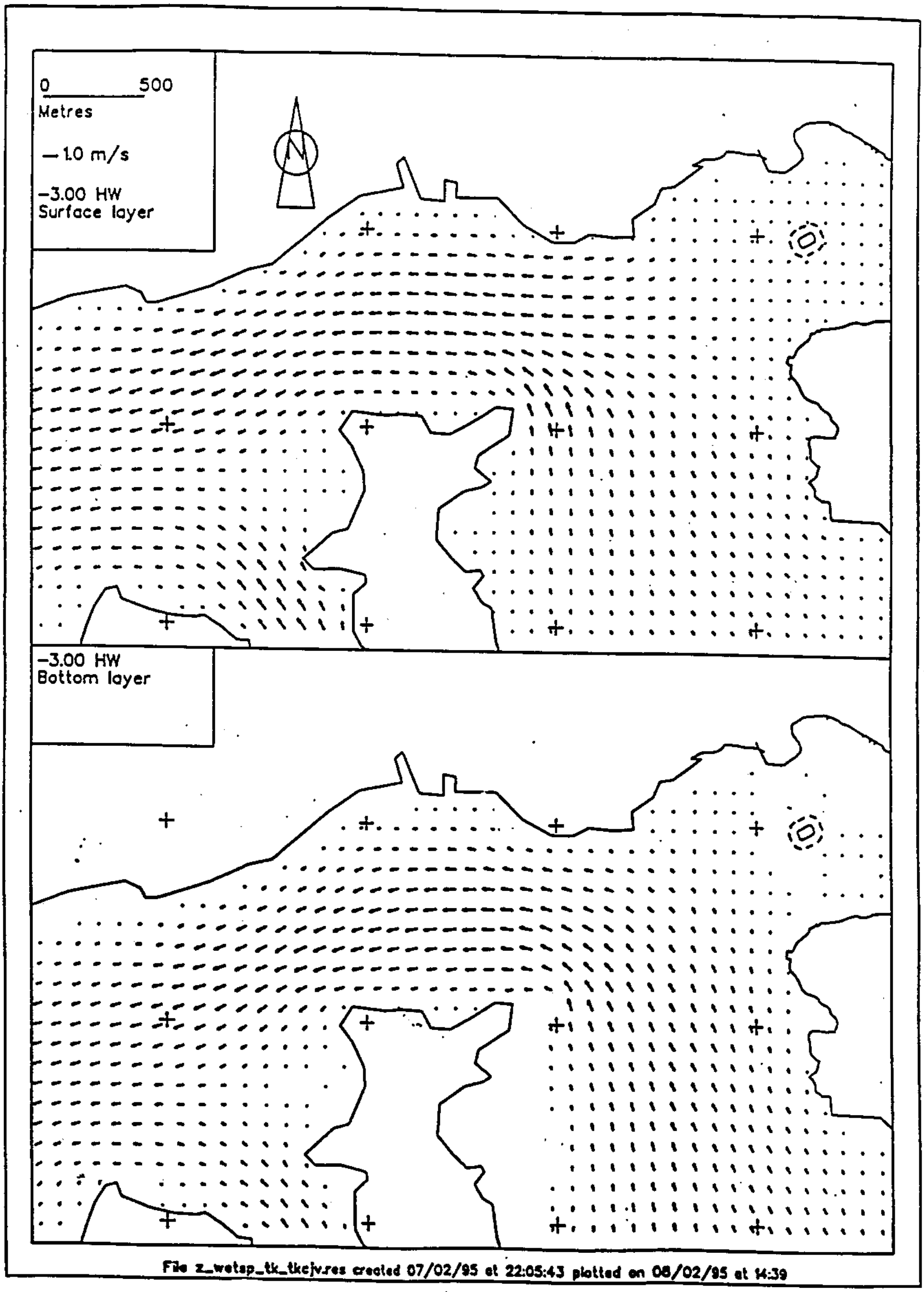
Velocity Vector Plots
Velocity Vs Time Plots
Vector Plots



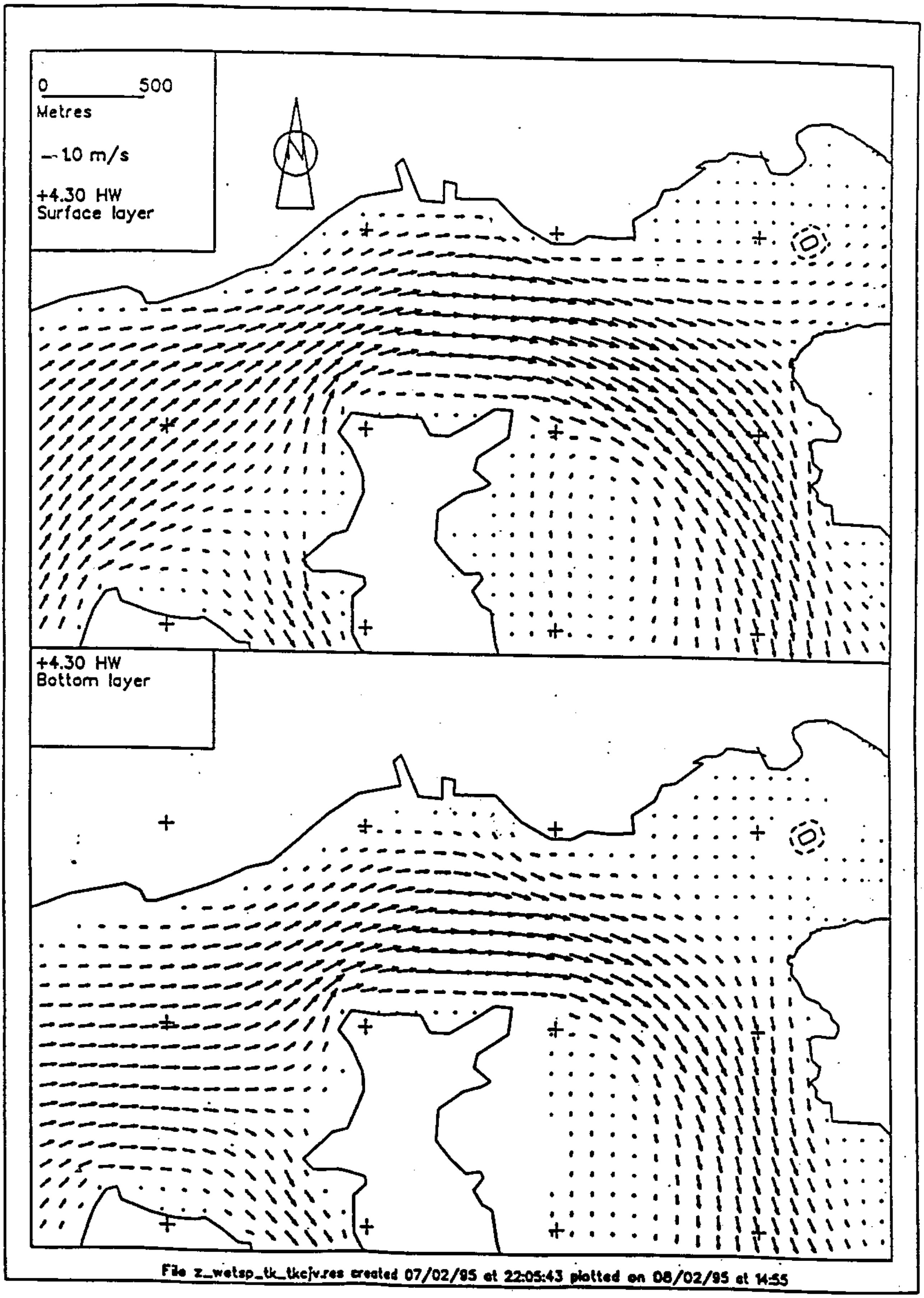
3a Wet Season Spring Tide Velocity Vectors - Base Layout : HW-14 hours



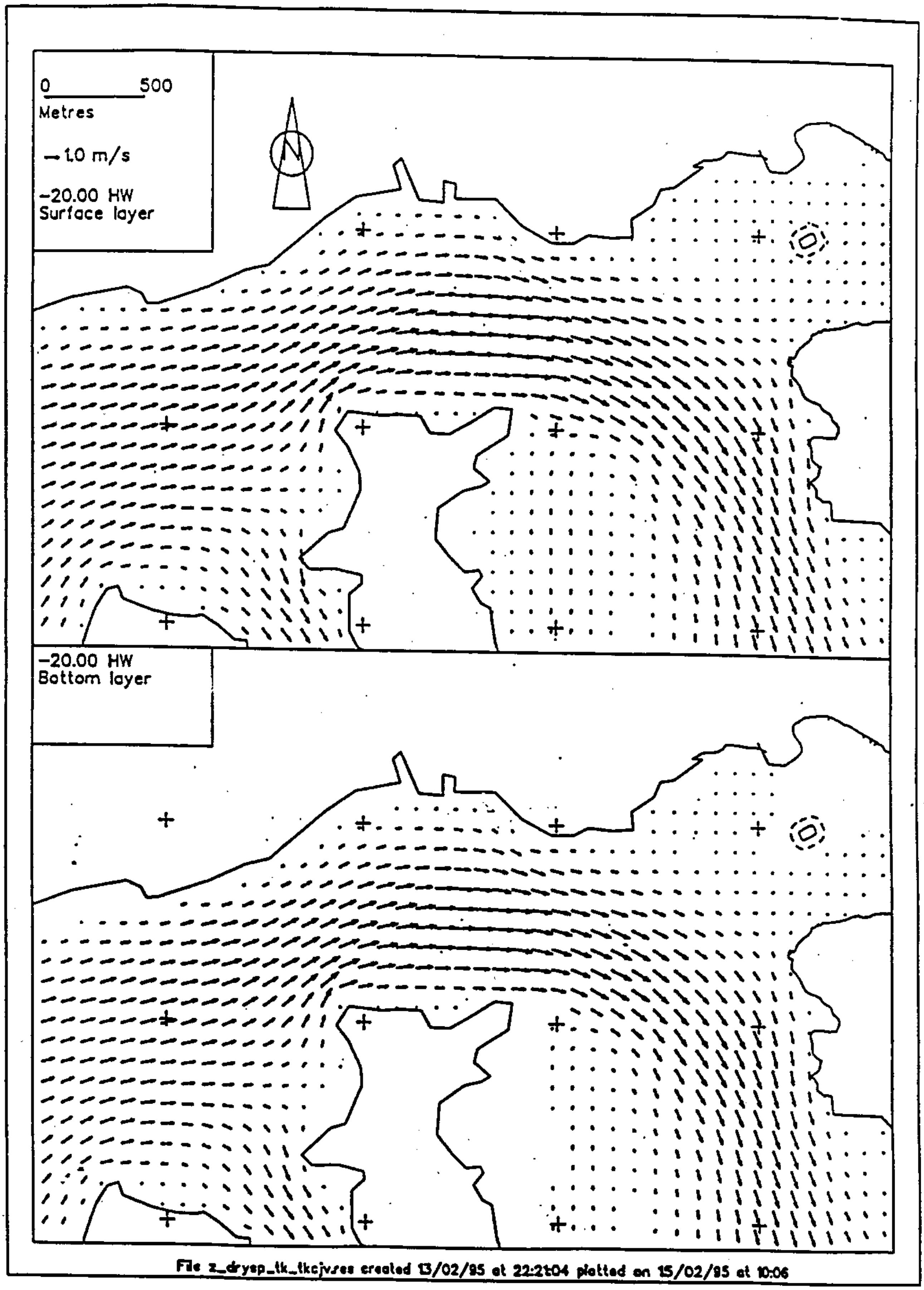
3b Wet Season Spring Tide Velocity Vectors - Base Layout : HW-6 hours



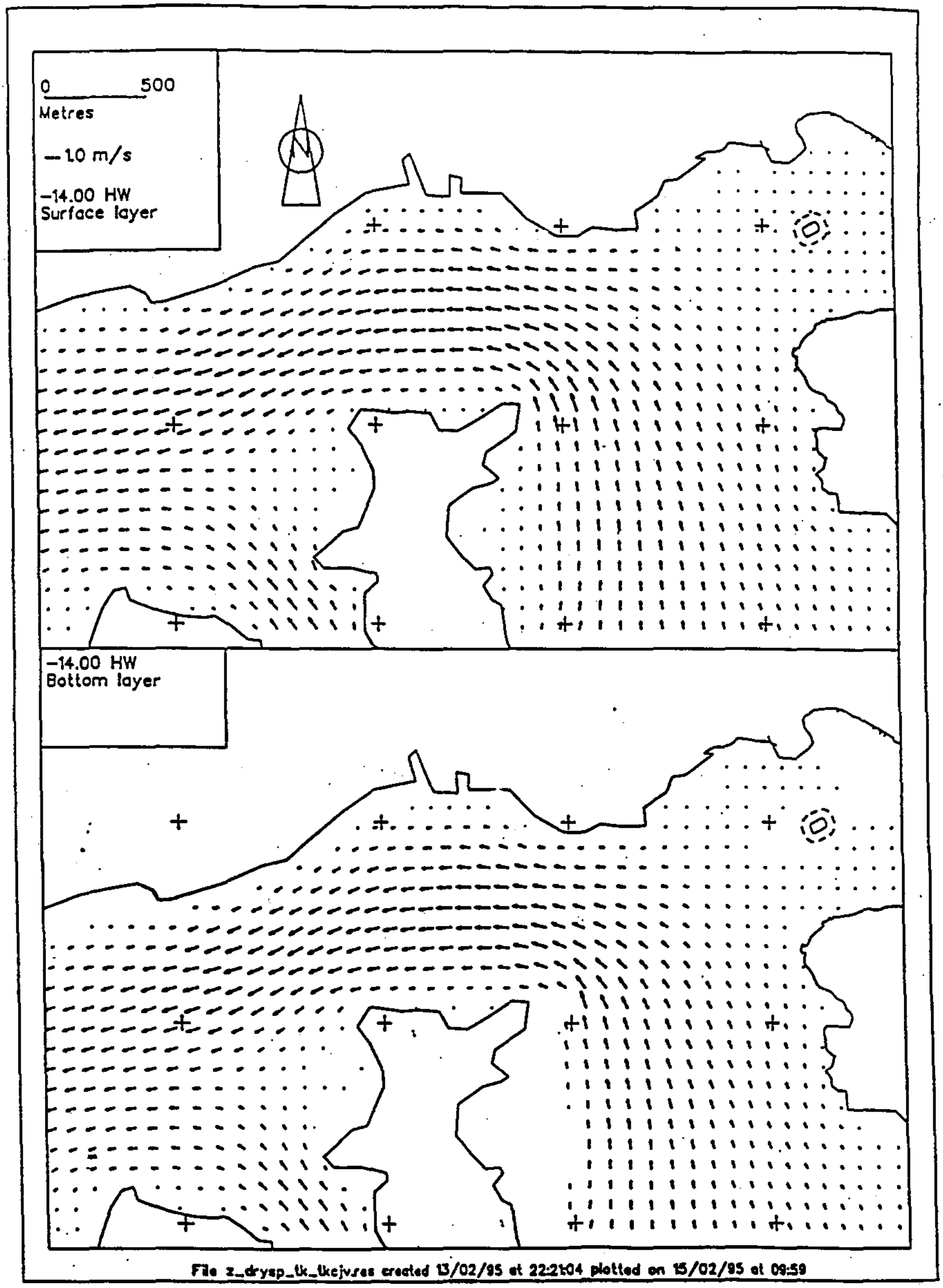
3c Wet Season Spring Tide Velocity Vectors - Base Layout : HW-3 hours



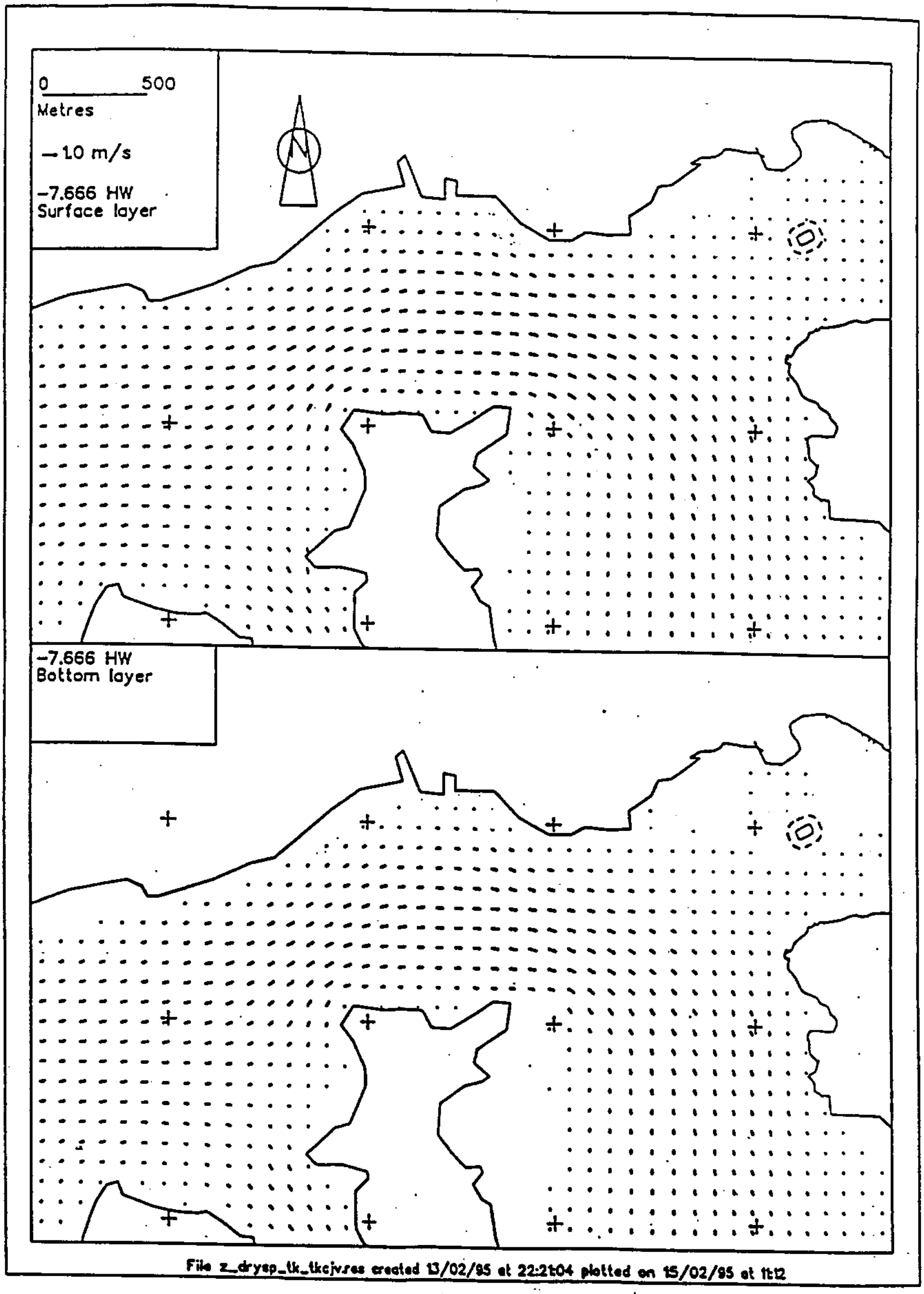
3d Wet Season Spring Tide Velocity Vectors - Base Layout : HW+4.3 ho



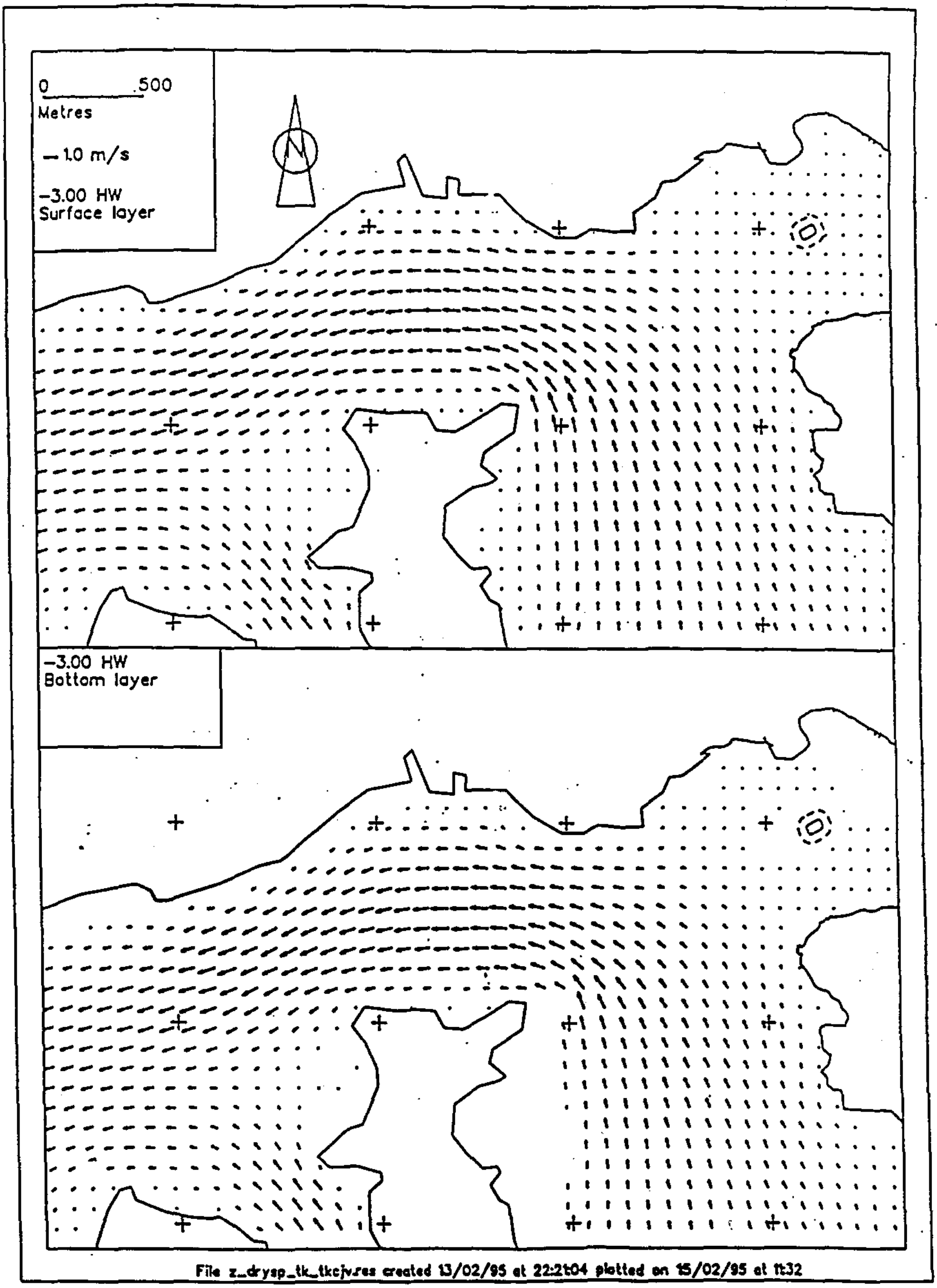
4a Dry Season Spring Tide Velocity Vectors - Base Layout : HW-20 hours



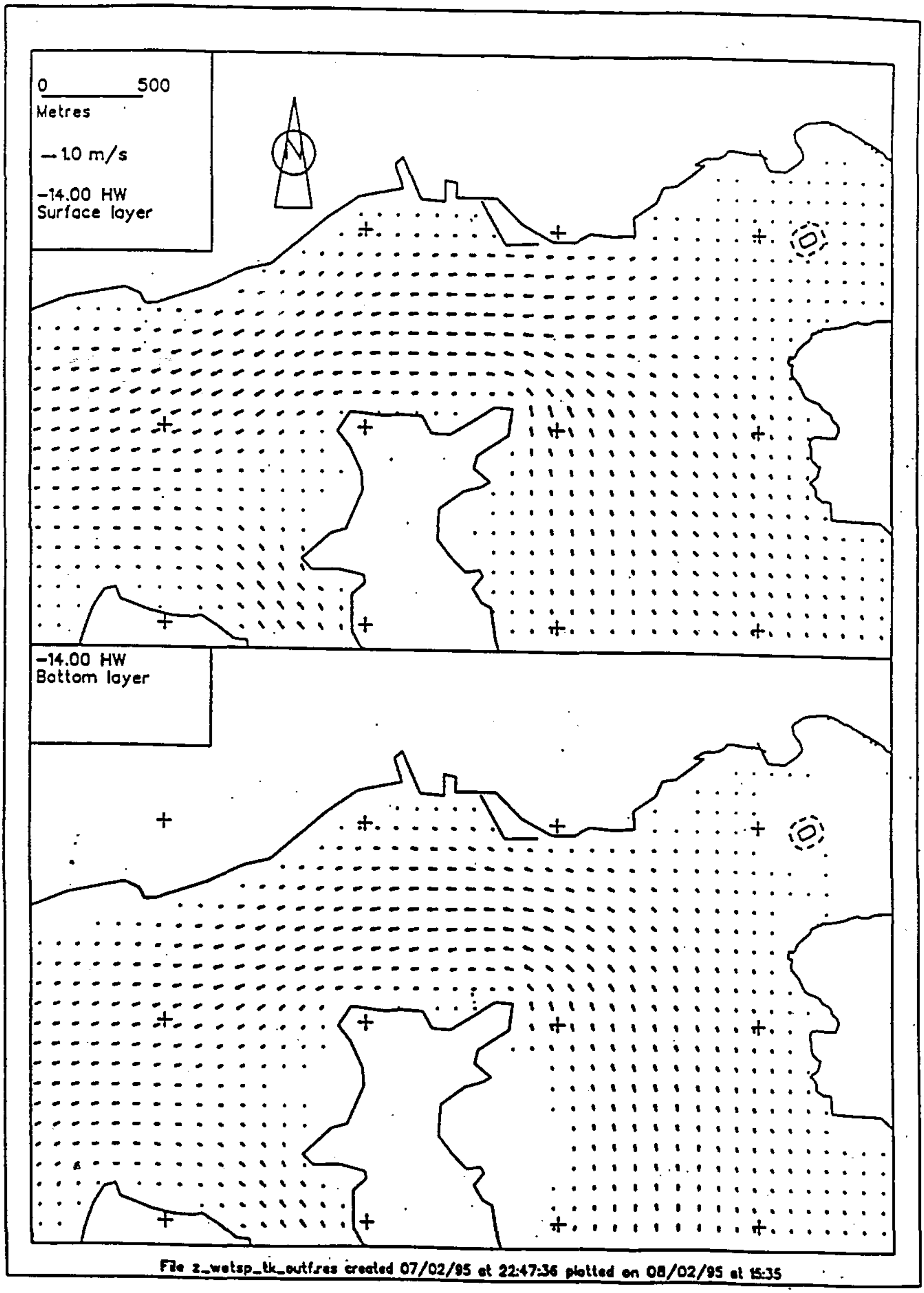
4b Dry Season Spring Tide Velocity Vectors - Base Layout : HW-14 hours



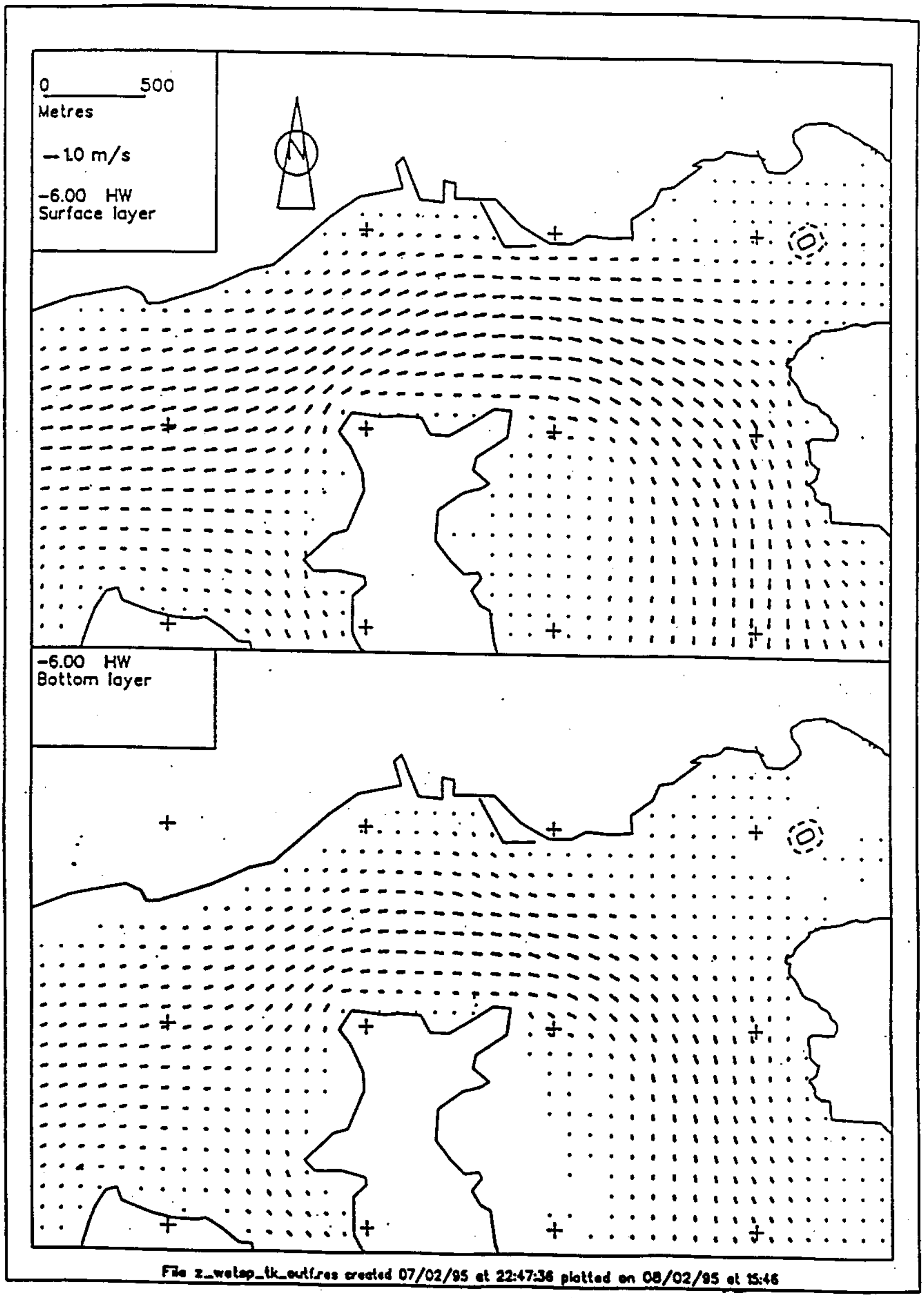
4c Dry Season Spring Tide Velocity Vectors - Base Layout : HW-7.6 hours



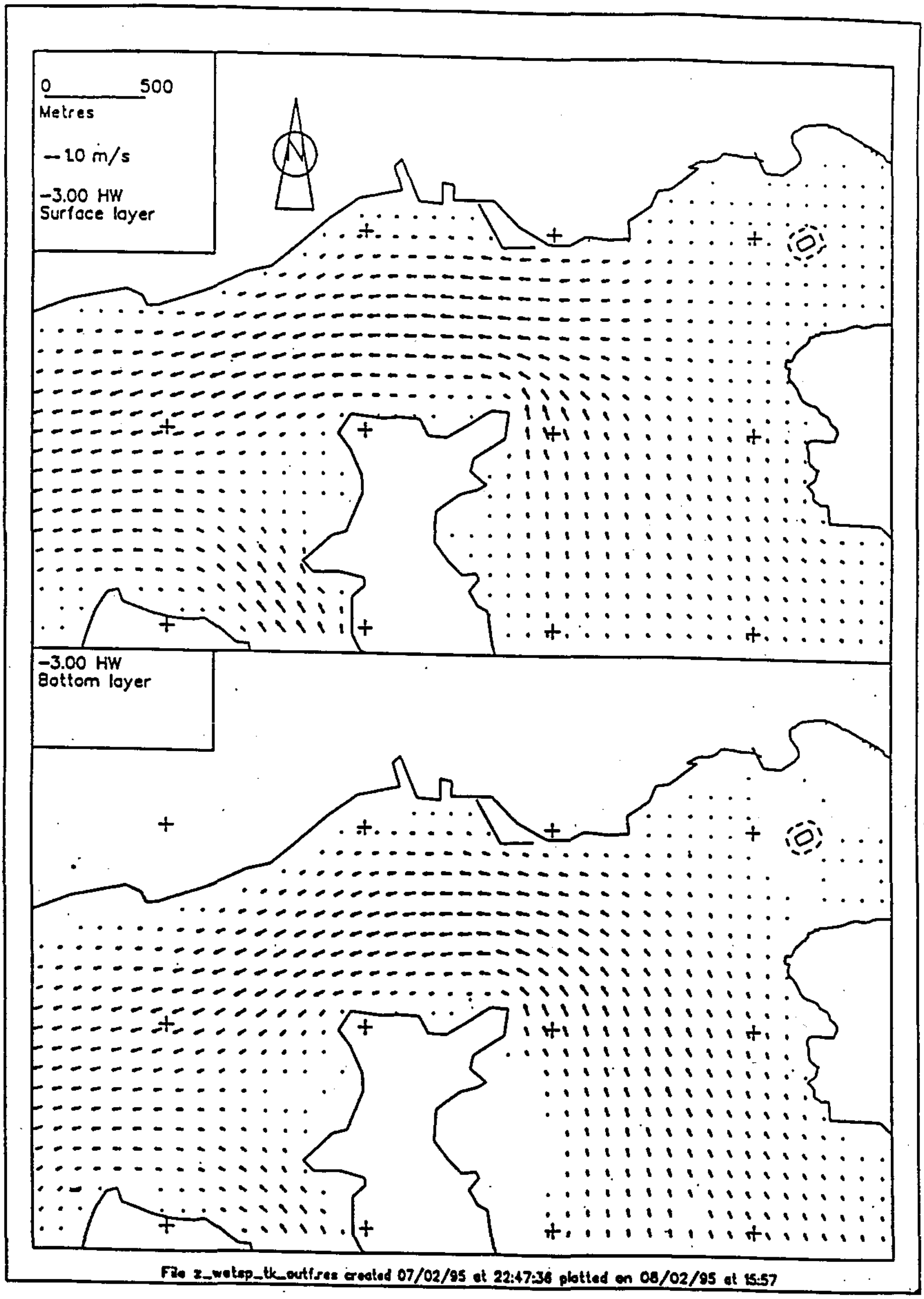
4d Dry Season Spring Tide Velocity Vectors - Base Layout : HW- 3 hours



5a Wet Season Spring Tide Velocity Vectors - Scenario Layout : HW-14 hou



5b Wet Season Spring Tide Velocity Vectors - Scenario Layout : HW-6 hour



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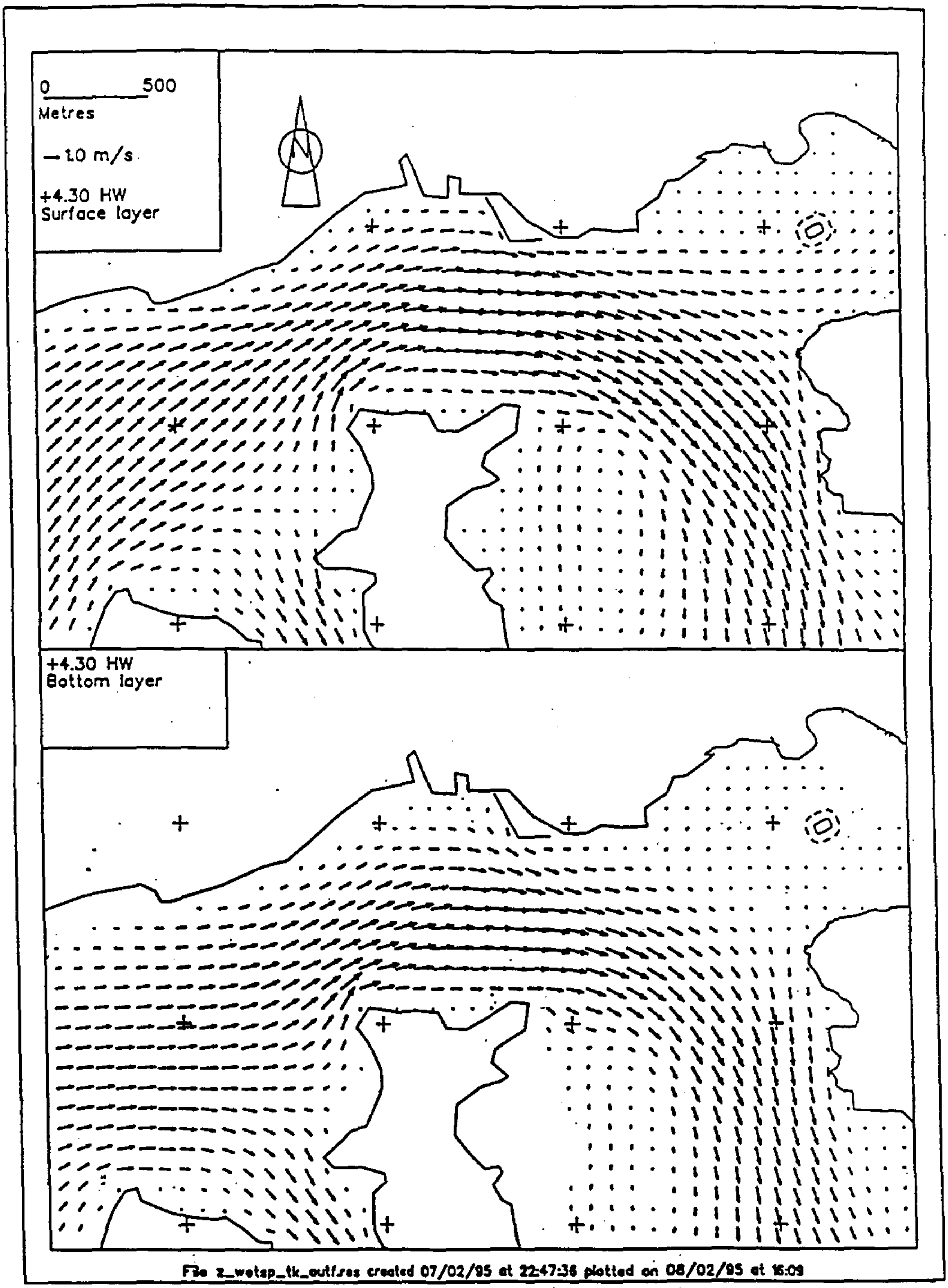
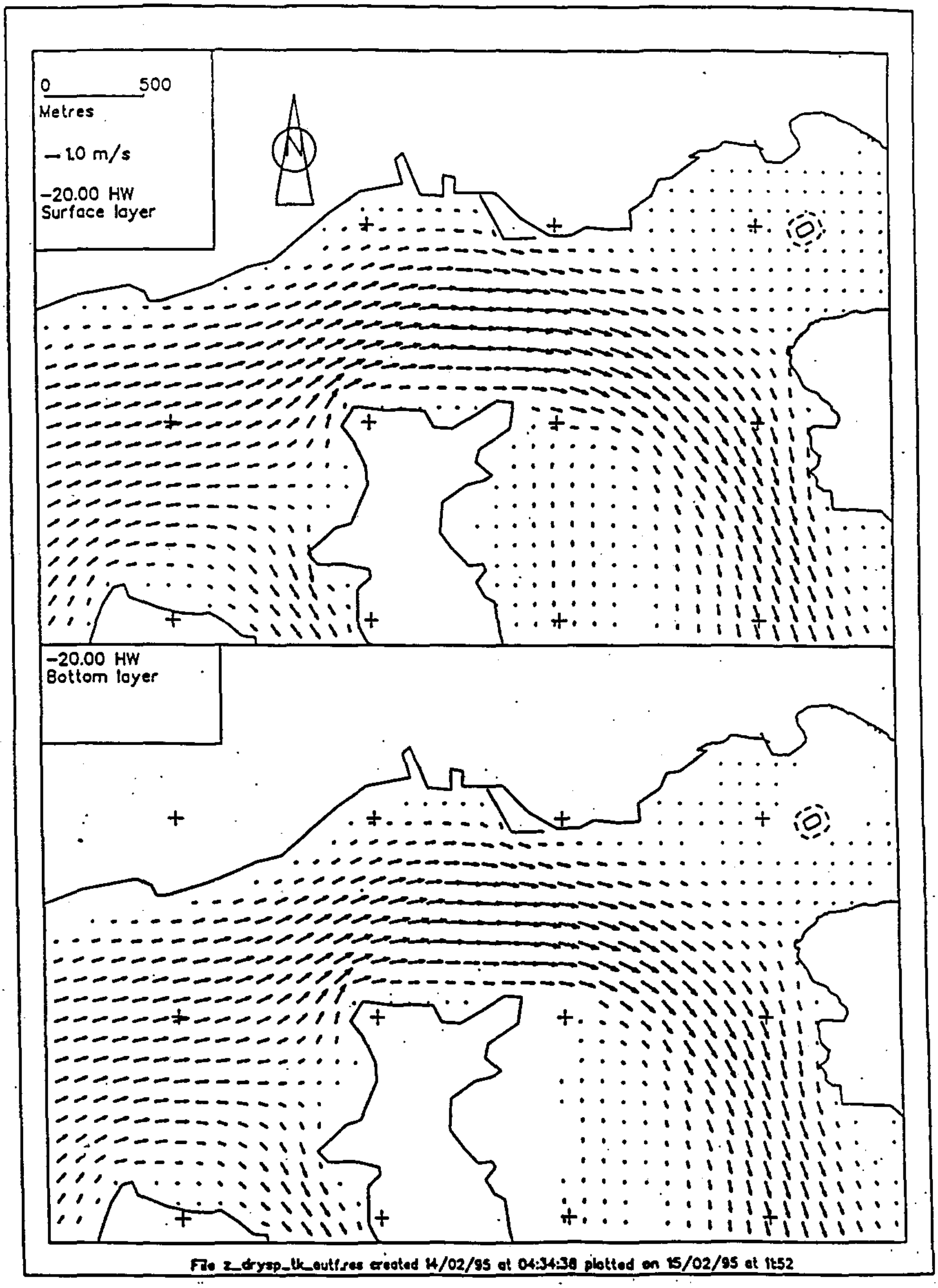
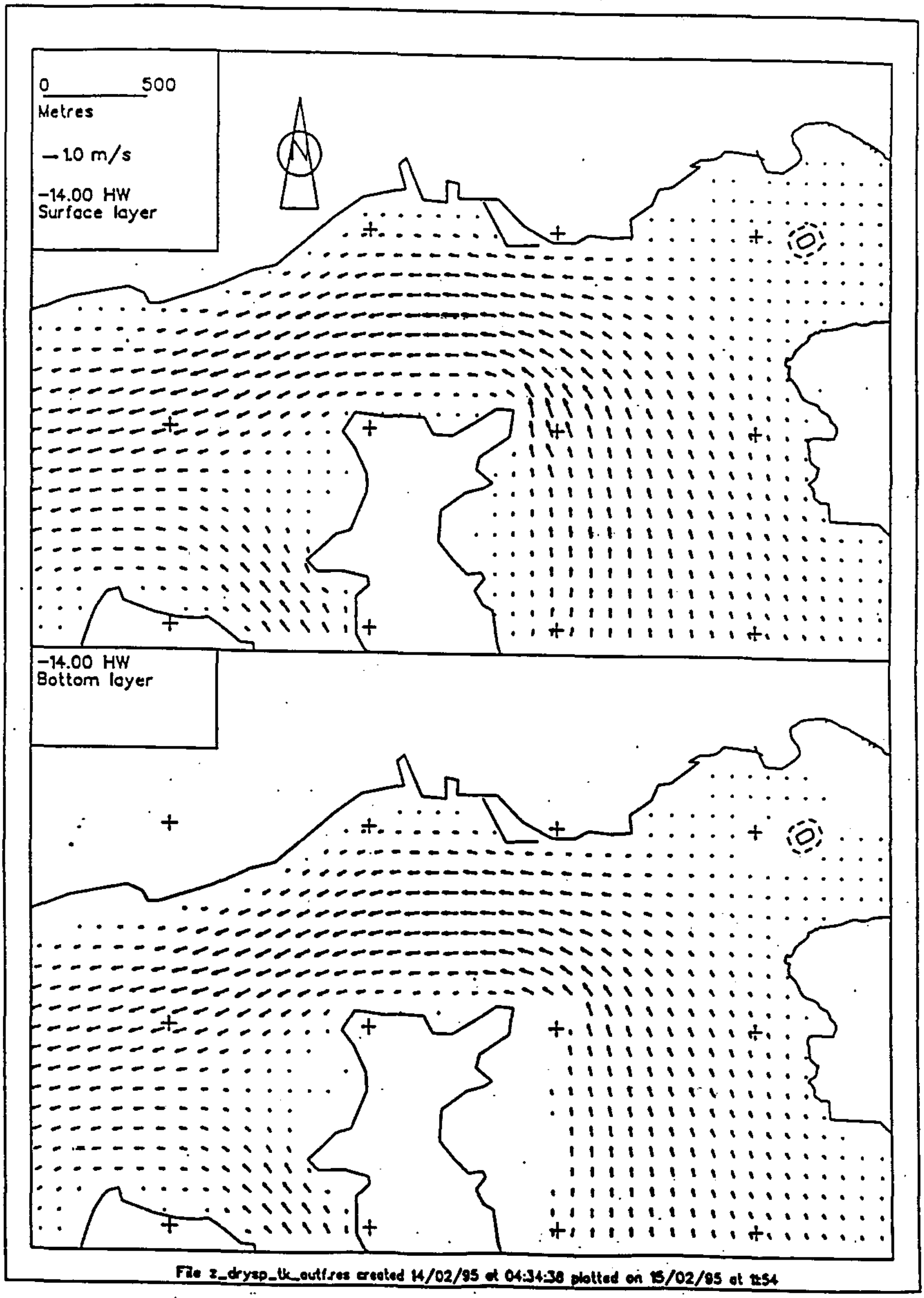


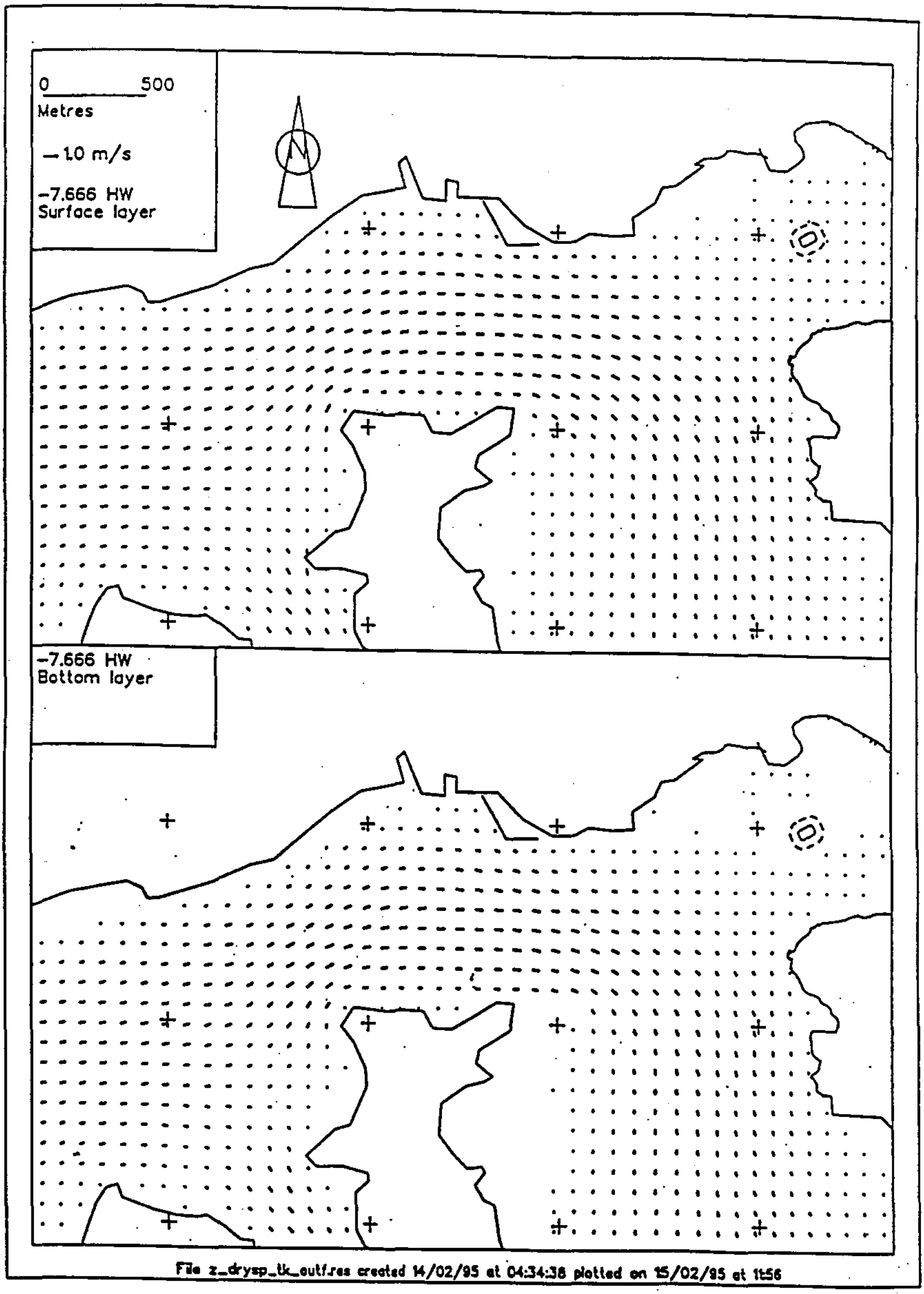
5d Wet Season Spring Tide Velocity Vectors - Scenario Layout : HW+4.3 h



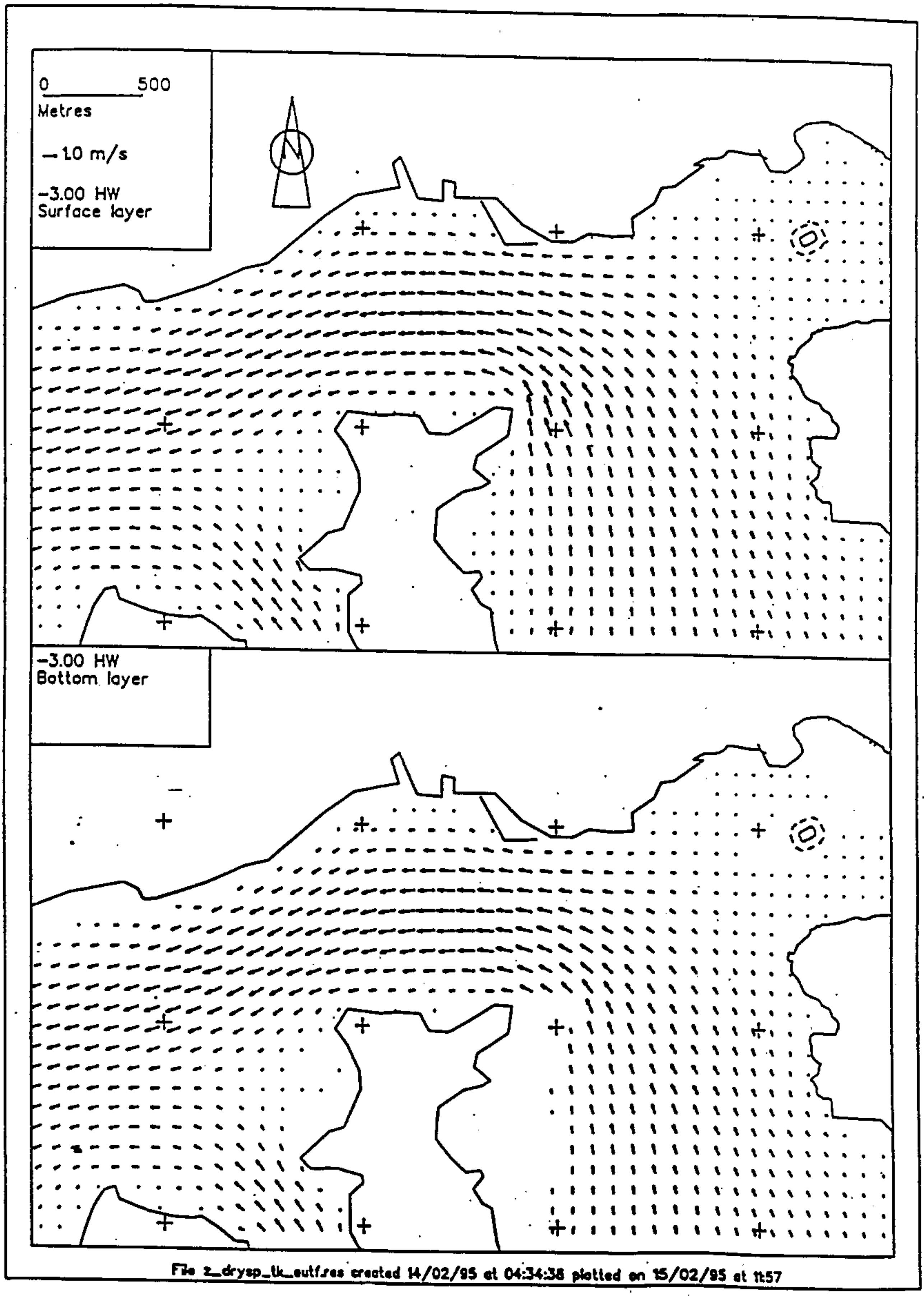
6a Dry Season Spring Tide Velocity Vectors - Scenario Layout : HW-20 hours



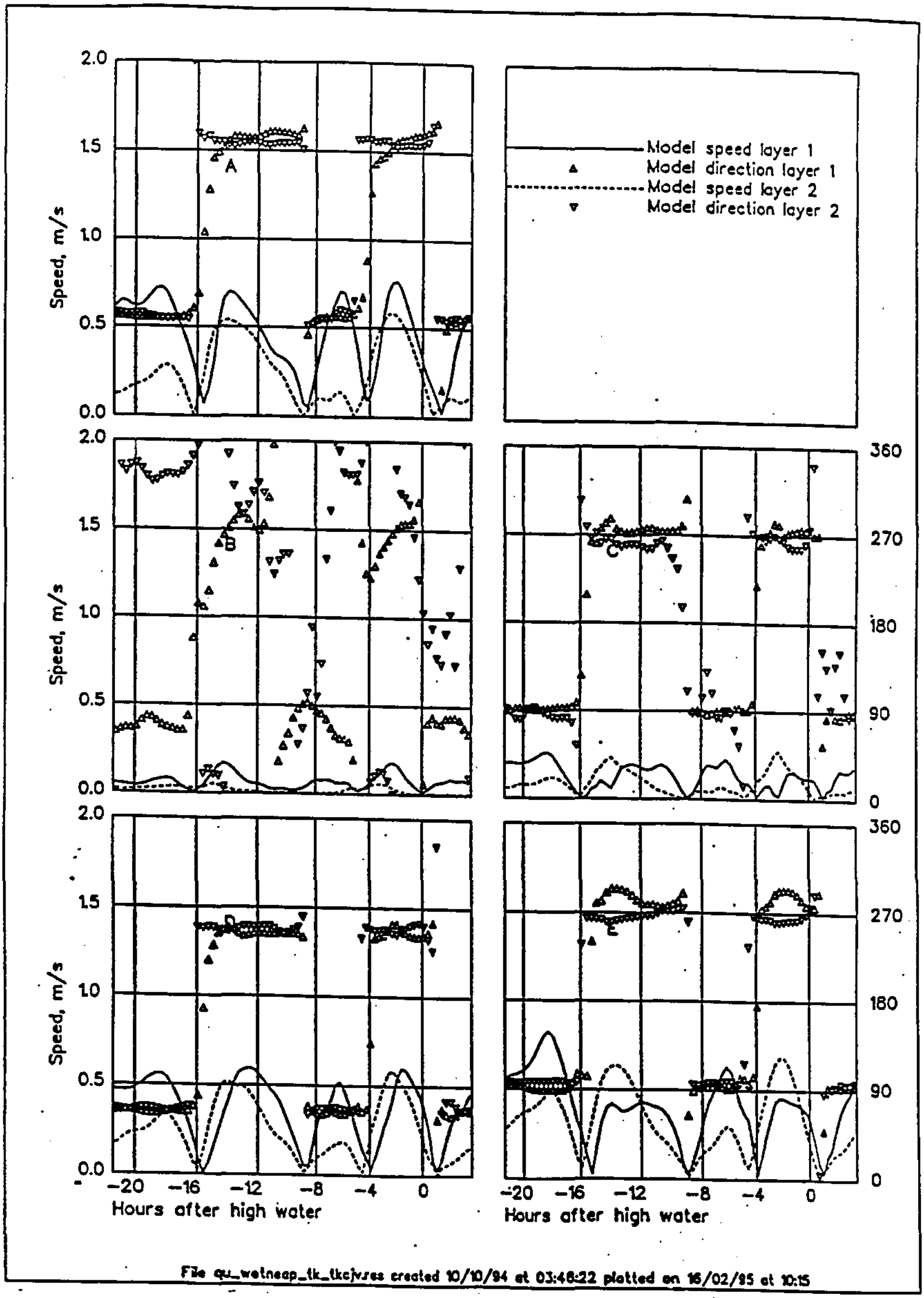
6b Dry Season Spring Tide Velocity Vectors - Scenario Layout : HW-14 hou



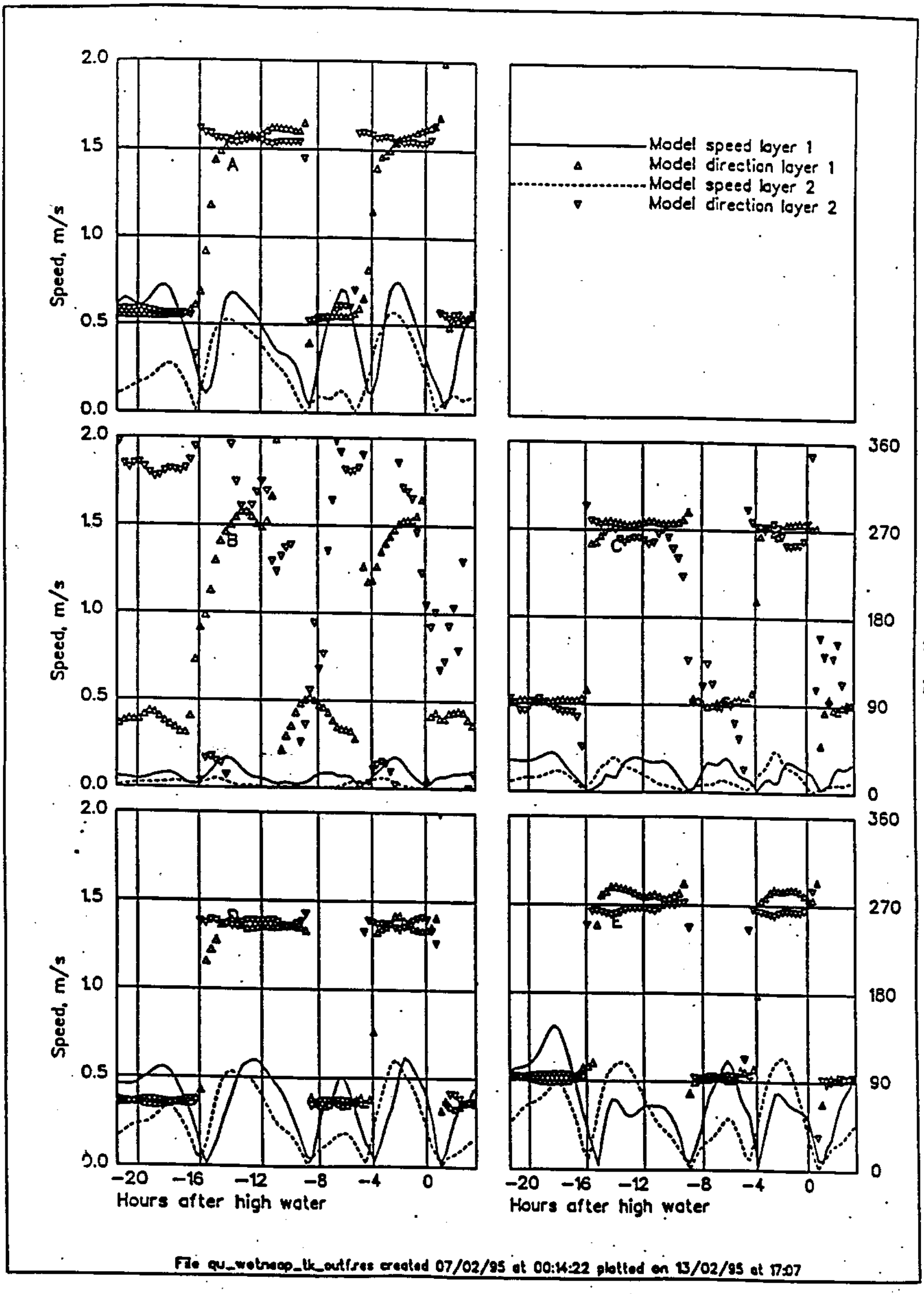
6c Dry Season Spring Tide Velocity Vectors - Scenario Layout : HW-7.6 hour



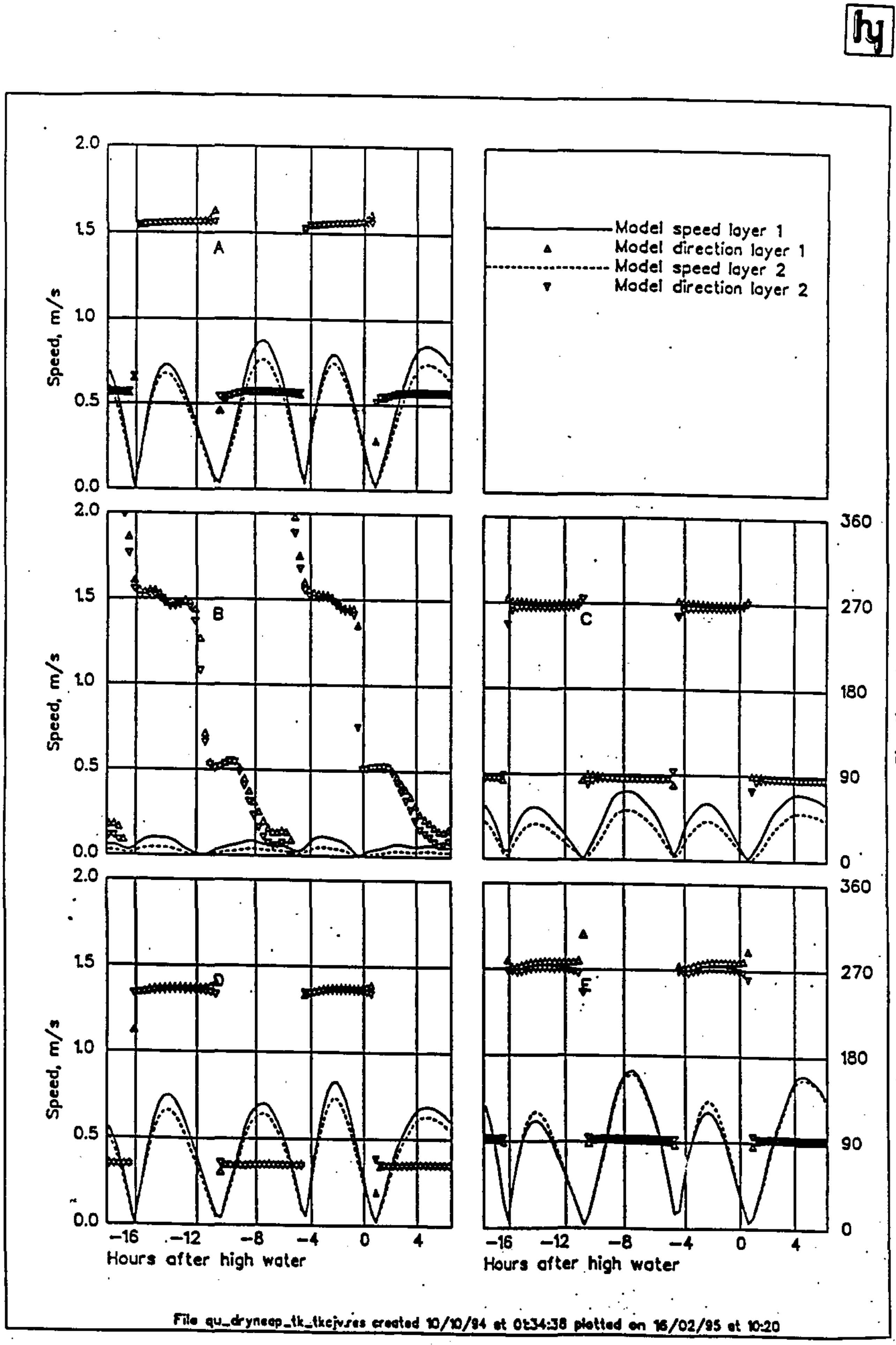
6d Dry Season Spring Tide Velocity Vectors - Scenario Layout : HW- 3 hou



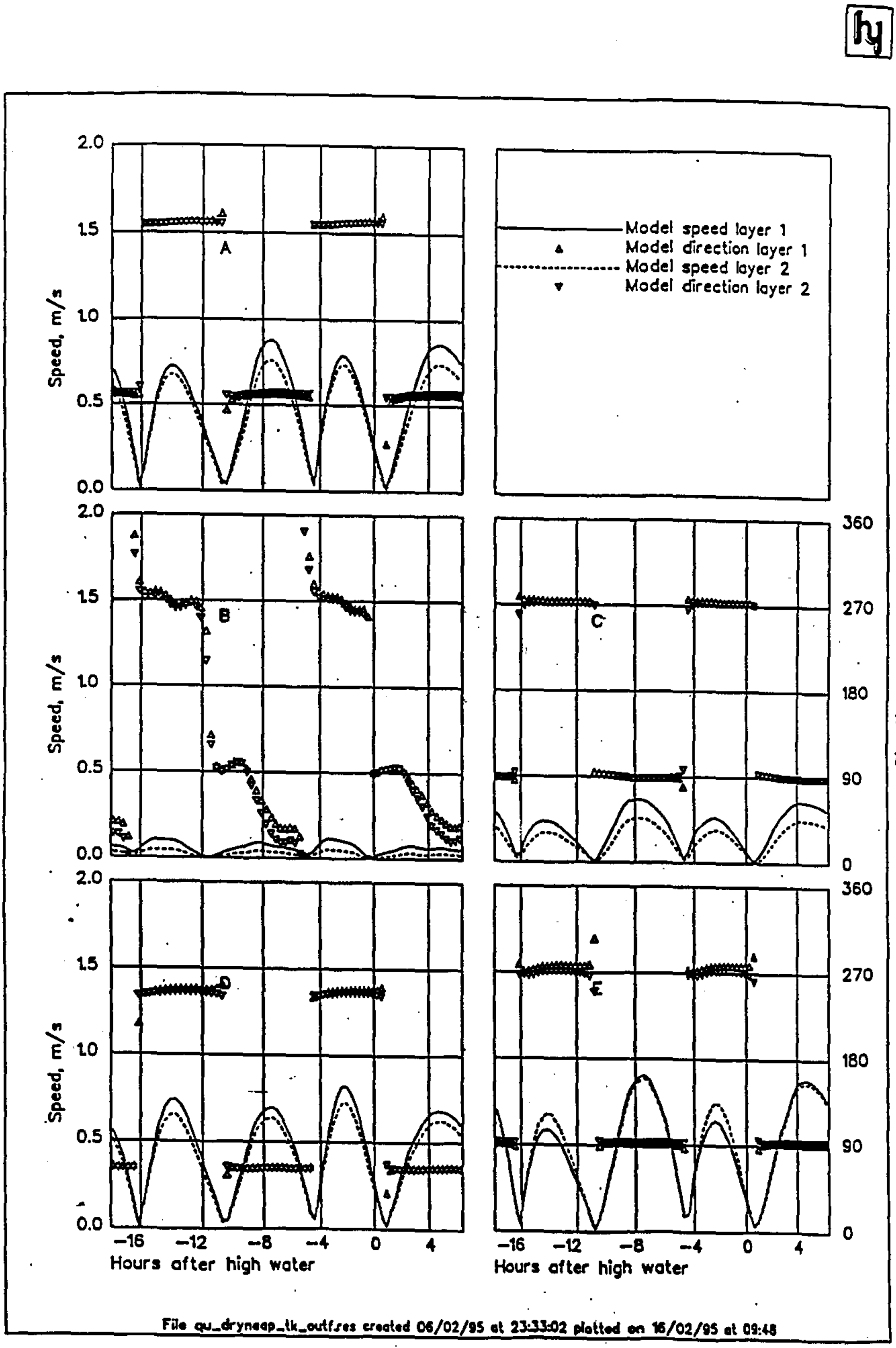
7a Water Velocities, Stations A-E, Wet Season Neap Tide, Base Layout



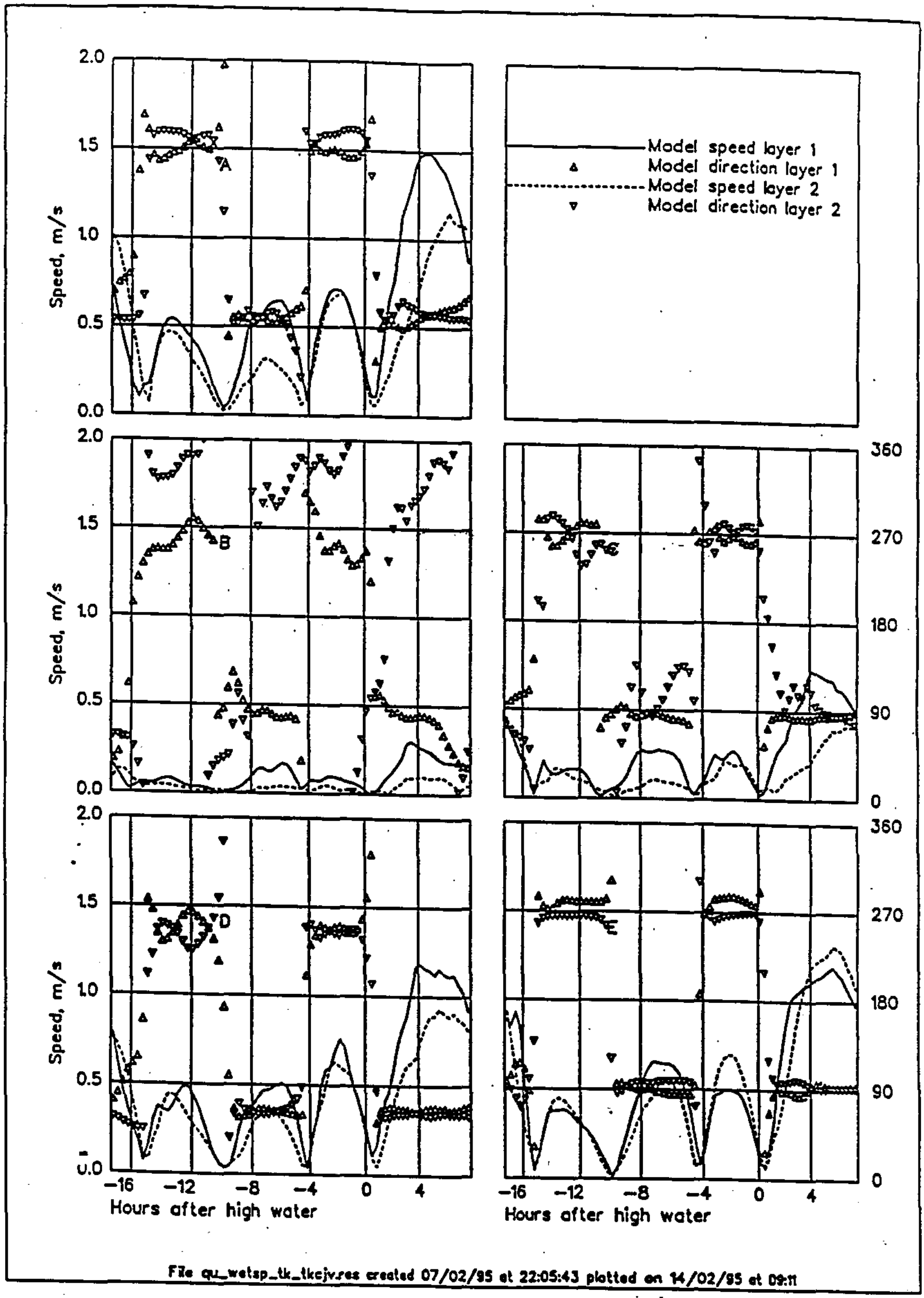
7b Water Velocities, Stations A-E, Wet Season Neap Tide, Scenario Layout



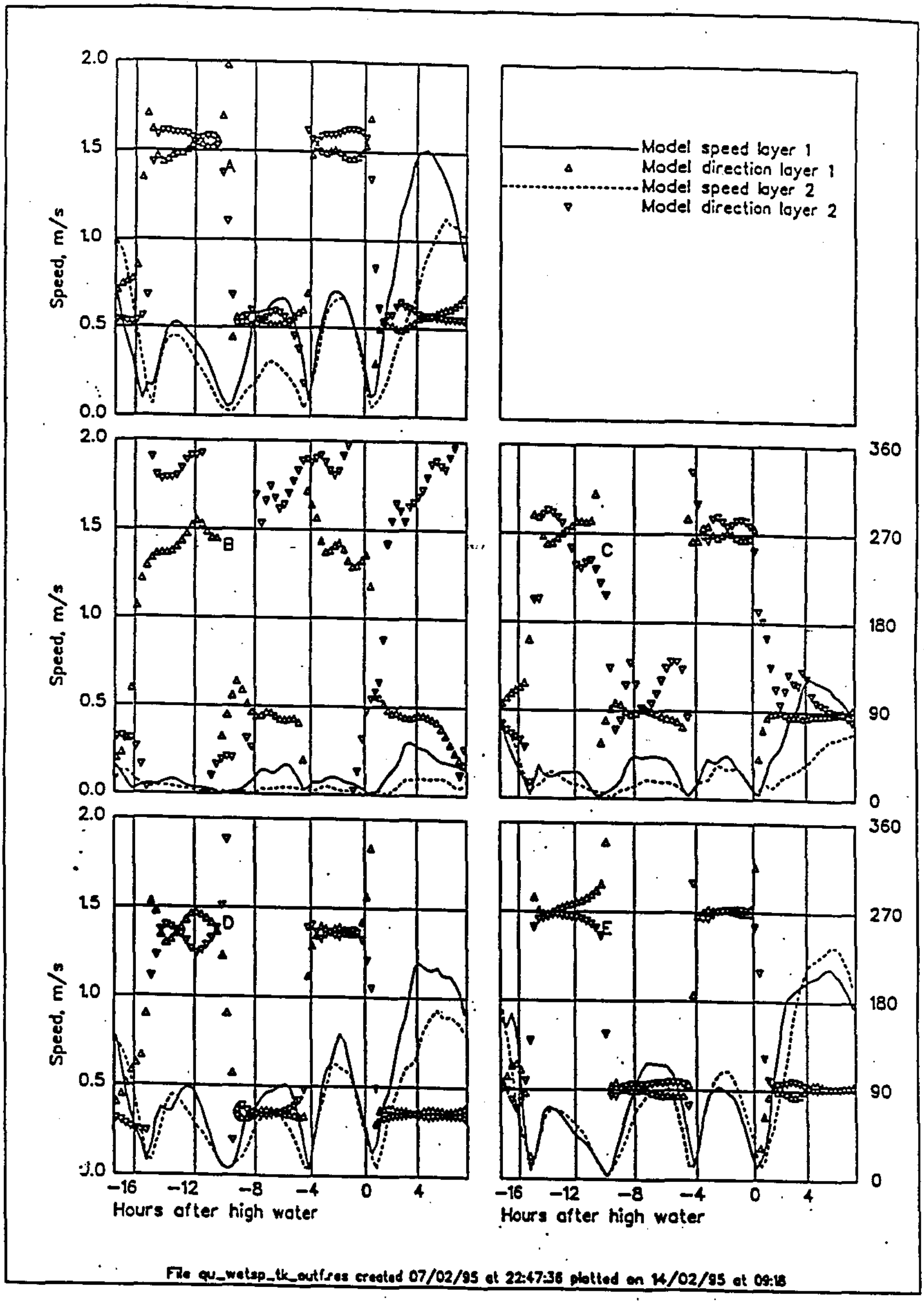
8a Water Velocities, Stations A-E, Dry Season Neap Tide, Base Layout



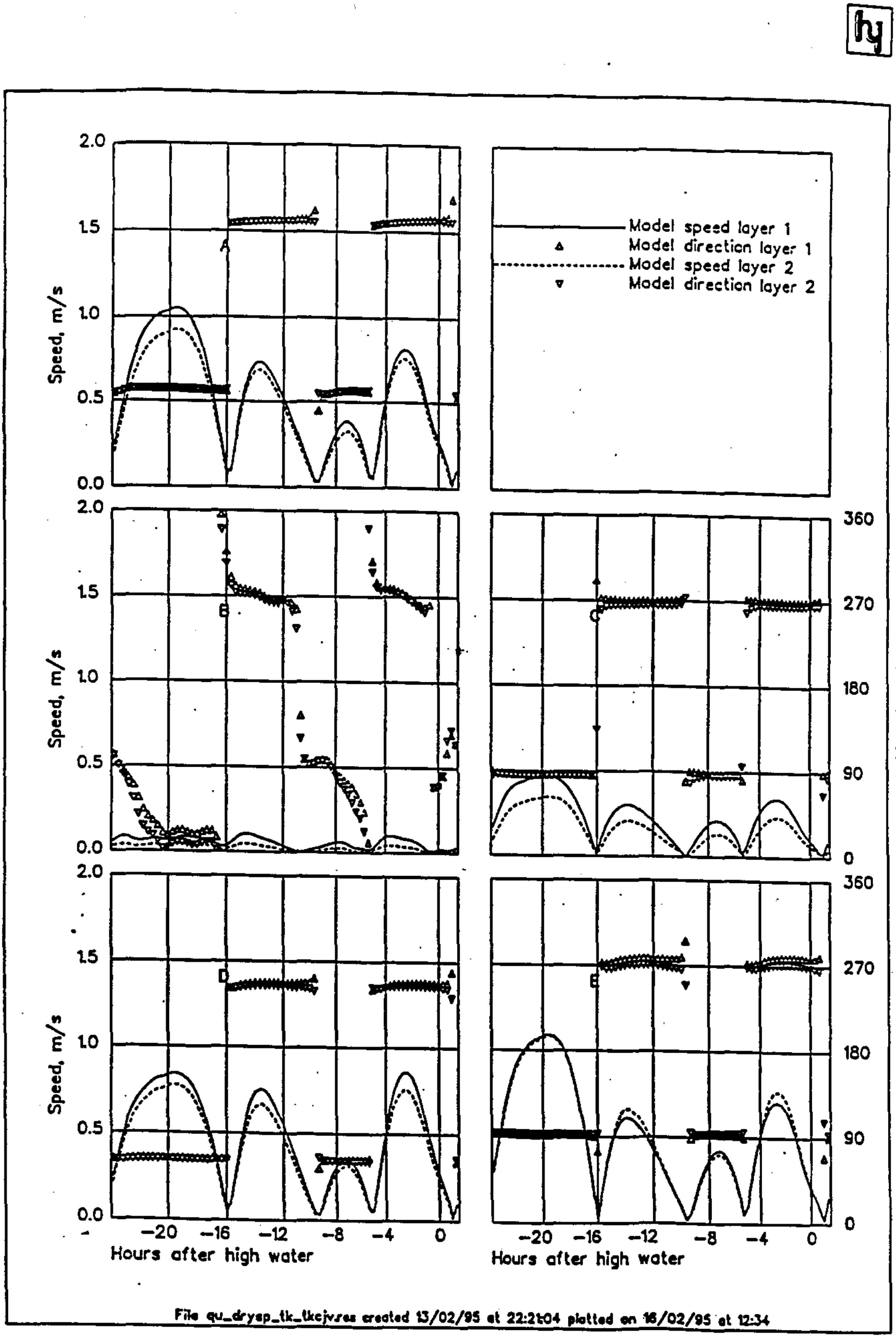
8b Water Velocities, Stations A-E, Dry Season Neap Tide, Scenario Layout



9a Water Velocities, Stations A-E, Wet Season Spring Tide, Base Layout



9b Water Velocities, Stations A-E, Wet Season Spring Tide, Scenario Layou



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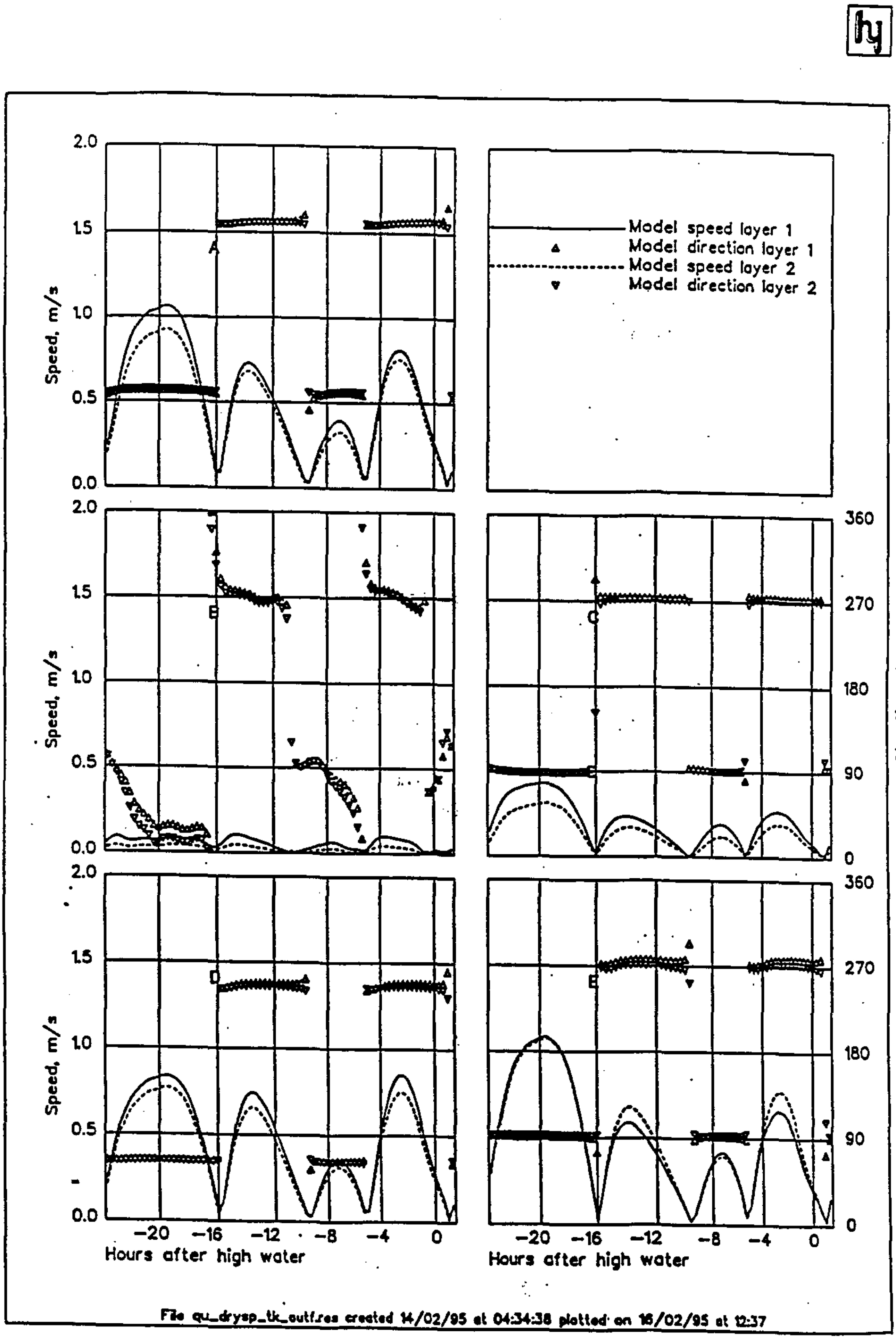
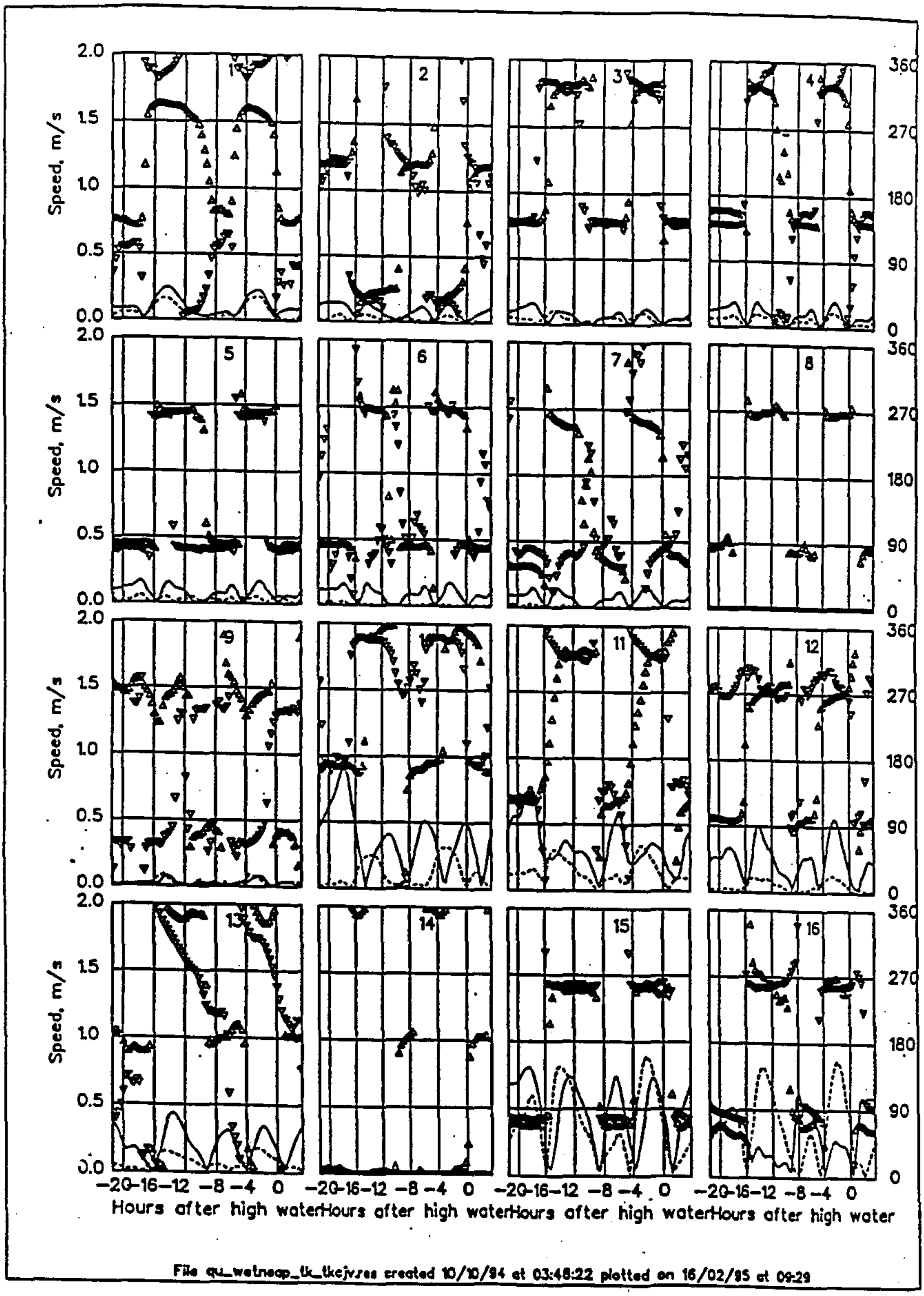
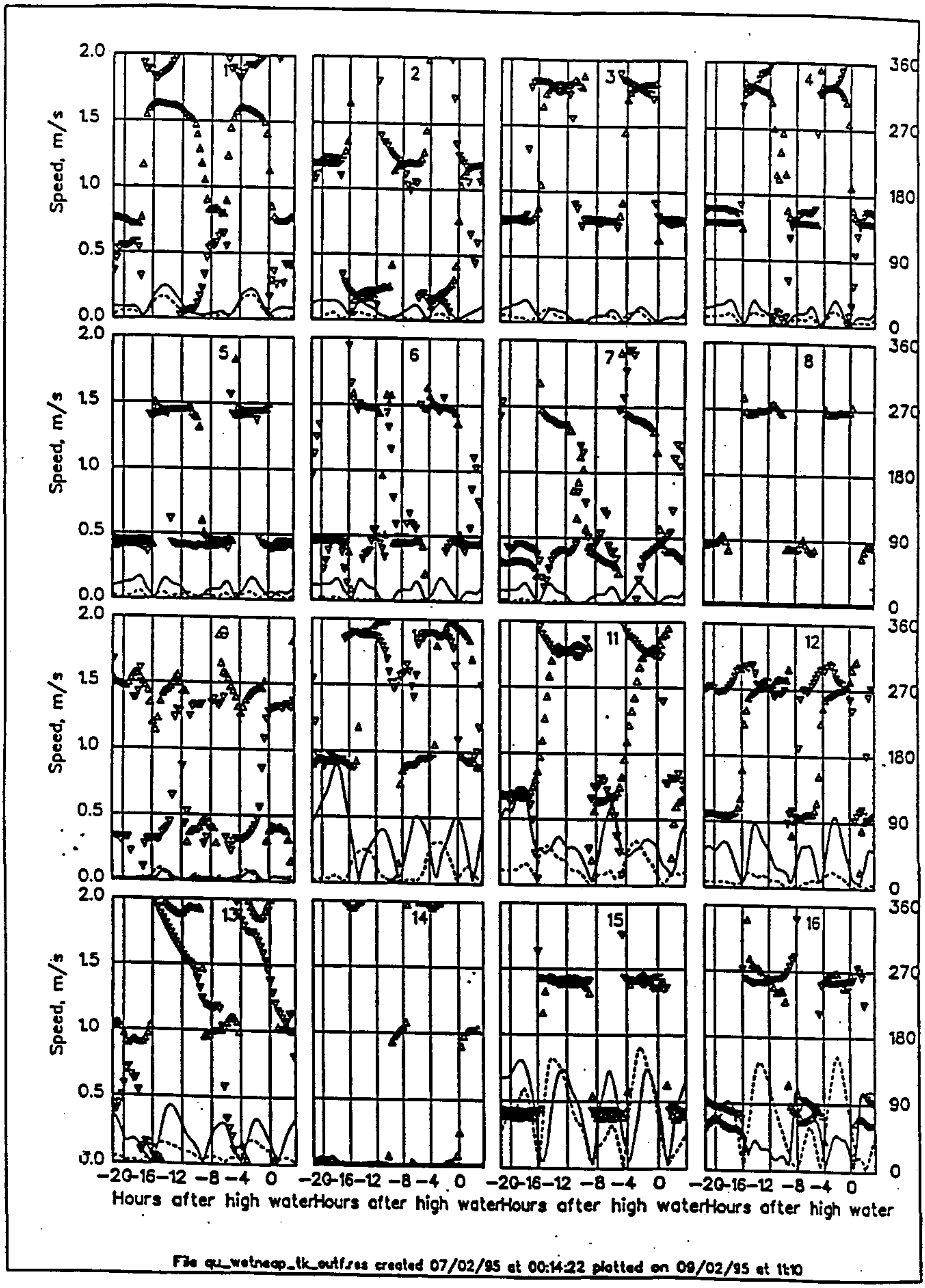


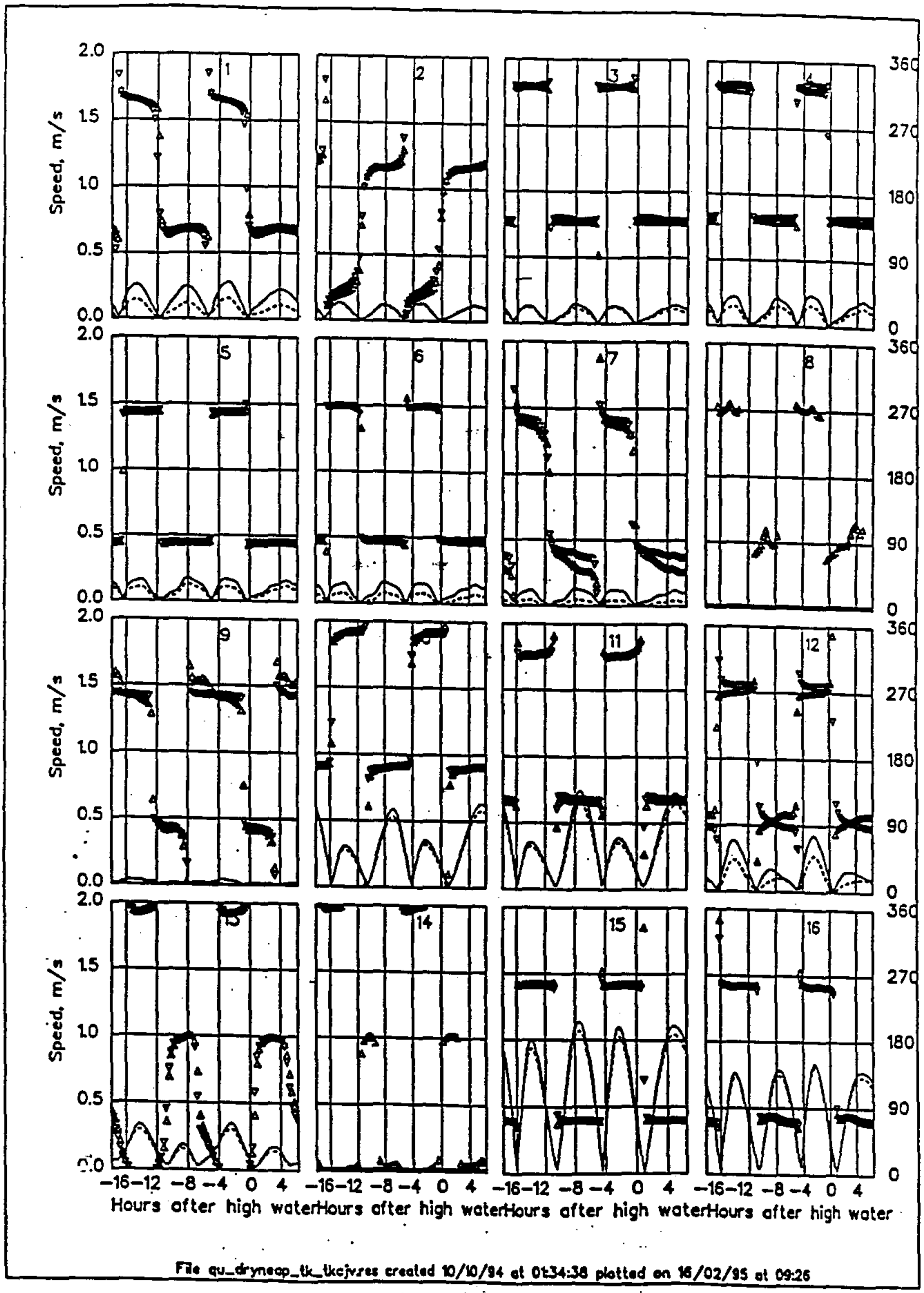
10b Water Velocities, Stations A-E, Dry Season Spring Tide, Scenario Layout



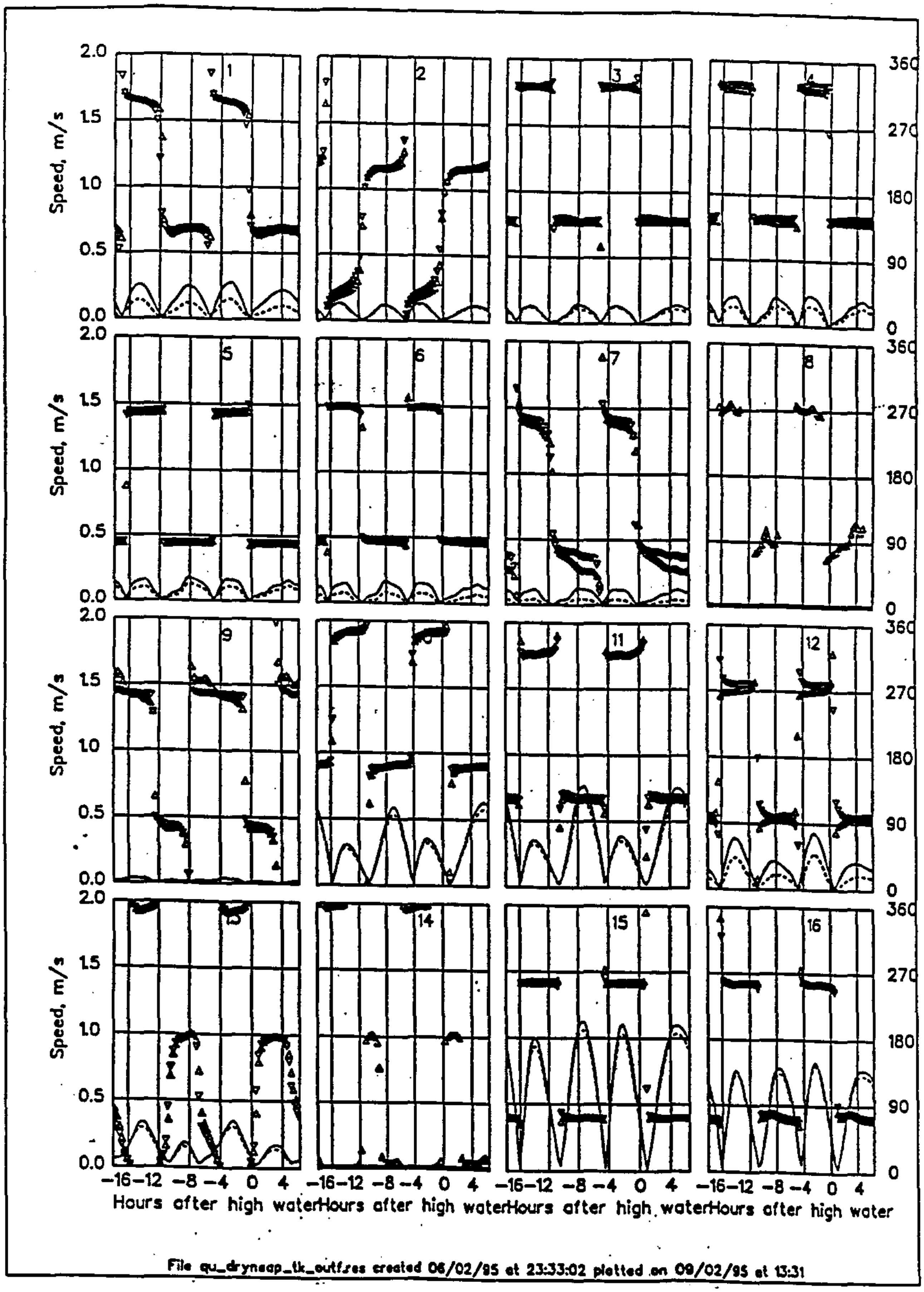
11a Water Velocities, Stations 1-16, Wet Season Neap Tide, Base Layout



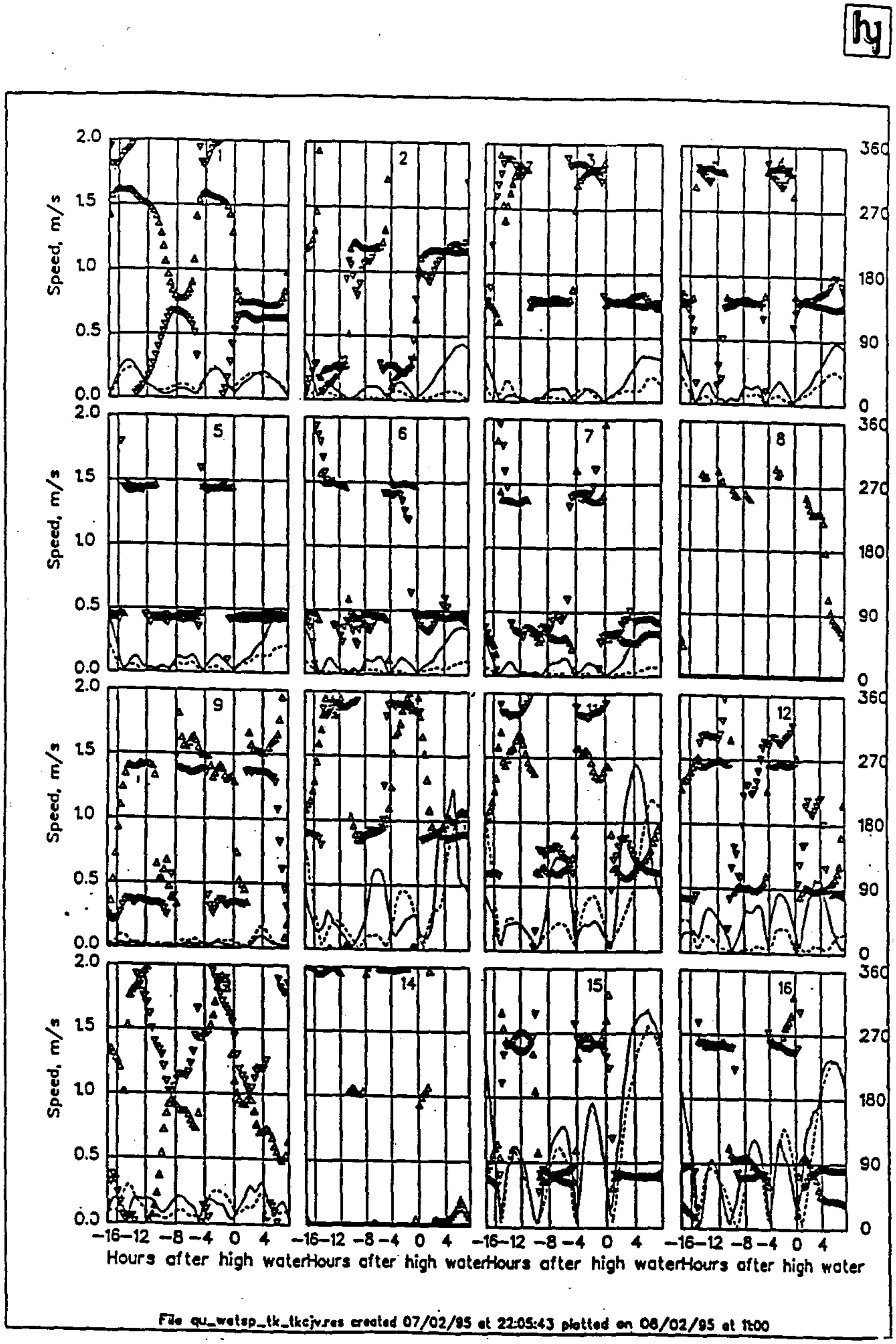
11b Water Velocities, Stations 1-16, Wet Season Neap Tide, Scenario Layo



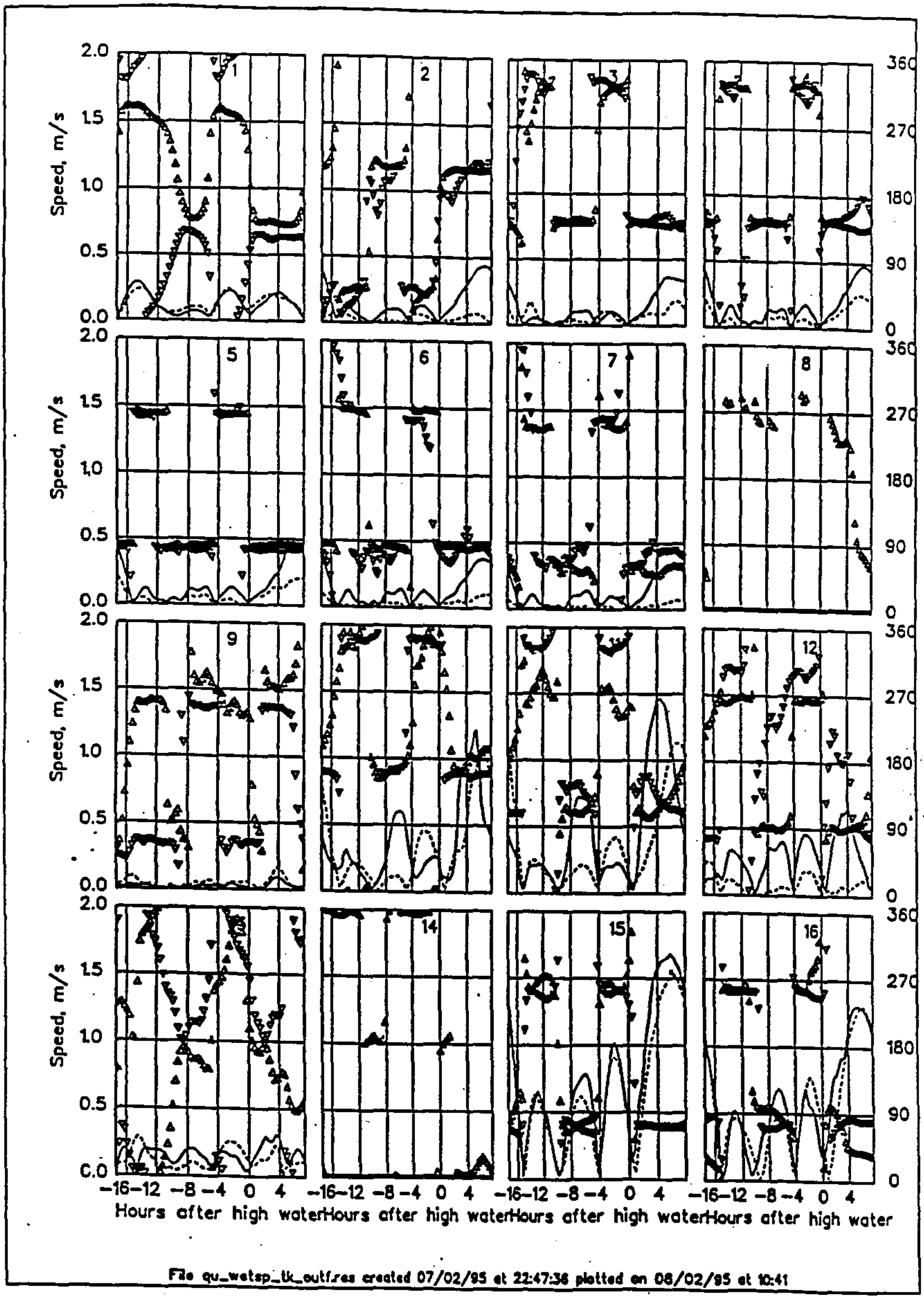
12a Water Velocities, Stations 1-16, Dry Season Neap Tide, Base Layout



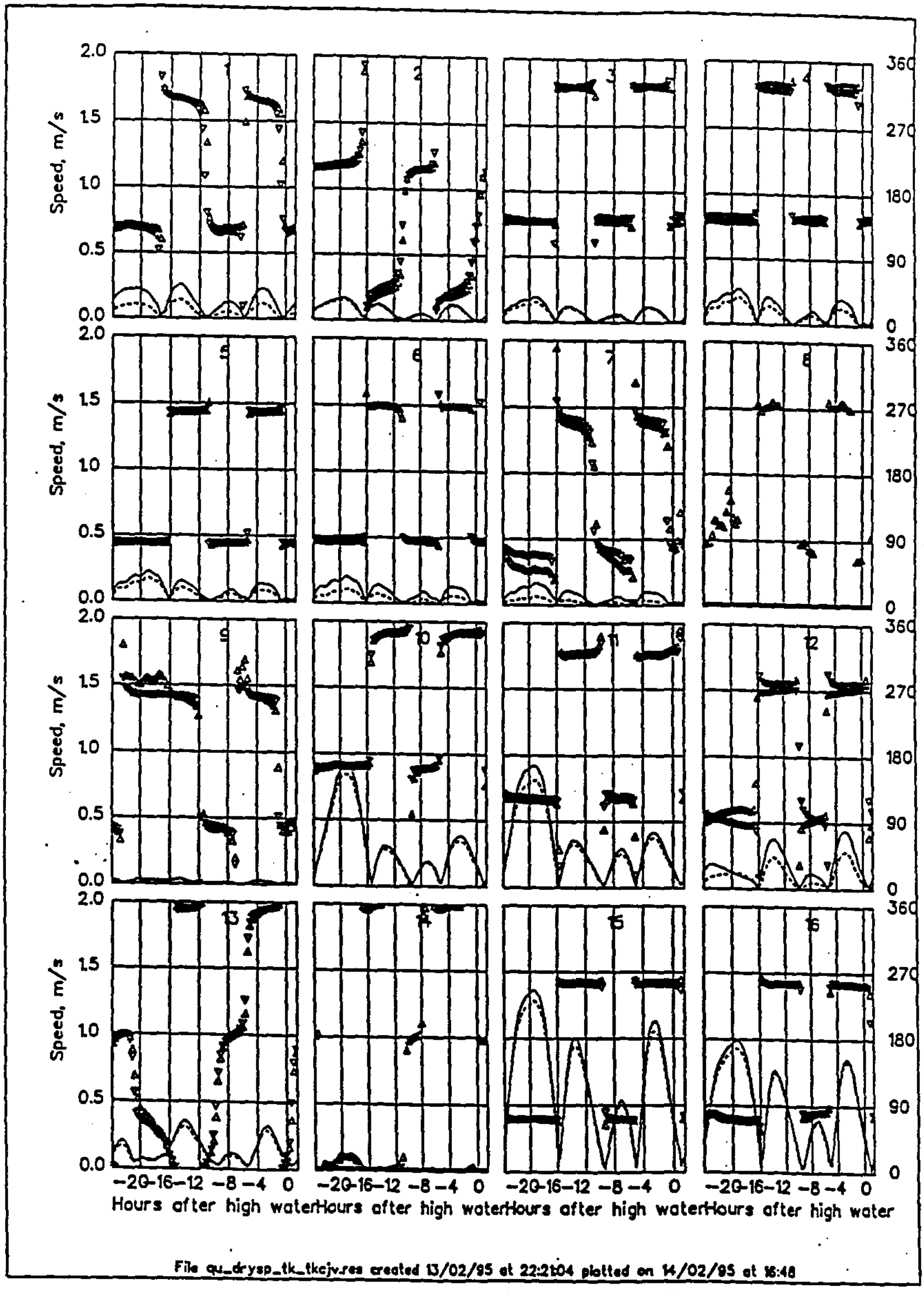
12b Water Velocities, Stations 1-16, Dry Season Neap Tide, Scenario Layout



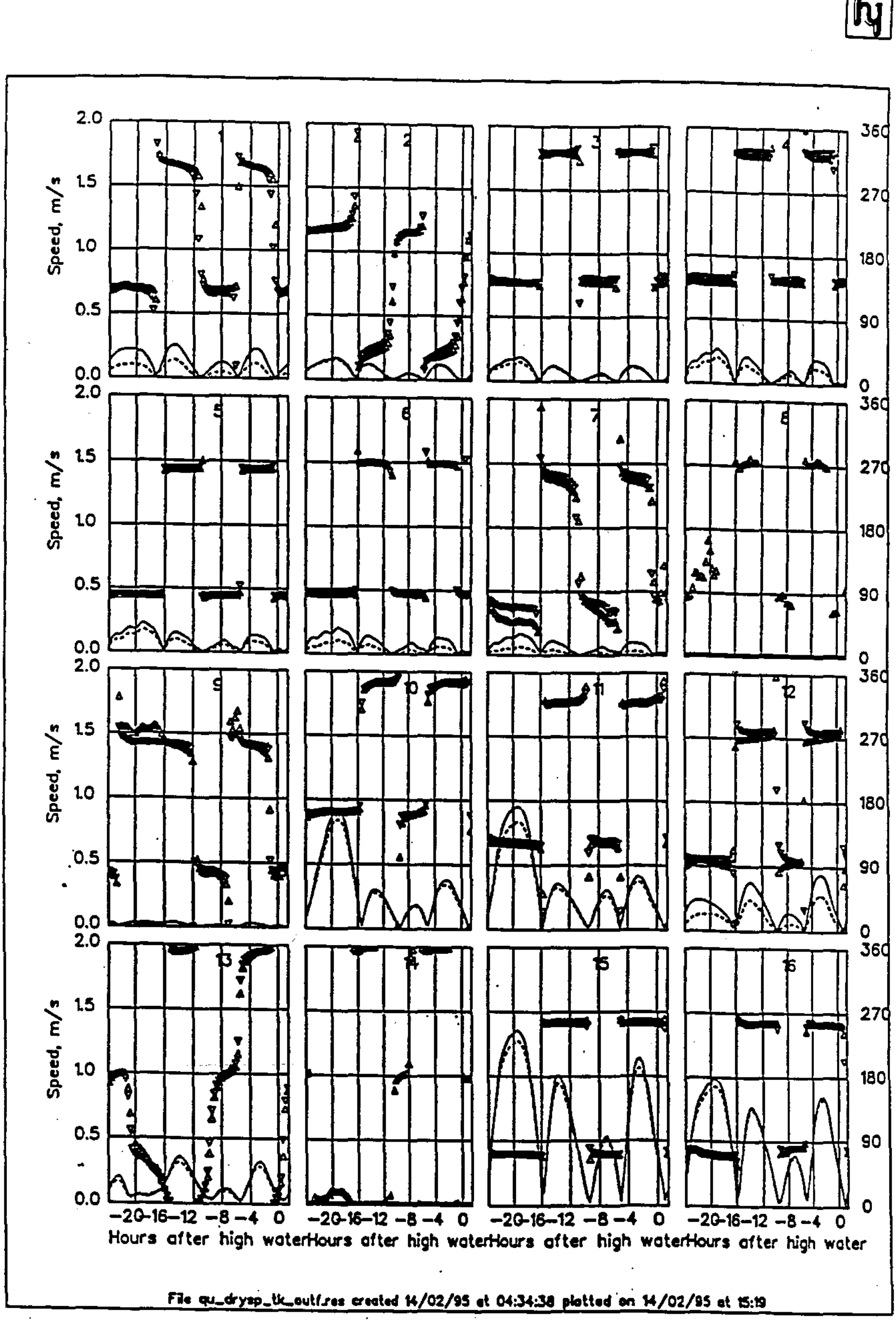
13a Water Velocities, Stations 1-16, Wet Season Spring Tide, Base Layout



13b Water Velocities, Stations 1-16, Wet Season Spring Tide, Scenario Layout



14a Water Velocities, Stations 1-16, Dry Season Spring Tide, Base Layout



14b Water Velocities, Stations 1-16, Dry Season Spring Tide, Scenario Layout

Appendix E

Water Quality Modelling Results

Mott Connell

TING KAU AND SHAM TSENG SEA OUTFALL

SIMULATION OF TIDAL FLOWS AND WATER QUALITY

Report HWR 152

July 1995

Mott Connell
12th Floor, Sun Hung Kai Centre
30 Harbour Road
Wanchai
Hong Kong

Hydraulics and Water Research (Asia) Ltd
12/F Park Commercial Centre
2-12 Shelter Street
Causeway Bay
Hong Kong

CONTENTS

TABLES

C O N T E N T S (continued)

FIGURES

APPENDICES

1 INTRODUCTION

In October 1994, Mott Connell commissioned Hydraulics and Water Research (Asia) to carry out simulations of the effluent discharge from a proposed outfall serving the Ting Kau and Sham Tseng coastline. The purpose of the simulations was to allow Mott Connell to refine the length of the sea outfall and to ensure that the level of effluent treatment proposed would allow the discharge to comply with the Water Quality Objectives (WQO) defined by the Environmental Protection Department (EPD) of the Hong Kong Government. Of particular concern in this study, was the impact of the effluent discharge on *E.coli* concentrations on the neighbouring beaches. In addition to the local impact of the discharge from the sea outfall itself, the combined impact of the proposed discharge together with the other known effluent sources in Hong Kong waters was also of concern.

Initially, a number of simulations of bacterial dispersion from the proposed outfall alone were carried out using the WAHMO bacterial plume model to examine bacteria concentrations on the neighbouring beaches under different seasonal conditions and for different outfall lengths and effluent treatment levels. As a result of these initial simulations, an outfall length and level of treatment was proposed. The WAHMO two-dimensional two-layer model of water quality was then applied to simulate full water quality and to examine the cumulative impact of the proposed outfall and all other effluent discharges in Hong Kong waters. This report presents the results of the full water quality modelling study

2 THE MATHEMATICAL MODELS

The WAHMO two-dimensional two-layer models of water quality and tidal flows used in this study had been set up under an earlier study of the Route 3 Ting Kau Bridge to simulate wet and dry season conditions (References 1 & 2). The models had been calibrated and validated in these earlier studies by comparing the model results with available field data and with the results from larger area lower resolution models which had been calibrated using larger field data sets.

2.1 The Layouts Simulated

Two models were used to provide the required tidal flow fields for the water quality modelling. A high resolution model using a 50m grid covering the area show in Figure 1a (Reference 1) was used to provide the flow fields for the evaluation of local impacts. A larger area model using a 250m grid (Reference 3) was used to simulate all committed reclamations in Hong Kong waters and to provide the hydraulic data required in the simulation of the cumulative impact of all relevant effluent discharges on water quality in the vicinity of the proposed outfall.

The high resolution model of tidal flows obtained boundary conditions from a larger area 100m grid model set up in the Civil Engineering Department of the Hong Kong Government and was used to simulate wet and dry season spring and neap tidal cycles for two reclamation layouts. The Baseline reclamation layout was taken to be that simulated in the earlier study of the Ting Kau Bridge (Reference 1) and included Container Terminals 8 and 9 with associated dredged channels, Tsing Yi North, South and Duplicate South Bridges, Rambler Channel Bridge, the Tsuen Wan Area 35 reclamation, the Ting Kau Bridge and the typhoon shelter between the Tsing Yi North and South bridges. The Scenario Layout simulated in this study then additionally included the proposed reclamation required for the Ting Kau treatment works and the removal of several rock outcrops proposed under the Ma Wan Improvement Scheme (Figure 2).

3 THE SIMULATIONS OF TIDAL FLOWS

The WAHMO two-dimensional two-layer model was used to simulate wet and dry season spring and neap tidal flows. The results of these simulations for the Baseline and Scenario Layouts are illustrated for the spring tide simulations in Figures 3 to 6 in the form of velocity vector diagrams and, in Figures 7 to 14, as plots of the variation in water velocity over the tidal cycle at the selected Stations shown in Figures 1b and 1c for each of the 4 tidal cycles simulated. The Stations selected for more detailed examination of water speeds were based on those used in earlier studies (Stations 1-16 from References 1 and 4) and 5 new Stations (A-E) selected for this study in order to examine the possible local impacts of the proposed reclamation in more detail.

Examination of the water velocity plots (Figures 7 to 10) shows that, locally, the reclamation imposes little change on the existing tidal flows. In general, at Stations A, B, D and E, the reclamation does not change water speeds noticeably on all tide types; at Station C in the embayment, peak flood and ebb water speeds are found to reduce by the order of 3cm/s or less. At Station E, off the northern shore of Ma Wan, on the wet season neap tide, the model predicted a small reduction in peak flood tide water speeds of the order of 3cm/s. This is most probably the result of the local dredging simulated as part of the Ma Wan Improvement Scheme (Figure 2). At Station 12, existing peak ebb tide water speeds were predicted to increase on all tides simulated (Figures 11 to 14). For the dry season neap tide, the peak speed of the order of 0.17m/s was predicted to increase by up to 0.08m/s probably as a result of local accelerations in the flow to the east of the reclamation. Although this represents a large percentage increase ($\approx$ 50%) for the dry season neap tide, peak spring tide water speeds are much larger at around 0.5m/s and the increase in the smaller dry season neap tide water speeds should not have any impact on, for example, bed stability or navigation.

At Stations more remote from the reclamation than those considered in the previous paragraph, the reclamation was found to have no discernable impact (Figures 11 to 14).

3.1 Summary

The reclamation occupies the eastern side of a small embayment where existing water depths are of the order of 20m or less and it does not extend into the faster moving water in the main tidal flow channels. As a result, it was not expected that the reclamation would have a significant impact on large scale water movements or, therefore, in the absence of any new effluent sources, large scale water quality.

Following construction of the reclamation, some changes in local flow patterns are to be expected. It was found that the reclamation resulted in small reductions in flows within the bay and local increases in water speeds immediately offshore of the reclamation. Considering the existing relatively low water speeds and the magnitude of the changes caused by the reclamation, it was not considered that, for example, navigation in the vicinity of the reclamation or local patterns of siltation would be affected by these modified flow patterns. More remote from the reclamation, no discernable change in water velocities was found which is consistent with the reclamation remaining outside the main flow channel.

4 WATER QUALITY SIMULATIONS

4.1 Introduction

The results from the tidal flow simulations were used as the basic hydraulic data set by the WAHMO two-dimensional two-layer model of water quality. The effluent loading pattern used by the water quality model was based on that used in the most recent assessment of the impact of the Ting Kau Bridge on water quality (Reference 4).

Two types of simulations were carried out. For neap tidal conditions, because the tidal excursion would be relatively short, the impact of future discharges from remote but large outfalls (eg North West New Territories, Tuen Mun Area 38 and Siu Ho Wan) on *E. coli* concentrations on the local beaches would be small and the 50m grid water quality model was run using the boundary conditions derived in the earlier studies (Reference 2 and 4). On spring tides when tidal excursions are much larger than on neap tides, it was considered more important to revise the boundary conditions in the 50m model to allow for future discharges from major outfalls outside the local area. Consequently, the Extended WAHMO 250m model was re-run to simulate the overall large scale future water quality. New boundary conditions were then extracted from these model results for use in the local area 50m grid model.

4.2 Loading Patterns

The model was used to simulate vertically well mixed dry season conditions and stratified wet season conditions. In order to reflect the impact of stratification on the initial behaviour of the effluent plume, in the dry season, the effluent discharge from the proposed outfall was assumed to be vertically well mixed over the water column while, in the wet season, the initial discharge was assumed to be trapped in the lower layer of the model.

4.2.1 Neap Tide Simulations

The loading pattern for the wet and dry season neap tide simulations of the Baseline Layout was taken from the earlier studies of the Ting Kau Bridge (References 2 and 4) with modifications to some local effluent loads being made as a result of data obtained under this study. Table 1 shows the loading pattern used in this study for the neap tide simulations of the Baseline Layout.

For the Scenario Layout, the loading pattern was also based on those loads given in Table 1 but with all Series 11 discharges removed and replaced by the single load from the proposed outfall as detailed in Table 2.

4.2.2 Simulation of Cumulative Impacts

In order to simulate the cumulative impacts of all local and more remote effluent discharges in the vicinity of the Ting Kau and Sham Tseng outfall, the Extended WAHMO water quality model was rerun using the simulated flow fields and the corresponding effluent loading pattern for the Year 2003 taken from an earlier study (Reference 5) but with some modifications to three major outfalls.

The basic effluent loading pattern for the whole Extended WAHMO Model area is given in Appendix 1. For this study, the effluent loads marked in Appendix 1 were deleted and replaced by the Stonecutter's Stage I discharge (Table 3) and revised loads for the North West New Territories, Area 38 and Siu Ho Wan were also specified for this study (Table 3). The Extended WAHMO model was then re-run using the modified loading pattern and the results used to provide boundary conditions for the higher resolution 50m grid model. The 50m model then used the same local loading pattern as in the simulation of the neap tide conditions (Table 2) for the two cases with and without the proposed outfall.

4.3 Wet and Dry Season Neap Tide Simulations

Using the boundary conditions derived for the earlier studies and the loading pattern described in Section 4.1.1, the model was used to simulate wet and dry season neap tide conditions for the Baseline Layout and the Scenario Layout which included the proposed reclamation and outfall.

The model was used to simulate both the Baseline layout and the discharge from the proposed outfall. The results from the model have been presented in Appendix 2 as plots of the variation in each simulated parameter over the tidal cycle at the fixed Stations shown in Figure 1d and as tabulations of the tide averaged concentration of each parameter (Tables 4 and 5) for the Baseline and Scenario Layouts.

In Appendix 2, the results have been plotted for both simulations on the same axes to allow a direct comparison of the effect of collecting the existing diffuse effluent loads and discharging the estimated total future load (following treatment) through the proposed outfall. From the plots, for all parameters except *E. coli.*, at all Stations, there is little difference between the two cases. Dissolved Oxygen (DO) concentrations at Stations 14 and 15 can be seen to increase slightly while BOD concentrations decrease slightly on both wet and dry season neap tides. This impact at Stations 14 and 15 can also be seen in the tabulations of the tide averaged concentrations of Dissolved oxygen and BOD (Tables 4 and 5) and is probably the result of the removal of the diffuse effluent discharges (Table 1) to the confined waters of the Rambler Channel

In order to examine the differences between the Baseline Layout and the Scenario Layout in more detail, the differences in the tide averaged concentrations of each parameter at each of the selected Stations between the Baseline Layout and the Scenario Layout were calculated and are given in Table 6 and 7 - negative values indicate a decrease in concentration for the Scenario Layout. Apart from the *E. coli* concentrations, there is little change in the other parameters between the two simulations at all Stations. Tide averaged concentrations of DO at Station 15 increase by 0.05mg/l (dry season) and 0.07mg/l (wet season) while BOD concentrations at this Station decrease by 0.04mg/l in both seasons.

From Tables 6 and 7, *E. coli* concentrations can be seen to decrease at some Stations and increase at others. In order to obtain a clearer understanding of the impact of collecting the existing diffuse discharges and discharging all effluent after treatment through the proposed outfall, these differences have been plotted in Figure 15. It can be seen that significant reductions in the tide averaged *E. coli* concentrations have occurred in the near shore area (Stations 1-9, 22, 24 and 25, Figure 1d) with smaller reductions in the Rambler Channel (Stations 14 and 15). In the offshore region, some smaller increases in *E. coli* concentrations are predicted especially at Stations 18, 19 and 20. At these Stations, it can be seen that the largest increases occur in the surface layer in the dry season and in the bed layer in the wet season and are considered to be a direct result of the proximity of the proposed outfall to these Stations. The marginally larger increases occur at Station 20 in the surface layer in the dry season when tide averaged *E. coli* concentrations are predicted to increase from 85/100ml to 334/100ml.

4.4 Wet and Dry Season Spring Tide Simulations of Cumulative Impacts

As described in Section 4.1, in order to simulate the cumulative impact of the proposed outfall and all other future contributing effluent discharges, the Extended WAHMO 250m model was first used to simulate the future loading pattern in Hong Kong waters. In particular, the North West New Territories, Tuen Mun Area 38, Siu Ho Wan and Stonecutter's Island Stage I discharges were simulated using the loadings given in Table 3. The high resolution model then took boundary conditions from the larger area model's simulations. The overall loading pattern used (Appendix 1) was an estimated future loading pattern and was not the same as in the neap tide simulations and direct comparisons cannot be made between simulations of the two different tide types.

As in the simulation of the wet and dry season neap tides, the results from the high resolution model have been presented in Appendix 3 as plots of the concentrations of each parameter at the Stations shown in Figure 1d over the tidal cycle and as tabulations of the tide averaged concentrations of each parameter on the wet and dry season spring tides (Tables 8 and 9). The differences between the tide averaged concentrations of each parameter at each Station between the two layouts simulated are also presented in Tables 10 and 11 and plotted in Figure 15.

As in the simulation of neap tide conditions, the impact of collecting up the near shore effluent sources and discharging them with treatment through the proposed outfall was very small for all parameters modelled except *E. coli*. The plots of the modelled parameters (Appendix 3) and the tables of tide averaged concentrations show little, if any, change in all but the *E. coli* concentrations. Figure15 shows the differences in *E. coli* concentrations between the two cases simulated and it can be seen that the impact of the proposed outfall and treatment scheme is very similar to that on the neap tides. For the spring tide simulations, *E coli* concentrations at all Stations are considerably larger for the loading pattern simulated than on the neap tides with typical concentrations of the order of 1000-1500/100ml compared with 100-200/100ml at most Stations on the neap tides. However, the impact of the proposed outfall is similar for both the spring and neap tide Scenarios modelled.

5 SUMMARY AND CONCLUSIONS

The WAHMO two-dimensional two-layer models of wet and dry season tidal flows and water quality were applied to simulate the impact of a reclamation on water movements and the resulting impact of the modified flow field and a treated effluent discharge from an outfall on water quality.

The Ting Kau and Sham Tseng sewerage scheme would result in the collection of several diffuse shoreline effluent loads for treatment before discharge through an outfall. Following a series of simulations of bacterial plumes, an outfall location was selected and the water quality model was used to simulate the impact of removing the diffuse effluent sources and introducing the treated discharge from the proposed outfall. Initially, use was made of the existing high resolution (50m grid) model of the area previously set up to examine the Route 3 Ting Kau Bridge and neap tide conditions were simulated without any modification to the model boundary conditions. This was considered acceptable because the tidal excursions would be small, the impact of remote discharges on local water quality conditions on the beaches were expected to be small and the neap tide simulation would allow an assessment of the relative impact of removing the local shoreline effluent sources and introducing the outfall. For the spring tide simulations, the large area Extended WAHMO model was re-run to simulate a specified future effluent discharge pattern which included the SSDS Stage I outfall from Stonecutter's Island. The results from this model were then used to provide boundary conditions for the local area high resolution model which was re-run to simulate the proposed outfall and removal of shoreline discharges.

The results from the model indicated that, on all tide types simulated, the introduction of the treated discharge from the outfall had little impact on all water quality parameters simulated except *E. coli*. The most noticeable impact of the outfall was a reduction in *E. coli* concentrations in the near shore areas including the beaches. Offshore, in the vicinity of the outfall risers, some increases in *E. coli* concentrations were predicted as should be expected. In general, the increases in *E. coli* concentrations in the offshore waters remote from the outfall were very small and significantly less than the reductions in *E. coli* concentrations in the near shore waters.

6 REFERENCES

1 Route 3 - Ting Kau Bridge Sector. Hydraulic Model Studies of the Impact of Bridge Piers and a Breakwater on Tidal Flows in the Rambler Channel. Hydraulics and Water Research (Asia) Ltd Report HWR 095, November 1993

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3 Review of Strategic Sewage Disposal Scheme Stage II Options. Extended WAHMO Tidal Flow Model - Tidal Flow Simulations. Hydraulics and Water Research (Asia) Ltd Report HWR 125, November 1994.

4 Ting Kau Bridge Environmental Studies - Mathematical Modelling of the Effect of the TKCJV Bridge on Tidal Flows and Water Quality. Hydraulics and Water Research (Asia) Ltd Report HWR 127, November 1994.

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TABLES

Reference	Easting	Northing	BOD tonne/d	Factors on BOD			
				E.coli	Org.N	Am.N	Ox.N
TW1 (Tsuen Wan)	829900	822400	43.50	0.71	0.06	0.09	0.01
TKT/1	828700	825800	1.80	1.00	0.08	0.15	0
TKT/2	828900	825800	0.70	1.00	0.09	0.16	0
TKT/3	829100	825600	2.10	0.31	0.09	0.15	0
TKT/4	829300	825400	9.00	0.31	0.09	0.15	0
TKT/5	829500	825300	0.30	1.00	0.10	0.10	0
TKT/6	829600	825100	11.10	0.26	0.04	0.03	0
TKT/7	829500	825000	2.10	1.00	0.01	0.15	0
TKT/8	830000	823900	2.00	0.54	0.04	0.04	0
TKT/9	829900	823200	4.50	1.18	0.03	0.03	0
TKT/10	830500	822700	20.3	0.46	0.04	0.03	0
TKT/11	829400	823600	0.20	0.22	0.10	0.15	0
TKT/12	829500	823550	1.70	0.10	0.09	0.15	0
TKT/13	829500	823550	2.20	0.30	0.09	0.02	0
TKT/14	829750	823300	1.60	0.48	0.09	0.15	0
TKT/15	829200	821300	1.18	1.00	0.07	0.09	0
11.02	826200	825500	*0.105* *	1.16	0.08	0.12	0
11.12	822700	824700	*0.609* *	6.72	0.15	0.16	0
11.13	823700	825000	*0.294* *	6.74	0.15	0.16	0
11.14	824300	825100	*0.624* *	6.03	0.14	0.14	0
11.16+11.15	824500	825100	*0.095* *	5.39	0.12	0.13	0
11.99	826300	825200	*0.030* *	6.67	0.15	0.17	0
13A.80	823700	823200	0.06	1.20	0.09	0.12	0

* Modified from the loadings used in the simulations of Ting Kau Bridge (Reference 1) based on data obtained under the present study
All Series "11" loads were deleted in the simulation of the proposed outfall and replaced by those given in (Table 2)

TABLE 1 BASELINE WATER QUALITY MODEL LOCAL POLLUTION LOADS

Parameter	Load *	Reduction Factor
Discharge	13,367 m^3/day	-
BOD	2,310.kg/day	30%
Suspended Solids	2,216.kg/day	50%
NH_3N	0.305kg/day	0%
Organic N	0.116kg/day	10%
E. coli	2.29×10^{15}/day	50%

* This single load replaced the "Series 11" discharges indicated in Table 1 for the simulations of the discharge of treated effluent from the proposed outfall.

RISER	RISER LOCATIONS	
	Easting	Northing
1	824530	824620
2	824555	824665

TABLE 2 TING KAU AND SHAM TSENG EFFLUENT DISCHARGE DETAILS

OUTFALL	BOD LOADING
North West New Territories	21,100kg/day
Area 38	30,220kg/day
Siu Ho Wan	21,640kg/day

STONECUTTERS OUTFALL DETAILS	
Onshore Coordinates	(829160E, 818910N)
Offshore coordinates	(830670E, 819690N)
Number of Risers	24
Riser Spacing	50m
Discharge Depth	10m
Jet Diameter	250mm
Flow	16.36 m^3/s
Suspended Sediment Load	90mg/l
BOD Load	150mg/l
TKN Load	30mg/l
NH_4-N Load	23mg/l
TTM Load	2mg/l
PO_4-P Load	3mg/l
E. coli	9×10^5/100ml

TABLE 3 DETAILS OF MAJOR OUTFALLS USED IN THE SIMULATION OF CUMULATIVE IMPACTS

TING KAU AND SHAM TSENG SEWERAGE - DRY SEASON NEAP TIDE
BASELINE CONDITION

Station	Layer	Height	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	9.30	18.01	32.70	6.28	0.83	0.10	0.06	0.22	0.90	6.56	448
1	2	2.03	18.00	32.70	6.27	0.82	0.10	0.06	0.22	0.89	6.55	312
2	1	1.31	18.01	32.70	6.30	0.83	0.10	0.06	0.22	0.90	6.43	522
2	2	0.00	18.01	32.70	6.30	0.83	0.10	0.06	0.22	0.90	6.43	522
3	1	1.31	18.02	32.70	6.28	0.82	0.10	0.07	0.23	0.91	6.00	134
3	2	0.00	18.02	32.70	6.28	0.82	0.10	0.07	0.23	0.91	6.00	134
4	1	9.30	18.02	32.70	6.24	0.82	0.09	0.07	0.24	0.91	5.61	105
4	2	3.15	18.02	32.70	6.23	0.82	0.09	0.07	0.24	0.90	5.47	128
5	1	6.13	18.03	32.69	6.22	0.83	0.09	0.07	0.24	0.93	5.12	101
5	2	0.00	18.03	32.69	6.22	0.83	0.09	0.07	0.24	0.93	5.12	101
6	1	7.72	18.03	32.69	6.22	0.84	0.09	0.07	0.24	0.94	5.07	123
6	2	0.00	18.03	32.69	6.22	0.84	0.09	0.07	0.24	0.94	5.07	123
7	1	3.22	18.05	32.68	6.18	0.88	0.10	0.08	0.25	0.98	4.46	494
7	2	0.00	18.05	32.68	6.18	0.88	0.10	0.08	0.25	0.98	4.46	494
8	1	6.89	18.06	32.66	6.08	0.97	0.10	0.09	0.26	1.00	4.35	280
8	2	0.00	18.06	32.66	6.08	0.97	0.10	0.09	0.26	1.00	4.35	280
9	1	9.30	18.00	32.70	6.29	0.82	0.10	0.05	0.21	0.90	6.76	83
9	2	26.03	18.00	32.70	6.28	0.82	0.10	0.05	0.21	0.89	6.80	95
10	1	9.30	18.00	32.70	6.29	0.82	0.10	0.05	0.21	0.90	6.82	103
10	2	28.11	18.00	32.70	6.28	0.82	0.10	0.05	0.21	0.89	6.85	106
11	1	9.29	18.01	32.70	6.28	0.82	0.10	0.07	0.25	0.90	5.70	59
11	2	30.39	18.00	32.70	6.26	0.82	0.10	0.07	0.25	0.89	5.80	85
12	1	9.30	18.01	32.70	6.28	0.82	0.10	0.07	0.26	0.91	5.29	57
12	2	13.46	18.00	32.70	6.27	0.82	0.10	0.07	0.26	0.89	5.31	77
13	1	9.30	18.01	32.70	6.28	0.82	0.10	0.08	0.27	0.91	5.06	60
13	2	12.52	18.00	32.70	6.27	0.82	0.10	0.08	0.27	0.89	5.04	77
14	1	10.26	18.05	32.67	6.13	0.91	0.10	0.08	0.25	0.97	4.64	225
14	2	0.00	18.05	32.67	6.13	0.91	0.10	0.08	0.25	0.97	4.64	225
15	1	9.30	18.14	32.55	5.44	1.90	0.19	0.12	0.34	1.16	4.26	2488
15	2	4.51	18.14	32.55	5.41	1.88	0.19	0.12	0.34	1.15	4.13	3004
16	1	9.30	18.01	32.70	6.28	0.82	0.10	0.06	0.22	0.90	6.57	110
16	2	29.00	18.00	32.70	6.27	0.82	0.10	0.06	0.22	0.89	6.59	109
17	1	9.30	18.01	32.70	6.28	0.82	0.10	0.06	0.23	0.90	6.40	97
17	2	42.53	18.00	32.70	6.27	0.82	0.10	0.06	0.22	0.89	6.43	100
18	1	9.29	18.01	32.70	6.28	0.82	0.10	0.06	0.23	0.90	6.22	79
18	2	28.78	18.00	32.70	6.26	0.82	0.10	0.06	0.23	0.89	6.29	90
19	1	9.29	18.01	32.70	6.28	0.82	0.10	0.06	0.24	0.90	6.09	83
19	2	30.90	18.00	32.70	6.26	0.82	0.10	0.06	0.23	0.89	6.17	100
20	1	9.29	18.01	32.70	6.28	0.82	0.10	0.06	0.23	0.90	6.15	85
20	2	27.44	18.00	32.70	6.26	0.82	0.10	0.06	0.23	0.89	6.23	96
21	1	9.30	18.02	32.69	6.23	0.83	0.09	0.07	0.24	0.92	5.43	103
21	2	10.17	18.02	32.69	6.22	0.83	0.09	0.07	0.24	0.91	5.36	130
22	1	9.30	18.01	32.70	6.27	0.83	0.10	0.06	0.22	0.90	6.37	594
22	2	7.96	18.01	32.70	6.26	0.82	0.10	0.06	0.22	0.89	6.36	315
23	1	9.30	18.01	32.70	6.27	0.82	0.10	0.06	0.23	0.90	6.13	122
23	2	20.64	18.01	32.70	6.25	0.82	0.10	0.06	0.23	0.89	6.16	140
24	1	1.30	18.01	32.70	6.30	0.82	0.10	0.06	0.22	0.90	6.51	284
24	2	0.00	18.01	32.70	6.30	0.82	0.10	0.06	0.22	0.90	6.51	284
25	1	8.95	18.01	32.70	6.27	0.83	0.10	0.06	0.22	0.90	6.36	553
25	2	0.00	18.01	32.70	6.27	0.83	0.10	0.06	0.22	0.90	6.36	553

TABLE 4a TIDE AVERAGED CONCENTRATIONS AT SELECTED STATIONS, DRY SEASON NEAP TIDE, BASELINE CONDITION

TING KAU AND SHAM TSENG SEWERAGE - DRY SEASON NEAP TIDE
LONG SEA OUTFALL

Station	Layer	Height	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	9.30	18.01	32.70	6.28	0.82	0.10	0.06	0.22	0.90	6.56	102
1	2	2.03	18.00	32.70	6.27	0.82	0.10	0.06	0.22	0.89	6.55	110
2	1	1.31	18.01	32.70	6.30	0.82	0.10	0.06	0.22	0.90	6.43	93
2	2	0.00	18.01	32.70	6.30	0.82	0.10	0.06	0.22	0.90	6.43	93
3	1	1.31	18.02	32.70	6.28	0.82	0.10	0.06	0.23	0.91	6.03	102
3	2	0.00	18.02	32.70	6.28	0.82	0.10	0.06	0.23	0.91	6.03	102
4	1	9.30	18.02	32.70	6.24	0.82	0.09	0.07	0.24	0.91	5.64	80
4	2	3.15	18.02	32.70	6.23	0.82	0.09	0.07	0.23	0.90	5.49	95
5	1	6.13	18.03	32.69	6.23	0.83	0.09	0.07	0.24	0.93	5.15	51
5	2	0.00	18.03	32.69	6.23	0.83	0.09	0.07	0.24	0.93	5.15	51
6	1	7.73	18.03	32.69	6.22	0.83	0.09	0.07	0.24	0.93	5.09	52
6	2	0.00	18.03	32.69	6.22	0.83	0.09	0.07	0.24	0.93	5.09	52
7	1	3.22	18.05	32.68	6.19	0.87	0.09	0.08	0.25	0.97	4.48	59
7	2	0.00	18.05	32.68	6.19	0.87	0.09	0.08	0.25	0.97	4.48	59
8	1	6.89	18.06	32.67	6.09	0.95	0.10	0.08	0.26	1.00	4.39	158
8	2	0.00	18.06	32.67	6.09	0.95	0.10	0.08	0.26	1.00	4.39	158
9	1	9.30	18.00	32.70	6.29	0.82	0.10	0.05	0.21	0.90	6.75	88
9	2	26.03	18.00	32.70	6.28	0.82	0.10	0.05	0.21	0.89	6.80	98
10	1	9.30	18.00	32.70	6.29	0.82	0.10	0.05	0.21	0.90	6.82	99
10	2	28.11	18.00	32.70	6.28	0.82	0.10	0.05	0.21	0.89	6.85	105
11	1	9.29	18.01	32.70	6.28	0.82	0.10	0.07	0.25	0.90	5.69	74
11	2	30.39	18.00	32.70	6.26	0.82	0.10	0.07	0.25	0.89	5.80	91
12	1	9.30	18.01	32.70	6.28	0.82	0.10	0.08	0.26	0.91	5.28	64
12	2	13.46	18.00	32.70	6.26	0.82	0.10	0.07	0.26	0.89	5.31	82
13	1	9.30	18.01	32.70	6.28	0.82	0.10	0.08	0.27	0.91	5.05	65
13	2	12.52	18.00	32.70	6.27	0.82	0.10	0.08	0.27	0.89	5.03	82
14	1	10.26	18.05	32.68	6.14	0.90	0.10	0.08	0.25	0.97	4.67	134
14	2	0.00	18.05	32.68	6.14	0.90	0.10	0.08	0.25	0.97	4.67	134
15	1	9.30	18.14	32.56	5.48	1.86	0.19	0.12	0.34	1.15	4.28	2434
15	2	4.51	18.13	32.56	5.46	1.84	0.19	0.12	0.34	1.14	4.14	2943
16	1	9.30	18.01	32.70	6.28	0.82	0.10	0.06	0.22	0.90	6.57	103
16	2	29.00	18.00	32.70	6.27	0.82	0.10	0.06	0.22	0.89	6.59	109
17	1	9.30	18.01	32.70	6.28	0.82	0.10	0.06	0.23	0.90	6.40	112
17	2	42.53	18.00	32.70	6.27	0.82	0.10	0.06	0.22	0.89	6.44	105
18	1	9.29	18.01	32.70	6.28	0.82	0.10	0.06	0.23	0.90	6.22	136
18	2	28.78	18.00	32.70	6.26	0.82	0.10	0.06	0.23	0.89	6.29	99
19	1	9.29	18.01	32.70	6.28	0.82	0.10	0.06	0.24	0.90	6.10	186
19	2	30.90	18.00	32.70	6.26	0.82	0.10	0.06	0.23	0.89	6.17	111
20	1	9.29	18.01	32.70	6.28	0.83	0.10	0.06	0.23	0.90	6.16	334
20	2	27.44	18.00	32.70	6.26	0.82	0.10	0.06	0.23	0.89	6.23	106
21	1	9.30	18.02	32.69	6.23	0.82	0.09	0.07	0.24	0.92	5.46	68
21	2	10.17	18.02	32.70	6.22	0.82	0.09	0.07	0.24	0.91	5.38	85
22	1	9.30	18.01	32.70	6.27	0.82	0.10	0.06	0.22	0.90	6.36	108
22	2	7.96	18.01	32.70	6.26	0.82	0.10	0.06	0.22	0.89	6.36	105
23	1	9.30	18.01	32.70	6.27	0.82	0.10	0.06	0.23	0.90	6.15	131
23	2	20.64	18.01	32.70	6.25	0.82	0.10	0.06	0.23	0.89	6.17	121
24	1	1.30	18.01	32.70	6.30	0.82	0.10	0.06	0.22	0.90	6.51	102
24	2	0.00	18.01	32.70	6.30	0.82	0.10	0.06	0.22	0.90	6.51	102
25	1	8.95	18.01	32.70	6.27	0.82	0.10	0.06	0.22	0.90	6.36	97
25	2	0.00	18.01	32.70	6.27	0.82	0.10	0.06	0.22	0.90	6.36	97

TABLE 4b TIDE AVERAGED CONCENTRATIONS AT SELECTED STATIONS, DRY SEASON NEAP TIDE, LONG SEA OUTFALL

TING KAU AND SHAM TSENG SEWERAGE - WET SEASON NEAP TIDE
BASELINE CONDITION

Station	Layer	Height	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	11.40	27	29.00	4.47	0.84	0.01	0.11	0.80	12.14	8.51	660
1	2	0.00	27	29.00	4.47	0.84	0.01	0.11	0.80	12:14	8.51	660
2	1	1.38	27	29.00	4.45	0.81	0.02	0.12	0.75	11.20	7.86	658
2	2	0.00	27	29.00	4.45	0.81	0.02	0.12	0.75	11.20	7.86	658
3	1	1.37	27	29.00	4.43	0.76	0.02	0.13	0.68	9.41	6.74	120
3	2	0.00	27	29.00	4.43	0.76	0.02	0.13	0.68	9.41	6.74	120
4	1	9.43	27	29.00	4.44	0.75	0.02	0.13	0.66	9.13	6.30	110
4	2	3.09	27	29.00	4.10	0.71	0.03	0.13	0.64	8.00	5.77	97
5	1	6.19	27	29.00	4.51	0.77	0.03	0.13	0.65	9.29	5.77	111
5	2	0.00	27	29.00	4.51	0.77	0.03	0.13	0.65	9.29	5.77	111
6	1	7.79	27	29.00	4.51	0.77	0.03	0.13	0.65	9.34	5.72	138
6	2	0.00	27	29.00	4.51	0.77	0.03	0.13	0.65	9.34	5.72	138
7	1	3.29	27	29.00	4.59	0.84	0.04	0.14	0.65	9.93	5.06	485
7	2	0.00	27	29.00	4.59	0.84	0.04	0.14	0.65	9.93	5.06	485
8	1	6.95	27	29.00	4.48	0.93	0.05	0.15	0.65	10.01	4.92	302
8	2	0.00	27	29.00	4.48	0.93	0.05	0.15	0.65	10.01	4.92	302
9	1	9.41	27	29.00	4.81	0.90	0.00	0.10	0.89	14.67	9.82	87
9	2	25.99	27	29.00	3.94	0.85	0.01	0.11	0.84	13.10	9.10	92
10	1	9.44	27	29.00	4.76	0.89	0.00	0.10	0.88	14.22	9.59	102
10	2	28.04	27	29.00	3.94	0.85	0.01	0.11	0.84	13.04	9.07	106
11	1	9.26	27	29.00	4.45	0.73	0.02	0.13	0.67	8.78	6.81	66
11	2	30.49	27	29.00	4.05	0.66	0.02	0.14	0.59	6.34	5.74	71
12	1	9.15	27	29.00	4.49	0.71	0.02	0.13	0.64	7.97	6.41	61
12	2	13.67	27	29.00	4.06	0.63	0.02	0.15	0.54	5.22	5.12	67
13	1	9.07	27	29.00	4.56	0.70	0.02	0.14	0.62	7.44	6.13	58
13	2	12.81	27	29.00	4.02	0.63	0.02	0.15	0.54	5.02	4.98	73
14	1	10.33	27	29.00	4.50	0.87	0.04	0.14	0.65	9.82	5.26	245
14	2	0.00	27	29.00	4.50	0.87	0.04	0.14	0.65	9.82	5.26	245
15	1	9.34	27	29.00	3.78	1.83	0.14	0.19	0.68	11.25	4.48	3156
15	2	4.54	27	29.00	3.42	1.54	0.13	0.19	0.66	10.19	3.32	3849
16	1	9.43	27	29.00	4.53	0.84	0.01	0.11	0.81	12.56	8.75	134
16	2	28.94	27	29.00	4.04	0.79	0.02	0.12	0.75	10.76	7.95	113
17	1	9.43	27	29.00	4.46	0.81	0.01	0.12	0.78	11.66	8.27	137
17	2	42.47	27	29.00	4.06	0.76	0.02	0.12	0.72	9.87	7.52	94
18	1	9.40	27	29.00	4.41	0.79	0.01	0.12	0.74	10.73	7.80	91
18	2	28.74	27	29.00	4.08	0.74	0.02	0.13	0.69	9.02	7.10	82
19	1	9.39	27	29.00	4.40	0.76	0.02	0.13	0.70	9.70	7.26	94
19	2	30.87	27	29.00	4.07	0.71	0.02	0.13	0.65	8.05	6.60	86
20	1	9.40	27	29.00	4.42	0.77	0.02	0.12	0.72	10.24	7.54	96
20	2	27.40	27	29.00	4.08	0.72	0.02	0.13	0.67	8.49	6.83	88
21	1	9.41	27	29.00	4.47	0.76	0.03	0.13	0.66	9.15	6.08	111
21	2	10.13	27	29.00	4.11	0.72	0.03	0.13	0.65	8.12	5.73	100
22	1	9.46	27	29.00	4.40	0.80	0.02	0.12	0.74	10.63	7.63	934
22	2	7.87	27	29.00	4.13	0.74	0.02	0.13	0.69	9.06	6.96	243
23	1	9.40	27	29.00	4.39	0.75	0.02	0.13	0.69	9.39	6.91	116
23	2	20.61	27	29.00	4.07	0.70	0.03	0.13	0.63	7.68	6.24	90
24	1	1.37	27	29.00	4.46	0.82	0.01	0.12	0.77	11.68	8.19	360
24	2	0.00	27	29.00	4.46	0.82	0.01	0.12	0.77	11.68	8.19	360
25	1	9.02	27	29.00	4.40	0.81	0.02	0.12	0.75	11.02	7.73	743
25	2	0.00	27	29.00	4.40	0.81	0.02	0.12	0.75	11.02	7.73	743

TABLE 5a TIDE AVERAGED CONCENTRATIONS AT SELECTED STATIONS, WET SEASON NEAP TIDE, BASELINE CONDITION

TING KAU AND SHAM TSENG SEWERAGE - WET SEASON NEAP TIDE
LONG SEA OUTFALL

Station	Layer	Height	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	11.40	27	29.00	4.47	0.82	0.01	0.11	0.79	12.12	8.49	78
1	2	0.00	27	29.00	4.47	0.82	0.01	0.11	0.79	12.12	8.49	78
2	1	1.38	27	29.00	4.45	0.80	0.01	0.12	0.75	11.17	7.83	54
2	2	0.00	27	29.00	4.45	0.80	0.01	0.12	0.75	11.17	7.83	54
3	1	1.37	27	29.00	4.42	0.75	0.02	0.13	0.68	9.39	6.74	82
3	2	0.00	27	29.00	4.42	0.75	0.02	0.13	0.68	9.39	6.74	82
4	1	9.43	27	29.00	4.44	0.75	0.02	0.13	0.66	9.13	6.32	65
4	2	3.09	27	29.00	4.11	0.71	0.03	0.13	0.64	8.03	5.79	135
5	1	6.19	27	29.00	4.51	0.76	0.03	0.13	0.66	9.31	5.81	43
5	2	0.00	27	29.00	4.51	0.76	0.03	0.13	0.66	9.31	5.81	43
6	1	7.79	27	29.00	4.51	0.76	0.03	0.13	0.65	9.35	5.76	45
6	2	0.00	27	29.00	4.51	0.76	0.03	0.13	0.65	9.35	5.76	45
7	1	3.29	27	29.00	4.60	0.82	0.03	0.14	0.65	9.93	5.11	51
7	2	0.00	27	29.00	4.60	0.82	0.03	0.14	0.65	9.93	5.11	51
8	1	6.95	27	29.00	4.50	0.91	0.05	0.14	0.65	9.99	4.99	154
8	2	0.00	27	29.00	4.50	0.91	0.05	0.14	0.65	9.99	4.99	154
9	1	9.41	27	29.00	4.81	0.90	0.00	0.10	0.89	14.68	9.82	90
9	2	25.99	27	29.00	3.94	0.85	0.01	0.11	0.84	13.10	9.10	107
10	1	9.44	27	29.00	4.76	0.89	0.00	0.10	0.88	14.22	9.59	92
10	2	28.04	27	29.00	3.94	0.85	0.01	0.11	0.84	13.04	9.07	115
11	1	9.26	27	29.00	4.46	0.73	0.02	0.13	0.67	8.81	6.82	75
11	2	30.49	27	29.00	4.05	0.66	0.02	0.14	0.58	6.31	5.72	98
12	1	9.15	27	29.00	4.49	0.71	0.02	0.13	0.64	7.99	6.42	70
12	2	13.67	27	29.00	4.05	0.64	0.02	0.15	0.54	5.23	5.12	76
13	1	9.07	27	29.00	4.56	0.70	0.02	0.14	0.62	7.46	6.15	67
13	2	12.81	27	29.00	4.02	0.63	0.02	0.15	0.54	5.02	4.98	75
14	1	10.33	27	29.00	4.51	0.86	0.04	0.14	0.65	9.82	5.33	117
14	2	0.00	27	29.00	4.51	0.86	0.04	0.14	0.65	9.82	5.33	117
15	1	9.34	27	29.00	3.85	1.79	0.14	0.19	0.68	11.15	4.51	3024
15	2	4.54	27	29.00	3.49	1.50	0.12	0.19	0.66	10.11	3.34	3753
16	1	9.43	27	29.00	4.53	0.84	0.01	0.11	0.81	12.56	8.75	86
16	2	28.94	27	29.00	4.04	0.79	0.02	0.12	0.75	10.76	7.95	132
17	1	9.43	27	29.00	4.46	0.81	0.01	0.12	0.78	11.67	8.28	80
17	2	42.47	27	29.00	4.06	0.76	0.02	0.12	0.72	9.87	7.52	144
18	1	9.40	27	29.00	4.41	0.79	0.01	0.12	0.74	10.75	7.81	66
18	2	28.74	27	29.00	4.08	0.74	0.02	0.13	0.69	9.02	7.10	187
19	1	9.39	27	29.00	4.39	0.76	0.02	0.13	0.70	9.72	7.27	88
19	2	30.87	27	29.00	4.08	0.71	0.02	0.13	0.65	8.06	6.61	195
20	1	9.40	27	29.00	4.41	0.77	0.02	0.12	0.72	10.22	7.53	70
20	2	27.40	27	29.00	4.08	0.73	0.02	0.13	0.67	8.49	6.83	332
21	1	9.41	27	29.00	4.47	0.75	0.03	0.13	0.66	9.16	6.12	56
21	2	10.13	27	29.00	4.12	0.72	0.03	0.13	0.65	8.15	5.76	127
22	1	9.46	27	29.00	4.39	0.78	0.02	0.12	0.73	10.56	7.59	61
22	2	7.87	27	29.00	4.13	0.74	0.02	0.13	0.68	9.02	6.95	179
23	1	9.40	27	29.00	4.39	0.75	0.02	0.13	0.69	9.41	6.93	83
23	2	20.61	27	29.00	4.08	0.70	0.03	0.13	0.63	7.67	6.23	151
24	1	1.37	27	29.00	4.46	0.81	0.01	0.12	0.77	11.68	8.19	71
24	2	0.00	27	29.00	4.46	0.81	0.01	0.12	0.77	11.68	8.19	71
25	1	9.02	27	29.00	4.40	0.79	0.02	0.12	0.75	10.99	7.70	59
25	2	0.00	27	29.00	4.40	0.79	0.02	0.12	0.75	10.99	7.70	59

TABLE 5b TIDE AVERAGED CONCENTRATIONS AT SELECTED STATIONS, WET SEASON NEAP TIDE, LONG SEA OUTFALL

DRY SEASON NEAP TIDE

Station	Layer	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-346
1	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-202
2	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-429
2	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-429
3	1	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.03	-32
3	2	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.03	-32
4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	-25
4	2	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.02	-33
5	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	-50
5	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	-50
6	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01	0.02	-71
6	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01	0.02	-71
7	1	0.00	0.00	0.01	-0.01	-0.01	0.00	0.00	-0.01	0.02	-435
7	2	0.00	0.00	0.01	-0.01	-0.01	0.00	0.00	-0.01	0.02	-435
8	1	0.00	0.01	0.01	-0.02	0.00	-0.01	0.00	0.00	0.04	-122
8	2	0.00	0.01	0.01	-0.02	0.00	-0.01	0.00	0.00	0.04	-122
9	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	5
9	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4
10	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1
11	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	15
11	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
12	1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	-0.01	7
12	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
13	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	5
13	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	5
14	1	0.00	0.01	0.01	-0.01	0.00	0.00	0.00	0.00	0.03	-91
14	2	0.00	0.01	0.01	-0.01	0.00	0.00	0.00	0.00	0.03	-91
15	1	0.00	0.01	0.05	-0.04	0.00	0.00	0.00	-0.01	0.02	-54
15	2	-0.01	0.01	0.05	-0.04	0.00	0.00	0.00	-0.01	0.01	-61
16	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-7
16	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
17	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15
17	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	5
18	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57
18	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9
19	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	103
19	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11
20	1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	249
20	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10
21	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.03	-35
21	2	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.02	-45
22	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-486
22	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-210
23	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	9
23	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-19
24	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-182
24	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-182
25	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-456
25	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-456

TABLE 6 DIFFERENCES IN CONCENTRATIONS AT SELECTED STATIONS BETWEEN THE BASELINE AND SCENARIO LAYOUTS - DRY SEASON NEAP TIDE

DIFFERENCES IN TIDE AVERAGED CONCENTRATIONS
WET SEASON NEAP TIDE

Station	Layer	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	0.00	0.00	0.00	-0.02	0.00	0.00	-0.01	-0.02	-0.02	-582
1	2	0.00	0.00	0.00	-0.02	0.00	0.00	-0.01	-0.02	-0.02	-582
2	1	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.03	-0.03	-604
2	2	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.03	-0.03	-604
3	1	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.02	0.00	-38
3	2	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.02	0.00	-38
4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	-45
4	2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.02	38
5	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.01	0.02	0.04	-68
5	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.01	0.02	0.04	-68
6	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.04	-93
6	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.04	-93
7	1	0.00	0.00	0.01	-0.02	-0.01	0.00	0.00	0.00	0.05	-434
7	2	0.00	0.00	0.01	-0.02	-0.01	0.00	0.00	0.00	0.05	-434
8	1	0.00	0.00	0.02	-0.02	0.00	-0.01	0.00	-0.02	0.07	-148
8	2	0.00	0.00	0.02	-0.02	0.00	-0.01	0.00	-0.02	0.07	-148
9	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	3
9	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-10
10	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9
11	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	9
11	2	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.03	-0.02	27
12	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	9
12	2	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	9
13	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	9
13	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
14	1	0.00	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	0.07	-128
14	2	0.00	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	0.07	-128
15	1	0.00	0.00	0.07	-0.04	0.00	0.00	0.00	-0.10	0.03	-132
15	2	0.00	0.00	0.07	-0.04	-0.01	0.00	0.00	-0.08	0.02	-96
16	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-48
16	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19
17	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	-57
17	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50
18	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	-25
18	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	105
19	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	-6
19	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	109
20	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.01	-26
20	2	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	244
21	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.04	-55
21	2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.03	27
22	1	0.00	0.00	0.00	-0.02	0.00	0.00	-0.01	-0.07	-0.04	-873
22	2	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.04	-0.01	-64
23	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	-33
23	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	61
24	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-289
24	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-289
25	1	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	-0.03	-0.03	-684
25	2	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	-0.03	-0.03	-684

TABLE 7 DIFFERENCES IN CONCENTRATIONS AT SELECTED STATIONS BETWEEN THE BASELINE AND SCENARIO LAYOUTS - WET SEASON NEAP TIDE

TING KAU AND SHAM TSENG SEWERAGE - DRY SEASON SPRING TIDE
BASELINE CONDITION

Station	Layer	Height	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	9.47	19.00	27.23	5.64	0.65	0.10	0.37	0.20	0.63	27.21	1800
1	2	2.03	19.00	27.22	5.61	0.65	0.10	0.37	0.20	0.62	27.20	1844
2	1	1.48	19.00	27.20	5.67	0.65	0.10	0.37	0.20	0.62	27.03	1763
2	2	0.00	19.00	27.20	5.67	0.65	0.10	0.37	0.20	0.62	27.03	1763
3	1	1.49	19.00	27.19	5.66	0.65	0.10	0.37	0.20	0.62	26.35	1117
3	2	0.00	19.00	27.19	5.66	0.65	0.10	0.37	0.20	0.62	26.35	1117
4	1	9.48	19.00	27.20	5.63	0.66	0.10	0.37	0.20	0.61	25.16	960
4	2	3.15	19.00	27.20	5.61	0.65	0.10	0.37	0.20	0.61	24.32	1126
5	1	6.30	19.00	27.11	5.69	0.66	0.10	0.37	0.20	0.60	23.41	720
5	2	0.00	19.00	27.11	5.69	0.66	0.10	0.37	0.20	0.60	23.41	720
6	1	7.90	19.00	27.09	5.70	0.66	0.10	0.37	0.20	0.60	23.26	733
6	2	0.00	19.00	27.09	5.70	0.66	0.10	0.37	0.20	0.60	23.26	733
7	1	3.40	19.00	27.05	5.73	0.71	0.10	0.38	0.21	0.60	20.92	965
7	2	0.00	19.00	27.05	5.73	0.71	0.10	0.38	0.21	0.60	20.92	965
8	1	7.06	19.00	27.12	5.61	0.82	0.11	0.38	0.22	0.60	20.57	917
8	2	0.00	19.00	27.12	5.61	0.82	0.11	0.38	0.22	0.60	20.57	917
9	1	9.48	19.00	27.03	5.80	0.62	0.10	0.37	0.20	0.63	28.45	1267
9	2	26.03	19.00	26.95	5.72	0.62	0.10	0.38	0.20	0.61	28.35	2654
10	1	9.48	19.00	27.00	5.81	0.62	0.10	0.37	0.20	0.63	28.46	1302
10	2	28.11	19.00	26.93	5.73	0.62	0.10	0.38	0.20	0.60	28.38	2649
11	1	9.47	19.00	27.40	5.52	0.67	0.11	0.37	0.20	0.64	26.87	1331
11	2	30.39	19.00	27.39	5.49	0.67	0.11	0.37	0.20	0.63	26.81	1672
12	1	9.47	19.00	27.48	5.47	0.68	0.11	0.37	0.20	0.65	26.66	1283
12	2	13.46	19.00	27.50	5.42	0.69	0.11	0.37	0.20	0.65	26.48	1640
13	1	9.47	19.00	27.55	5.46	0.69	0.11	0.37	0.20	0.66	26.50	1231
13	2	12.52	19.00	27.60	5.38	0.70	0.11	0.37	0.20	0.66	26.11	1689
14	1	10.44	19.00	27.04	5.68	0.75	0.10	0.38	0.21	0.60	21.93	852
14	2	0.00	19.00	27.04	5.68	0.75	0.10	0.38	0.21	0.60	21.93	852
15	1	9.48	19.00	27.58	4.87	1.83	0.20	0.39	0.31	0.64	16.08	4551
15	2	4.51	19.00	27.58	4.84	1.80	0.20	0.39	0.31	0.64	15.60	5061
16	1	9.48	19.00	27.29	5.62	0.65	0.10	0.37	0.20	0.64	27.24	1357
16	2	29.00	19.00	27.25	5.58	0.65	0.11	0.37	0.20	0.62	27.23	1919
17	1	9.48	19.00	27.32	5.60	0.65	0.11	0.37	0.20	0.64	27.19	1388
17	2	42.53	19.00	27.28	5.57	0.65	0.11	0.37	0.20	0.63	27.18	1798
18	1	9.46	19.00	27.35	5.57	0.66	0.11	0.37	0.20	0.64	27.11	1418
18	2	28.78	19.00	27.32	5.55	0.66	0.11	0.37	0.20	0.63	27.10	1752
19	1	9.47	19.00	27.36	5.55	0.66	0.11	0.37	0.20	0.64	26.96	1409
19	2	30.90	19.00	27.35	5.53	0.66	0.11	0.37	0.20	0.63	26.94	1699
20	1	9.46	19.00	27.35	5.56	0.66	0.11	0.37	0.20	0.64	27.02	1430
20	2	27.44	19.00	27.33	5.54	0.66	0.11	0.37	0.20	0.63	26.99	1718
21	1	9.48	19.00	27.14	5.66	0.65	0.10	0.37	0.20	0.60	24.58	854
21	2	10.17	19.00	27.17	5.63	0.65	0.10	0.37	0.20	0.60	24.09	1016
22	1	9.47	19.00	27.21	5.62	0.66	0.11	0.37	0.20	0.62	27.00	2051
22	2	7.96	19.00	27.22	5.60	0.65	0.10	0.37	0.20	0.62	26.92	1807
23	1	9.48	19.00	27.22	5.62	0.65	0.10	0.37	0.20	0.62	26.77	1304
23	2	20.64	19.00	27.23	5.59	0.65	0.10	0.37	0.20	0.62	26.70	1540
24	1	1.48	19.00	27.23	5.66	0.65	0.10	0.37	0.20	0.63	27.20	1509
24	2	0.00	19.00	27.23	5.66	0.65	0.10	0.37	0.20	0.63	27.20	1509
25	1	9.13	19.00	27.19	5.63	0.65	0.10	0.37	0.20	0.62	26.78	1942
25	2	0.00	19.00	27.19	5.63	0.65	0.10	0.37	0.20	0.62	26.78	1942

TABLE 8a TIDE AVERAGED CONCENTRATIONS AT SELECTED STATIONS, DRY SEASON SPRING TIDE, BASELINE CONDITION

TING KAU AND SHAM TSENG SEWERAGE - DRY SEASON SPRING TIDE
LONG SEA OUTFALL

Station	Layer	Height	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	9.47	19	27.23	5.64	0.64	0.10	0.37	0.20	0.63	27.21	1412
1	2	2.03	19	27.22	5.61	0.65	0.10	0.37	0.20	0.62	27.20	1659
2	1	1.48	19	27.20	5.67	0.64	0.10	0.37	0.20	0.62	27.02	1230
2	2	0.00	19	27.20	5.67	0.64	0.10	0.37	0.20	0.62	27.02	1230
3	1	1.49	19	27.19	5.66	0.65	0.10	0.37	0.20	0.62	26.35	1094
3	2	0.00	19	27.19	5.66	0.65	0.10	0.37	0.20	0.62	26.35	1094
4	1	9.48	19	27.20	5.63	0.65	0.10	0.37	0.20	0.61	25.16	928
4	2	3.15	19	27.20	5.61	0.65	0.10	0.37	0.20	0.61	24.32	1089
5	1	6.30	19	27.11	5.69	0.65	0.10	0.37	0.20	0.60	23.41	628
5	2	0.00	19	27.11	5.69	0.65	0.10	0.37	0.20	0.60	23.41	628
6	1	7.90	19	27.09	5.70	0.66	0.10	0.37	0.20	0.60	23.26	608
6	2	0.00	19	27.09	5.70	0.66	0.10	0.37	0.20	0.60	23.26	608
7	1	3.40	19	27.05	5.73	0.70	0.10	0.38	0.21	0.60	20.91	455
7	2	0.00	19	27.05	5.73	0.70	0.10	0.38	0.21	0.60	20.91	455
8	1	7.06	19	27.12	5.61	0.82	0.11	0.38	0.22	0.60	20.57	815
8	2	0.00	19	27.12	5.61	0.82	0.11	0.38	0.22	0.60	20.57	815
9	1	9.48	19	27.03	5.80	0.62	0.10	0.37	0.20	0.63	28.45	1275
9	2	26.03	19	26.95	5.72	0.62	0.10	0.38	0.20	0.61	28.35	2662
10	1	9.48	19	27.00	5.81	0.62	0.10	0.37	0.20	0.63	28.46	1299
10	2	28.11	19	26.93	5.73	0.62	0.10	0.38	0.20	0.60	28.38	2652
11	1	9.47	19	27.40	5.52	0.67	0.11	0.37	0.20	0.64	26.87	1367
11	2	30.39	19	27.39	5.49	0.67	0.11	0.37	0.20	0.63	26.81	1689
12	1	9.47	19	27.48	5.47	0.68	0.11	0.37	0.20	0.65	26.66	1297
12	2	13.46	19	27.50	5.42	0.69	0.11	0.37	0.20	0.65	26.48	1652
13	1	9.47	19	27.55	5.46	0.69	0.11	0.37	0.20	0.66	26.50	1238
13	2	12.52	19	27.60	5.38	0.70	0.11	0.37	0.20	0.66	26.11	1695
14	1	10.44	19	27.04	5.68	0.74	0.10	0.38	0.21	0.60	21.93	751
14	2	0.00	19	27.04	5.68	0.74	0.10	0.38	0.21	0.60	21.93	751
15	1	9.48	19	27.58	4.87	1.83	0.20	0.39	0.31	0.64	16.08	4471
15	2	4.51	19	27.58	4.85	1.80	0.20	0.39	0.31	0.64	15.59	4975
16	1	9.48	19	27.29	5.62	0.65	0.10	0.37	0.20	0.64	27.24	1358
16	2	29.00	19	27.25	5.58	0.65	0.11	0.37	0.20	0.62	27.23	1929
17	1	9.48	19	27.32	5.60	0.66	0.11	0.37	0.20	0.64	27.19	1439
17	2	42.53	19	27.28	5.57	0.65	0.11	0.37	0.20	0.63	27.18	1820
18	1	9.46	19	27.35	5.57	0.66	0.11	0.37	0.20	0.64	27.11	1563
18	2	28.78	19	27.32	5.55	0.66	0.11	0.37	0.20	0.63	27.10	1773
19	1	9.47	19	27.36	5.55	0.67	0.11	0.37	0.20	0.64	26.96	1606
19	2	30.90	19	27.35	5.53	0.66	0.11	0.37	0.20	0.63	26.94	1720
20	1	9.46	19	27.35	5.56	0.67	0.11	0.37	0.20	0.64	27.02	1884
20	2	27.44	19	27.33	5.54	0.66	0.11	0.37	0.20	0.63	26.99	1741
21	1	9.48	19	27.14	5.66	0.65	0.10	0.37	0.20	0.60	24.58	795
21	2	10.17	19	27.17	5.63	0.65	0.10	0.37	0.20	0.60	24.09	955
22	1	9.47	19	27.21	5.62	0.65	0.10	0.37	0.20	0.62	26.99	1392
22	2	7.96	19	27.22	5.60	0.65	0.10	0.37	0.20	0.62	26.92	1553
23	1	9.48	19	27.22	5.62	0.65	0.10	0.37	0.20	0.62	26.77	1331
23	2	20.64	19	27.23	5.59	0.65	0.10	0.37	0.20	0.62	26.70	1529
24	1	1.48	19	27.23	5.66	0.65	0.10	0.37	0.20	0.63	27.20	1335
24	2	0.00	19	27.23	5.66	0.65	0.10	0.37	0.20	0.63	27.20	1335
25	1	9.13	19	27.19	5.63	0.64	0.10	0.37	0.20	0.62	26.77	1333
25	2	0.00	19	27.19	5.63	0.64	0.10	0.37	0.20	0.62	26.77	1333

TABLE 8b TIDE AVERAGED CONCENTRATIONS AT SELECTED STATIONS, DRY SEASON SPRING TIDE, LONG SEA OUTFALL

TING KAU AND SHAM TSENG SEWERAGE - WET SEASON SPRING TIDE
BASELINE CONDITION

Station	Layer	Height	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	11.49	27.25	26.82	4.48	0.65	0.06	0.29	0.28	5.68	20.37	1710
1	2	0.00	27.25	26.82	4.48	0.65	0.06	0.29	0.28	5.68	20.37	1710
2	1	1.46	27.20	27.22	4.47	0.65	0.06	0.29	0.28	5.69	19.06	1486
2	2	0.00	27.20	27.22	4.47	0.65	0.06	0.29	0.28	5.69	19.06	1486
3	1	1.45	27.18	27.51	4.42	0.64	0.05	0.28	0.28	5.65	18.01	1013
3	2	0.00	27.18	27.51	4.42	0.64	0.05	0.28	0.28	5.65	18.01	1013
4	1	9.51	27.17	27.55	4.37	0.63	0.05	0.28	0.28	5.59	17.59	967
4	2	3.09	27.14	27.87	4.28	0.63	0.05	0.27	0.28	5.48	15.85	1158
5	1	6.27	27.18	27.49	4.39	0.63	0.05	0.28	0.28	5.60	16.96	773
5	2	0.00	27.18	27.49	4.39	0.63	0.05	0.28	0.28	5.60	16.96	773
6	1	7.87	27.18	27.48	4.38	0.63	0.05	0.28	0.28	5.59	16.98	811
6	2	0.00	27.18	27.48	4.38	0.63	0.05	0.28	0.28	5.59	16.98	811
7	1	3.37	27.18	27.44	4.44	0.64	0.05	0.28	0.28	5.68	16.06	1030
7	2	0.00	27.18	27.44	4.44	0.64	0.05	0.28	0.28	5.68	16.06	1030
8	1	7.03	27.18	27.49	4.38	0.64	0.05	0.28	0.28	5.56	16.80	804
8	2	0.00	27.18	27.49	4.38	0.64	0.05	0.28	0.28	5.56	16.80	804
9	1	9.51	27.32	26.09	4.66	0.65	0.05	0.31	0.28	5.88	22.86	814
9	2	25.99	27.14	27.82	4.31	0.64	0.06	0.28	0.28	5.63	17.31	2177
10	1	9.54	27.32	26.12	4.64	0.65	0.05	0.31	0.28	5.86	22.74	902
10	2	28.04	27.14	27.81	4.30	0.64	0.06	0.28	0.28	5.62	17.31	2232
11	1	9.33	27.13	27.94	4.39	0.66	0.05	0.27	0.28	5.92	17.10	861
11	2	30.49	27.09	28.27	4.33	0.65	0.06	0.27	0.28	5.76	16.13	1023
12	1	9.21	27.10	28.24	4.43	0.68	0.05	0.27	0.29	6.22	16.24	647
12	2	13.67	27.01	28.90	4.34	0.66	0.05	0.26	0.29	5.97	14.30	824
13	1	9.14	27.09	28.35	4.44	0.69	0.05	0.27	0.29	6.36	15.91	593
13	2	12.81	26.97	29.22	4.35	0.66	0.05	0.25	0.29	6.01	13.37	831
14	1	10.41	27.18	27.50	4.37	0.64	0.05	0.28	0.28	5.55	17.23	834
14	2	0.00	27.18	27.50	4.37	0.64	0.05	0.28	0.28	5.55	17.23	834
15	1	9.41	27.21	27.23	4.33	0.95	0.08	0.29	0.30	5.45	17.91	3056
15	2	4.54	27.21	27.20	4.24	0.77	0.07	0.29	0.29	5.18	15.74	2769
16	1	9.53	27.25	26.81	4.50	0.65	0.06	0.29	0.28	5.73	20.52	1282
16	2	28.94	27.17	27.59	4.32	0.64	0.06	0.28	0.28	5.56	18.00	1715
17	1	9.52	27.21	27.21	4.43	0.64	0.06	0.29	0.28	5.69	19.26	1289
17	2	42.47	27.17	27.61	4.33	0.64	0.06	0.28	0.28	5.58	17.98	1479
18	1	9.48	27.19	27.44	4.40	0.64	0.05	0.28	0.28	5.69	18.56	1216
18	2	28.74	27.15	27.71	4.33	0.64	0.06	0.28	0.28	5.60	17.71	1357
19	1	9.46	27.18	27.46	4.40	0.64	0.05	0.28	0.28	5.69	18.47	1136
19	2	30.87	27.14	27.82	4.33	0.64	0.06	0.28	0.28	5.63	17.43	1222
20	1	9.47	27.18	27.46	4.40	0.64	0.05	0.28	0.28	5.69	18.49	1176
20	2	27.40	27.15	27.77	4.33	0.64	0.06	0.28	0.28	5.61	17.58	1268
21	1	9.49	27.18	27.53	4.37	0.63	0.05	0.28	0.28	5.59	17.46	896
21	2	10.13	27.14	27.83	4.27	0.63	0.05	0.28	0.28	5.45	15.97	1155
22	1	9.54	27.20	27.32	4.40	0.65	0.06	0.28	0.28	5.63	18.82	1785
22	2	7.87	27.17	27.55	4.35	0.64	0.06	0.28	0.28	5.57	18.06	1501
23	1	9.47	27.18	27.47	4.38	0.64	0.05	0.28	0.28	5.62	18.25	1122
23	2	20.61	27.14	27.85	4.31	0.64	0.06	0.28	0.28	5.57	17.10	1161
24	1	1.46	27.23	27.01	4.50	0.65	0.06	0.29	0.28	5.72	19.79	1289
24	2	0.00	27.23	27.01	4.50	0.65	0.06	0.29	0.28	5.72	19.79	1289
25	1	9.10	27.20	27.24	4.41	0.65	0.06	0.29	0.28	5.63	18.84	1655
25	2	0.00	27.20	27.24	4.41	0.65	0.06	0.29	0.28	5.63	18.84	1655

TABLE 9a TIDE AVERAGED CONCENTRATIONS AT SELECTED STATIONS, WET SEASO
SPRING TIDE, BASELINE CONDITION

TING KAU AND SHAM TSENG SEWERAGE - WET SEASON SPRING TIDE
LONG SEA OUTFALL

Station	Layer	Height	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	11.49	27.25	26.82	4.48	0.64	0.05	0.29	0.28	5.68	20.36	1098
1	2	0.00	27.25	26.82	4.48	0.64	0.05	0.29	0.28	5.68	20.36	1098
2	1	1.46	27.20	27.22	4.47	0.64	0.05	0.29	0.28	5.69	19.05	943
2	2	0.00	27.20	27.22	4.47	0.64	0.05	0.29	0.28	5.69	19.05	943
3	1	1.45	27.18	27.51	4.42	0.64	0.05	0.28	0.28	5.65	18.01	917
3	2	0.00	27.18	27.51	4.42	0.64	0.05	0.28	0.28	5.65	18.01	917
4	1	9.51	27.17	27.55	4.37	0.63	0.05	0.28	0.28	5.59	17.59	882
4	2	3.09	27.14	27.87	4.28	0.63	0.05	0.27	0.28	5.48	15.85	1119
5	1	6.27	27.18	27.49	4.39	0.63	0.05	0.28	0.28	5.60	16.96	668
5	2	0.00	27.18	27.49	4.39	0.63	0.05	0.28	0.28	5.60	16.96	668
6	1	7.87	27.18	27.48	4.39	0.63	0.05	0.28	0.28	5.59	16.97	675
6	2	0.00	27.18	27.48	4.39	0.63	0.05	0.28	0.28	5.59	16.97	675
7	1	3.37	27.18	27.44	4.44	0.63	0.05	0.28	0.28	5.68	16.06	472
7	2	0.00	27.18	27.44	4.44	0.63	0.05	0.28	0.28	5.68	16.06	472
8	1	7.03	27.18	27.49	4.39	0.64	0.05	0.28	0.28	5.56	16.79	688
8	2	0.00	27.18	27.49	4.39	0.64	0.05	0.28	0.28	5.56	16.79	688
9	1	9.51	27.32	26.09	4.66	0.65	0.05	0.31	0.28	5.88	22.86	815
9	2	25.99	27.14	27.82	4.31	0.64	0.06	0.28	0.28	5.63	17.31	2191
10	1	9.54	27.32	26.12	4.64	0.65	0.05	0.31	0.28	5.86	22.74	892
10	2	28.04	27.14	27.81	4.30	0.64	0.06	0.28	0.28	5.62	17.31	2237
11	1	9.33	27.13	27.94	4.39	0.66	0.05	0.27	0.28	5.92	17.10	878
11	2	30.49	27.09	28.27	4.33	0.65	0.06	0.27	0.28	5.76	16.13	1049
12	1	9.21	27.10	28.24	4.43	0.68	0.05	0.27	0.29	6.22	16.24	661
12	2	13.67	27.01	28.90	4.34	0.66	0.05	0.26	0.29	5.97	14.30	846
13	1	9.14	27.09	28.35	4.44	0.69	0.05	0.27	0.29	6.36	15.91	604
13	2	12.81	26.97	29.22	4.35	0.66	0.05	0.25	0.29	6.01	13.38	845
14	1	10.41	27.18	27.50	4.37	0.63	0.05	0.28	0.28	5.55	17.23	718
14	2	0.00	27.18	27.50	4.37	0.63	0.05	0.28	0.28	5.55	17.23	718
15	1	9.41	27.21	27.23	4.33	0.95	0.08	0.29	0.30	5.45	17.91	2977
15	2	4.54	27.21	27.20	4.24	0.77	0.07	0.29	0.29	5.18	15.74	2707
16	1	9.53	27.25	26.81	4.50	0.65	0.06	0.29	0.28	5.73	20.52	1255
16	2	28.94	27.17	27.59	4.32	0.64	0.06	0.28	0.28	5.56	18.00	1738
17	1	9.52	27.21	27.21	4.43	0.64	0.05	0.29	0.28	5.69	19.26	1262
17	2	42.47	27.17	27.61	4.33	0.64	0.06	0.28	0.28	5.58	17.98	1552
18	1	9.48	27.19	27.44	4.40	0.64	0.05	0.28	0.28	5.69	18.56	1216
18	2	28.74	27.15	27.71	4.33	0.64	0.06	0.28	0.28	5.60	17.71	1489
19	1	9.46	27.18	27.46	4.40	0.64	0.05	0.28	0.28	5.69	18.47	1117
19	2	30.87	27.14	27.82	4.33	0.64	0.06	0.28	0.28	5.63	17.43	1334
20	1	9.47	27.18	27.46	4.40	0.64	0.05	0.28	0.28	5.69	18.48	1169
20	2	27.40	27.15	27.77	4.33	0.64	0.06	0.28	0.28	5.61	17.58	1570
21	1	9.49	27.18	27.53	4.37	0.63	0.05	0.28	0.28	5.59	17.46	806
21	2	10.13	27.14	27.83	4.27	0.63	0.05	0.28	0.28	5.45	15.97	1106
22	1	9.54	27.20	27.32	4.40	0.64	0.05	0.28	0.28	5.63	18.82	1061
22	2	7.87	27.17	27.55	4.35	0.64	0.06	0.28	0.28	5.57	18.06	1248
23	1	9.47	27.18	27.47	4.38	0.64	0.05	0.28	0.28	5.62	18.25	1050
23	2	20.61	27.14	27.85	4.31	0.64	0.06	0.28	0.28	5.57	17.10	1185
24	1	1.46	27.23	27.01	4.50	0.64	0.05	0.29	0.28	5.72	19.78	998
24	2	0.00	27.23	27.01	4.50	0.64	0.05	0.29	0.28	5.72	19.78	998
25	1	9.10	27.20	27.24	4.41	0.64	0.05	0.29	0.28	5.63	18.84	1046
25	2	0.00	27.20	27.24	4.41	0.64	0.05	0.29	0.28	5.63	18.84	1046

TABLE 9b TIDE AVERAGED CONCENTRATIONS AT SELECTED STATIONS, WET SEASON SPRING TIDE, LONG SEA OUTFALL

DIFFERENCES IN TIDE AVERAGED CONCENTRATIONS
DRY SEASON SPRING TIDE

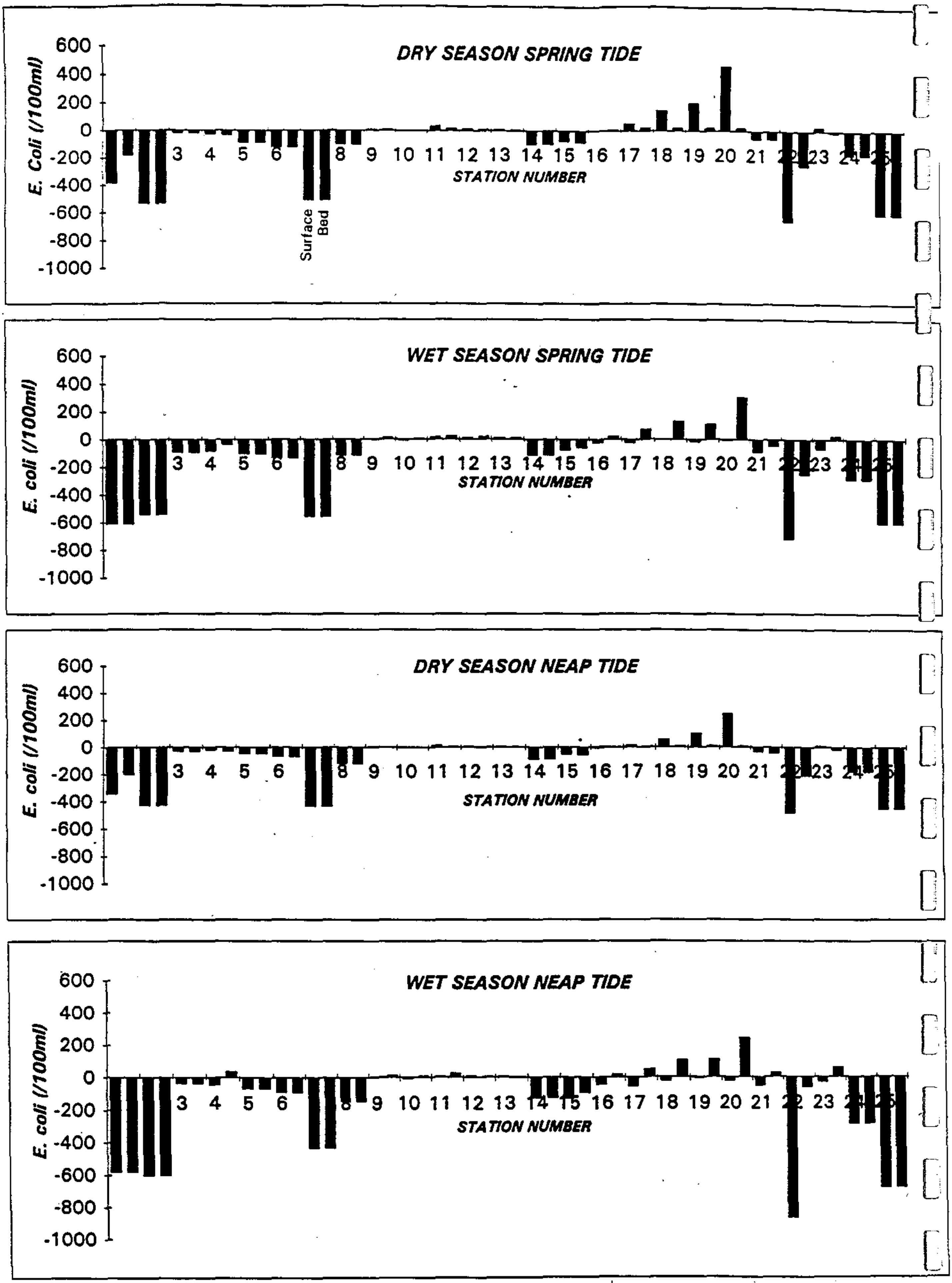
Station	Layer	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-388
1	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-185
2	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-533
2	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-533
3	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-23
3	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-23
4	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-32
4	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-37
5	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-92
5	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-92
6	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-125
6	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-125
7	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-510
7	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-510
8	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-102
8	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-102
9	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
9	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3
10	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
11	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36
11	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17
12	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
12	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12
13	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
13	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
14	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-101
14	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-101
15	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-80
15	2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.01	-86
16	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
16	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10
17	1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	51
17	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22
18	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	145
18	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21
19	1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	197
19	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21
20	1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	454
20	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
21	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-59
21	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-61
22	1	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.01	-659
22	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-254
23	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27
23	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-11
24	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-174
24	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-174
25	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-609
25	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-609

TABLE 10 DIFFERENCES IN CONCENTRATIONS AT SELECTED STATIONS BETWEEN THE BASELINE AND SCENARIO LAYOUTS - DRY SEASON SPRING TIDE

DIFFERENCES IN TIDE AVERAGED CONCENTRATIONS
WET SEASON SPRING TIDE

Station	Layer	Temp	Salinity	DO	BOD	Amm	OxN	OrgN	Chl	SS	EColi
1	1	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.01	-612
1	2	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.01	-612
2	1	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.01	-543
2	2	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.01	-543
3	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-96
3	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-96
4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-85
4	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-39
5	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-105
5	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-105
6	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-136
6	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-136
7	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-558
7	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-558
8	1	0.00	0.00	0.00	0.0C	0.00	0.00	0.00	0.00	-0.01	-116
8	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-116
9	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
9	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-10
10	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
11	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17
11	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26
12	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
12	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22
13	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11
13	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	14
14	1	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-116
14	2	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-116
15	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-79
15	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-62
16	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-27
16	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
17	1	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-27
17	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73
18	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
18	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	132
19	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-19
19	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	112
20	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-7
20	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	302
21	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-90
21	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-49
22	1	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	-724
22	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-253
23	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-72
23	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24
24	1	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.01	-291
24	2	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	-0.01	-291
25	1	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	-609
25	2	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	-609

TABLE 11 DIFFERENCES IN CONCENTRATIONS AT SELECTED STATIONS BETWEEN THE BASELINE AND SCENARIO LAYOUTS - WET SEASON SPRING TIDE



15 Differences in *E. coli* Concentrations between the Baseline and Scenario La

APPENDIX 1
EFFLUENT LOADING PATTERN
FOR THE YEAR 2003 ASSUMING NO SMP REDUCTION

		Ref.			BOD	Factors			
					tonne/d	E. coli	N Organic	N Ammonia	N Oxid…
	NTS3+NTS1 (New Territories)	1	820900	838100	0.74	0.68	0.09	0.17	
	NTS2 (New Territories)	1	814400	835200	0.03	0.68	0.09	0.17	0
	CT1 (Central)	1	833300	817100	25.90	0.71	0.06	0.08	
X	WW1 (Wanchai West)	1	835500	816400	9.93	0.67	0.06	0.07	
	WE1 (Wanchai East)	1	836400	816500	15.67	0.81	0.07	0.09	0
	NP1 (North Point)	1	838400	817400	15.50	1.05	0.08	0.11	
X	CW1 (Chai Wan)	1	843800	814900	6.18	1.11	0.08	0.11	0
	WF1 (Wah Fu)	1	831700	812300	2.42	1.24	0.09	0.12	
	TO1 (Tai O)	1	803300	813800	0.12	1.89	0.13	0.19	
	PC1 (Peng Chau)	1	821000	816800	0.32	1.18	0.08	0.12	0
X	YL1 (Yuen Long STW)	1	821200	837900	0.37	2.65	0.49	0.34	0.8
	TM2 (AREA 38)	1	811400	824400	See Table 3				
X	TW1 (Tsuen Wan)	1	829900	822400	46.99	0.71	0.06	0.09	0
X	KS1 (Kowloon South)	1	836500	817000	21.31	0.73	0.06	0.08	
X	KE1 (Kowloon East)	1	840000	827500	17.27	1.02	0.08	0.10	
X	KT1 (Kwun Tong)	1	840400	817200	34.66	1.09	0.08	0.13	0
X	JB1 (Junk Bay)	1	844400	814600	1.27	1.01	0.07	0.10	
	SK1 (Sai Kung STW)	1	846600	825700	0.05	0.01	0.30	0.20	0.5
	1.18	1	846500	826900	0.21	5.70	0.14	0.15	0
	1.19	1	846600	827500	0.12	4.93	0.13	0.14	
	1.99	1	846100	826700	0.20	0.70	0.06	0.08	
	1A.99+1A.80	1	849300	827200	0.65	3.52	0.10	0.12	0
	1B.09	1	844700	824300	0.59	0.44	0.05	0.05	
	1B.14+1B.13	1	844400	823800	0.76	0.88	0.04	0.04	
	1B.17	1	845000	825200	0.08	3.69	0.10	0.11	0
	1B.99	1	844900	825000	0.09	3.74	0.12	0.14	
	1C.09	1	846500	820300	0.05	1.23	0.09	0.12	
	1C.99	1	846300	821100	0.38	6.57	0.16	0.23	0
	2.13+2.14	1	844600	819600	2.85	2.97	0.07	1.06	
	2.80	1	844600	819500	0.01	1.20	0.09	0.12	
	2.99	1	844300	818100	0.06	0.27	0.03	0.03	
	3.01	1	842000	817300	2.86	0.98	0.07	0.10	
	3.09	1	841900	817700	0.04	1.18	0.08	0.12	0
	3.10	1	842300	817400	0.72	0.72	0.06	0.08	
	3.11+3.12	1	841900	817400	0.72	0.26	0.06	0.03	
	3.13	1	842300	816900	0.73	0.26	0.04	0.03	0
	3.15+3.80+3.99	1	842500	816800	0.44	1.34	0.09	0.12	
	4.10	1	839200	819900	4.67	1.04	0.08	0.15	
	4.12	1	840000	819600	1.08	0.74	0.06	0.08	0
	4.13	1	840300	819300	3.25	0.55	0.05	0.06	
	4.14+4.99	1	840500	819100	7.87	0.54	0.05	[illegible]	
	4.15+4.16	1	840700	818900	8.58	0.60	0.06	0.06	0
	4.18	1	841000	818500	6.16	1.01	0.07	0.15	
	4.19	1	841500	818000	0.93	0.65	0.06	0.07	

Note: Discharges marked 'X' replaced by the Stage I Stonecutter's Outfall (Table 3, main text)

APPENDIX 3 : OVERALL LOADING PATTERN, YEAR 2003 ASSUMING NO SMP REDUCTIONS

	Ref.			Loads BOD	Factors			
				tonne/d	E. coli	N Organic	N Ammonia	N
5A.10	1	838100	819800	1.72	0.75	0.06	0.08	
5A.11	1	839000	820000	4.13	0.51	0.05	0.06	
5B.01	1	837900	818400	0.57	0.85	0.07	0.09	
5B.02	1	838600	817800	14.68	0.97	0.07	0.10	
5B.15+5B.16	1	837900	819200	1.48	0.66	0.06	0.07	
5B.18	1	838100	819400	0.97	0.75	0.06	0.08	
5B.20	1	839500	819800	0.73	0.34	0.05	0.05	
5B.22	1	838100	819800	0.51	0.48	0.05	0.05	
5B.99	1	837900	818300	0.74	0.66	0.06	0.07	
6.13	1	835800	817100	0.47	0.71	0.06	0.08	
6.15	1	836800	817300	0.47	0.71	0.06	0.08	
6.17	1	836900	818300	0.25	0.76	0.06	0.08	
6.99	1	837600	817900	0.23	0.71	0.06	0.08	
10A.10	1	827600	825400	0.50	1.74	0.09	0.12	
10A.12+10A.13	1	828200	825500	1.12	0.00	0.02	0.00	
10A.14	1	828300	825500	1.56	0.31	0.04	0.04	
10A.16+10A.15	1	828700	825900	1.56	0.31	0.04	0.05	
10A.17	1	828800	825900	1.12	0.00	0.02	0.00	
10A.18	1	828800	825600	3.67	0.26	0.04	0.03	
10A.19	1	828900	825800	0.56	0.00	0.02	0.00	
10A.20	1	829100	825600	6.46	0.54	0.05	0.06	
10A.22	1	829500	825300	2.24	1.18	0.08	0.11	
10A.23+10A.24	1	829600	825100	8.93	0.46	0.03	0.03	
10A.29	1	830000	823900	4.26	0.22	0.03	0.04	
10A.34	1	830000	823200	4.93	0.10	0.03	0.02	
10A.36+10A.80	1	830500	822700	15.34	0.30	0.04	0.03	
10A.99	1	828700	825900	5.01	0.48	0.05	0.05	
10B.16+10B.17	1	829300	823600	0.78	0.00	0.02	0.00	
10B.18	1	829700	823300	0.79	0.00	0.02	0.00	
10B.99	1	829200	821300	1.18	1.28	0.07	0.09	
11.02	1	826200	825500	0.01	1.16	0.08	0.12	
11.09	1	822600	824700	0.02	1.04	0.08	0.11	
11.12	1	822700	824700	1.27	6.72	0.15	0.16	
11.13	1	823700	825000	2.63	6.74	0.15	0.16	
11.14	1	824300	825100	2.94	6.03	0.14	0.14	
11.16+11.15	1	824500	825100	1.59	5.39	0.12	0.13	
11.80	1	824300	825100	0.23	1.09	0.08	0.11	
11.99	1	826300	825200	1.42	6.67	0.15	0.17	
12.16	1	812400	825100	0.05	3.04	0.10	1.35	
12.20	1	816000	825700	7.91	1.38	0.05	0.08	
12.24	1	817000	825700	0.45	6.75	0.15	0.16	
12.25	1	817400	825700	2.08	4.49	0.11	0.12	
12.28	1	819080	825100	0.62	5.22	0.13	0.15	
12.80	1	817000	825000	0.21	1.18	0.08	0.12	
12.99+12.22+12.26	1	817400	825200	2.35	2.48	0.08	0.24	

APPENDIX 3 : OVERALL LOADING PATTERN, YEAR 2003 ASSUMING NO SMP REDUCTIONS

				Factors			
				tonne/d	E. coli	N [illegible]	N [illegible]
12D.50+12A.50+12A.51+12A.81 +12C.50+12D.81+12A.99	1	821000	837900	26.51	5.50	0.14	0.15
12B.01	1	807000	827500	0.01	1.25	0.09	0.36
12B.11	1	810500	831100	1.37	6.65	0.15	0.16
12B.14	1	812300	832400	1.39	6.55	0.15	0.16
12B.15	1	821600	833300	0.74	6.56	0.15	0.16
12B.16	1	813300	834200	0.74	6.56	0.15	0.16
12B.17	1	814300	834700	0.74	6.56	0.15	0.16
12B.18	1	815100	835000	0.74	6.56	0.15	0.16
12B.19	1	816000	836200	0.74	6.56	0.15	0.16
12B.81	1	812200	832100	0.03	1.19	0.08	0.12
12B.99	1	816200	836600	2.83	6.62	0.15	0.16
13A.80	1	823700	823200	0.06	1.20	0.09	0.12
13A.99	1	811100	816000	0.33	4.75	0.13	0.16
14.99+14.80	1	822000	815700	0.15	3.16	0.11	0.15
15.16	1	818000	814500	0.06	3.61	0.11	0.13
15.80	1	818100	814700	0.03	1.03	0.08	0.11
15.99	1	817600	811300	0.17	3.78	0.12	0.17
15A.80	1	810300	809600	0.02	1.13	0.08	0.11
15A.81	1	816100	810800	0.02	1.13	0.08	0.11
15A.99	1	812900	810600	0.25	5.22	0.14	0.20
16.01	1	821300	813600	0.12	3.74	0.12	0.14
17.80	1	821600	807800	0.04	1.15	0.08	0.12
17.99	1	820900	807700	0.45	5.32	0.14	0.19
18.01	1	807100	809200	0.03	1.24	0.09	0.12
18.99	1	806100	809000	0.08	4.97	0.13	0.17
18A.99	1	803700	812600	0.21	4.05	0.12	1.15
19.09	1	831400	807400	0.07	1.58	0.09	0.16
19.80	1	830000	809000	0.07	1.58	0.09	0.16
19.99	1	829200	810000	0.18	4.67	0.13	0.16
20.01	1	830300	814700	0.04	1.22	0.09	0.12
20.02	1	830600	814600	0.24	1.23	0.09	0.12
20.03	1	831000	813900	0.10	1.22	0.09	0.12
20.04	1	831500	813500	0.16	1.23	0.09	0.12
20.09	1	830700	814400	0.03	1.22	0.09	0.12
20.11	1	830600	814500	0.04	3.99	0.12	0.14
20.13	1	831100	813400	0.06	3.08	0.11	0.14
20.15	1	831700	812600	0.06	3.08	0.11	0.14
20.80	1	830400	814500	0.03	1.23	0.09	0.12
20.99	1	831200	813400	0.06	3.15	0.11	0.14
21.99	1	831800	812400	0.12	1.89	0.09	0.13
30.12	1	843400	814600	0.40	0.61	0.06	0.07
30.13	1	843600	814700	1.59	0.66	0.06	0.07
31.06+31.01+31.02+31.03+31.04+31.06	1	841200	816500	5.85	1.11	0.08	0.11
31.10	1	840100	817800	0.30	1.10	0.08	0.11
31.15+31.17	1	841300	816300	0.58	1.13	0.08	0.11
31.16	1	841500	816100	0.15	1.16	0.08	0.11
31.18+31.21+21.22	1	841900	816400	0.65	1.02	0.08	0.10
31.99	1	841700	815800	0.37	1.18	0.08	0.12

APPENDIX 3 : OVERALL LOADING PATTERN, YEAR 2003 ASSUMING NO SMP REDUCTIONS

	Ref.			BOD	Factors			
				tonne/d	E. coli	N Organic	N Ammonia	N o
32.10	1	837200	816300	0.57	1.15	0.08	0.11	
32.11	1	837500	816500	0.34	0.58	0.06	0.07	
32.14	1	838300	817500	0.74	1.06	0.08	0.11	
32.15	1	838900	817300	0.37	1.06	0.08	0.11	
32.17+32.16	1	839400	817500	1.50	0.65	0.06	0.08	
32.99	1	837900	816900	0.56	0.79	0.07	0.09	
33.11	1	836200	816500	0.97	0.79	0.07	0.08	
33.13+33.99	1	837100	816200	1.11	0.85	0.07	0.09	
34.12	1	835400	816700	0.40	0.69	0.06	0.07	
34.14+34.15	1	834000	816800	3.04	0.65	0.06	0.07	
34.99	1	833800	817800	0.13	0.72	0.06	0.08	
35.14+35.15	1	829500	816900	0.74	0.74	0.06	0.08	
35.16	1	831200	816100	1.14	0.74	0.06	0.08	
35.18+35.19	1	830200	817100	0.40	0.70	0.06	0.08	
35.21	1	831600	816400	0.37	0.74	0.06	0.08	
35.22+35.23	1	832000	816800	2.26	0.74	0.06	0.08	
35.24	1	832350	816950	1.12	0.74	0.06	0.08	
35.25	1	832600	817100	1.12	0.74	0.06	0.08	
35.27	1	833000	816900	1.12	0.74	0.06	0.08	
35.28	1	833400	816900	1.12	0.74	0.06	0.08	
35.30	1	833900	816750	1.12	0.74	0.06	0.08	
35.31	1	834000	816700	1.12	0.74	0.06	0.08	
35.99	1	832650	817100	1.19	0.87	0.07	0.08	
38.50	1	822300	840600	0.69	4.54	0.13	0.28	
38.51	1	822300	840600	1.34	4.52	0.12	0.14	
38.52	1	822300	840600	3.43	4.39	0.12	0.14	
38.81	1	822300	840600	0.41	1.17	0.08	0.12	
39.99	1	822300	840600	2.63	5.24	0.13	0.15	
40.99	1	841000	844900	1.54	5.84	0.14	0.15	
99.99	1	822300	840600	70.97	3.26	0.10	0.15	
Macau A	2	772647	808033	27.00	0.98	0.09	0.15	
Macau B	2	772706	807133	2.25	0.98	0.09	0.15	
Macau C	2	771056	805776	6.75	0.98	0.09	0.15	
Macau D (Taipa)	2	773029	803194	0.45	0.98	0.09	0.15	
Humen – Pearl River	3	758161	876441	Set as boundary conditions				
Jiaomen – Pearl River	3	766172	871816					
Hougqizli – Pearl River	3	763163	864604					
Hengmen – Pearl River	3	762100	848763					
Hengmen – Pearl River	3	762100	848763					
X O/F 2 with DWF interceptor	4	832980	821000	0.24	0.25	0.04	0.03	
X O/F 3 with DWF interceptor	4	833100	820930	0.18	0.41	0.05	0.05	
X O/F 4 with DWF interceptor	4	833100	820930	0.22	0.77	0.06	0.08	
X O/F 5 with DWF interceptor	4	833645	820475	0.21	0.76	0.06	0.08	
X O/F 6 with DWF interceptor	4	833900	820240	1.25	0.87	0.07	0.09	
X O/F 7a with DWF interceptor	4	834405	819690	1.13	0.84	0.07	0.09	
X O/F 8a with DWF interceptor	4	834445	818815	0.63	0.86	0.07	0.09	
X O/F 9 with DWF interceptor	4	834925	817890	0.34	0.79	0.07	0.08	

Note: Discharges marked 'X' replaced by the Stage I Stonecutter's Outfall (Table 3, main text)

APPENDIX 3 : OVERALL LOADING PATTERN, YEAR 2003 ASSUMING NO SMP REDUCTIONS

Outfall No./Reference	Data Ref.	Easting	Northing	Loads				
				BOD	Factors			
				tonne/d	E. coli	N Organic	N Ammonia	N
NTS6	5	840900	844600	0.10	0.93	0.09	0.15	
NTS4	5	822300	840600	1.20	0.96	0.09	0.15	
CC1	5	820000	808400	1.17	1.07	0.08	0.11	
MW1	5	821000	816800	0.19	1.09	0.12	0.13	
MA1	5	821100	817300	0.13	1.09	0.12	0.13	
SO2	5	844800	810100	0.44	0.95	0.07	0.10	
TLE1	5	838700	820300	2.92	1.99	0.18	0.30	0
SHW1 (Siu Ho Wan)	5			See Table 3				
AB1 (Aberdeen)	5	832600	811900	12.15	1.06	0.08	0.10	
SN1 (Stanley)	5	839900	808600	0.12	1.11	0.11	0.19	0
NWNT (Urmston ROAD)	5			See Table 3				
AL2 (Ap Lei Chau)	5	833400	810300	3.48	1.13	0.08	0.11	
X SKW7	5	841700	816200	6.37	1.02	0.08	0.10	
X TKW2	5	838600	817800	18.45	0.82	0.07	0.09	
X CW1	5	843700	814800	6.18	1.11	0.08	0.11	
X NWK1	5	831300	819610	75.11	0.79	0.05	0.09	

Note: Discharges marked 'X' replaced by the Stage I Stonecutter's Outfall (Table 3, main text)

APPENDIX 3 : OVERALL LOADING PATTERN, YEAR 2003 ASSUMING NO SMP REDUCTIONS

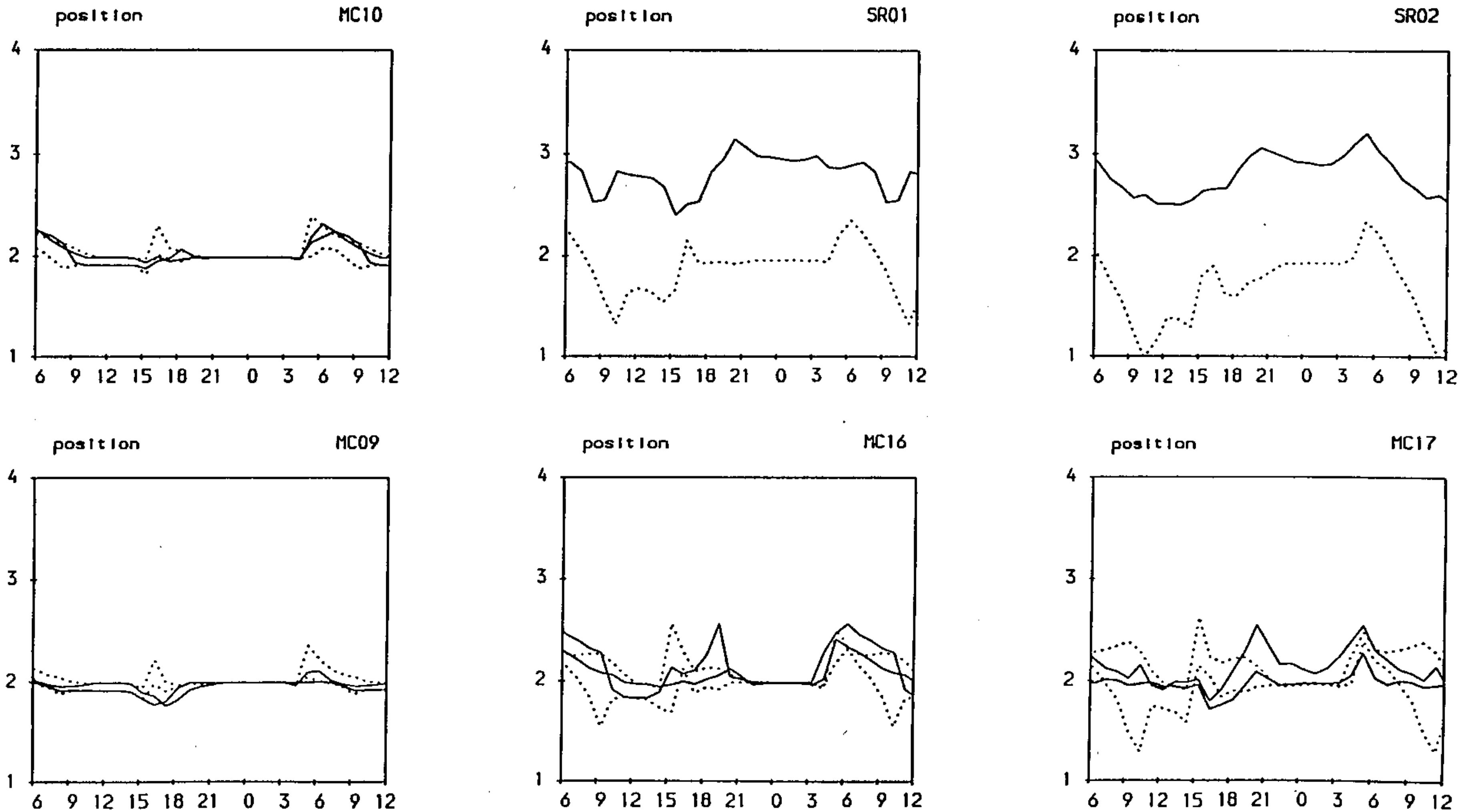
APPENDIX 2
RESULTS OF THE SIMULATION OF WET AND DRY SEASON NEAP TIDE WATER QUALITY

TK+Sham Tseng Wet Neap CJV v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

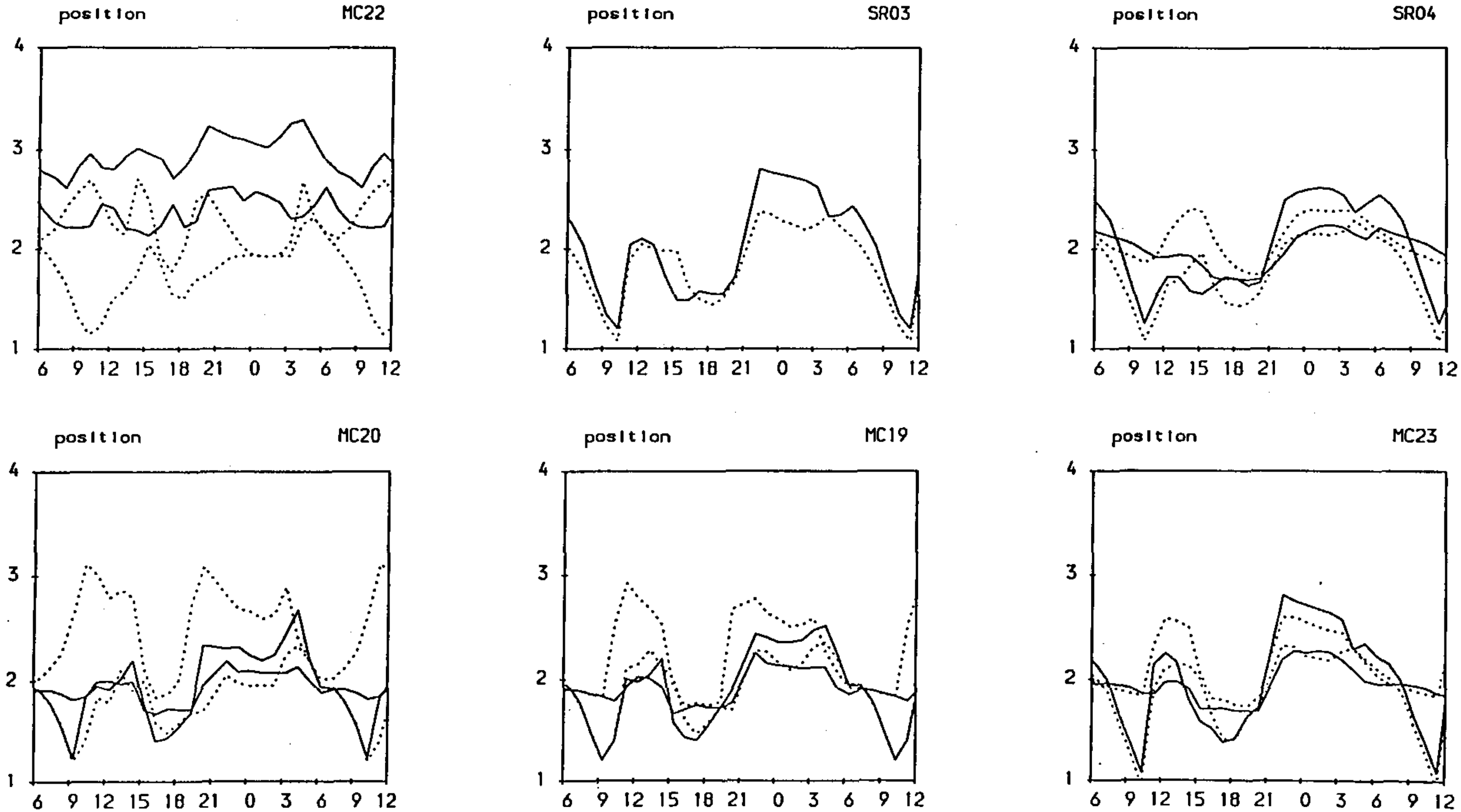


TK+Sham Tseng Wet Neap CJV v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 3/03/95 ——— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer

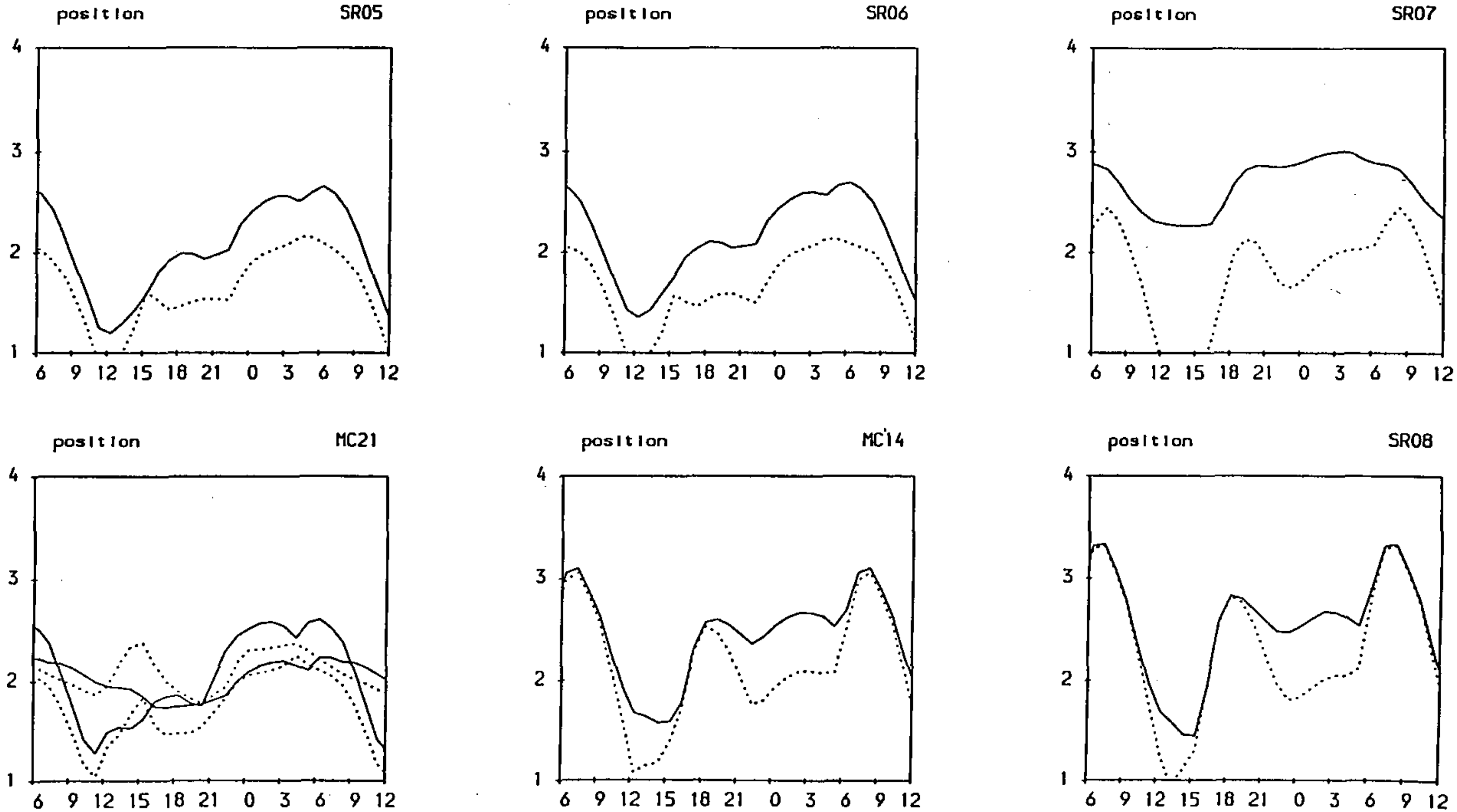


TK+Sham Tseng Wet Neap   CJV v LSO

E.Coli (no/100ml) against time   (log to base 10 on y-axis)

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer

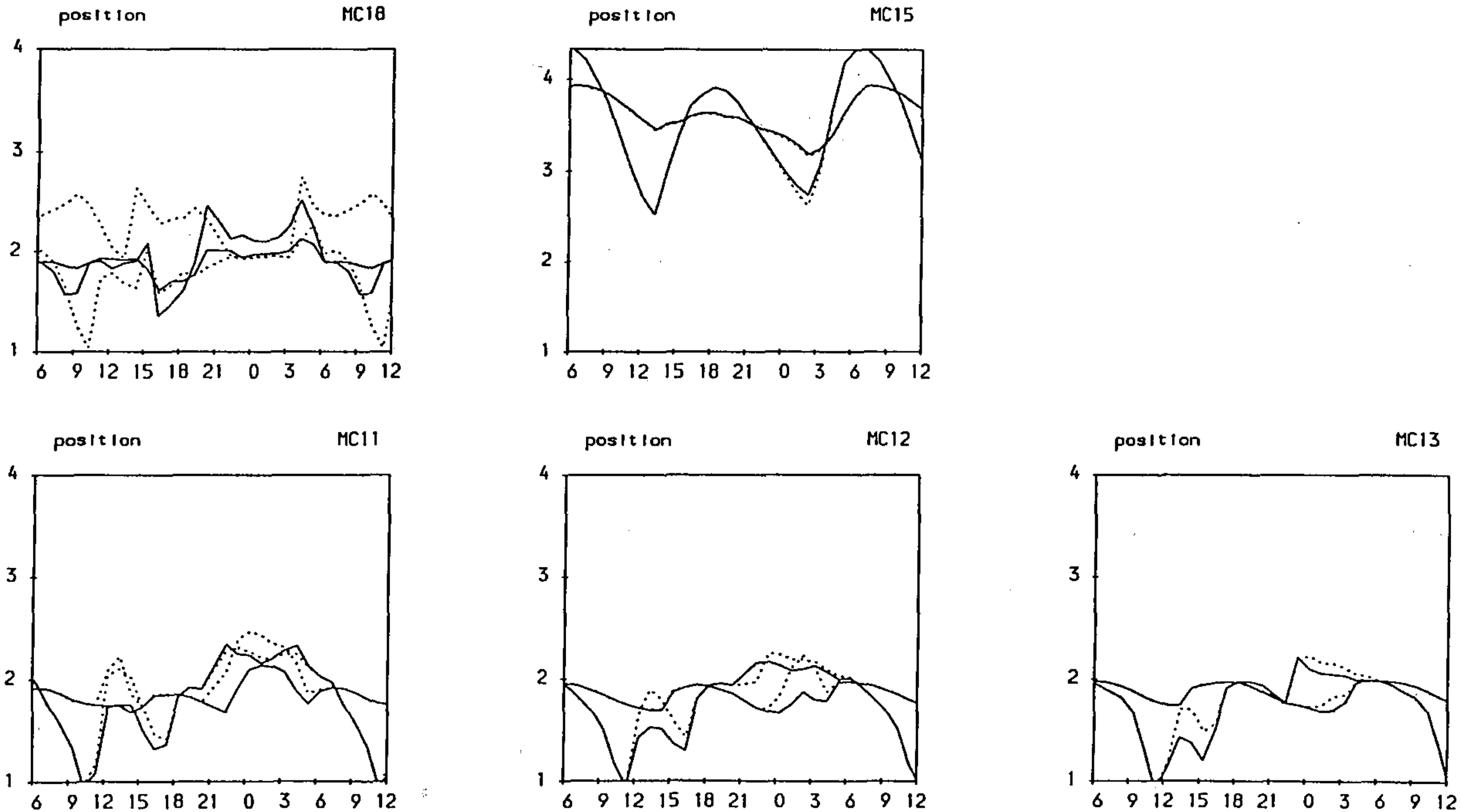


TK+Sham Tseng Wet Neap   CJV v LSO

E.Coli (no/100ml) against time   (log to base 10 on y-axis)

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

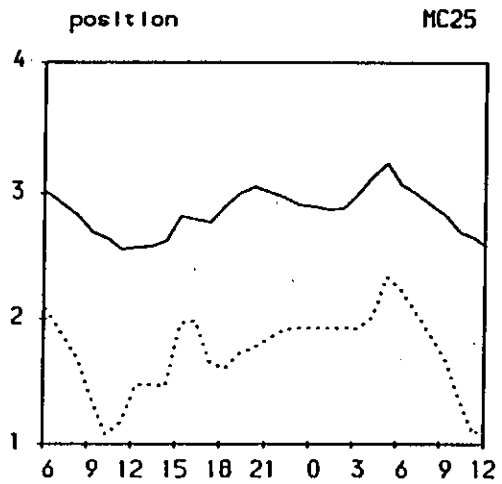


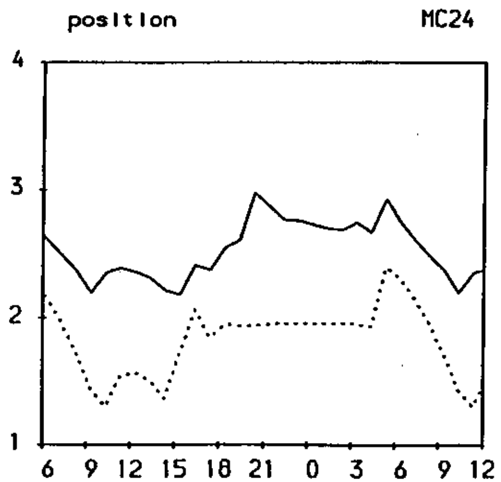
TK+Sham Tseng Wet Neap CJV v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



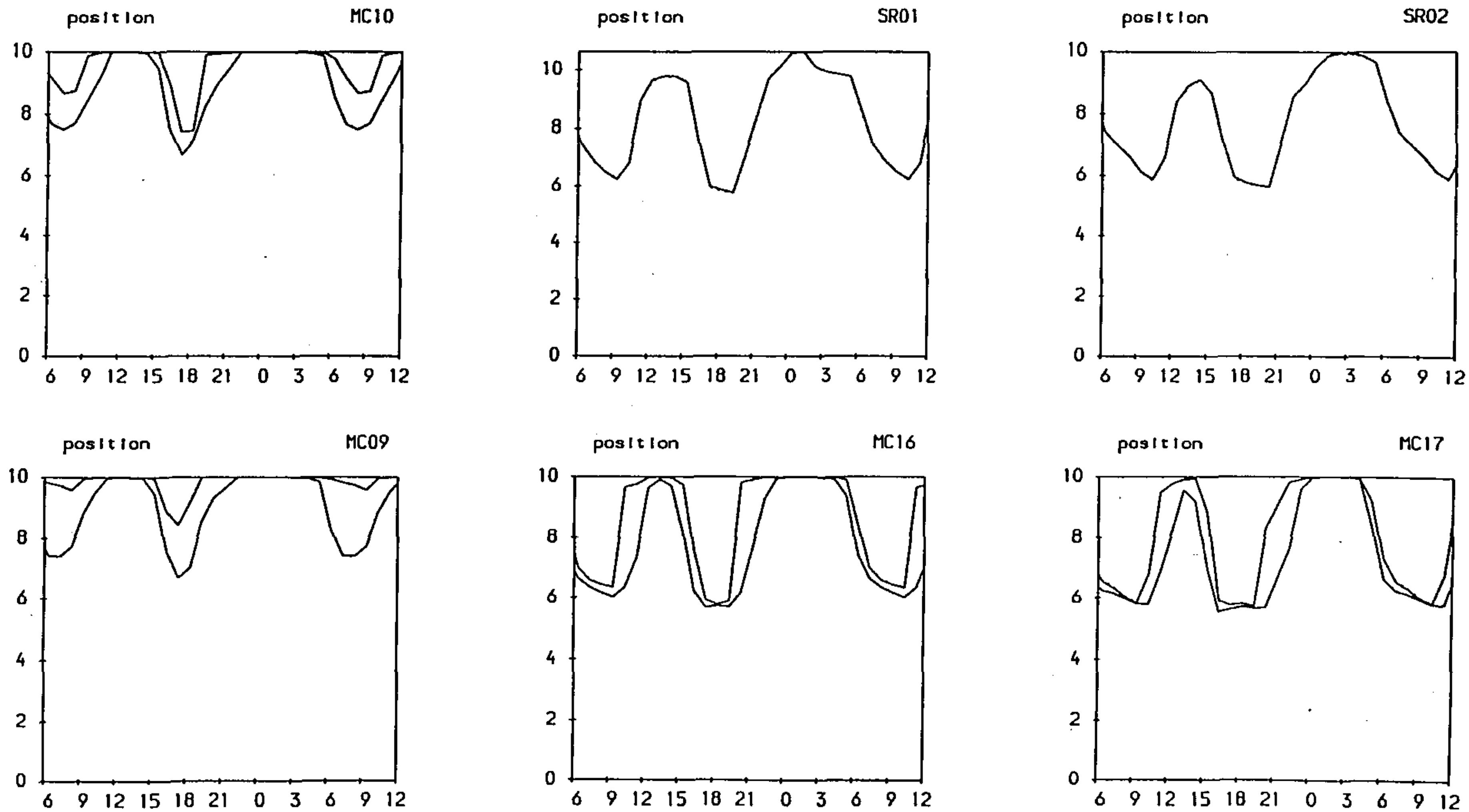


TK+Sham Tseng Wet Neap   CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

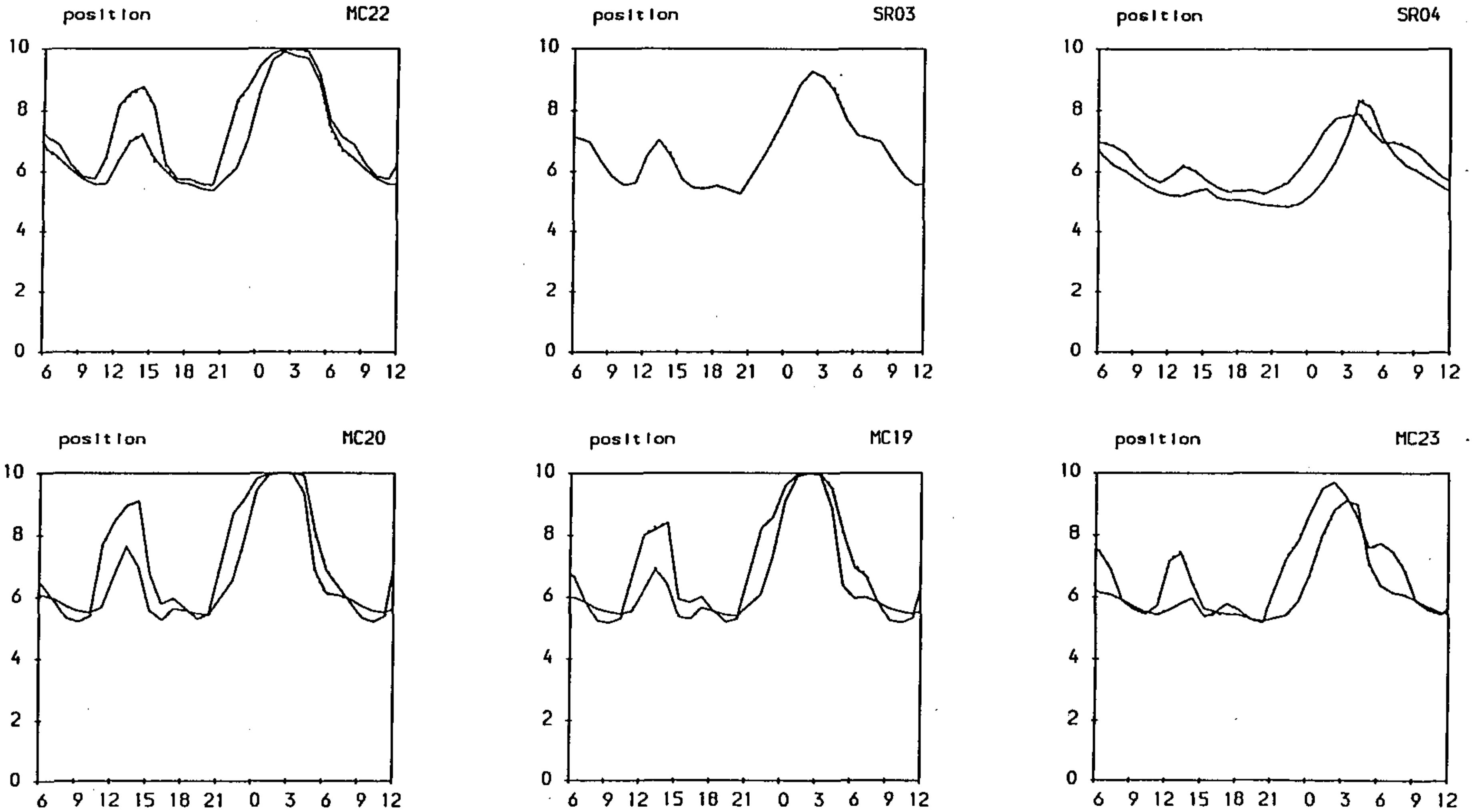


TK+Sham Tseng Wet Neap CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

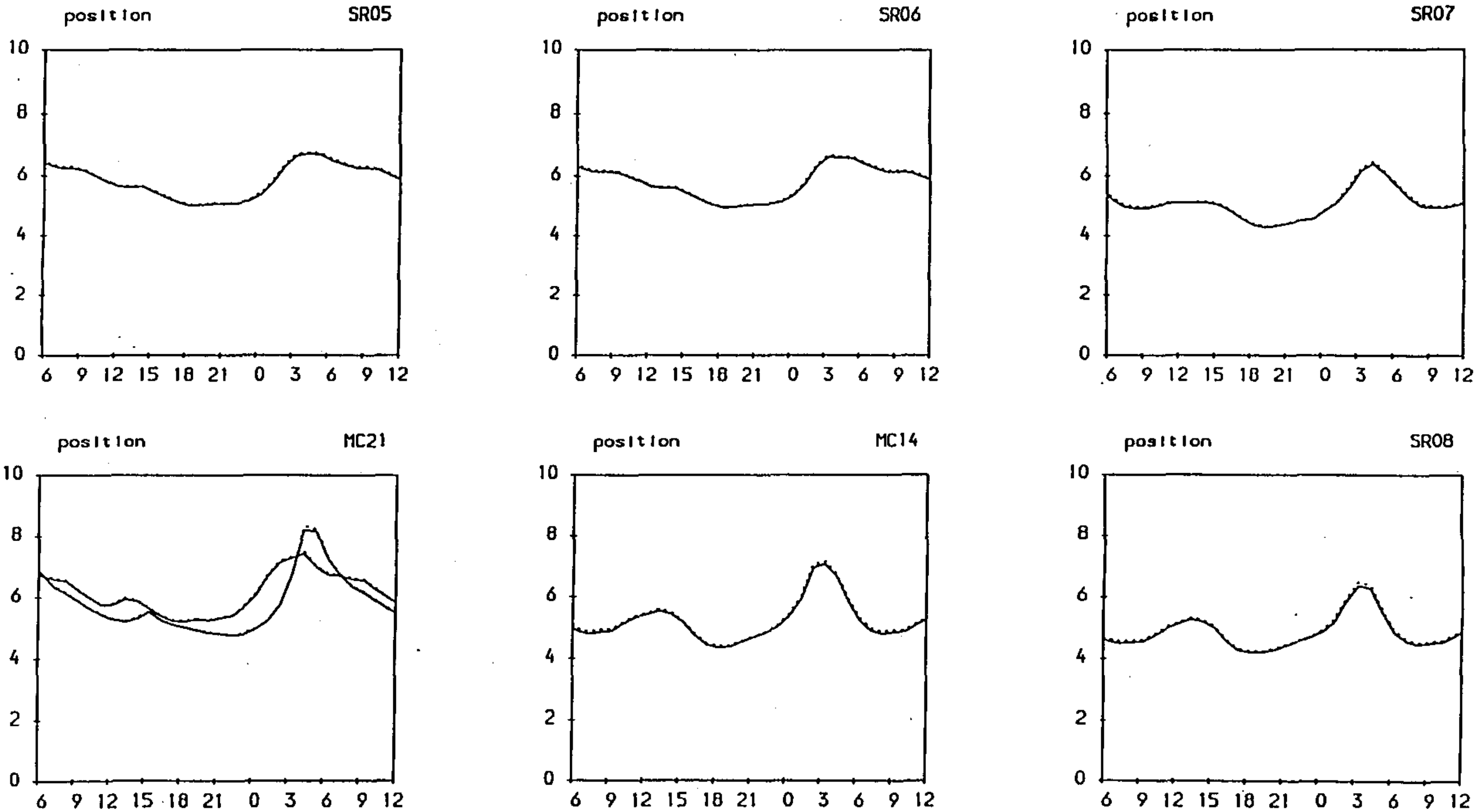


TK+Sham Tseng Wet Neap   CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid   DM 3/03/95   ——— TKCJV   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

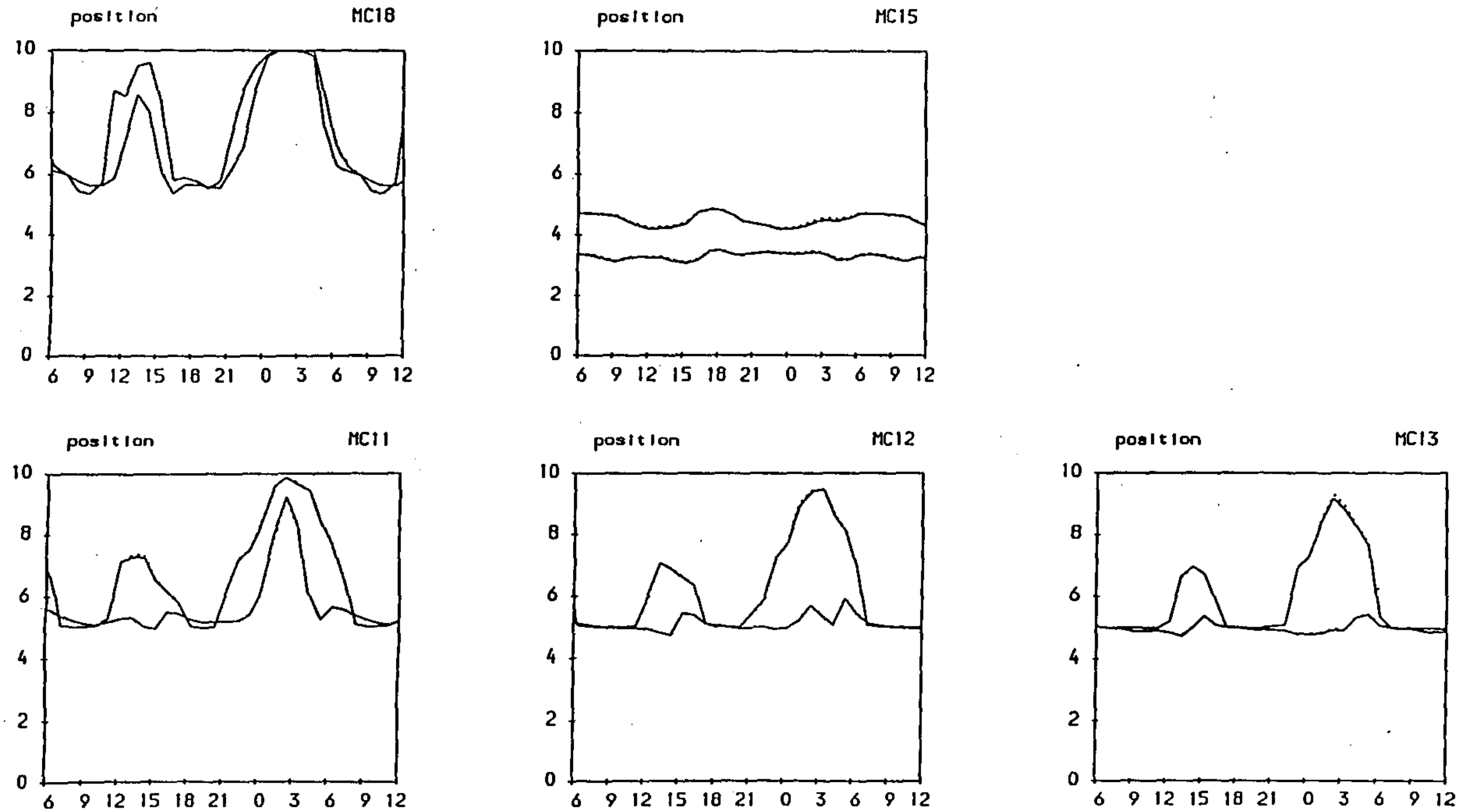


TK+Sham Tseng Wet Neap CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

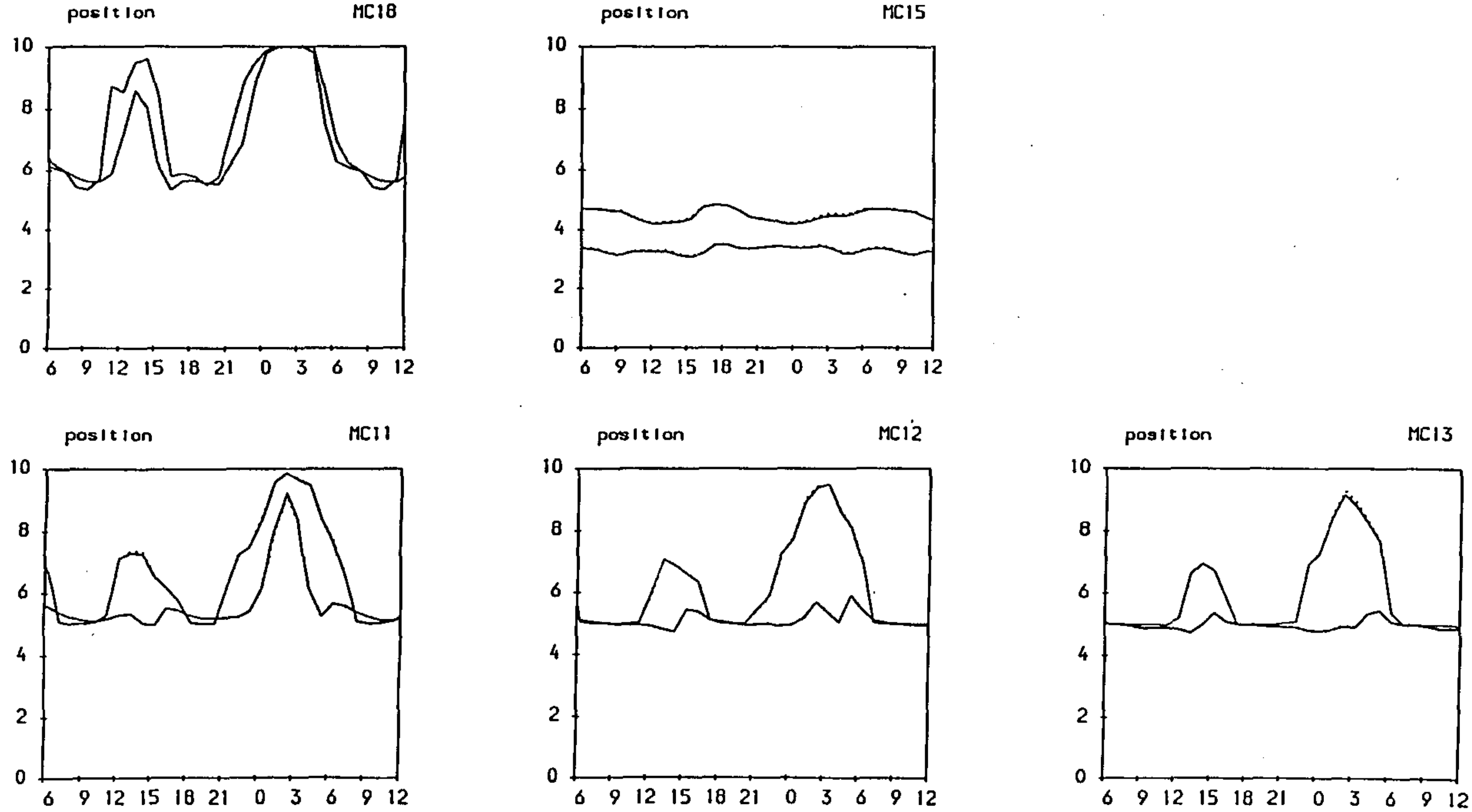


TK+Sham Tseng Wet Neap   CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: ✱ Upper layer, △ Lower layer

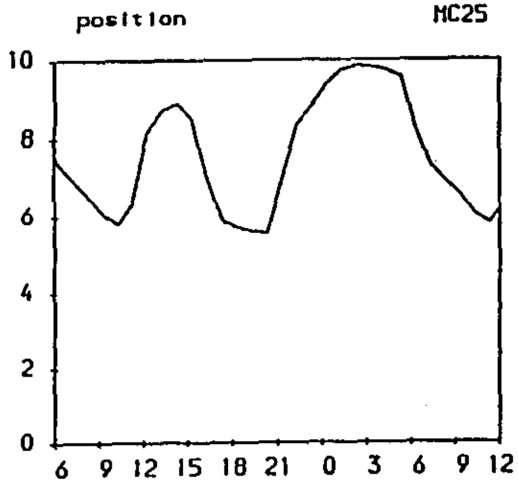


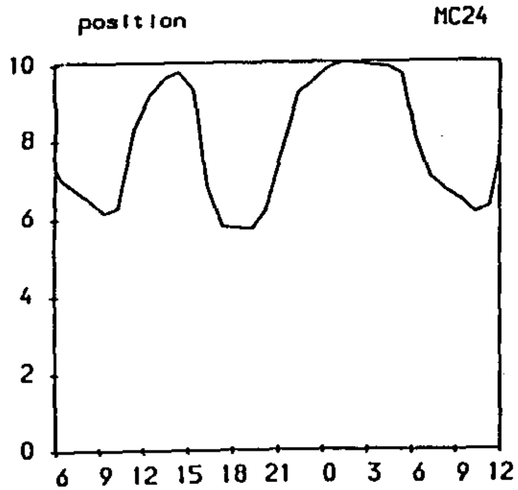
TK+Sham Tseng Wet Neap   CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········· LongSO

Observed symbols: * Upper layer, △ Lower layer



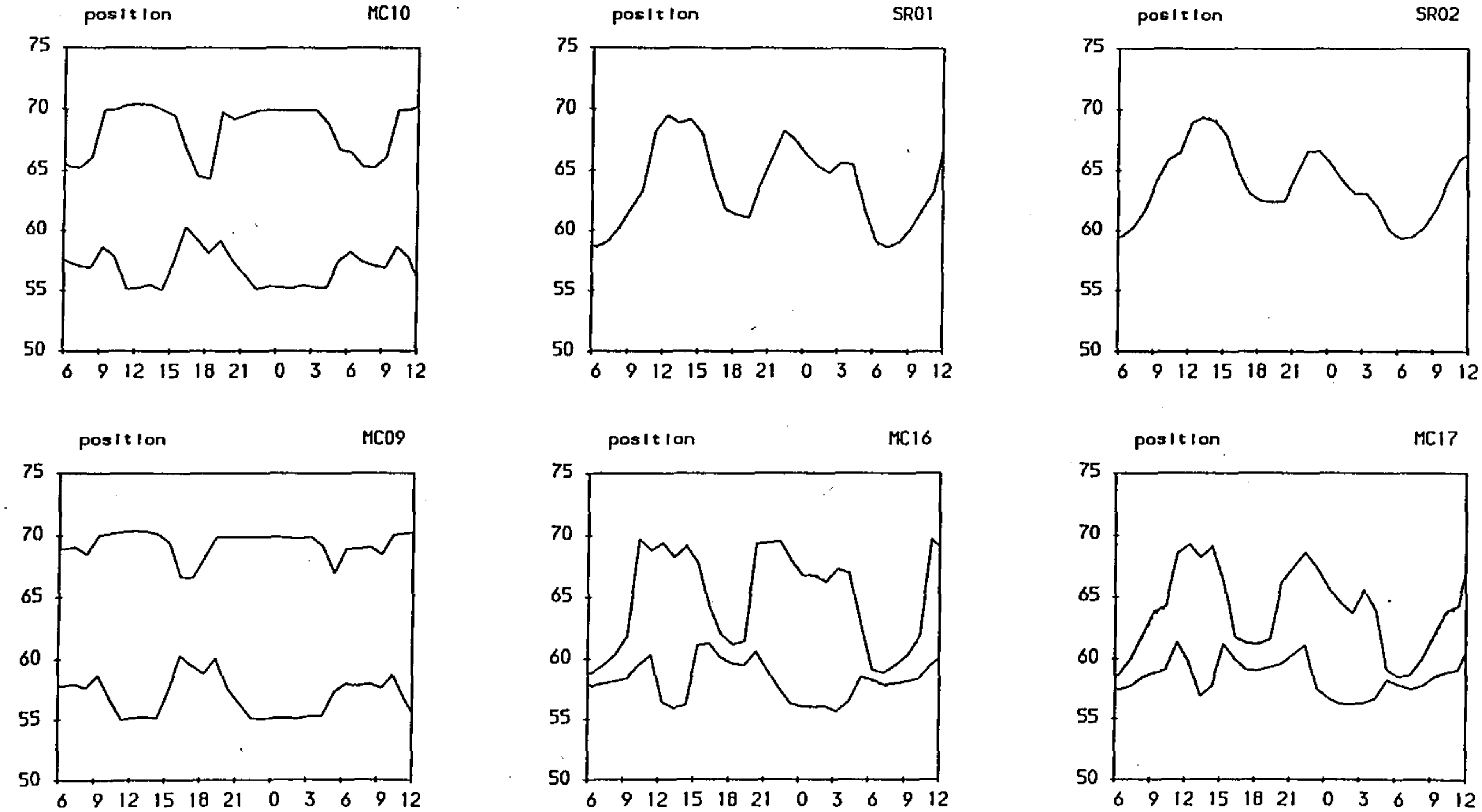


TK+Sham Tseng Wet Neap CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

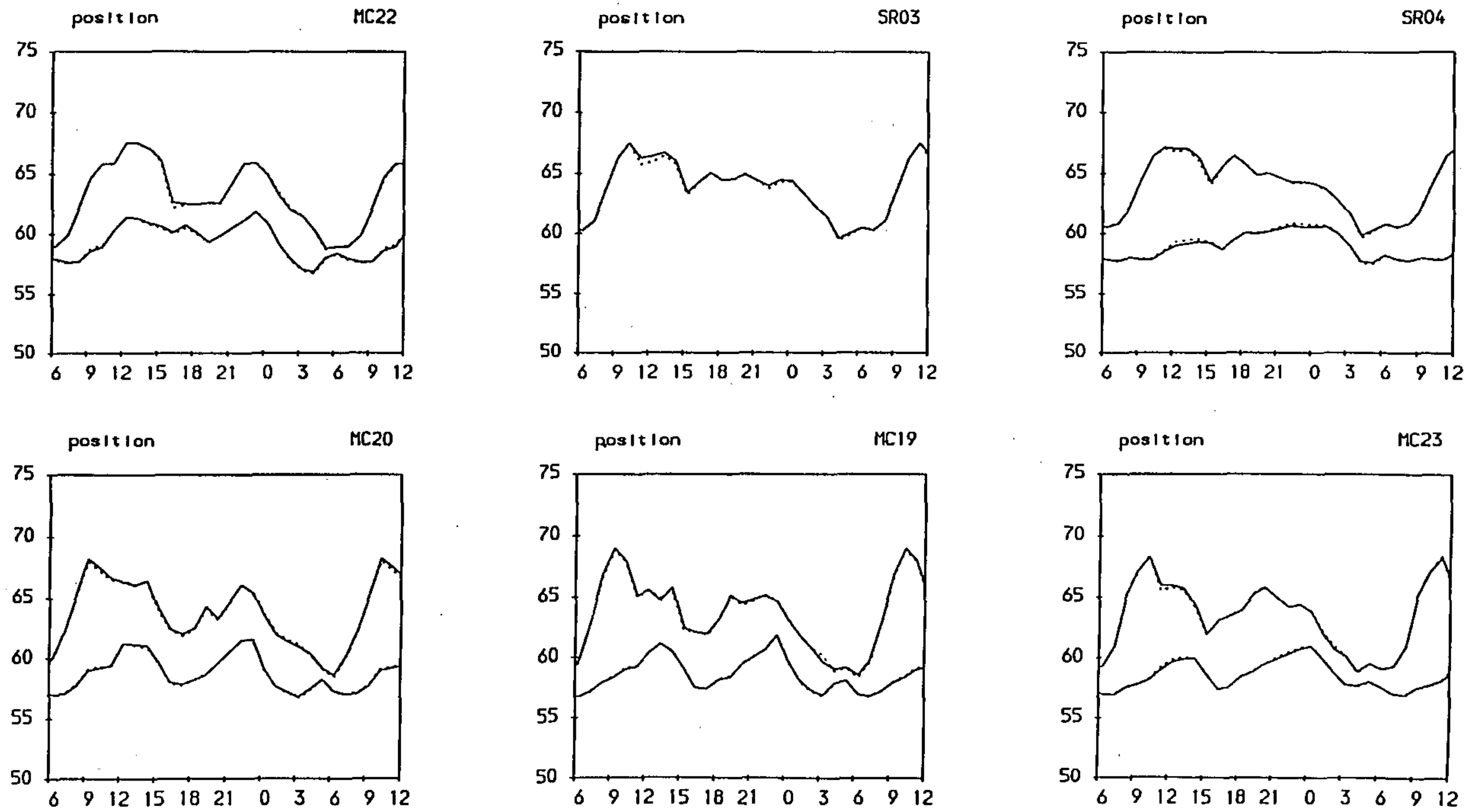


TK+Sham Tseng Wet Neap CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

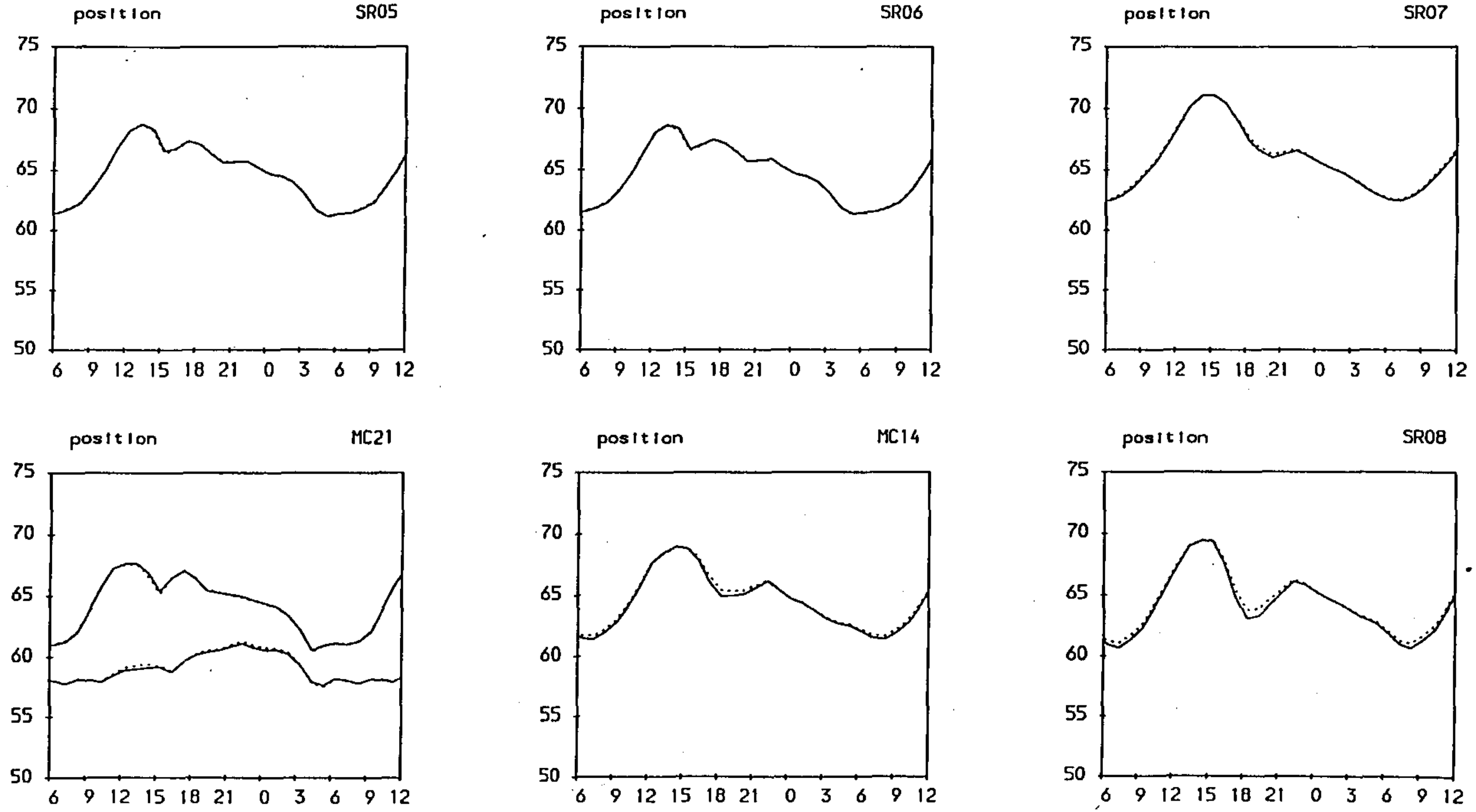


TK+Sham Tseng Wet Neap CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 3/03/95 ——— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

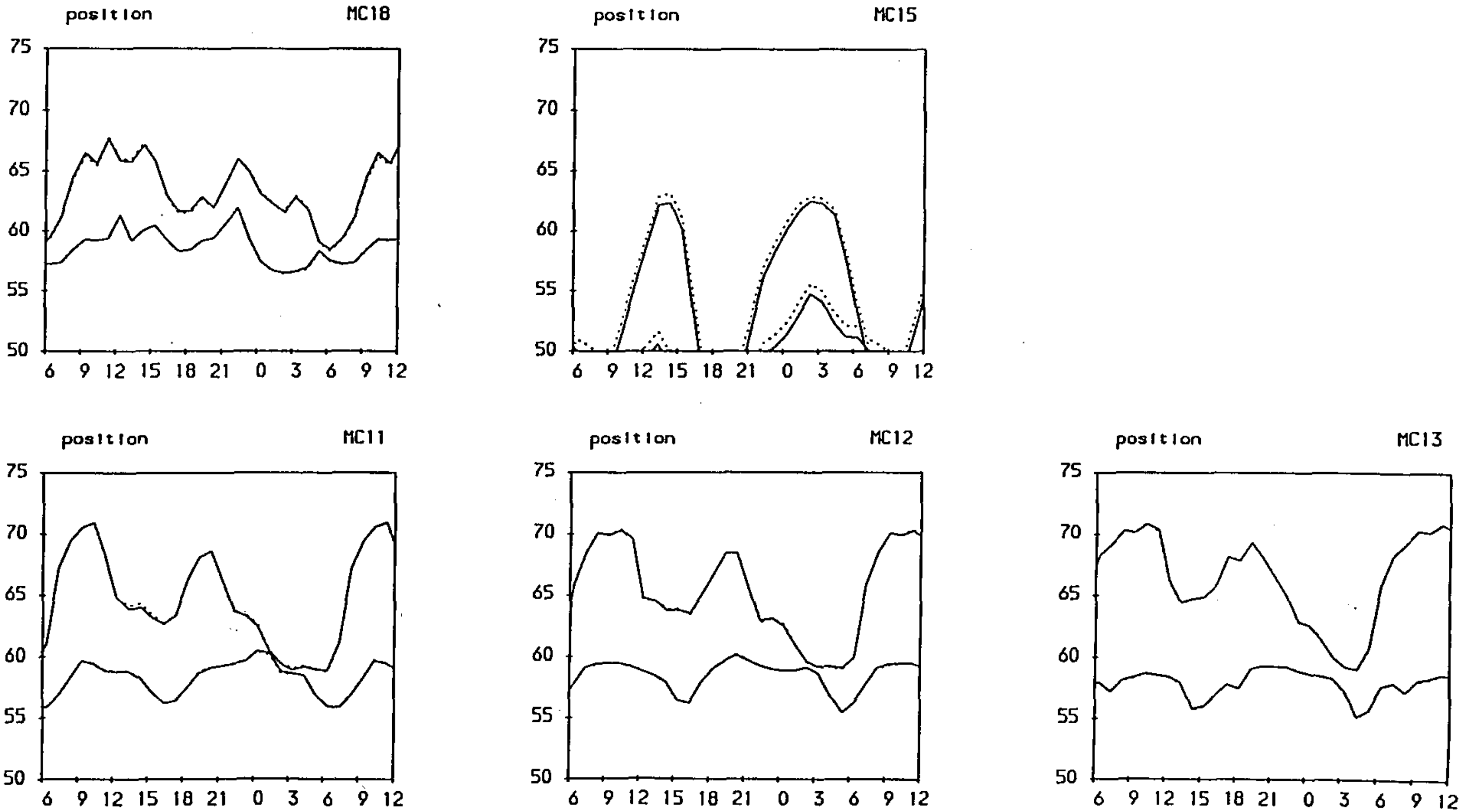


TK+Sham Tseng Wet Neap CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: ✱ Upper layer, △ Lower layer

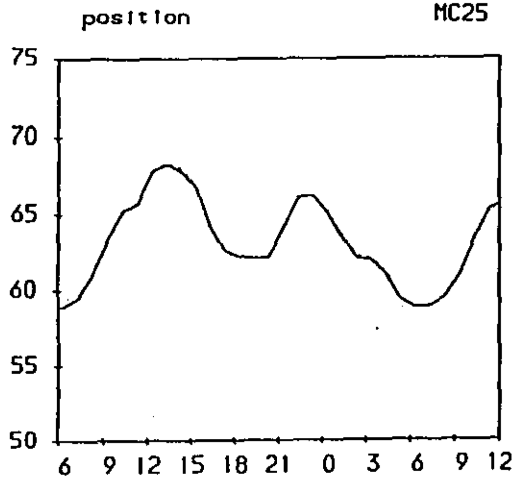


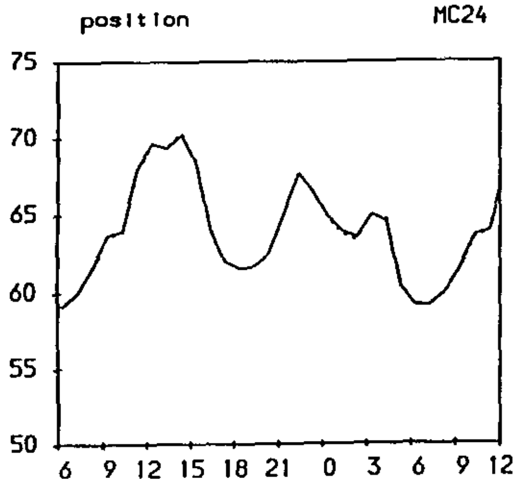
TK+Sham Tseng Wet Neap CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



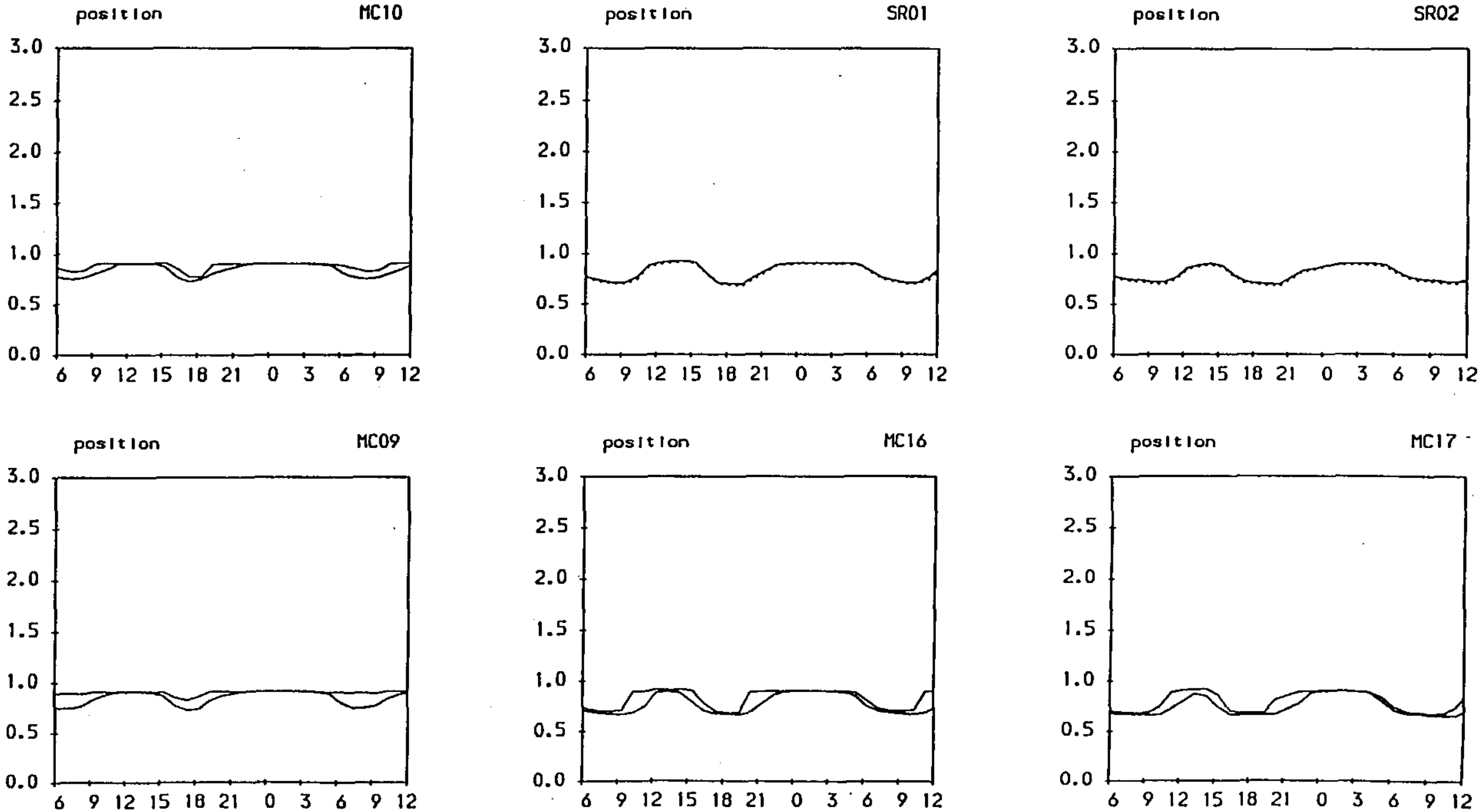


TK+Sham Tseng Wet Neap CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

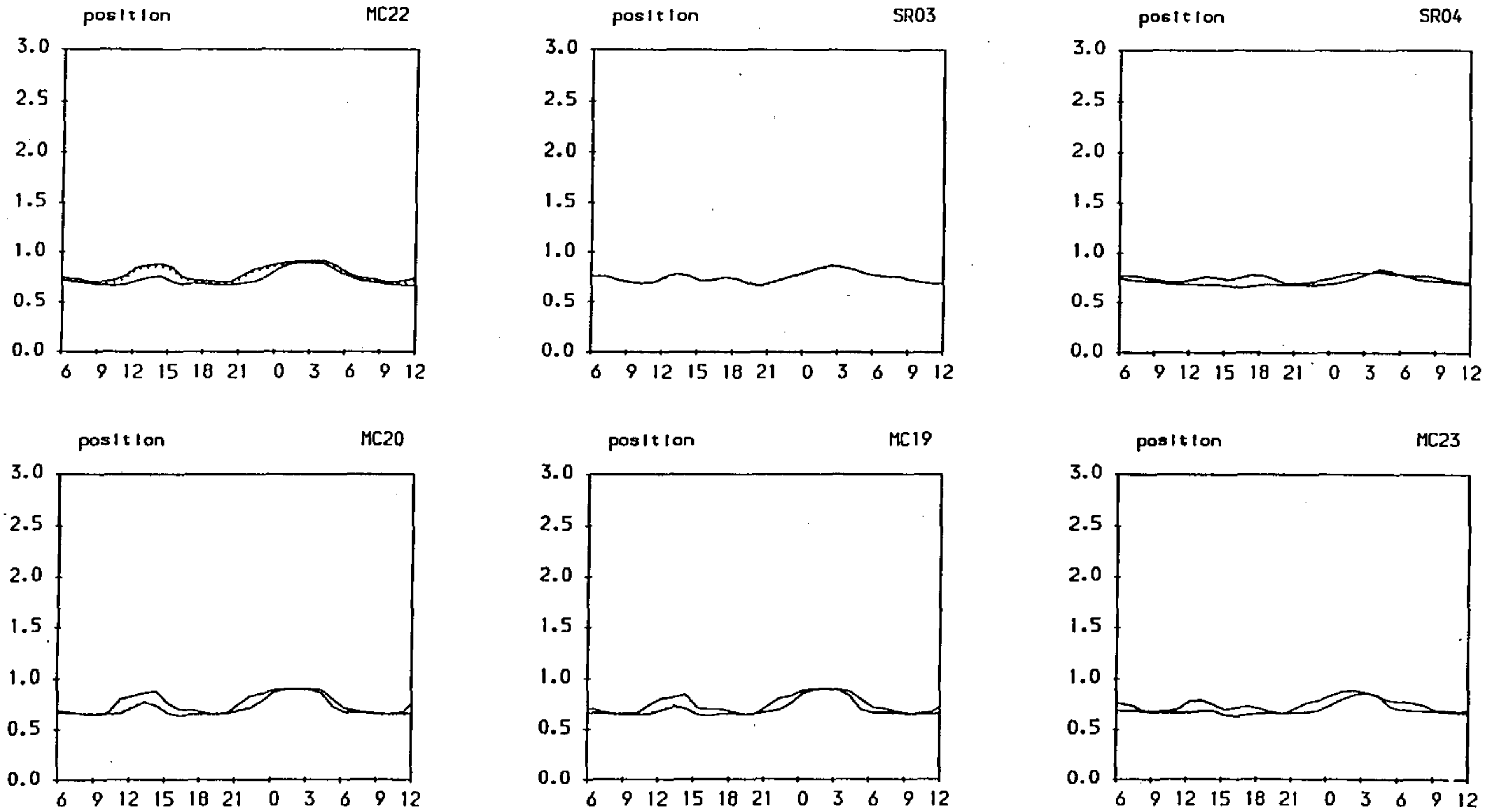


TK+Sham Tseng Wet Neap CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

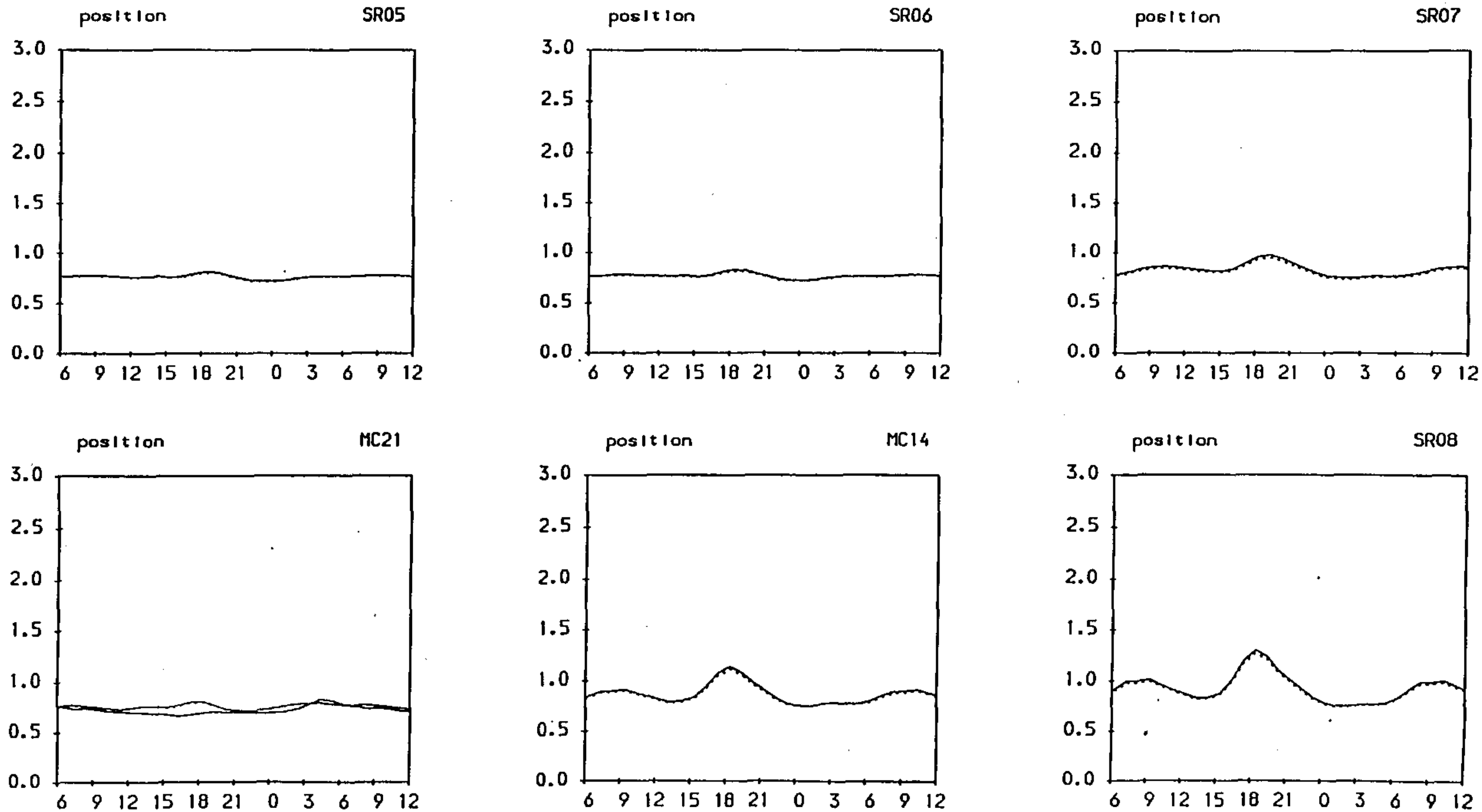


TK+Sham Tseng Wet Neap CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

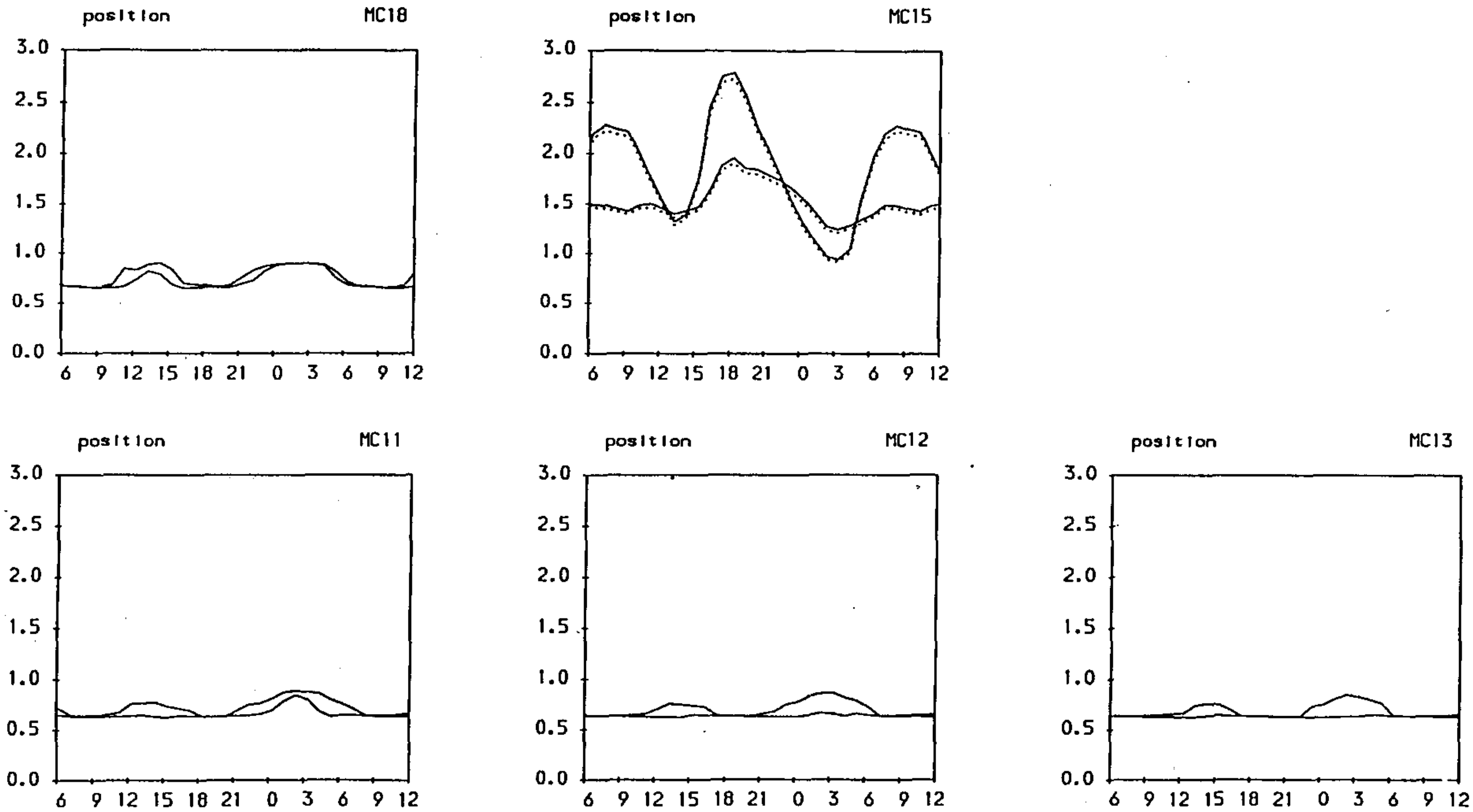


TK+Sham Tseng Wet Neap CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

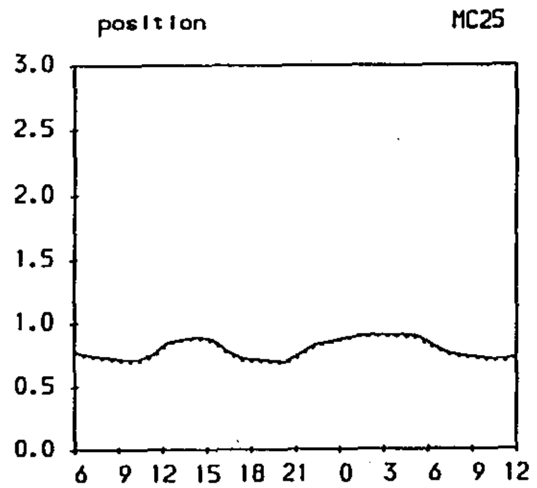


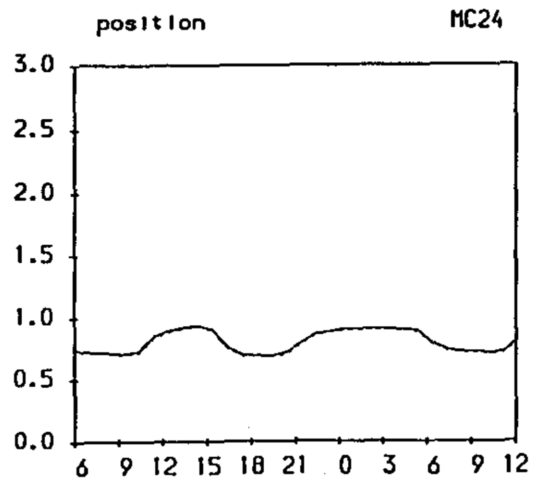
TK+Sham Tseng Wet Neap   CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



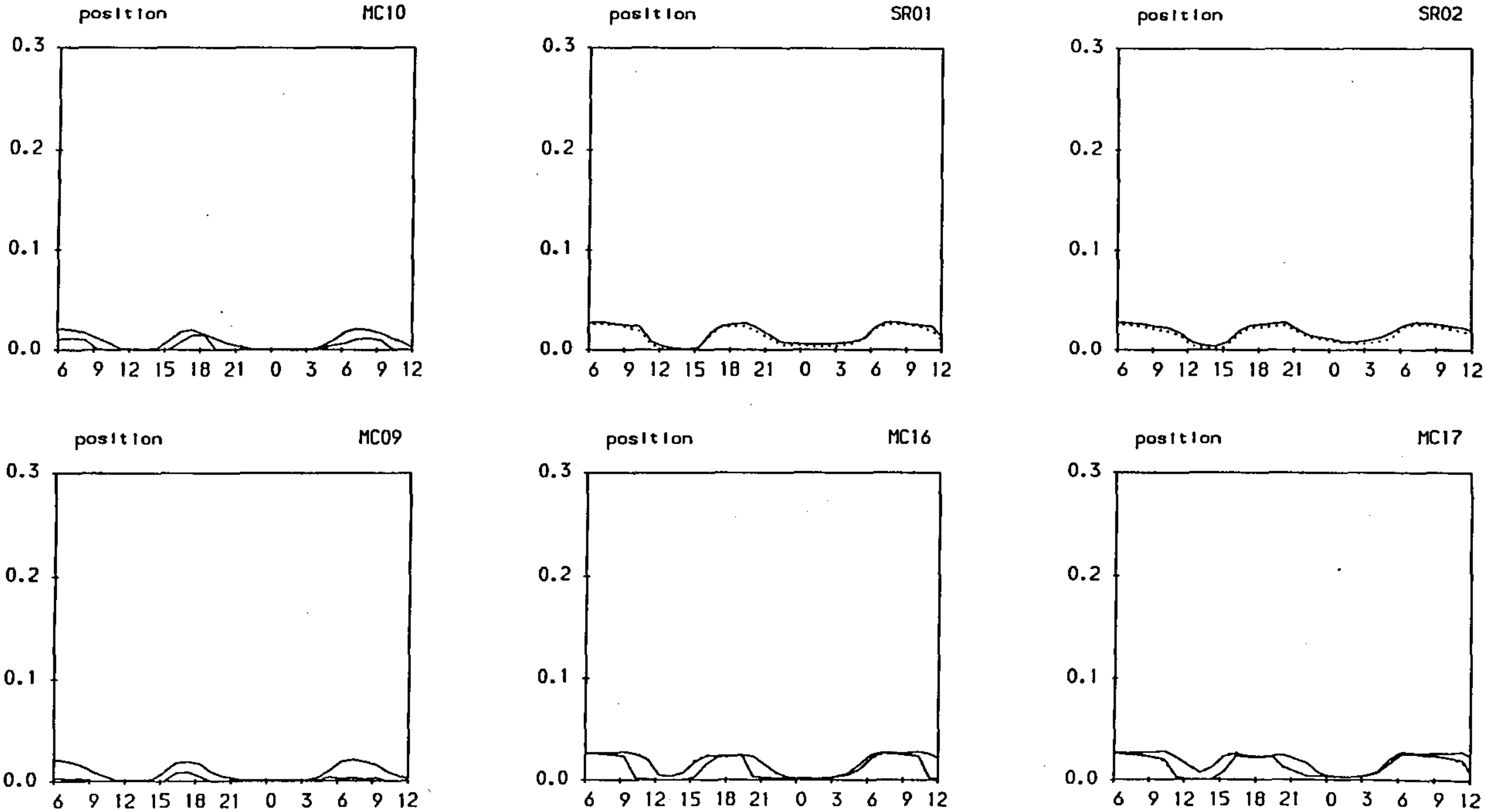


TK+Sham Tseng Wet Neap CJV v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

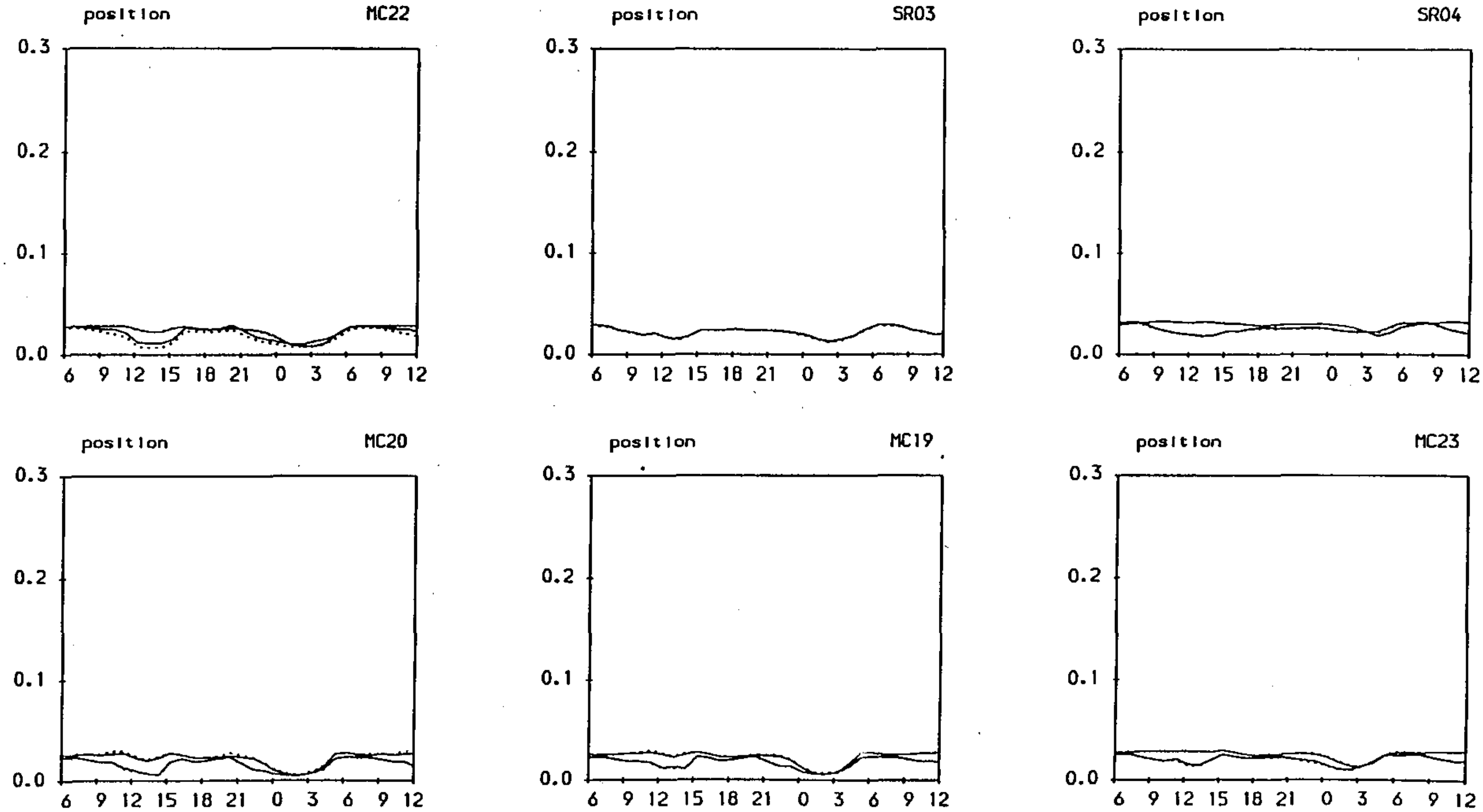


TK+Sham Tseng Wet Neap CJV v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 ——— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

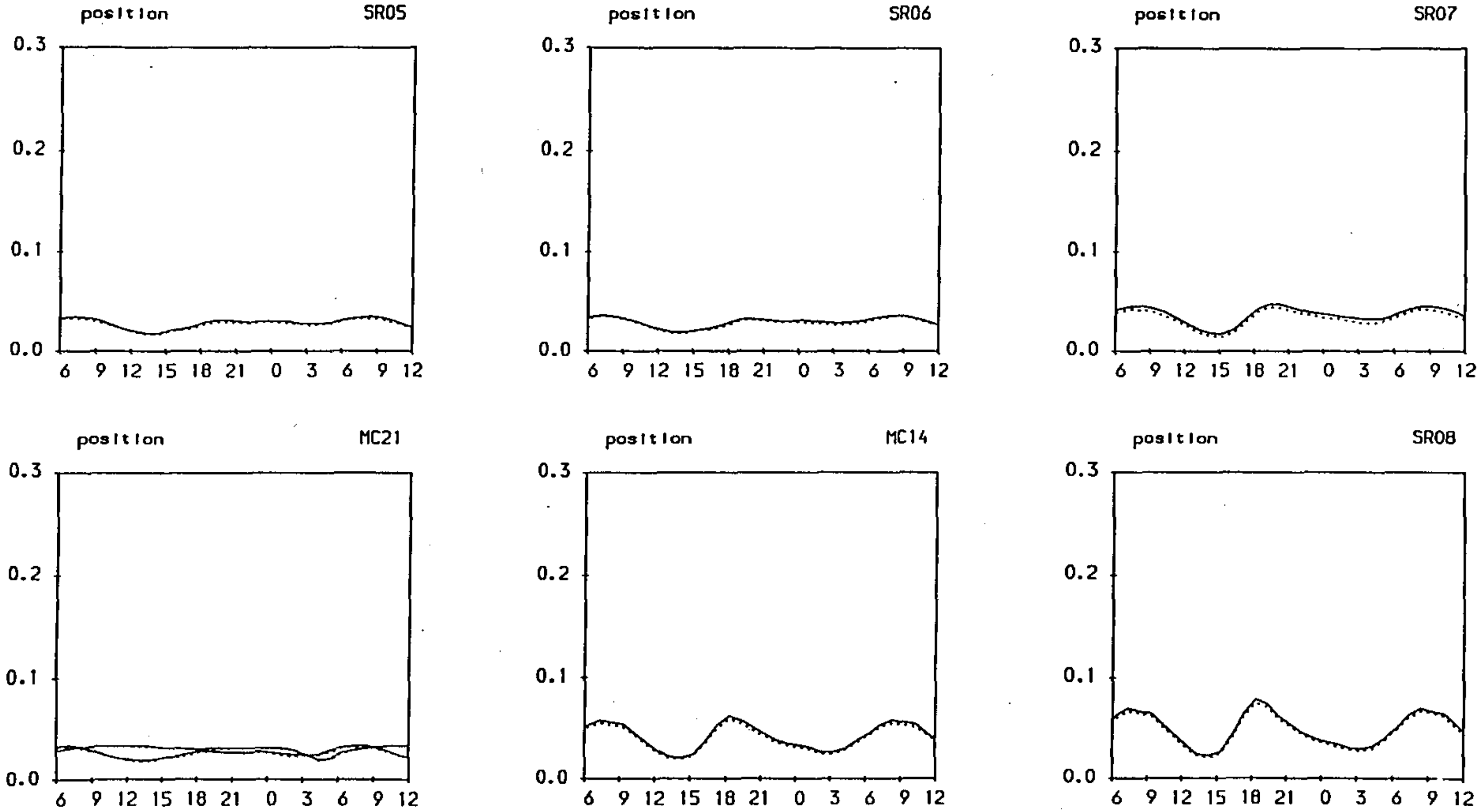


TK+Sham Tseng Wet Neap   CJV v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

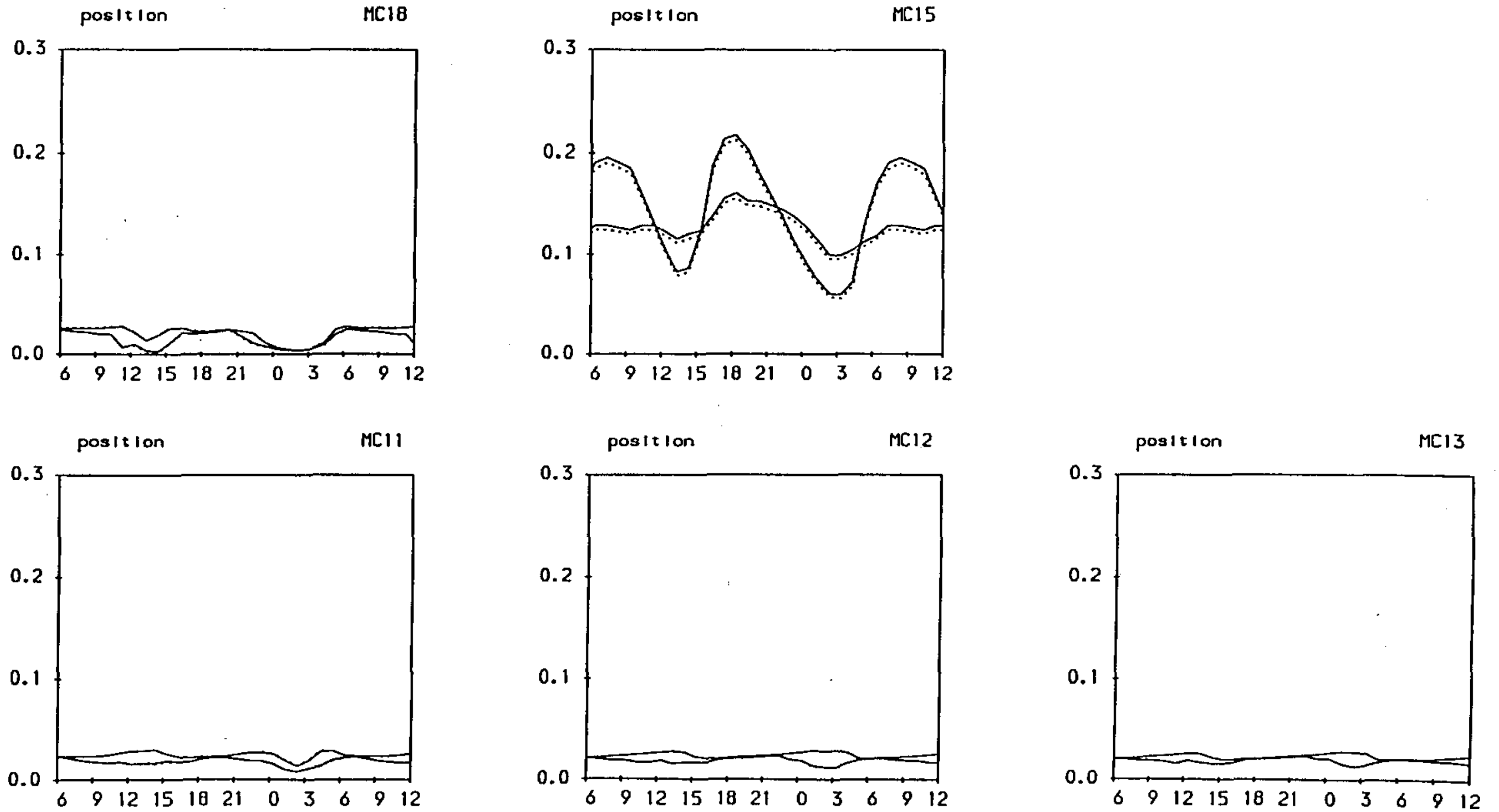


TK+Sham Tseng Wet Neap CJV v LSO

Ammoniacal Nitrogen (mg N/L) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

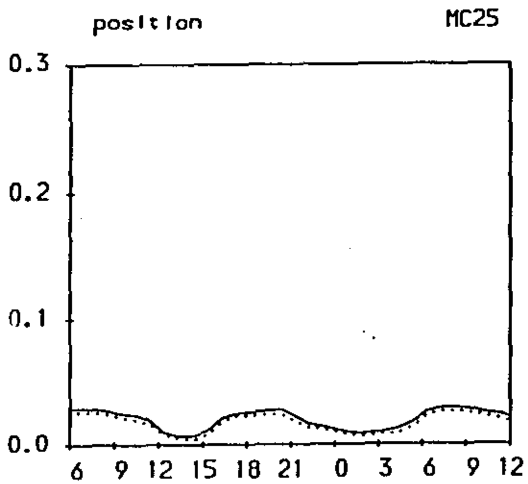


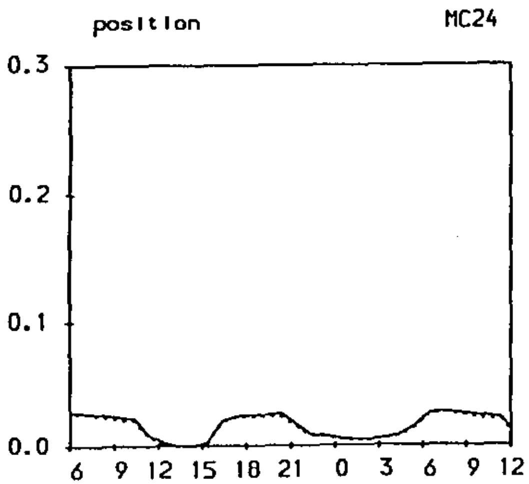
TK+Sham Tseng Wet Neap CJV v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



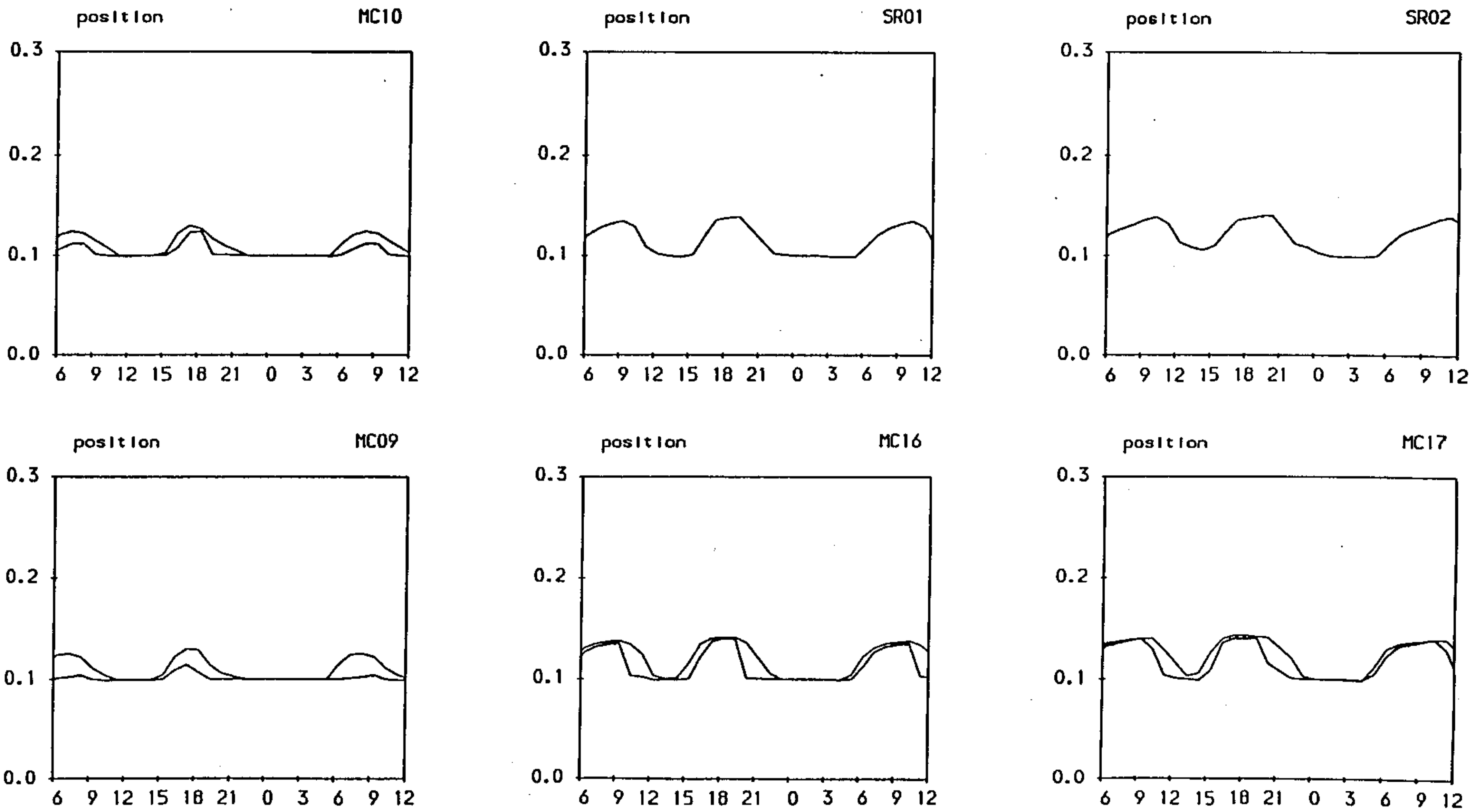


TK+Sham Tseng Wet Neap CJV v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

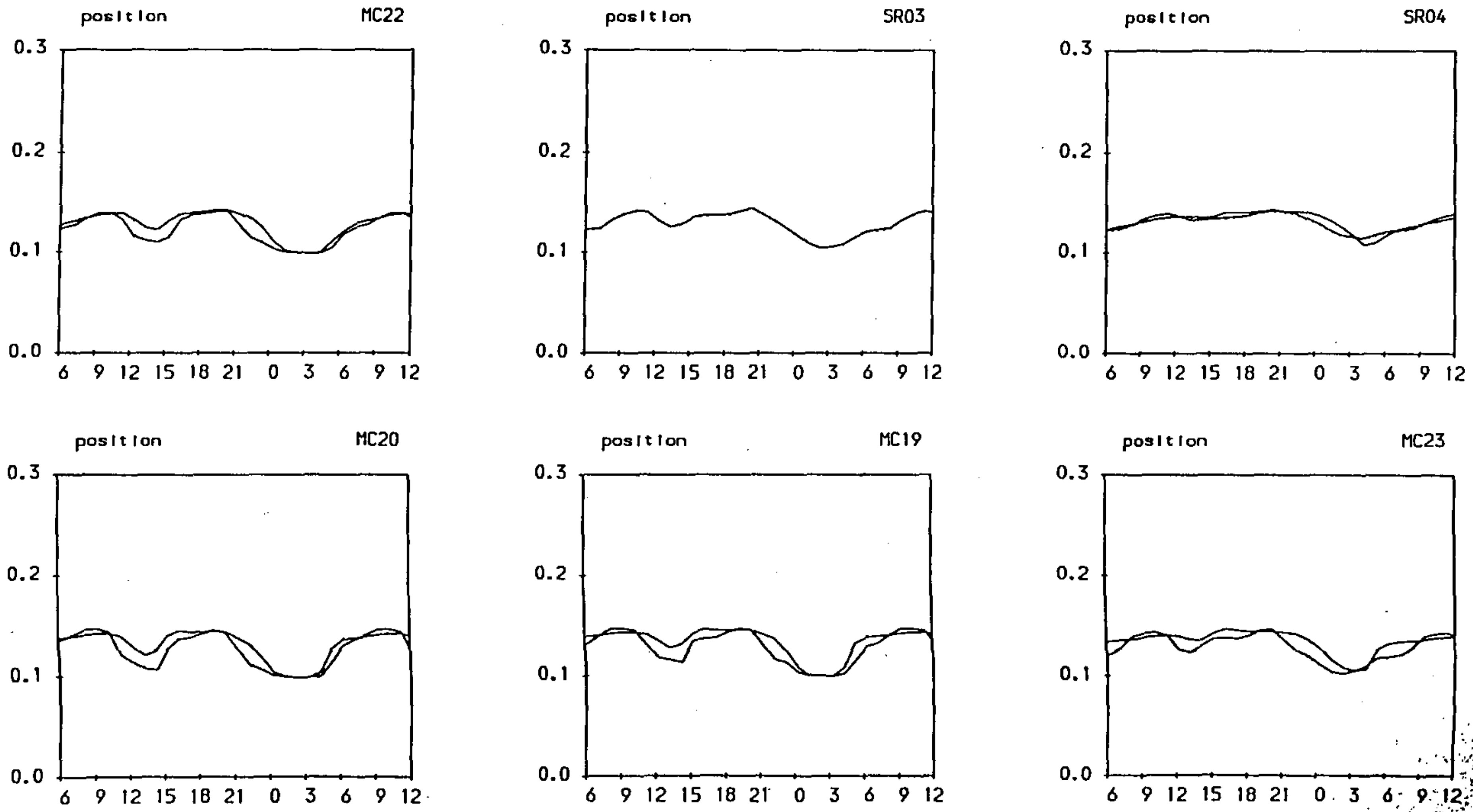


TK+Sham Tseng Wet Neap CJV v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 ——— TKCJV ········ LongSO

Observed symbols: * Upper layer, Δ Lower layer

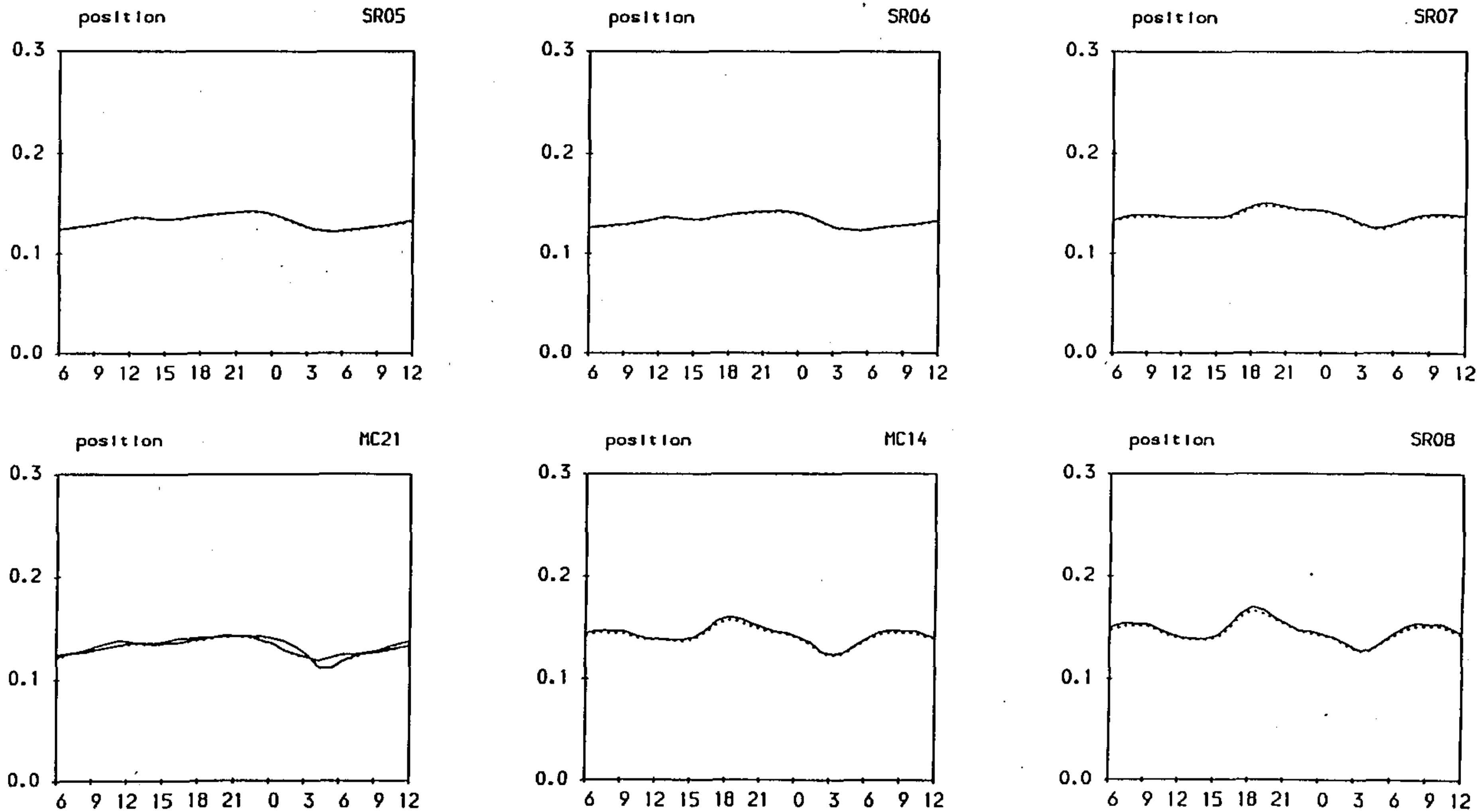


TK+Sham Tseng Wet Neap   CJV v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 3/03/95   ——— TKCJV   ········ LongSO

Observed symbols: ⁎ Upper layer, ▵ Lower layer

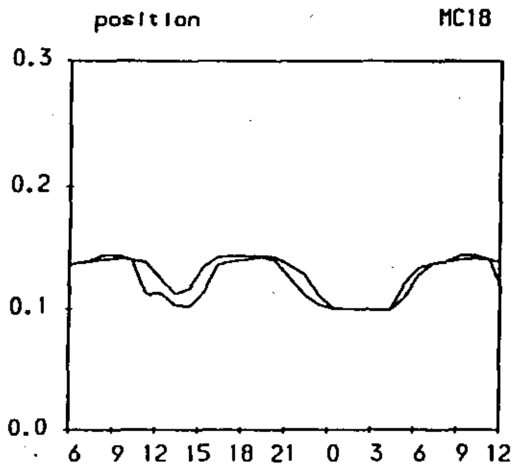


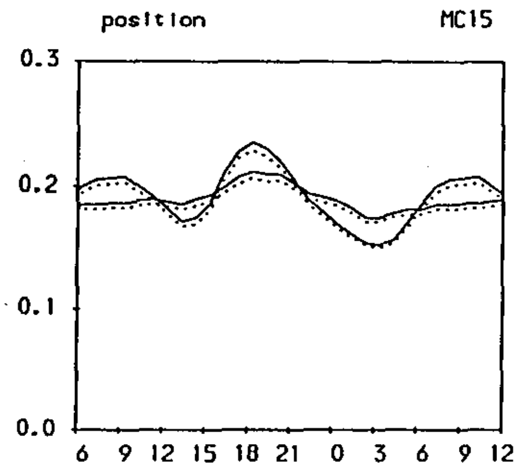
TK+Sham Tseng Wet Neap CJV v LSO

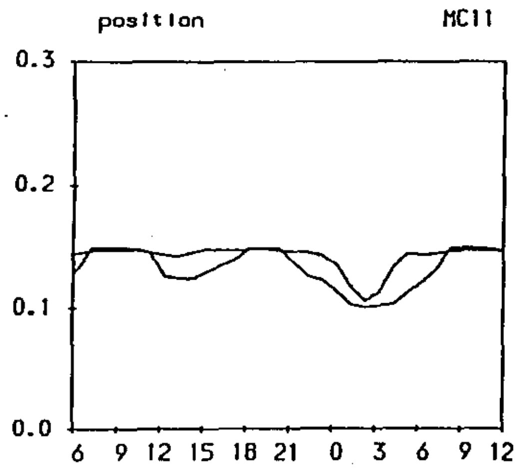
Oxidised Nitrogen (mg N/L) against time

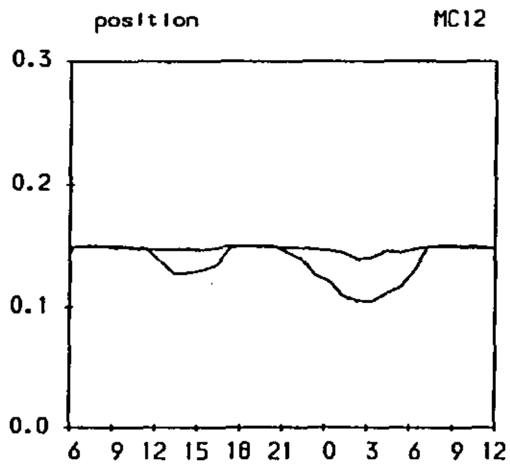
2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

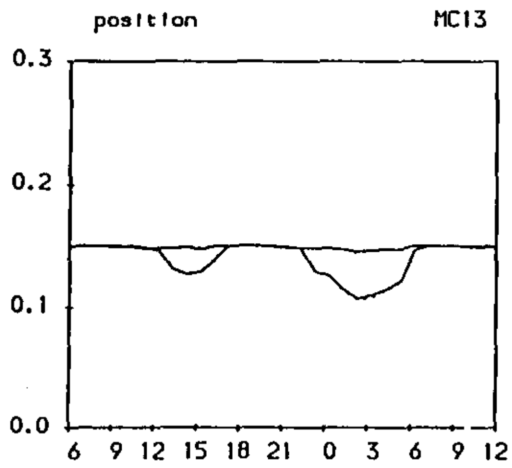
Observed symbols: * Upper layer, ▵ Lower layer









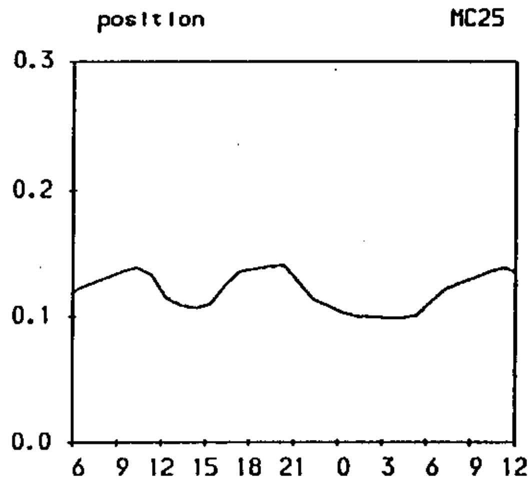


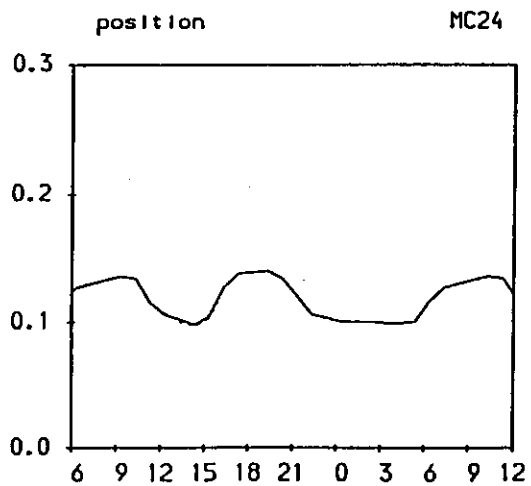
TK+Sham Tseng Wet Neap   CJV v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



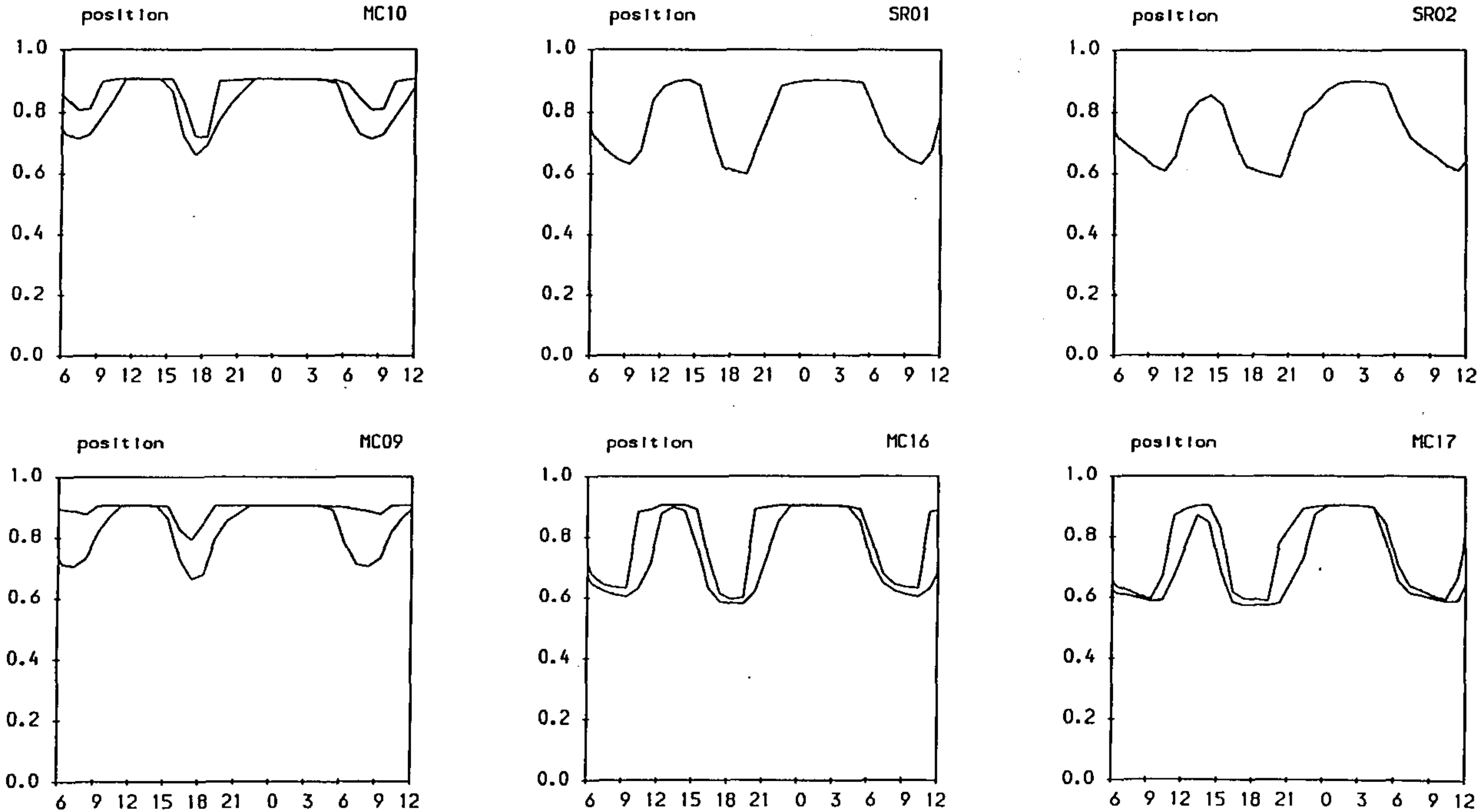


TK+Sham Tseng Wet Neap   CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

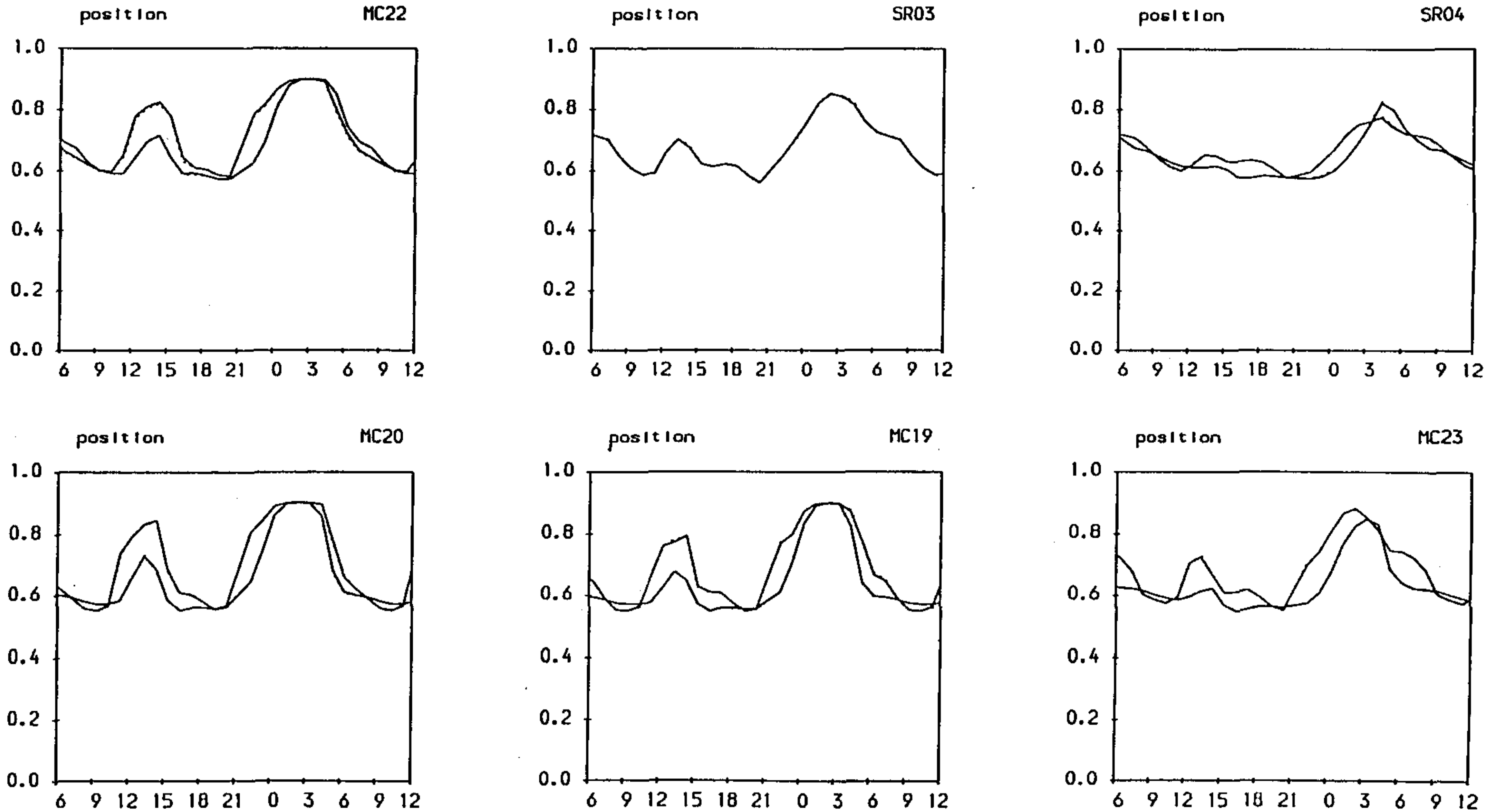


TK+Sham Tseng Wet Neap CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, ∆ Lower layer

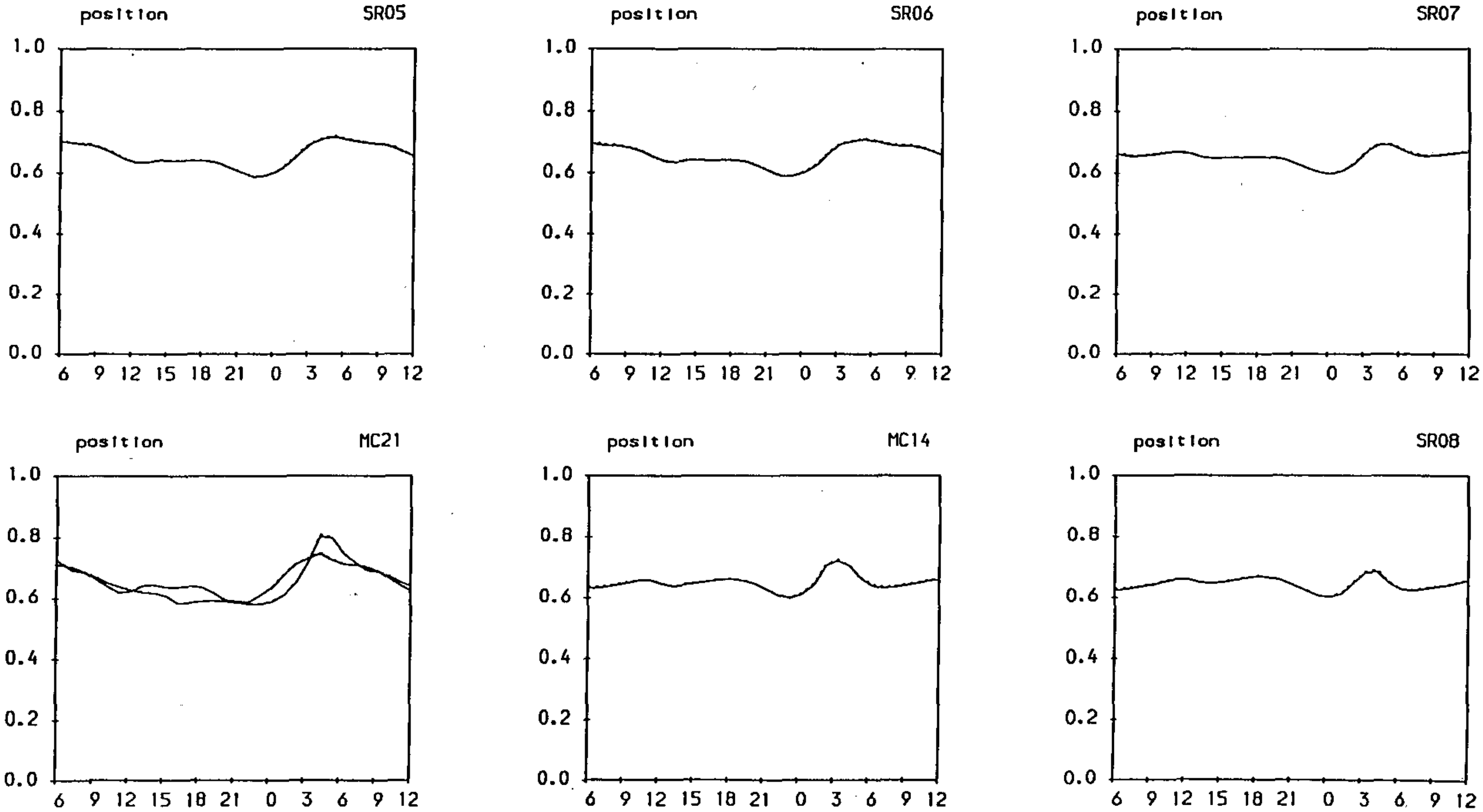


TK+Sham Tseng Wet Neap CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 ——— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer

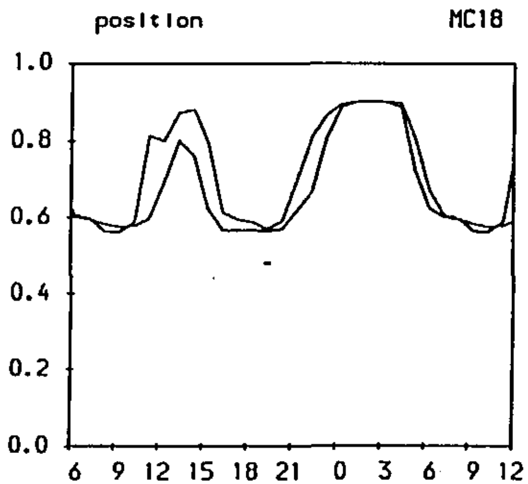


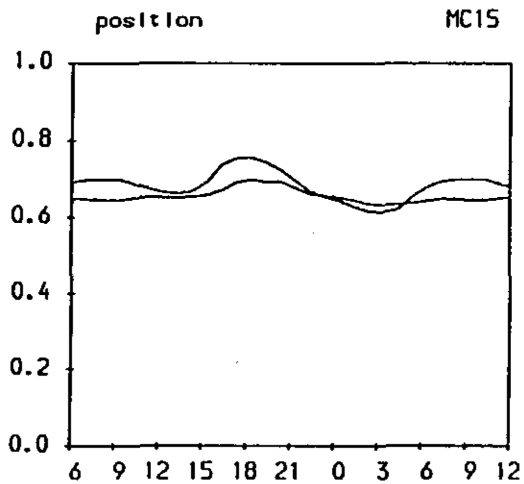
TK+Sham Tseng Wet Neap   CJV v LSO

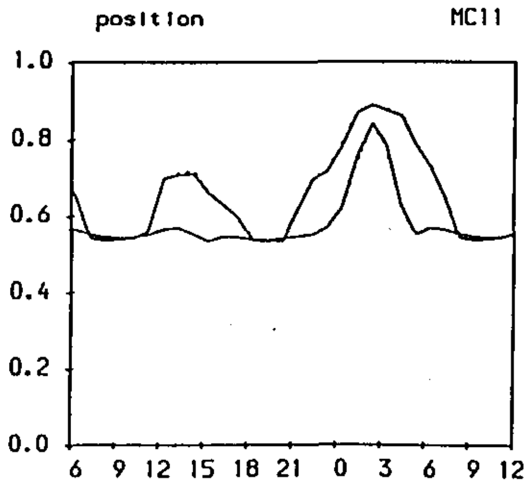
Organic Nitrogen (mg N/l) against time

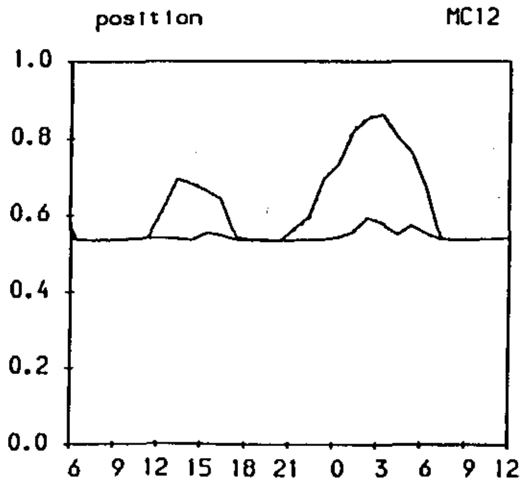
2 Layer, 50m grid   DM 3/03/95   —— TKCJV   .... LongSO

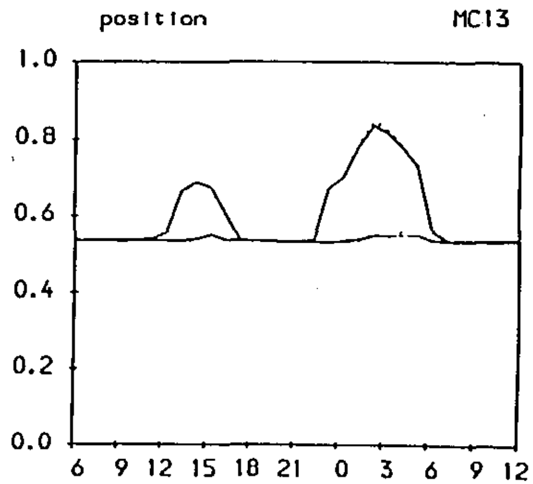
Observed symbols: * Upper layer, △ Lower layer









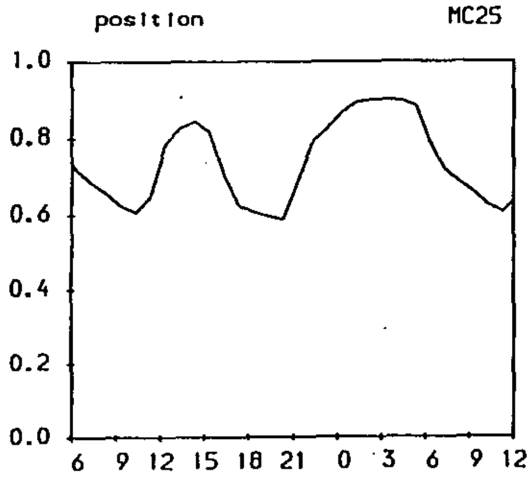


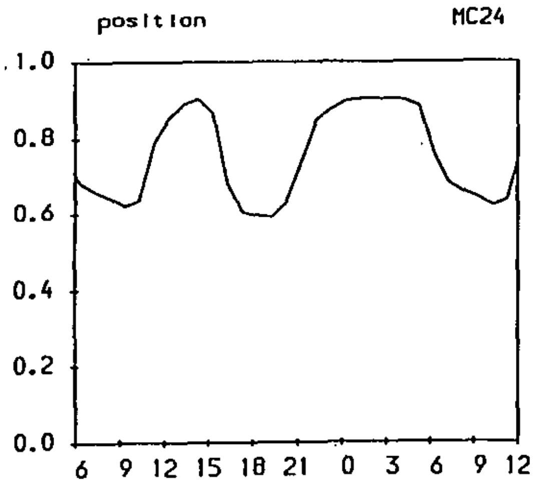
TK+Sham Tseng Wet Neap   CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



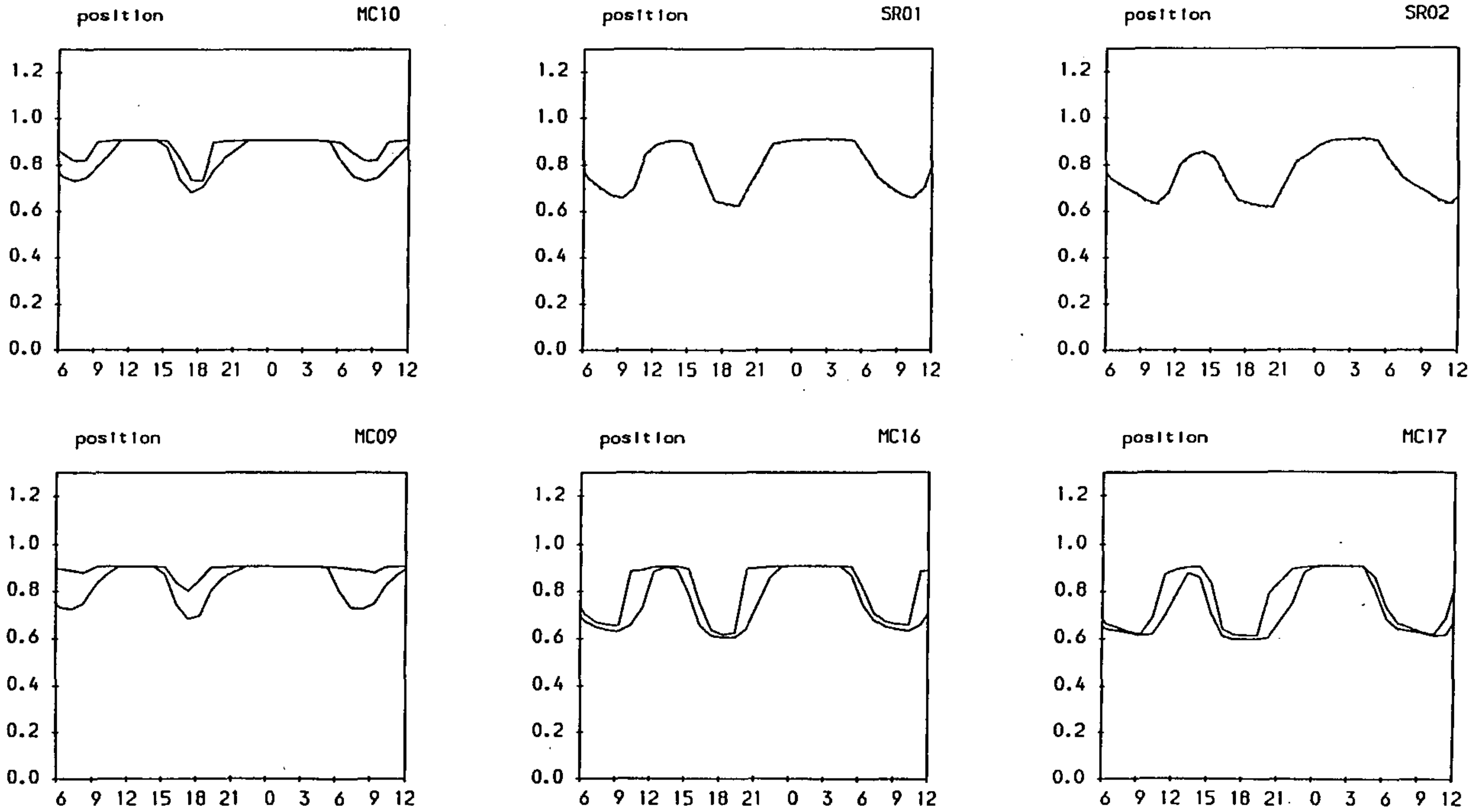


TK+Sham Tseng Wet Neap   CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

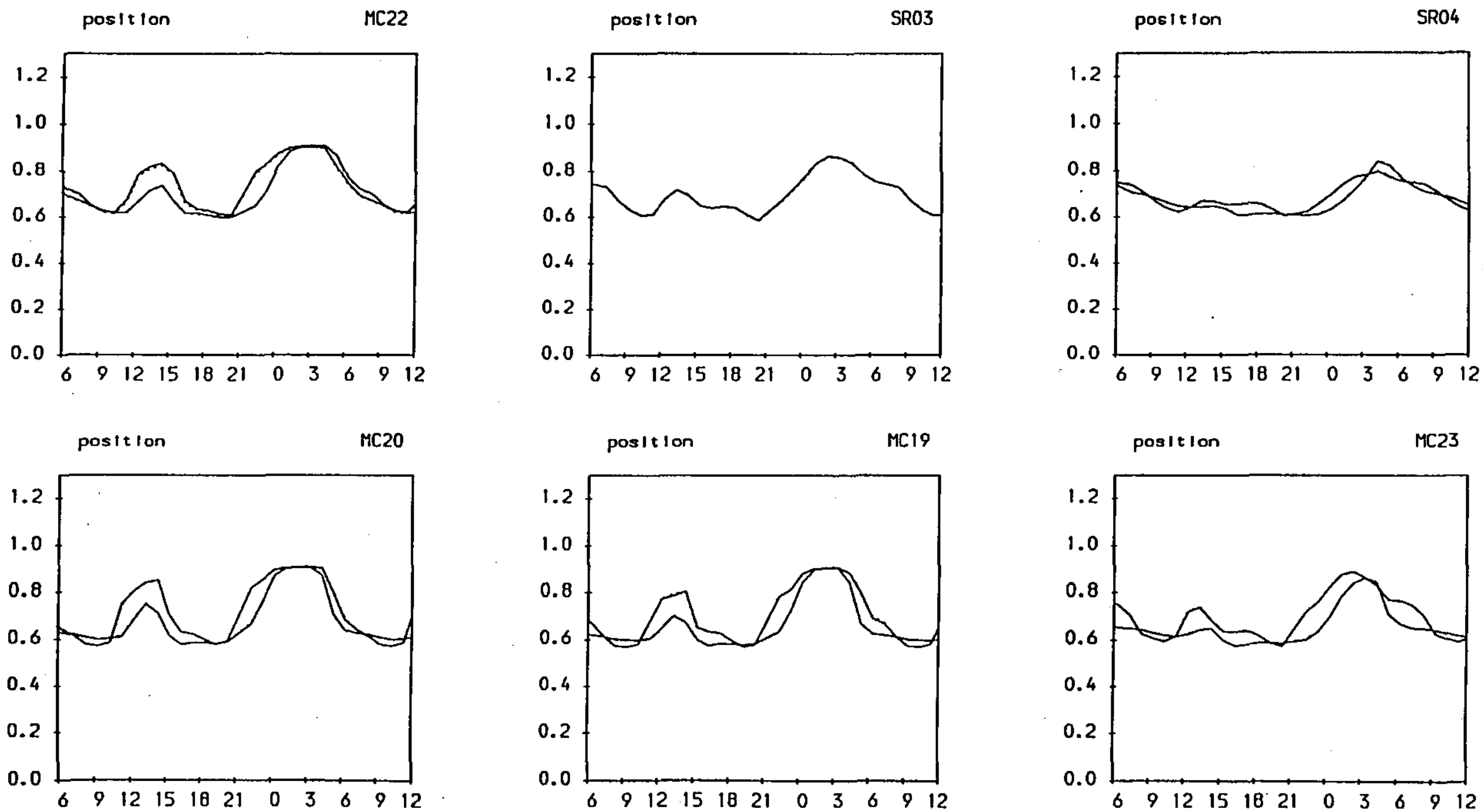


TK+Sham Tseng Wet Neap CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer

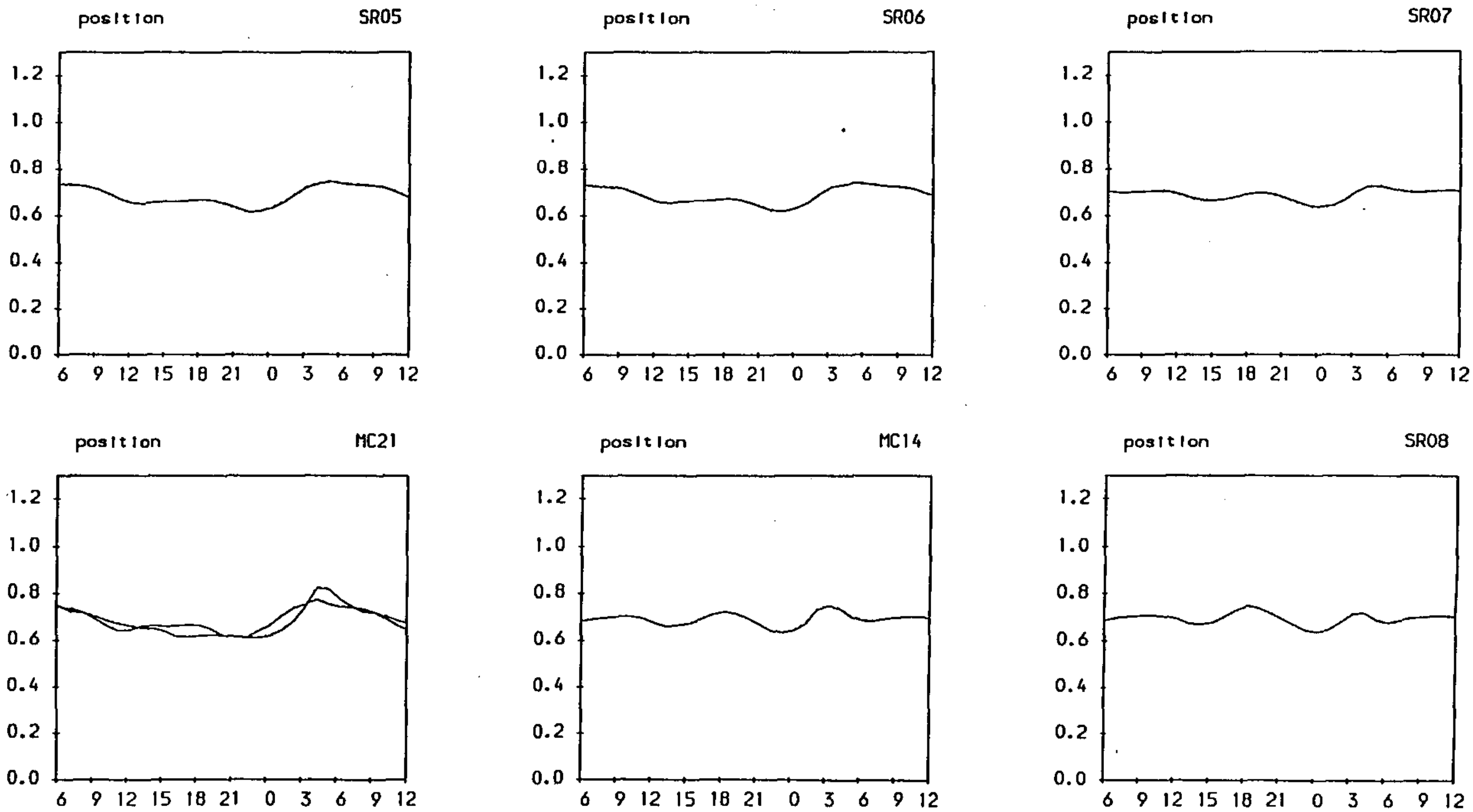


TK+Sham Tseng Wet Neap CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

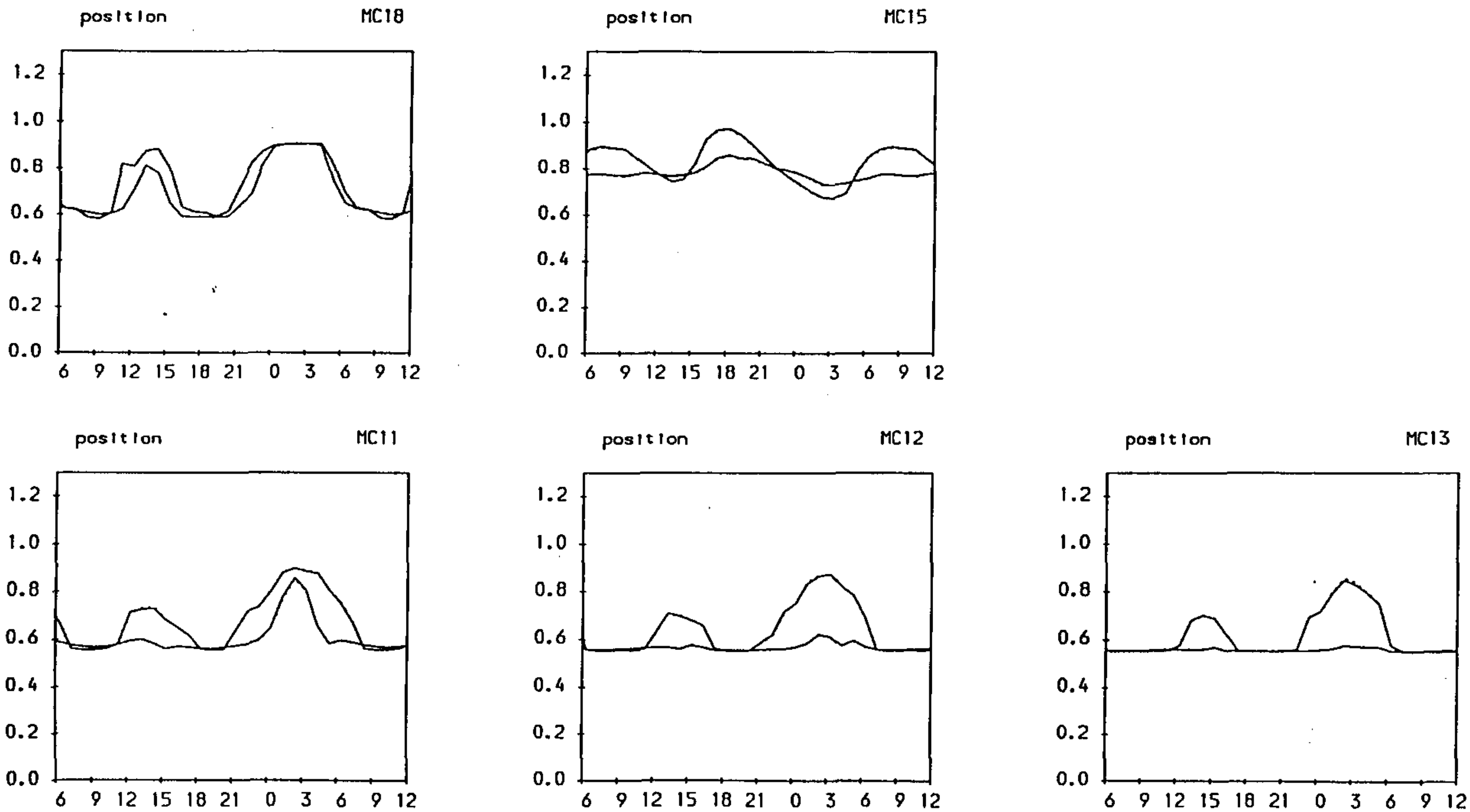


TK+Sham Tseng Wet Neap   CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, Δ Lower layer

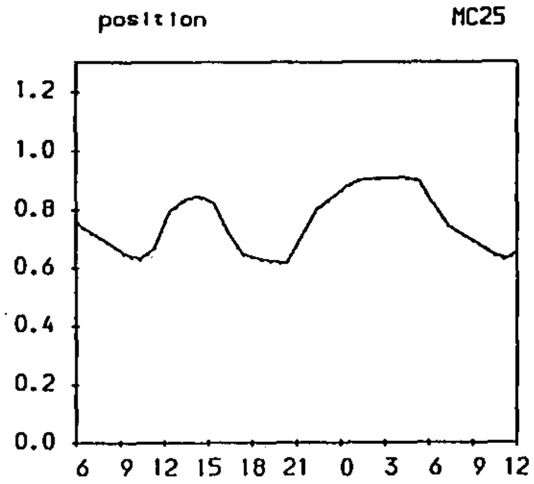


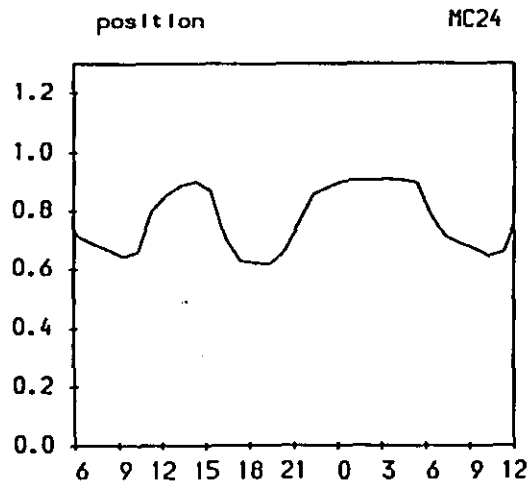
TK+Sham Tseng Wet Neap   CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer



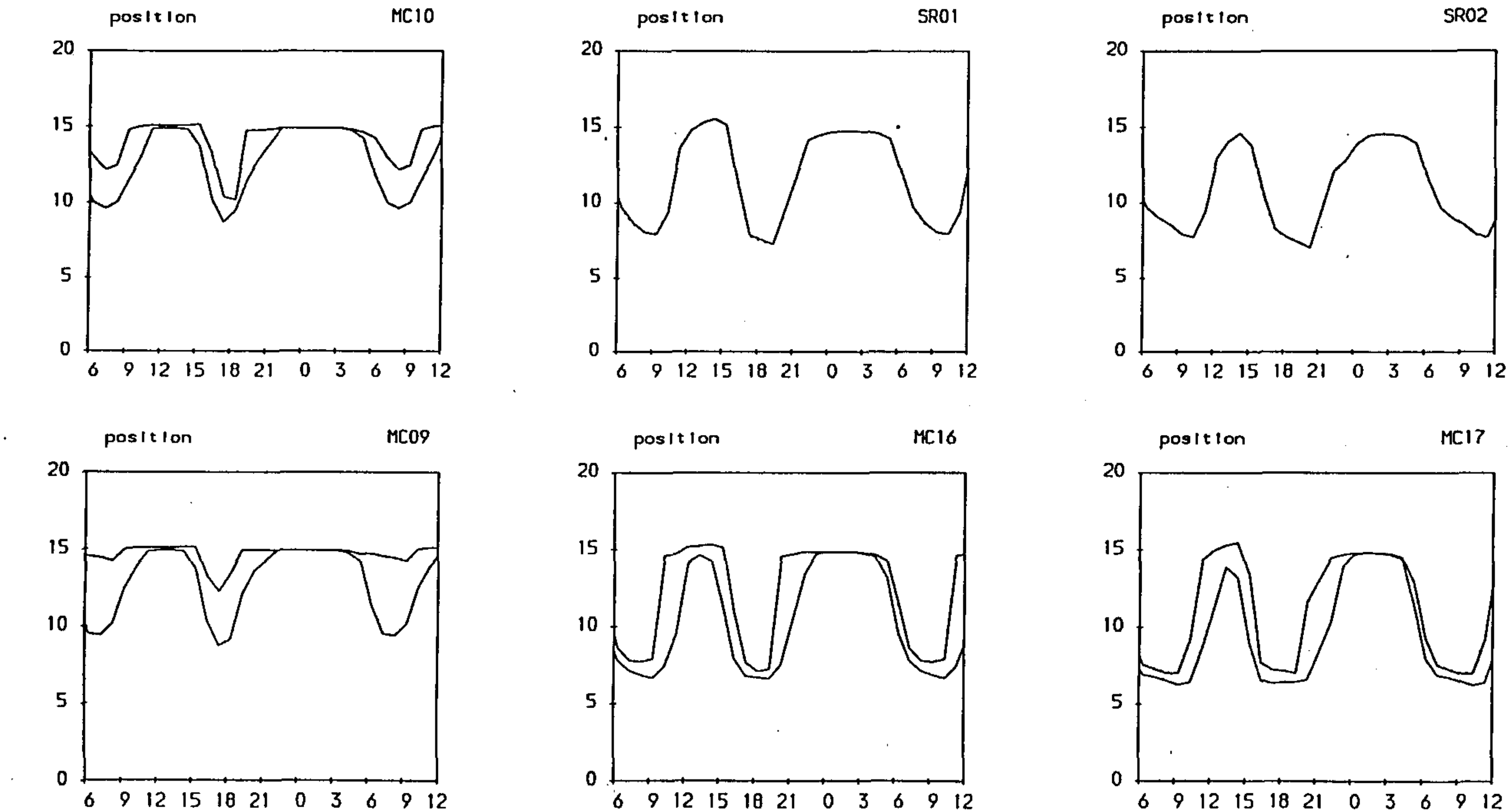


TK+Sham Tseng Wet Neap CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

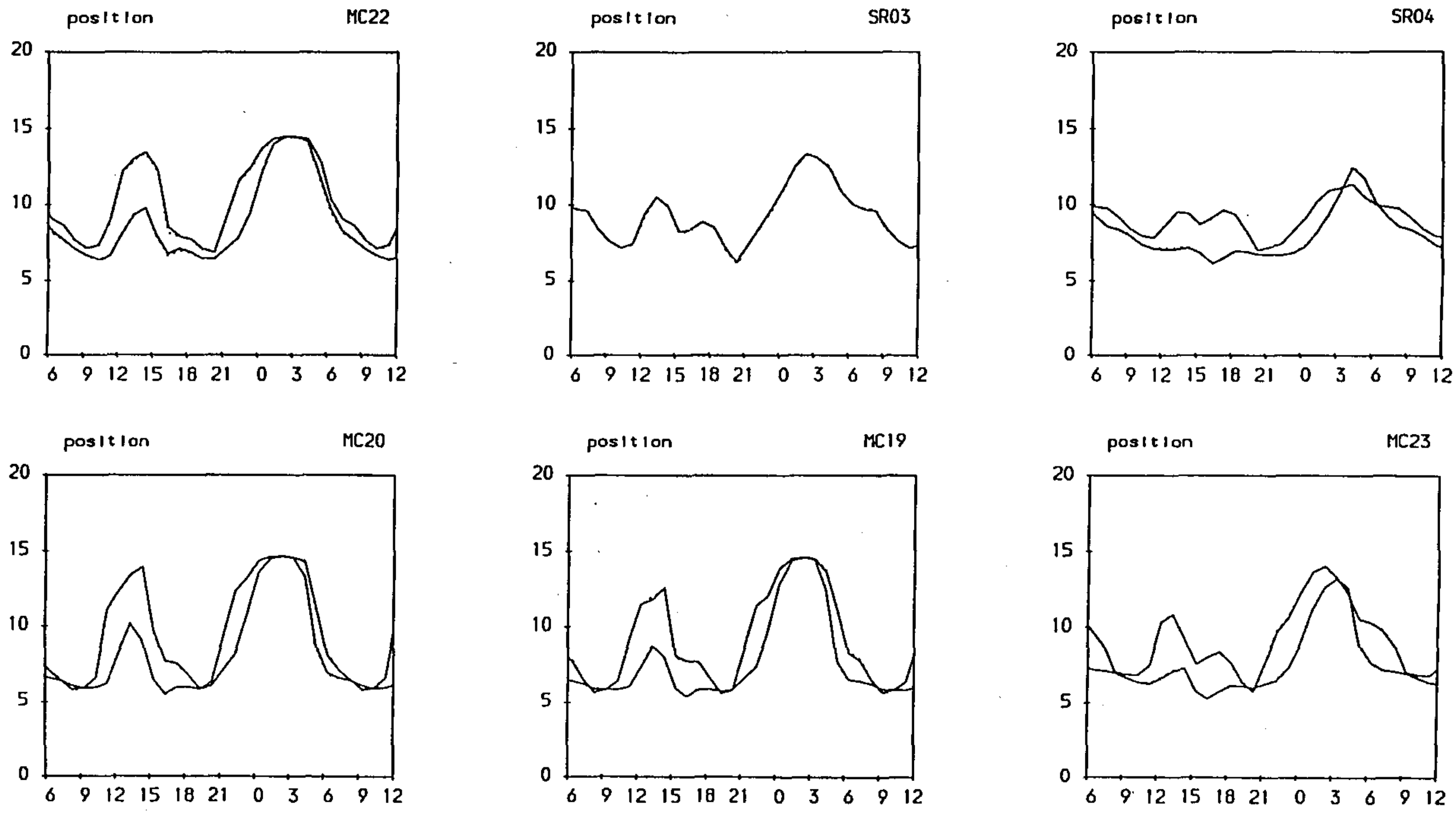


TK+Sham Tseng Wet Neap CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 3/03/95 ——— TKCJV .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

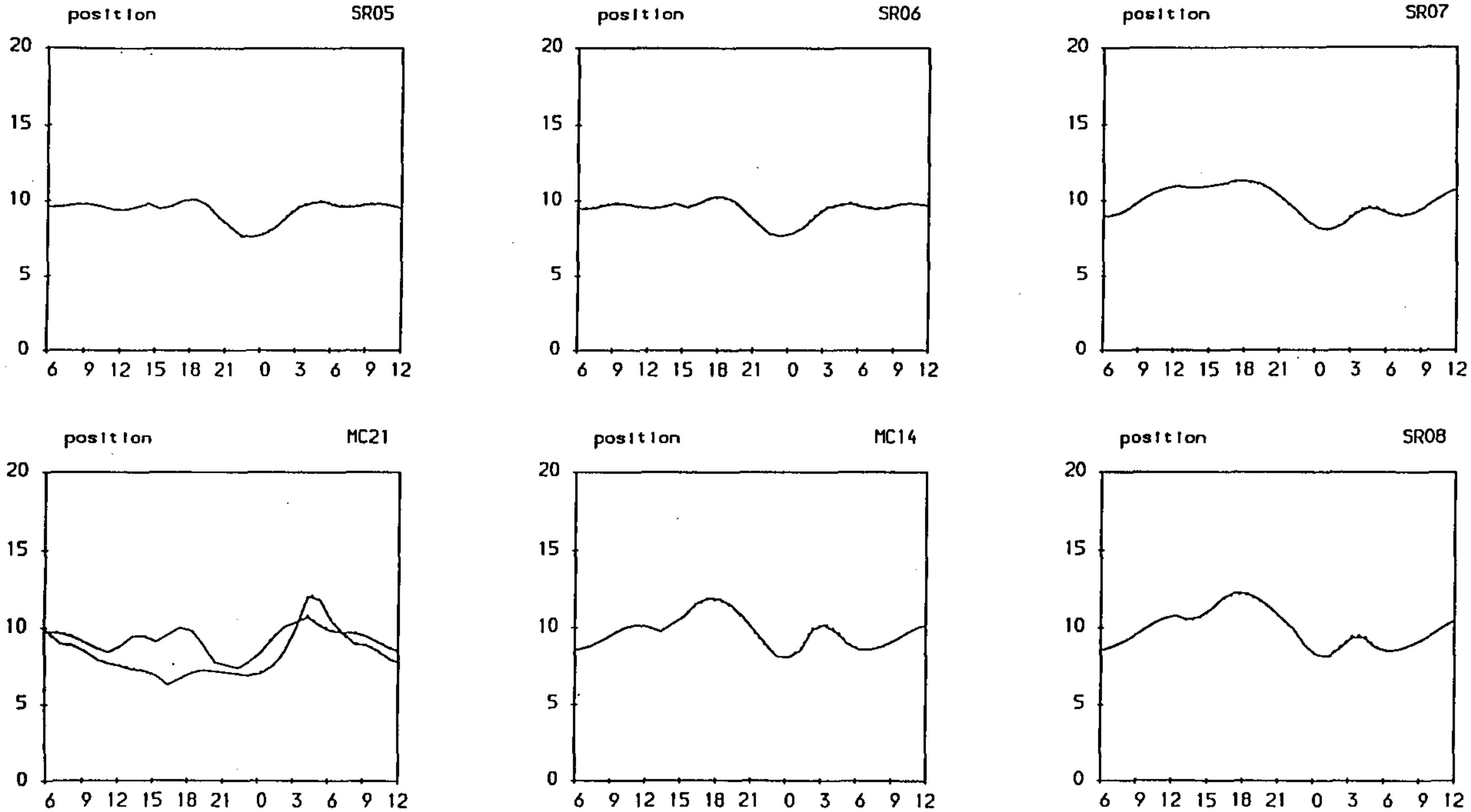


TK+Sham Tseng Wet Neap   CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid   DM 3/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, Δ Lower layer

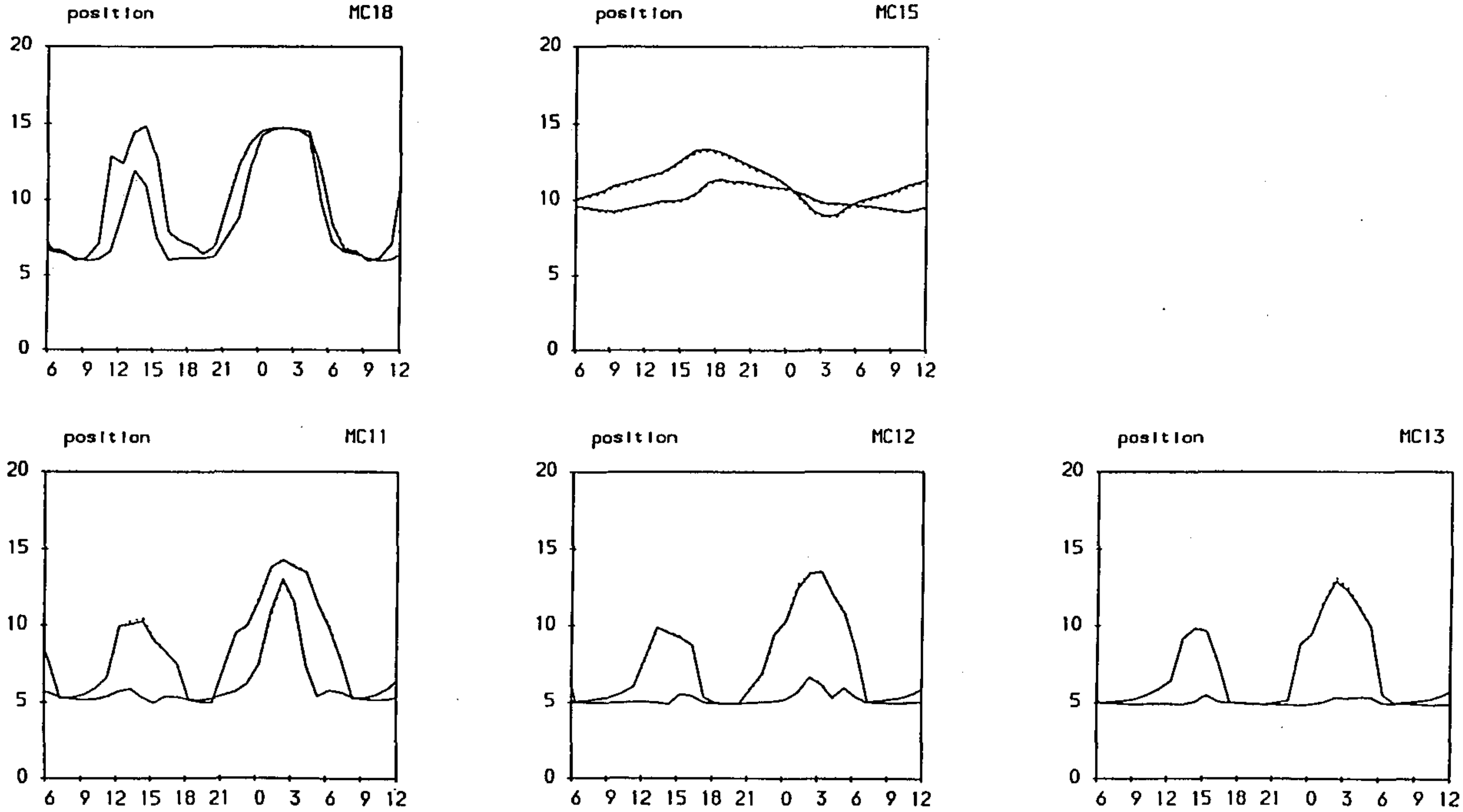


TK+Sham Tseng Wet Neap   CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid   DM 3/03/95   ——— TKCJV   ········· LongSO

Observed symbols: * Upper layer, △ Lower layer

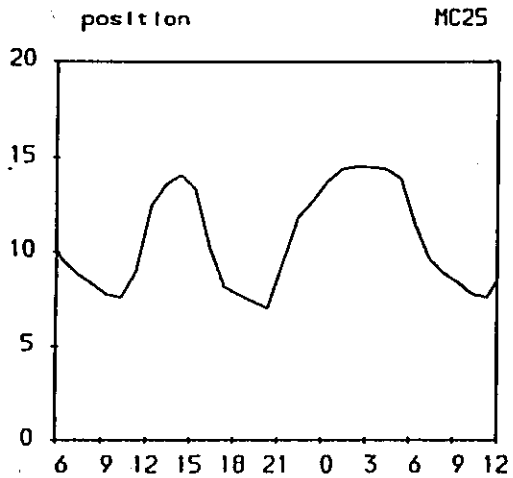


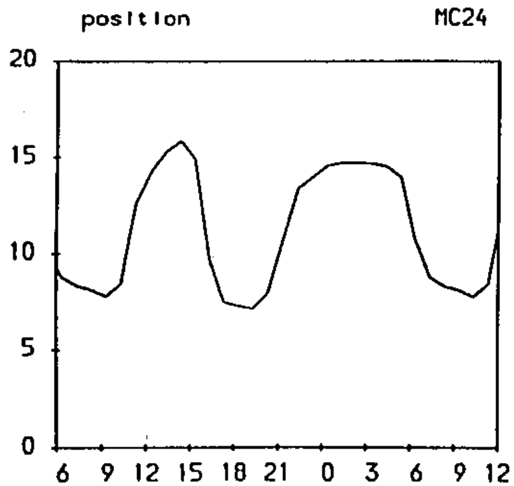
TK+Sham Tseng Wet Neap CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 3/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



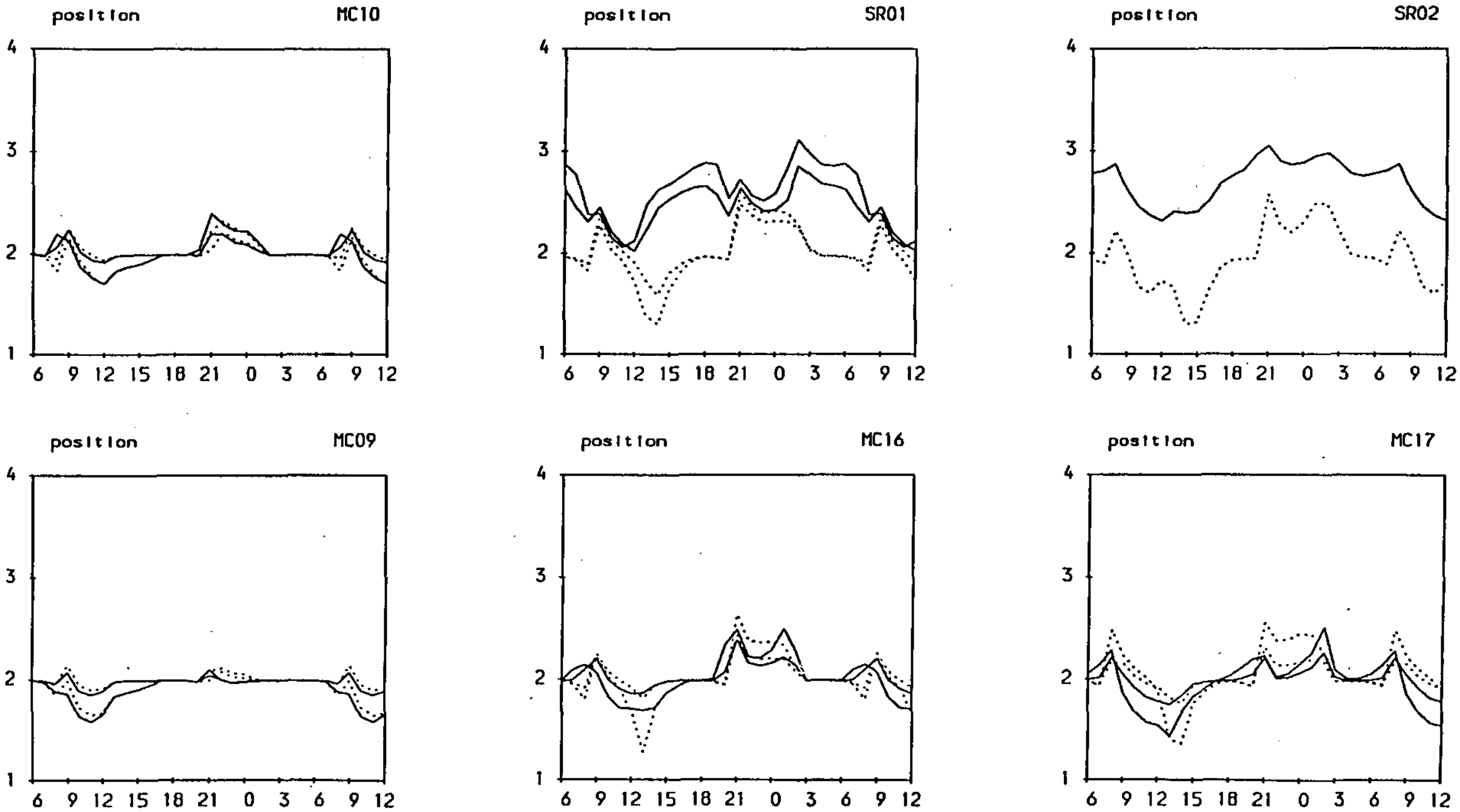


TK+Sham Tseng Dry Neap   CJV v LSO

E.Coli (no/100ml) against time   (log to base 10 on y-axis)

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

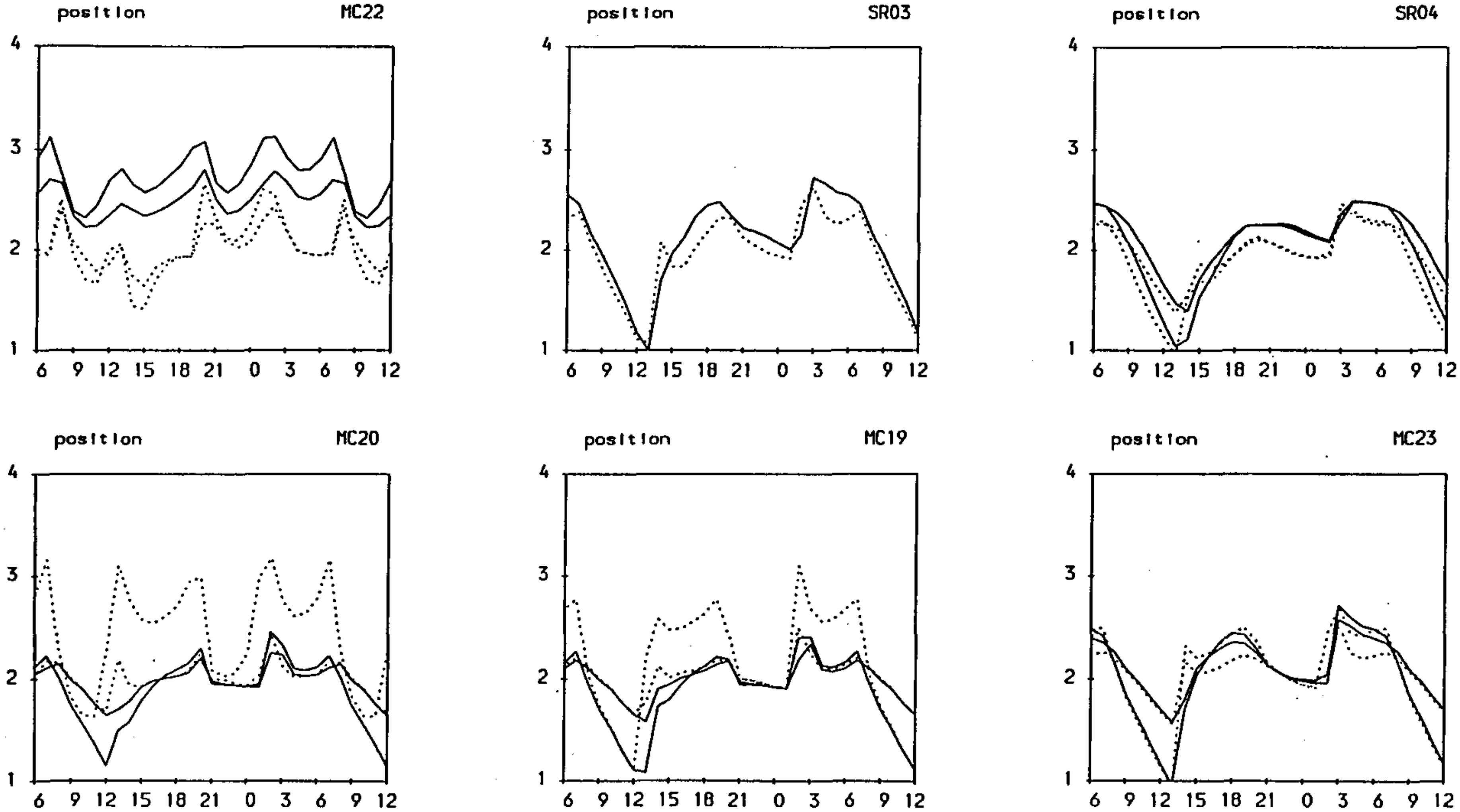


TK+Sham Tseng Dry Neap CJV v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 2/03/95 ——— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

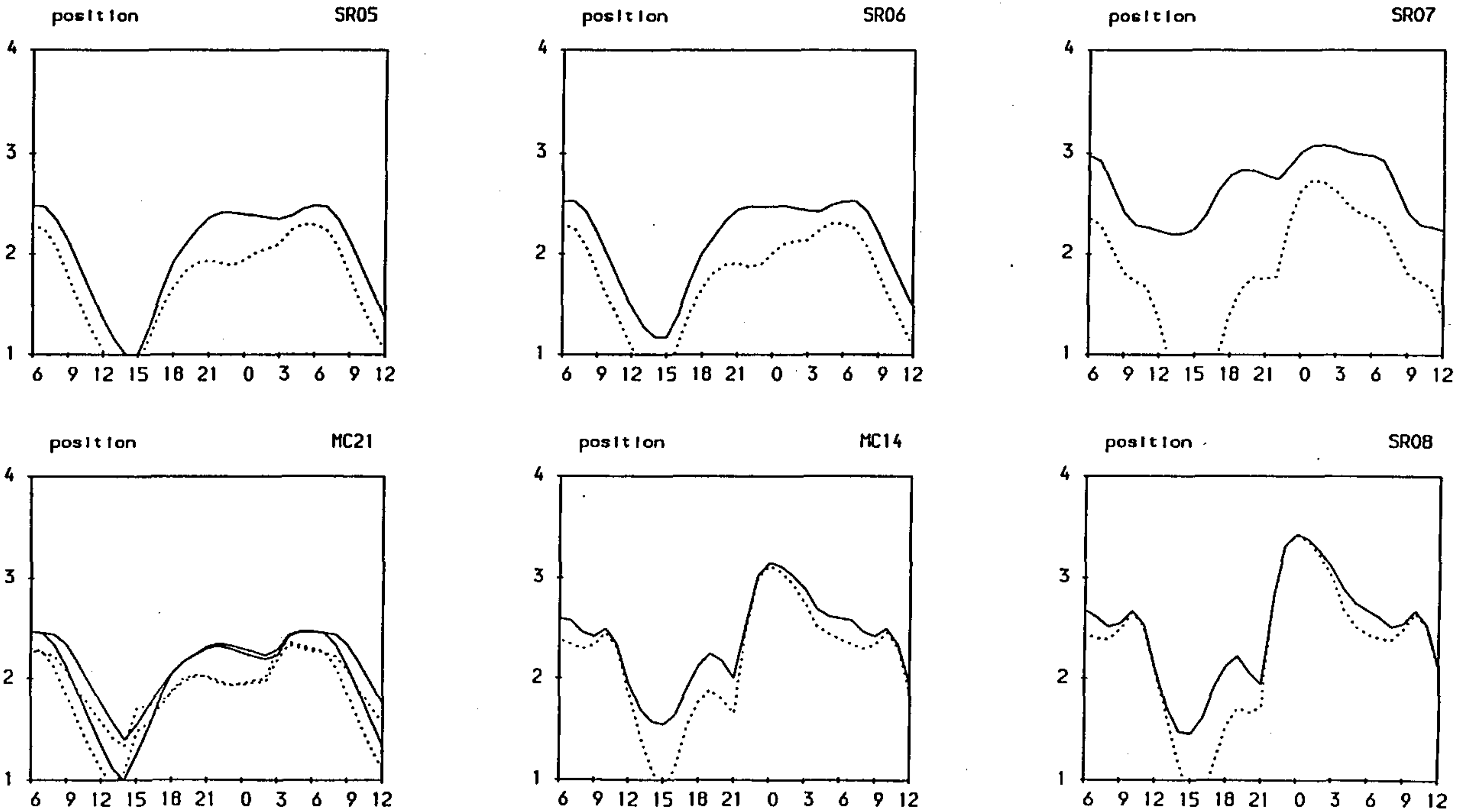


TK+Sham Tseng Dry Neap CJV v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 2/03/95 ——— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



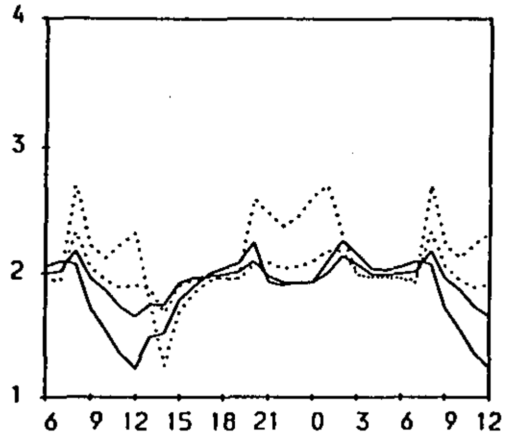
TK+Sham Tseng Dry Neap CJV v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

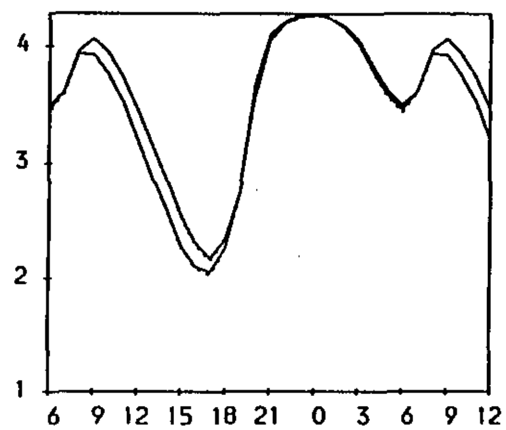
2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

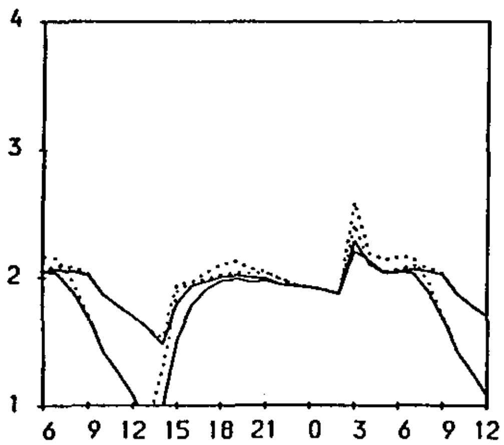
position MC18



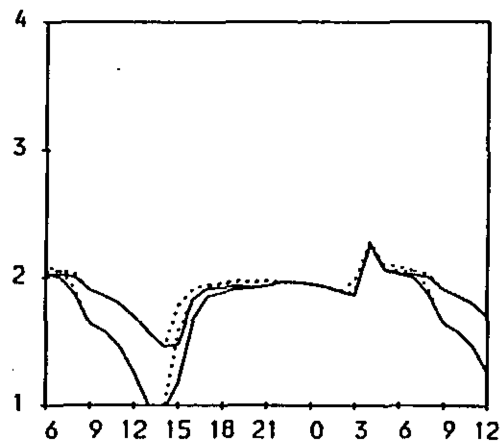
position MC15



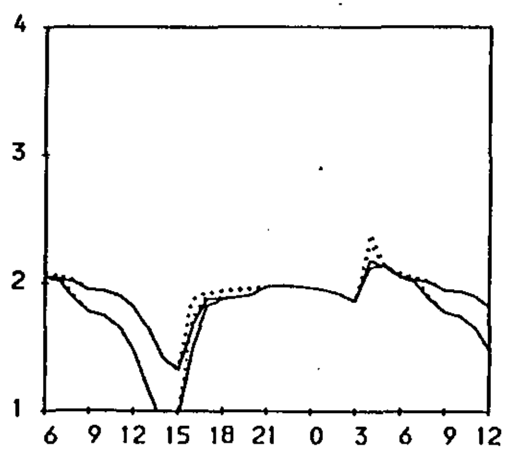
position MC11



position MC12



position MC13

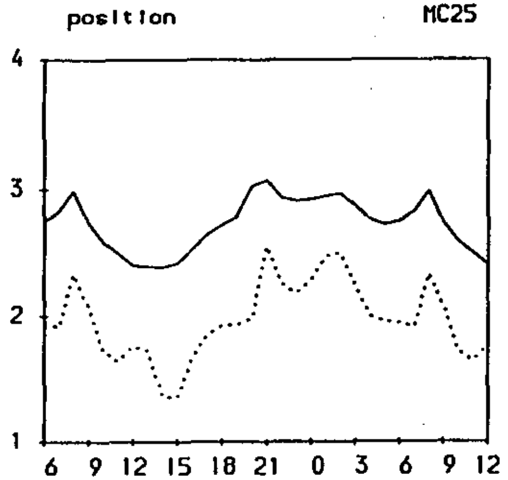


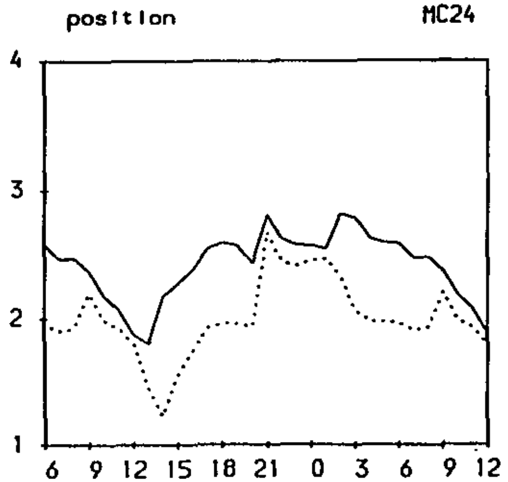
TK+Sham Tseng Dry Neap CJV v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 2/03/95 ——— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer



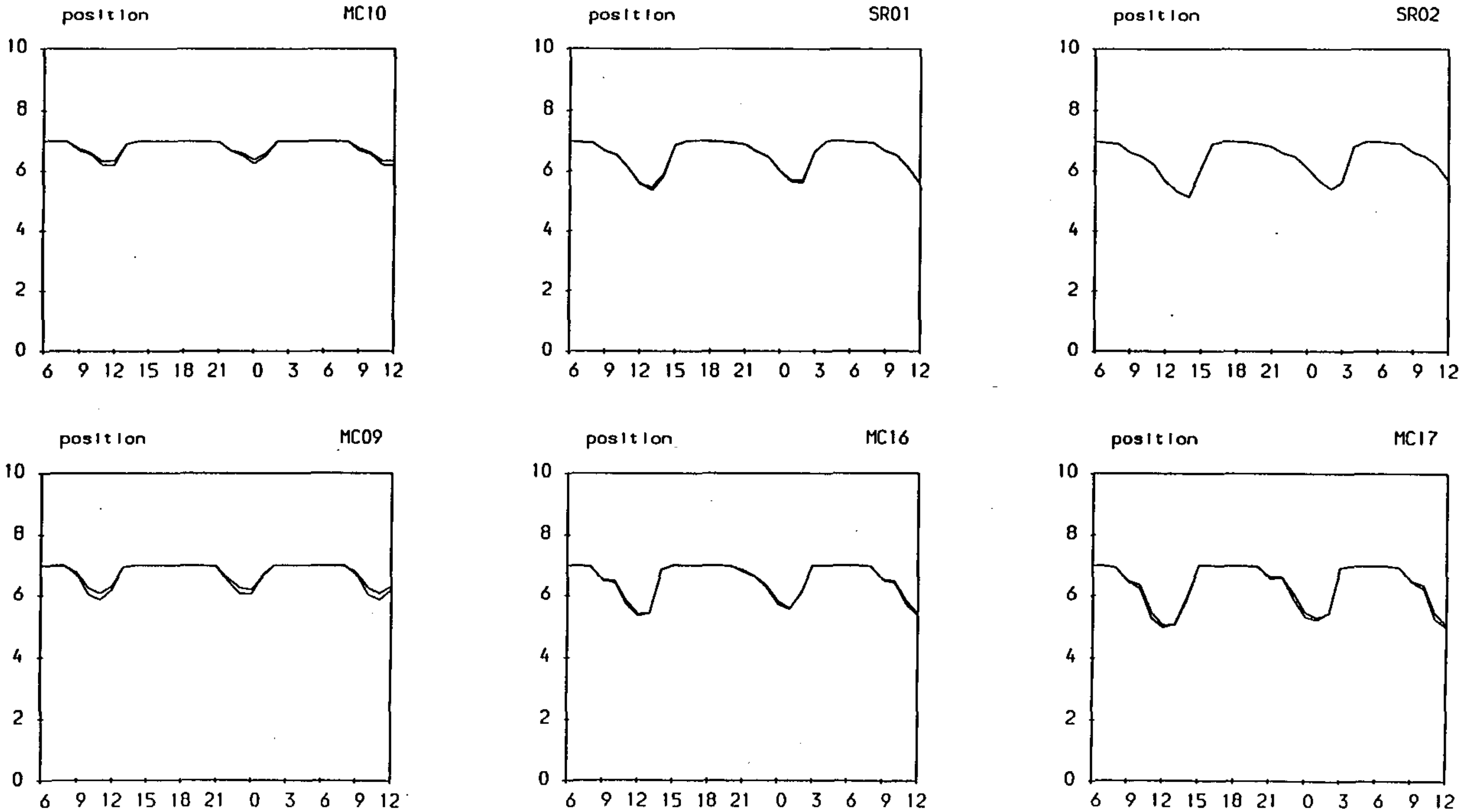


TK+Sham Tseng Dry Neap CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

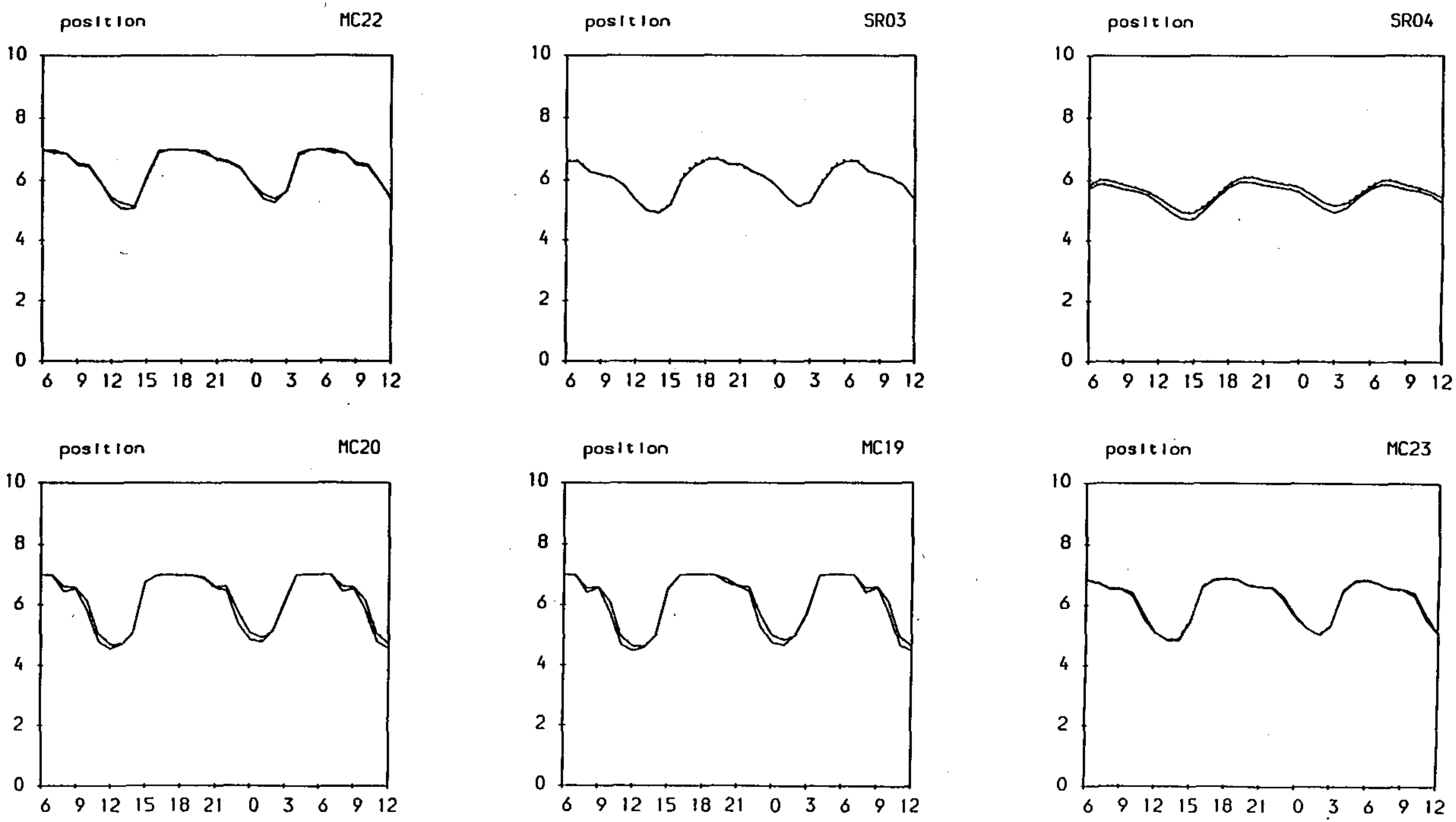


TK+Sham Tseng Dry Neap CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

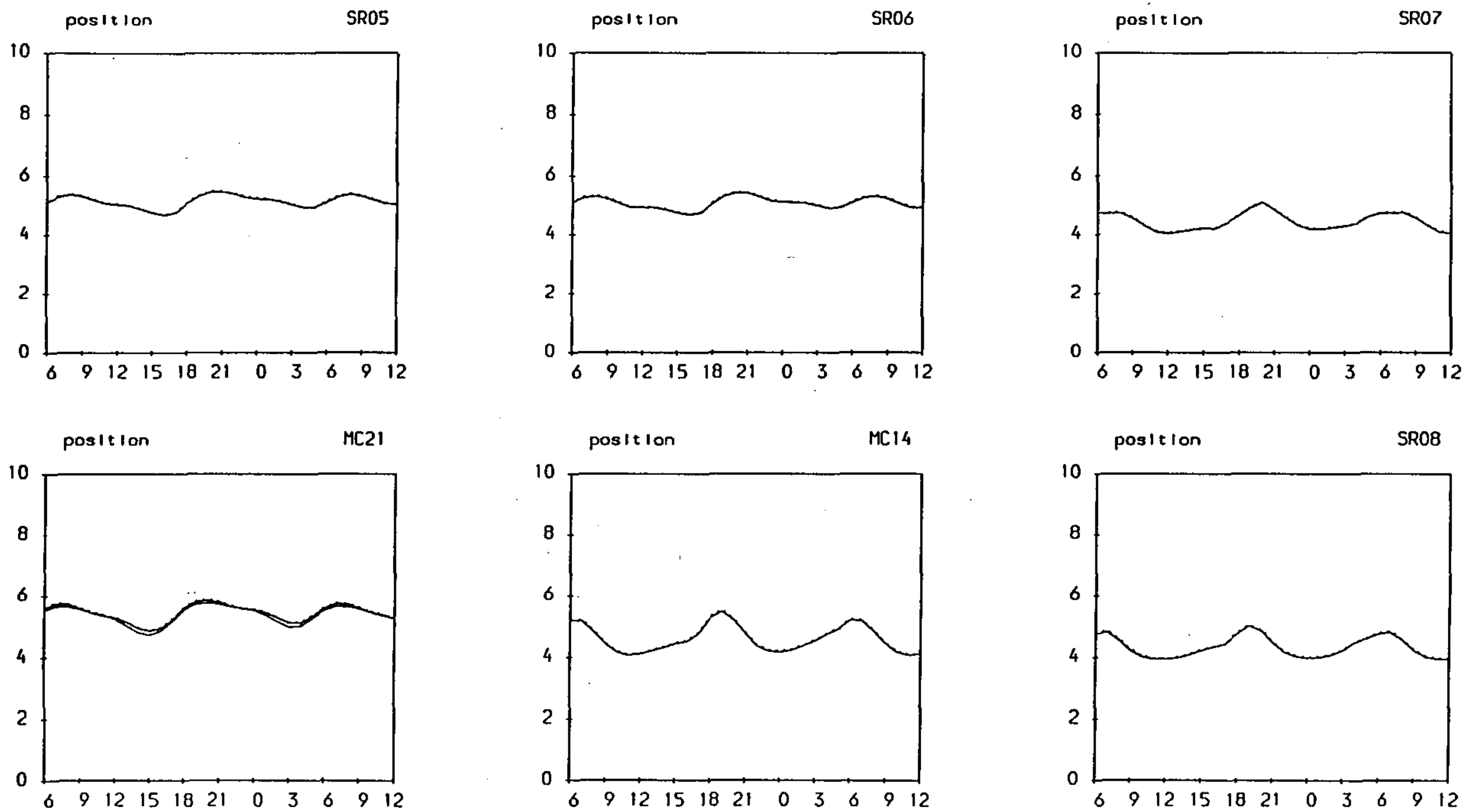


TK+Sham Tseng Dry Neap   CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

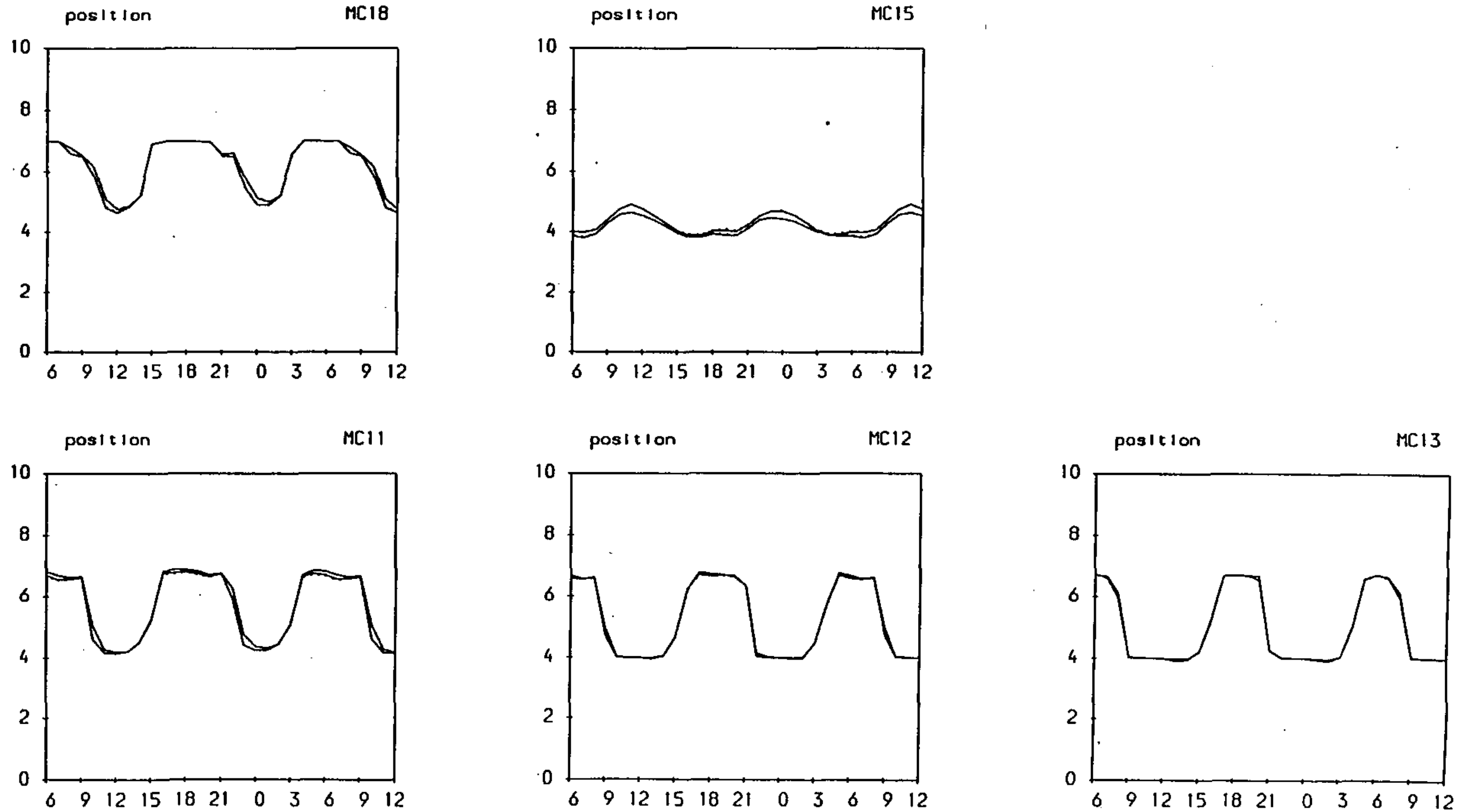


TK+Sham Tseng Dry Neap   CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

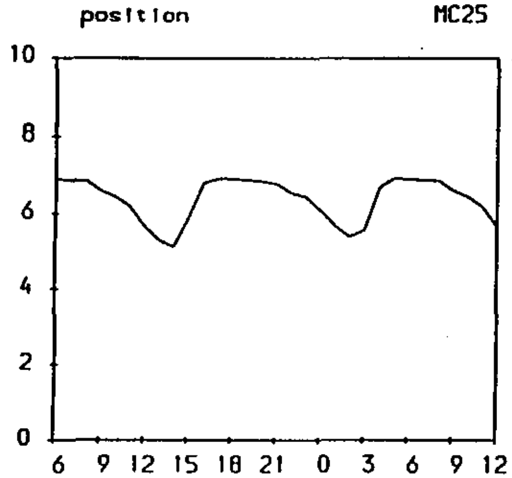


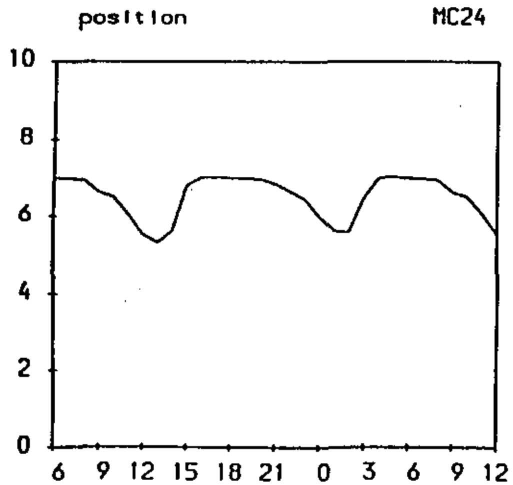
TK+Sham Tseng Dry Neap   CJV v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer



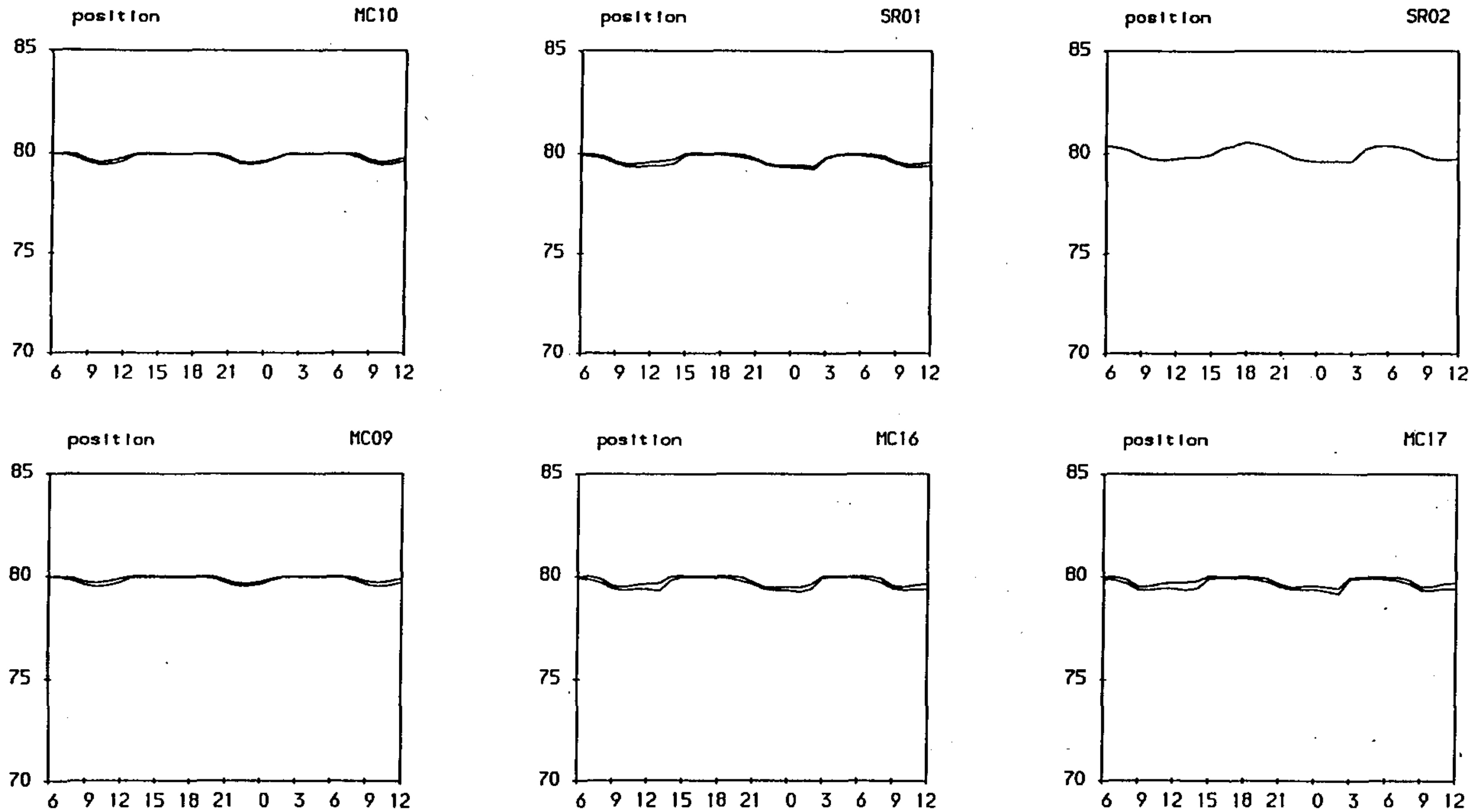


TK+Sham Tseng Dry Neap CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer

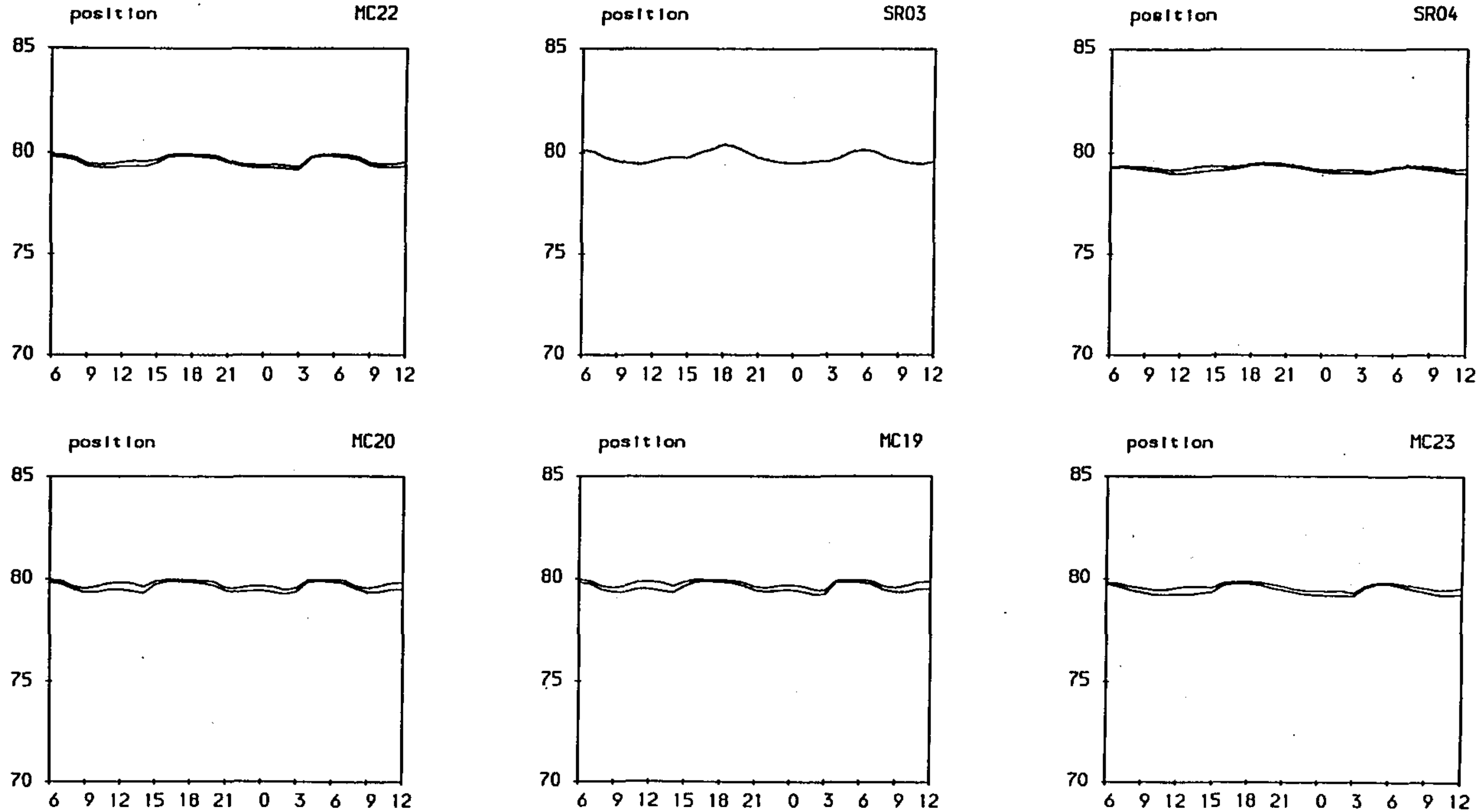


TK+Sham Tseng Dry Neap   CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

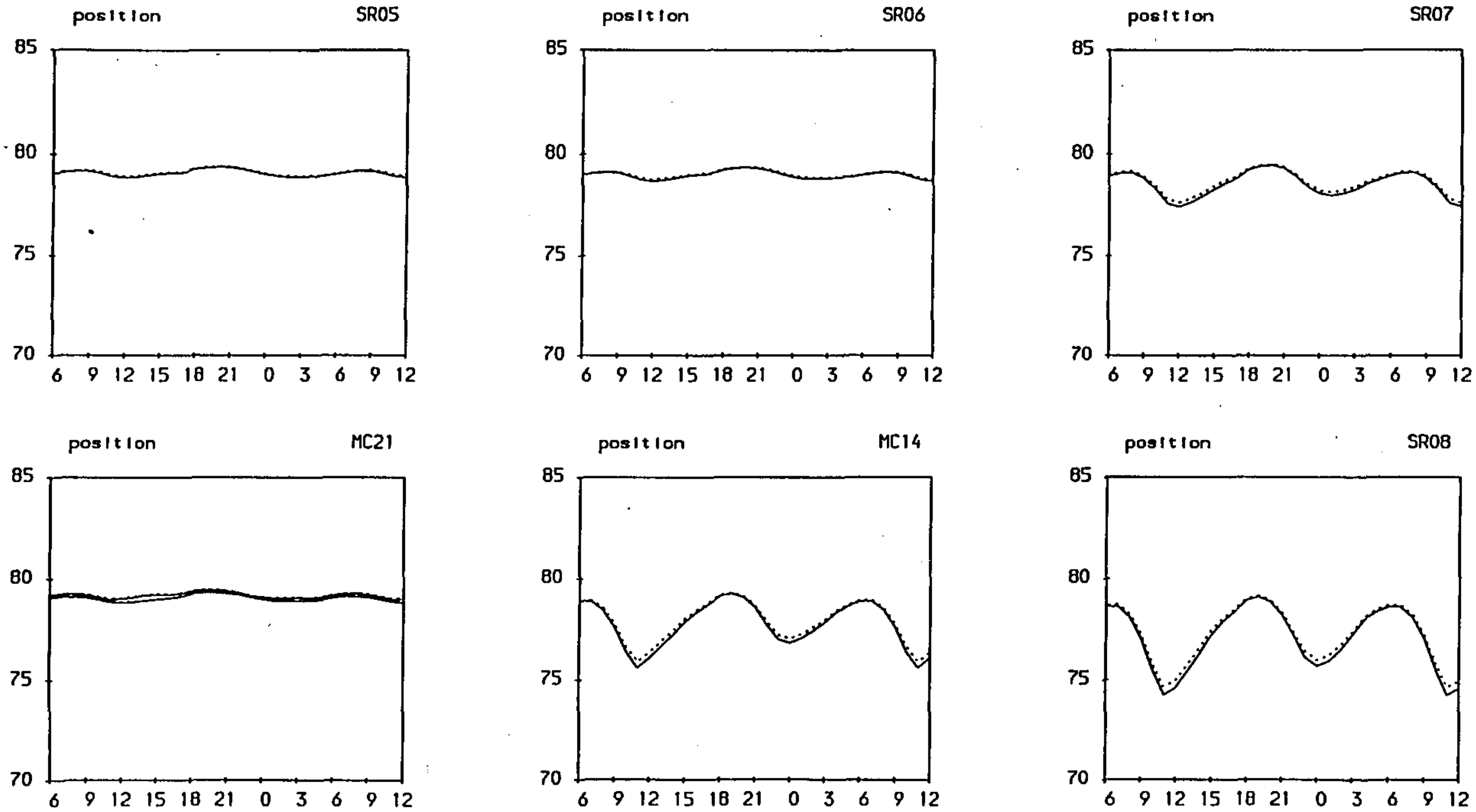


TK+Sham Tseng Dry Neap   CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

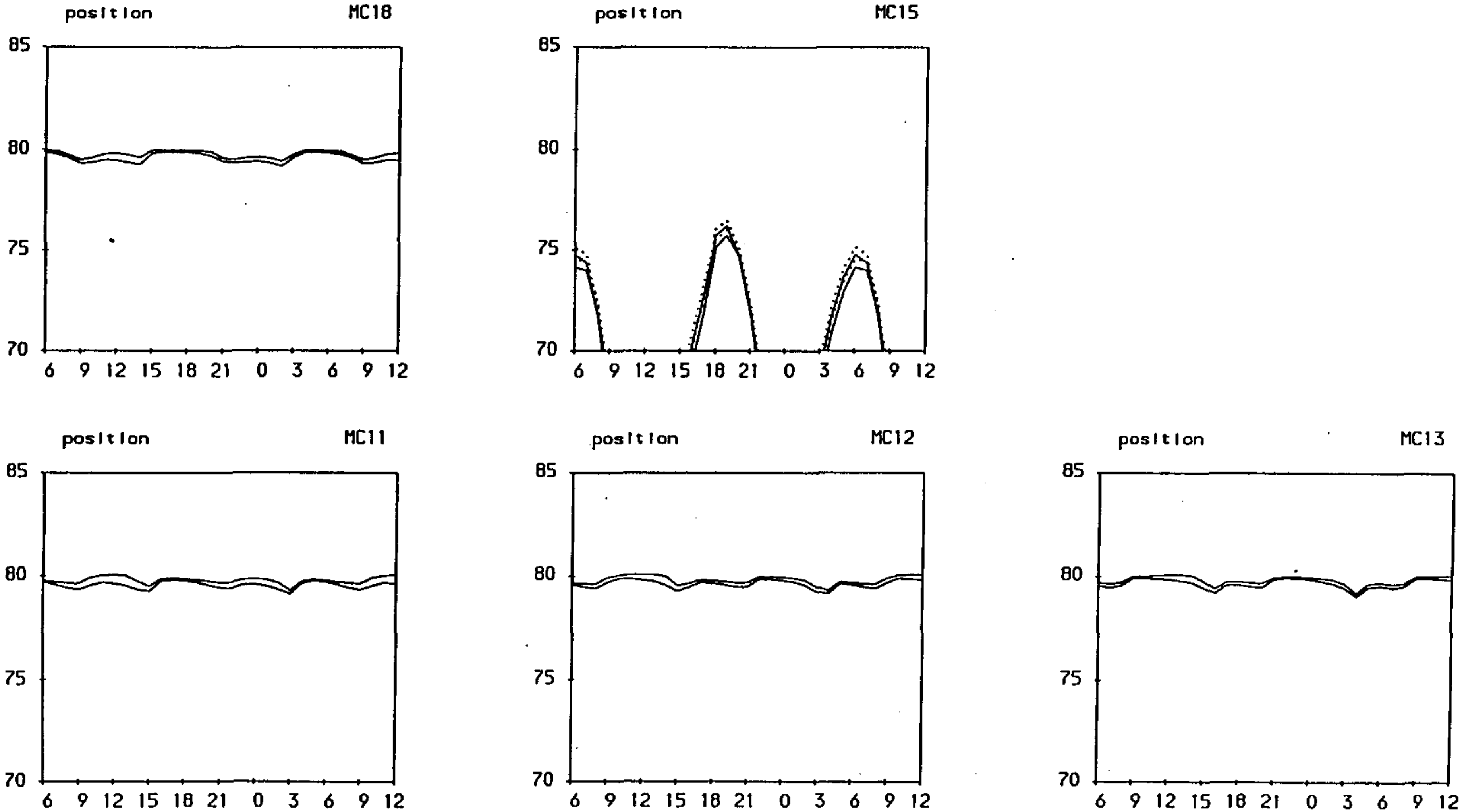


TK+Sham Tseng Dry Neap CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

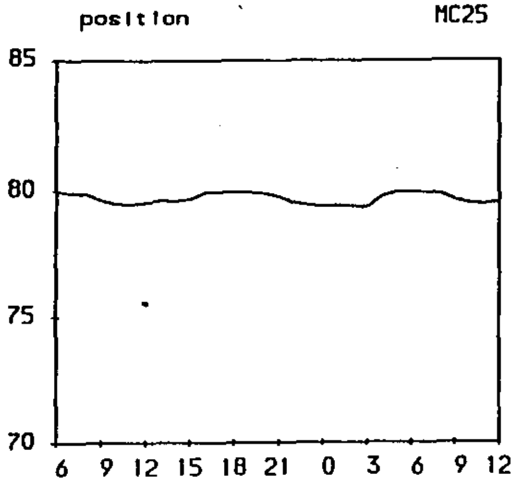


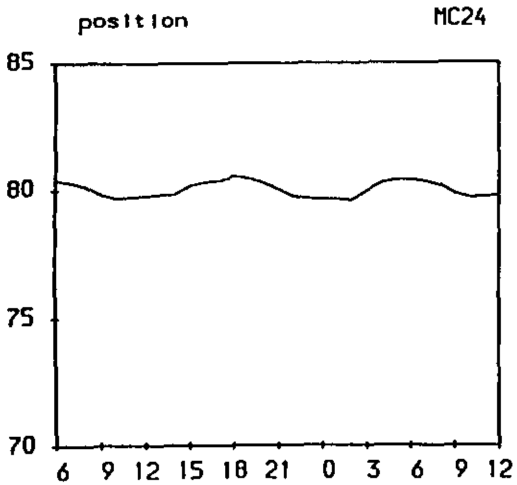
TK+Sham Tseng Dry Neap   CJV v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, Δ Lower layer



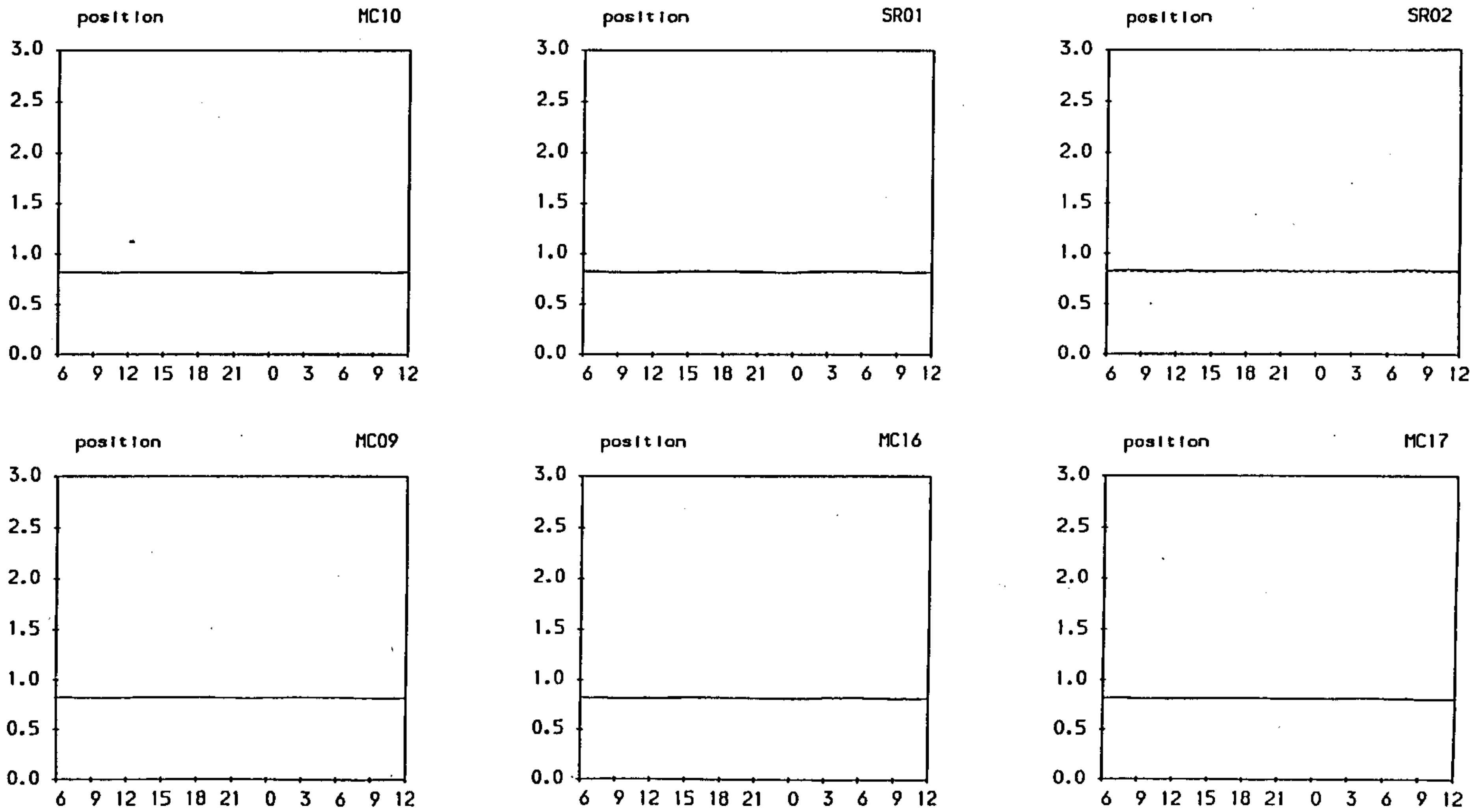


TK+Sham Tseng Dry Neap   CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

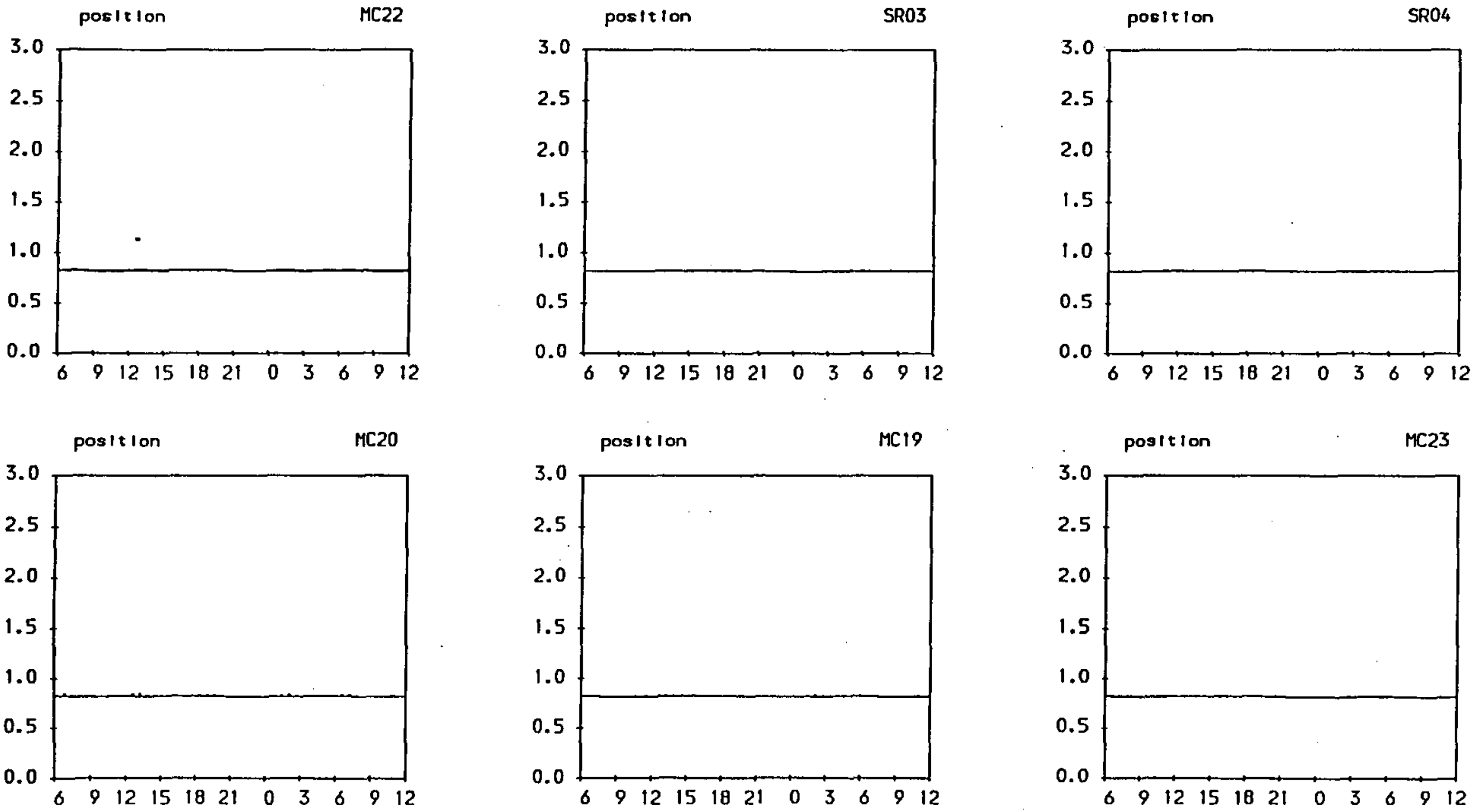


TK+Sham Tseng Dry Neap   CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

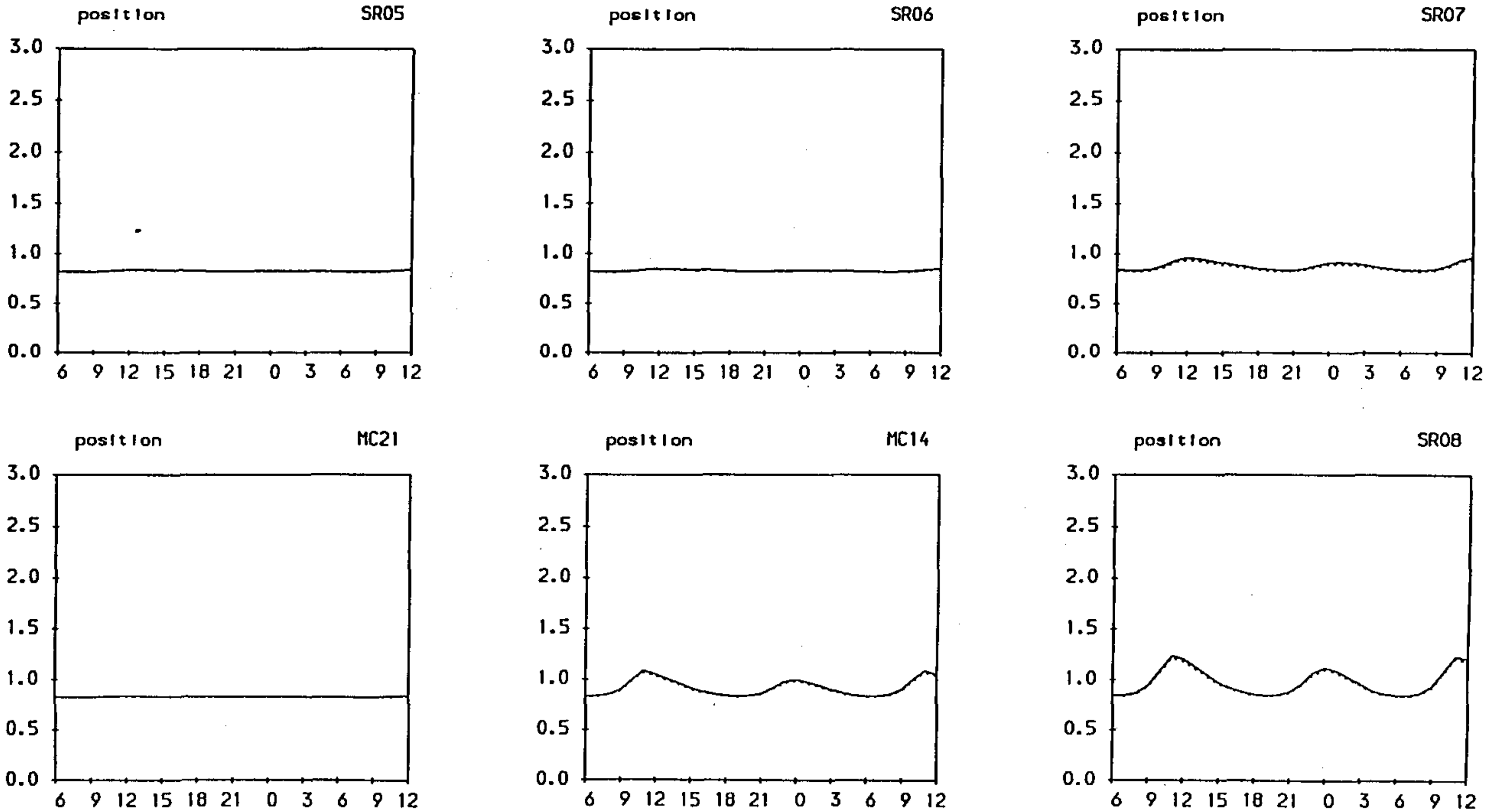


TK+Sham Tseng Dry Neap CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

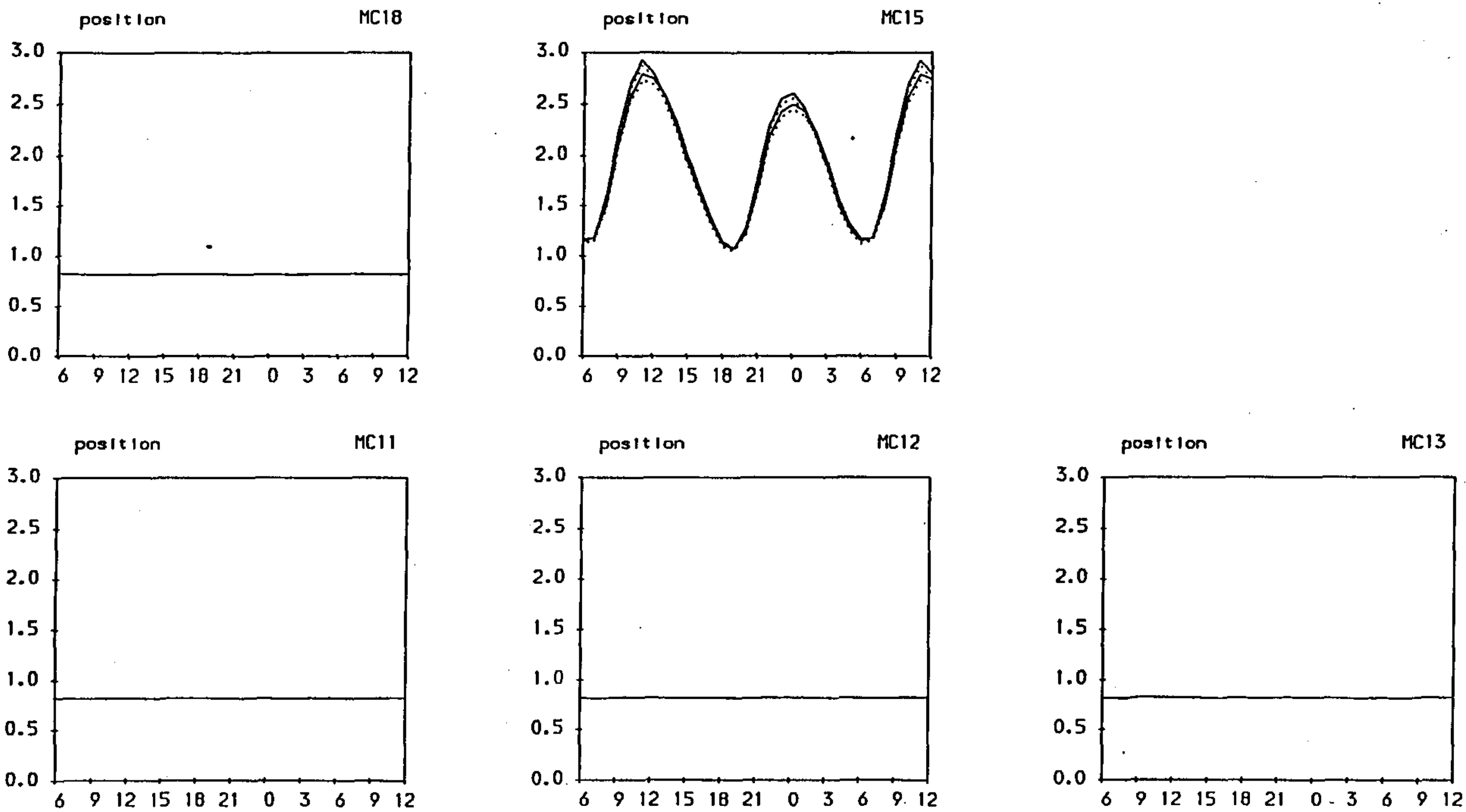


TK+Sham Tseng Dry Neap CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

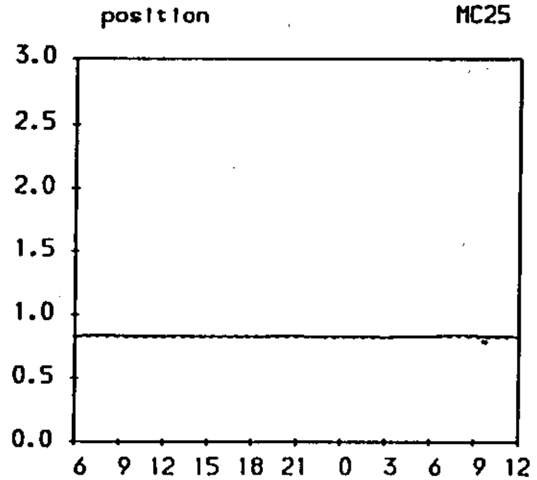


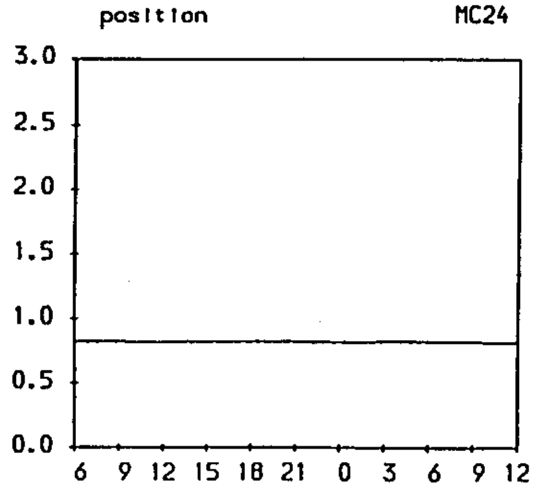
TK+Sham Tseng Dry Neap   CJV v LSO

BOD (mg/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer



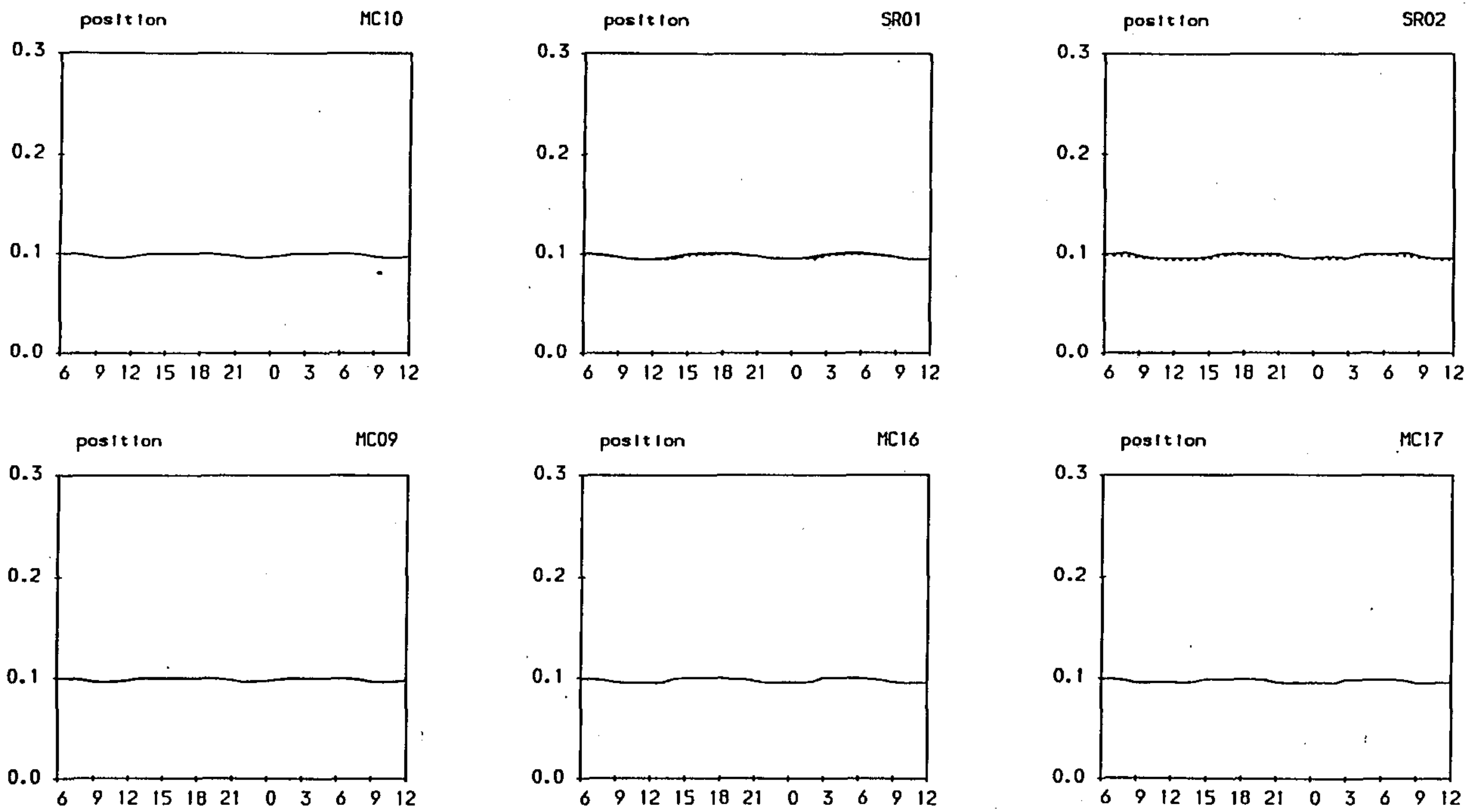


TK+Sham Tseng Dry Neap CJV v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

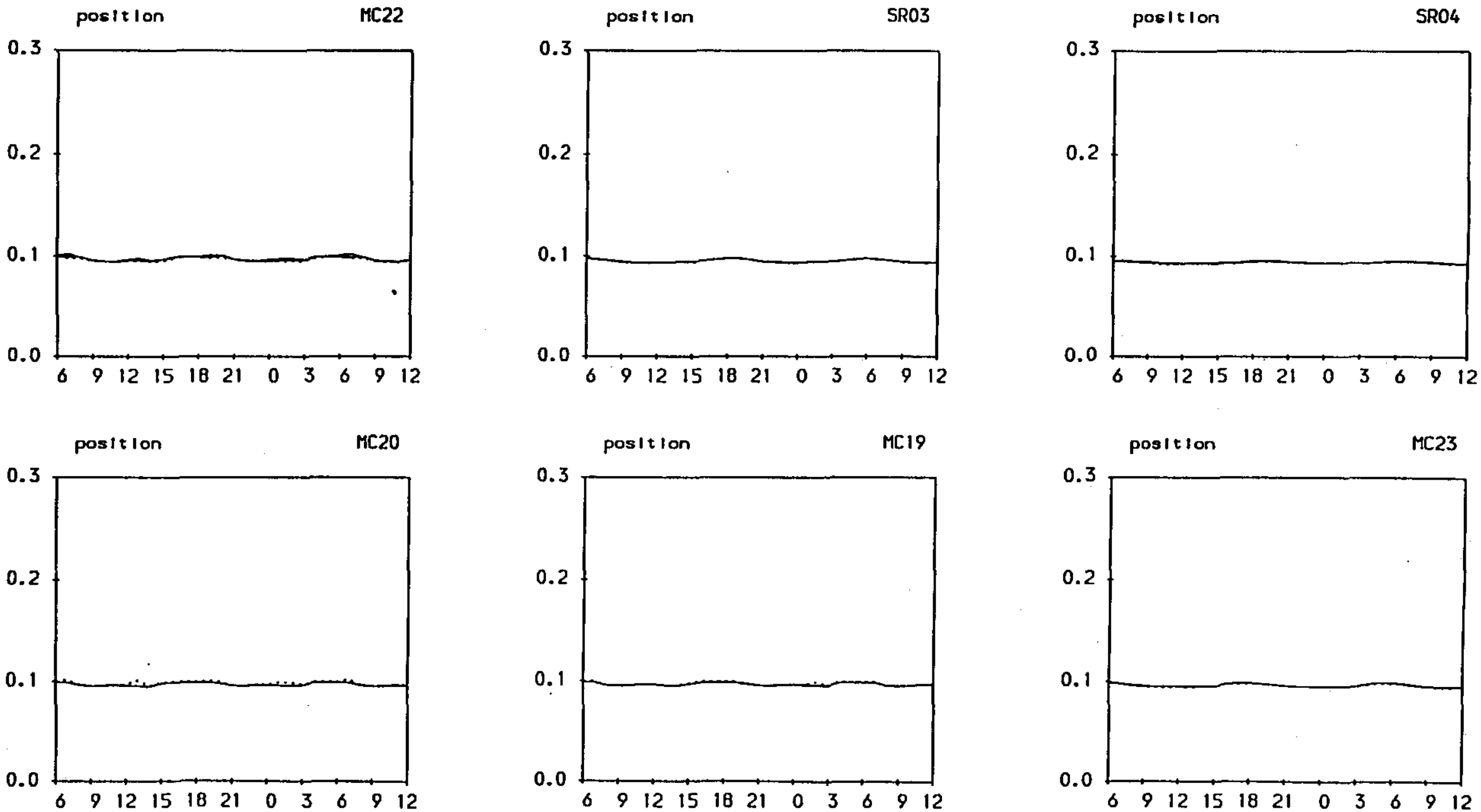


TK+Sham Tseng Dry Neap CJV v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, Δ Lower layer

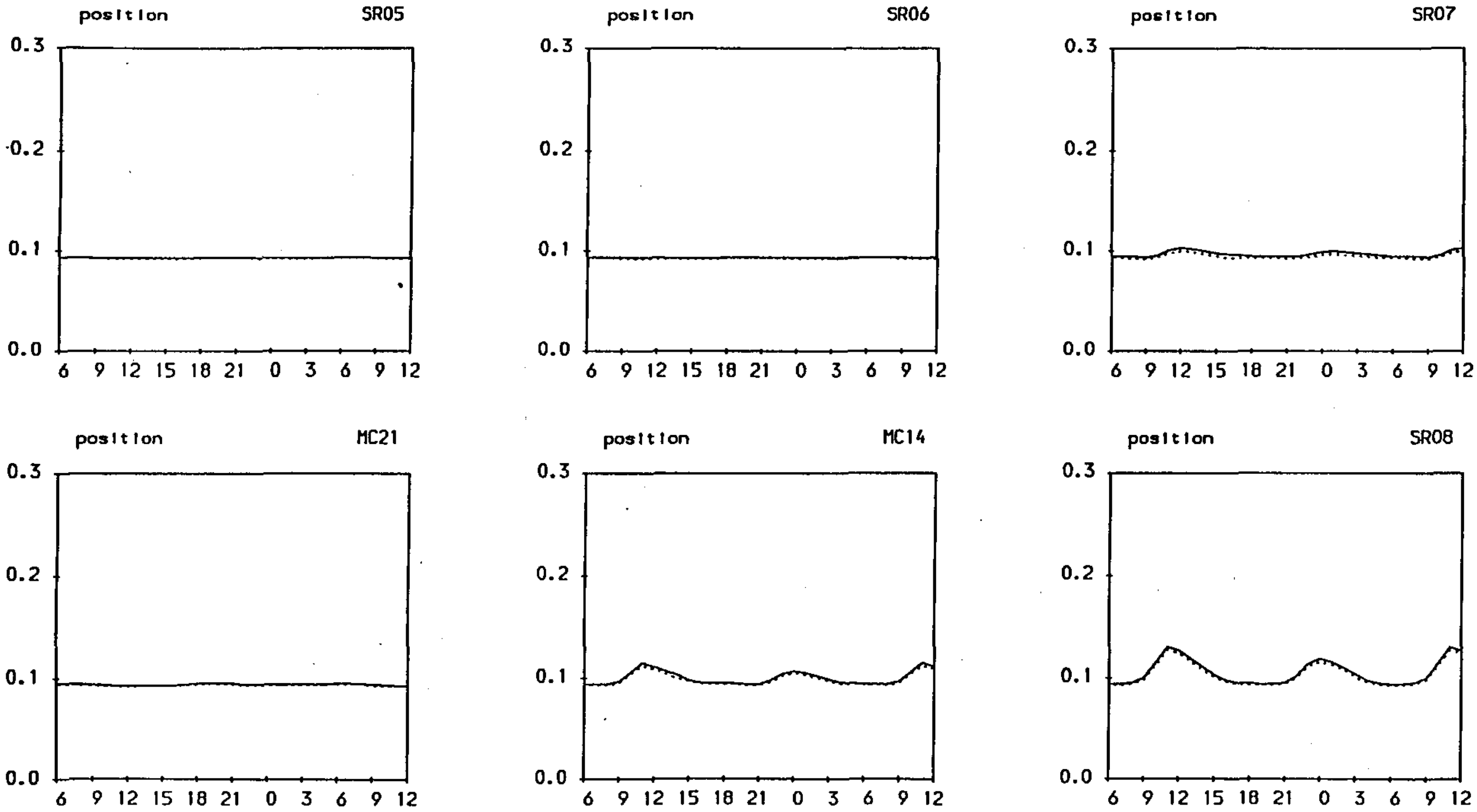


TK+Sham Tseng Dry Neap CJV v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 ——— TKCJV ········ LongSO

Observed symbols: * Upper layer, Δ Lower layer

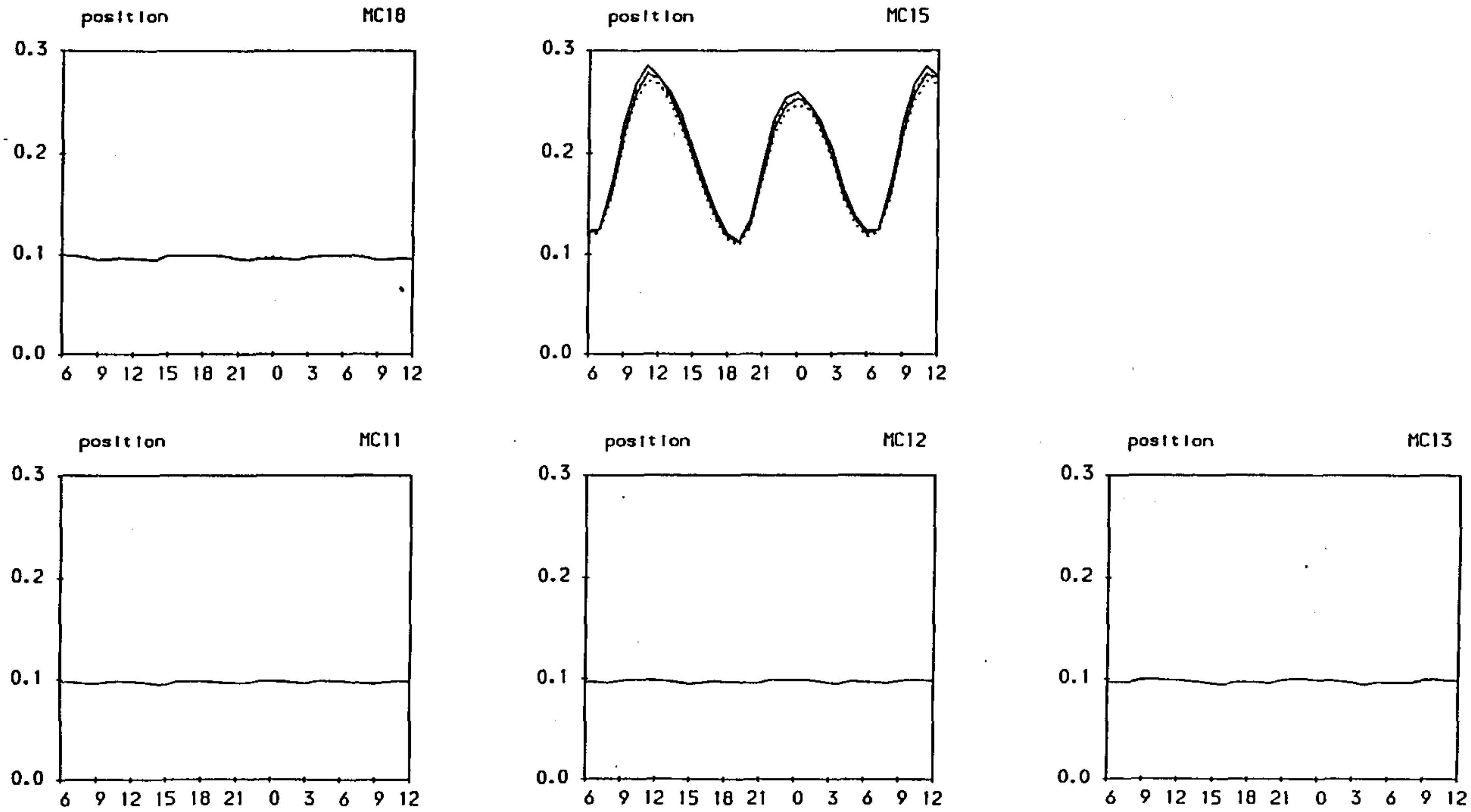


TK+Sham Tseng Dry Neap CJV v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

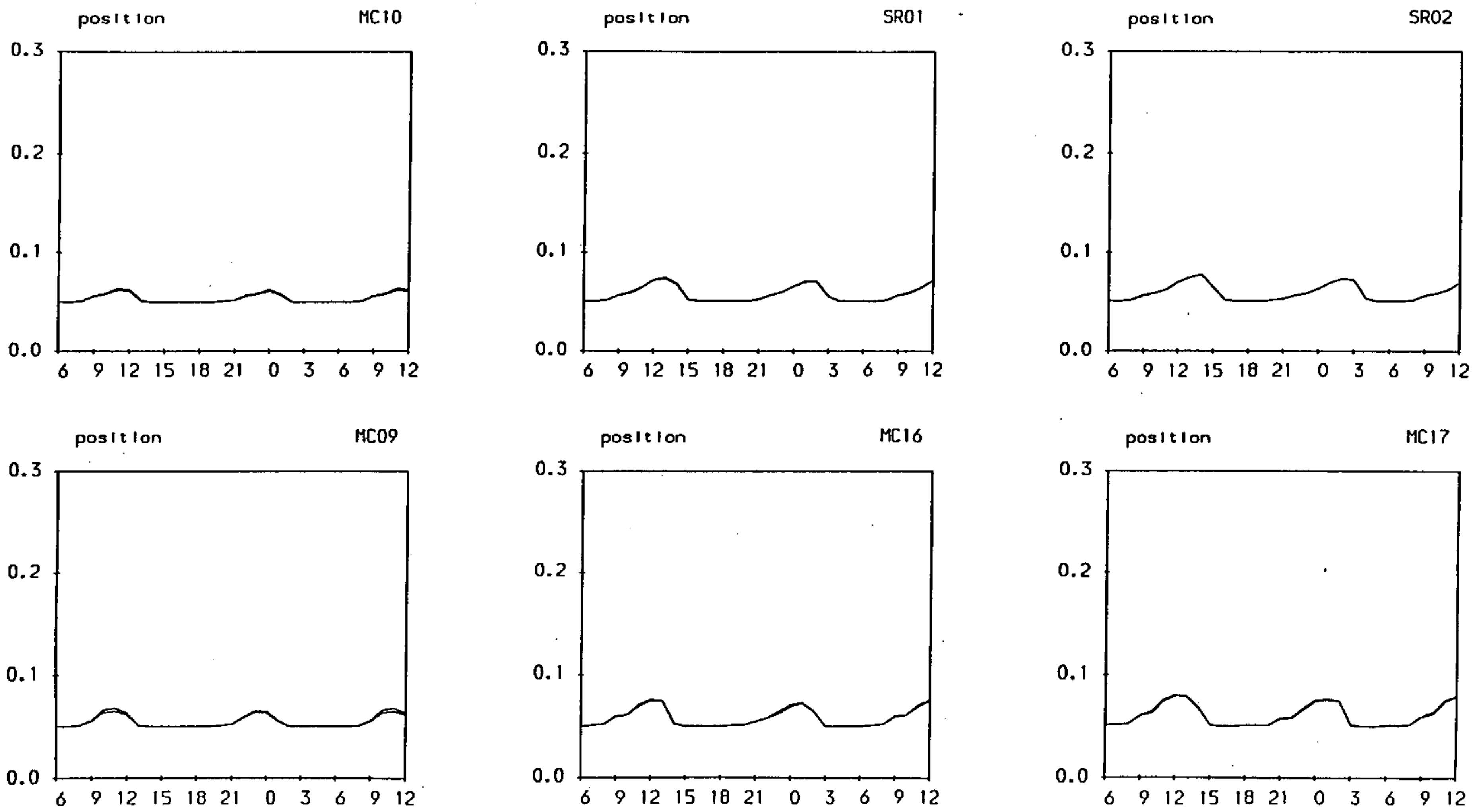


TK+Sham Tseng Dry Neap   CJV v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 2/03/95   ——— TKCJV   .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

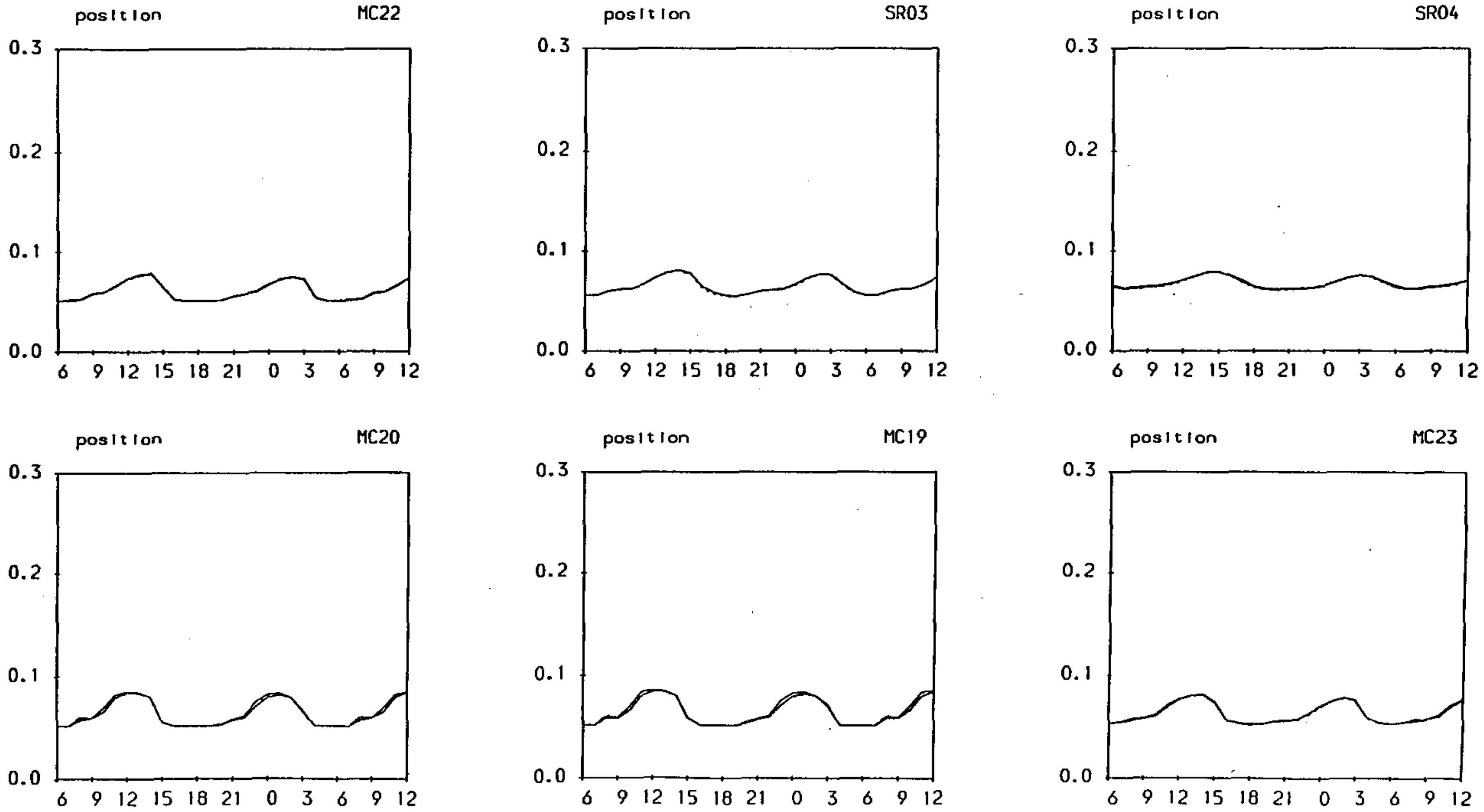


TK+Sham Tseng Dry Neap CJV v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

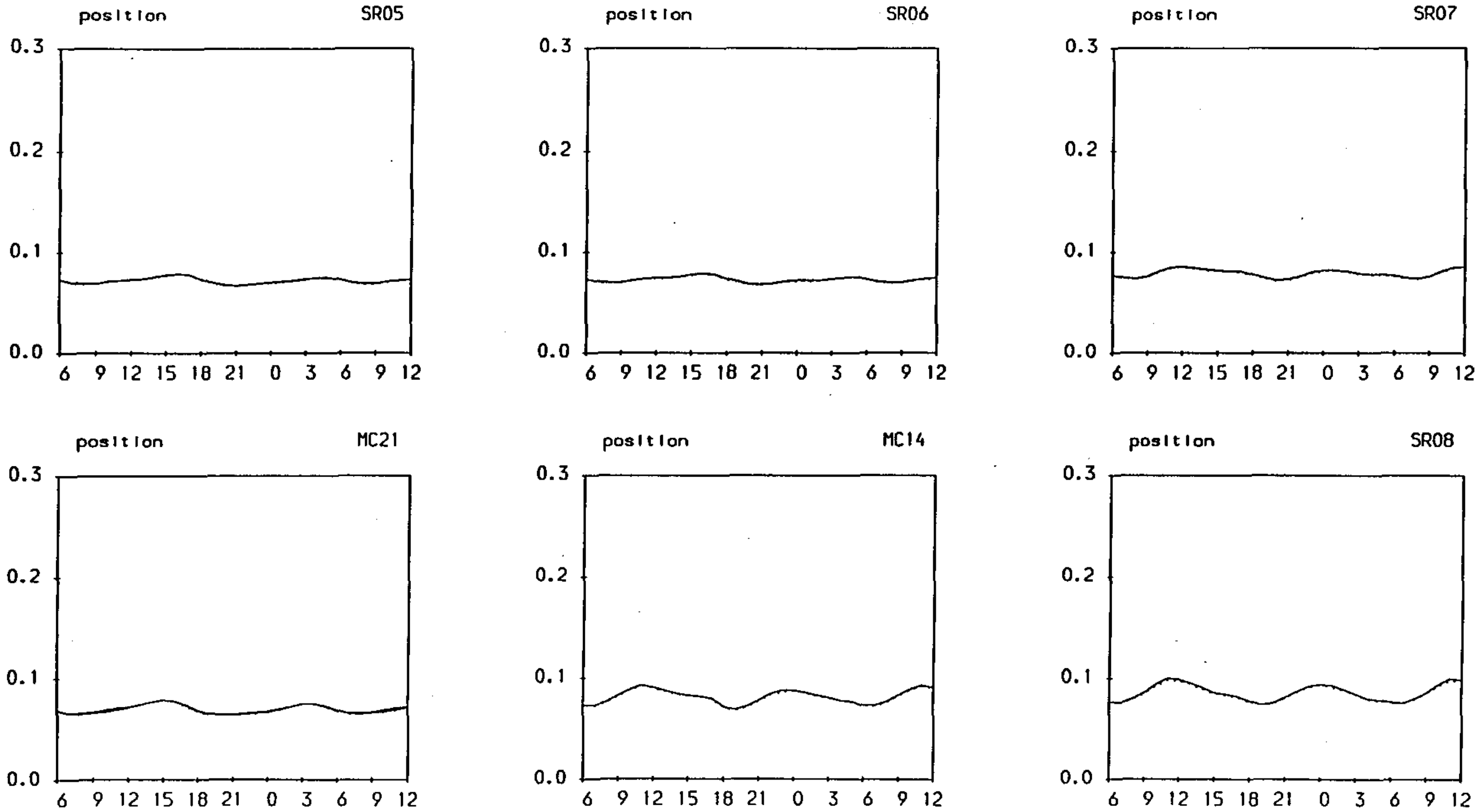


TK+Sham Tseng Dry Neap   CJV v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

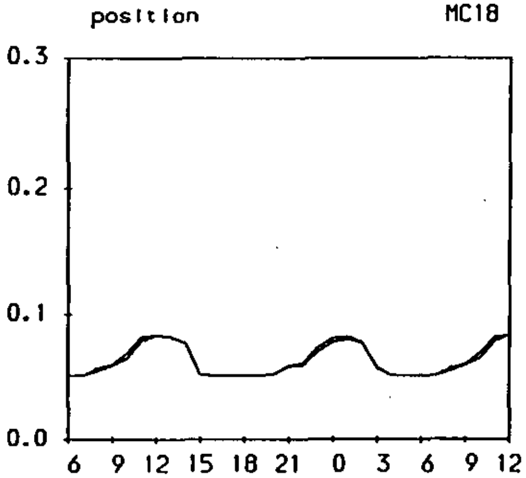


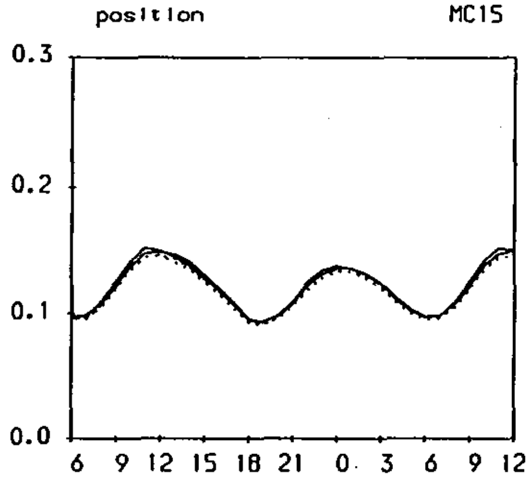
TK+Sham Tseng Dry Neap CJV v LSO

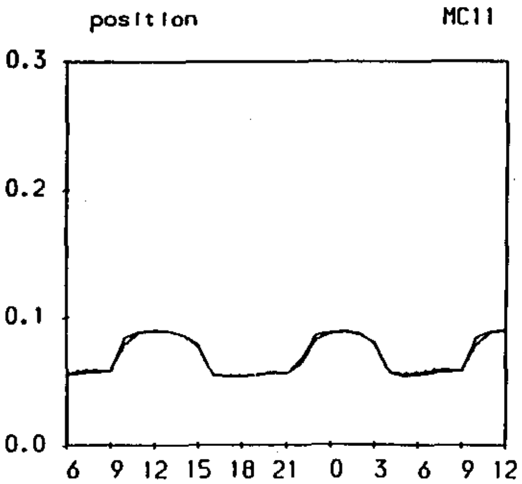
Oxidised Nitrogen (mg N/l) against time

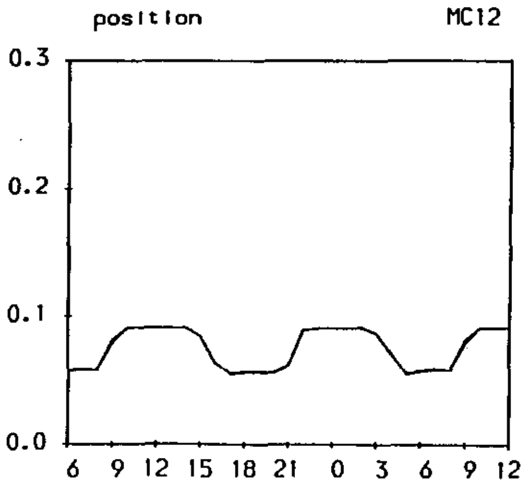
2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

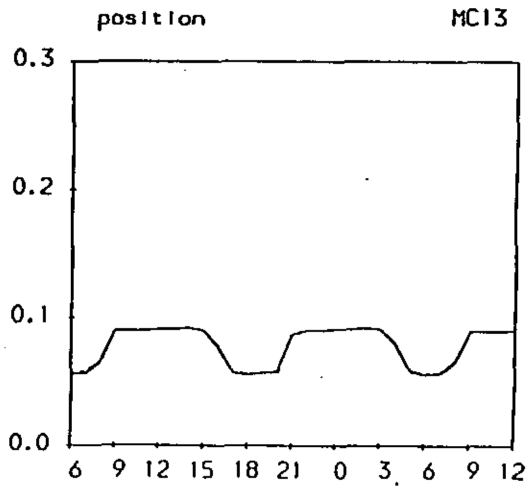
Observed symbols: * Upper layer, Δ Lower layer









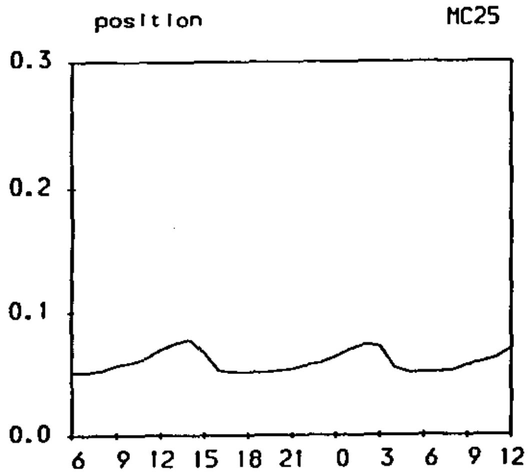


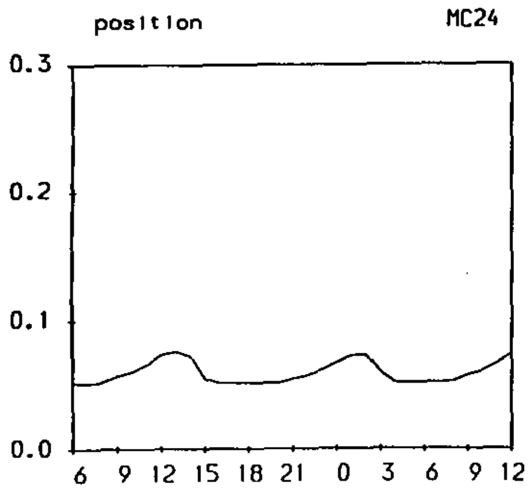
TK+Sham Tseng Dry Neap CJV v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, ∆ Lower layer



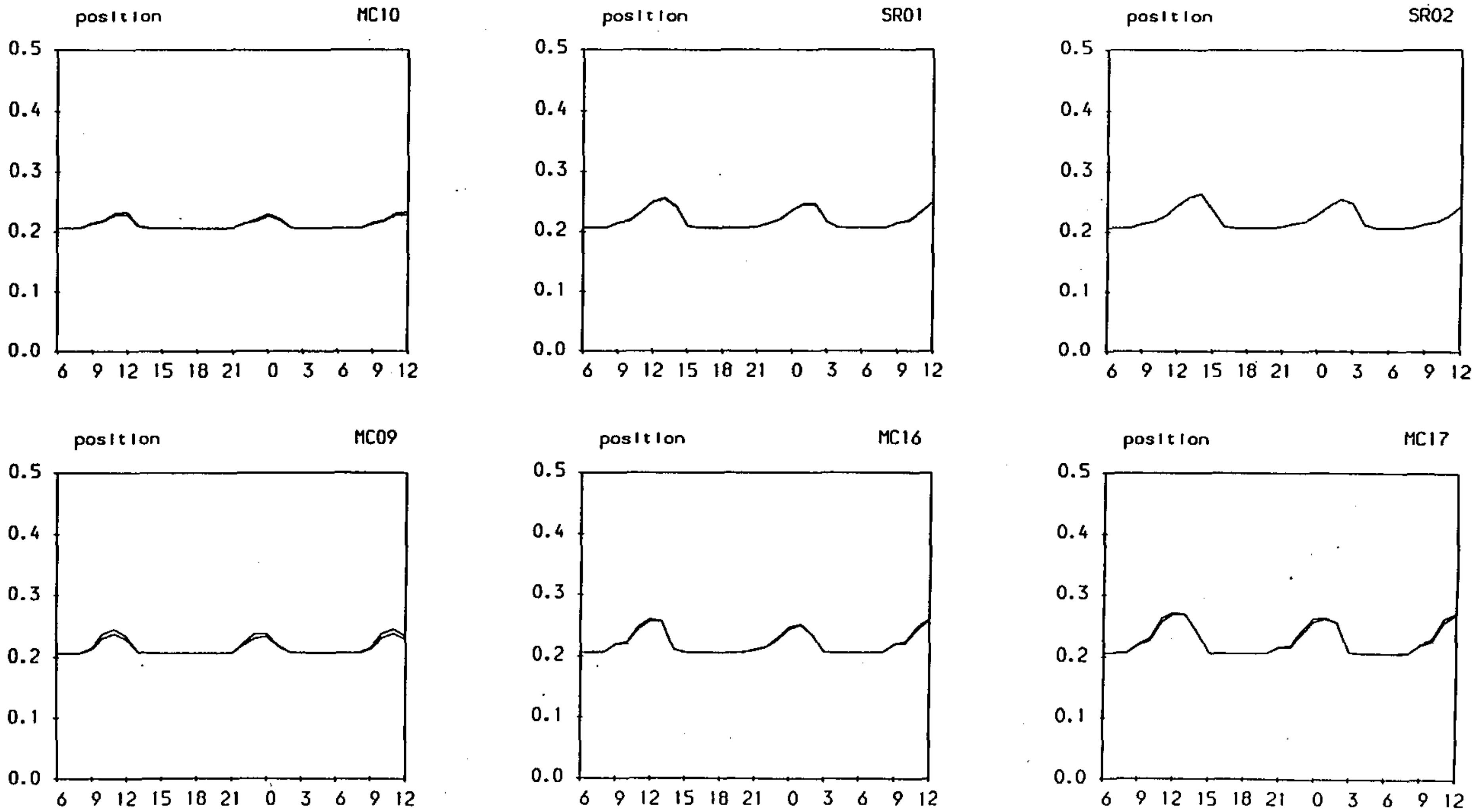


TK+Sham Tseng Dry Neap CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

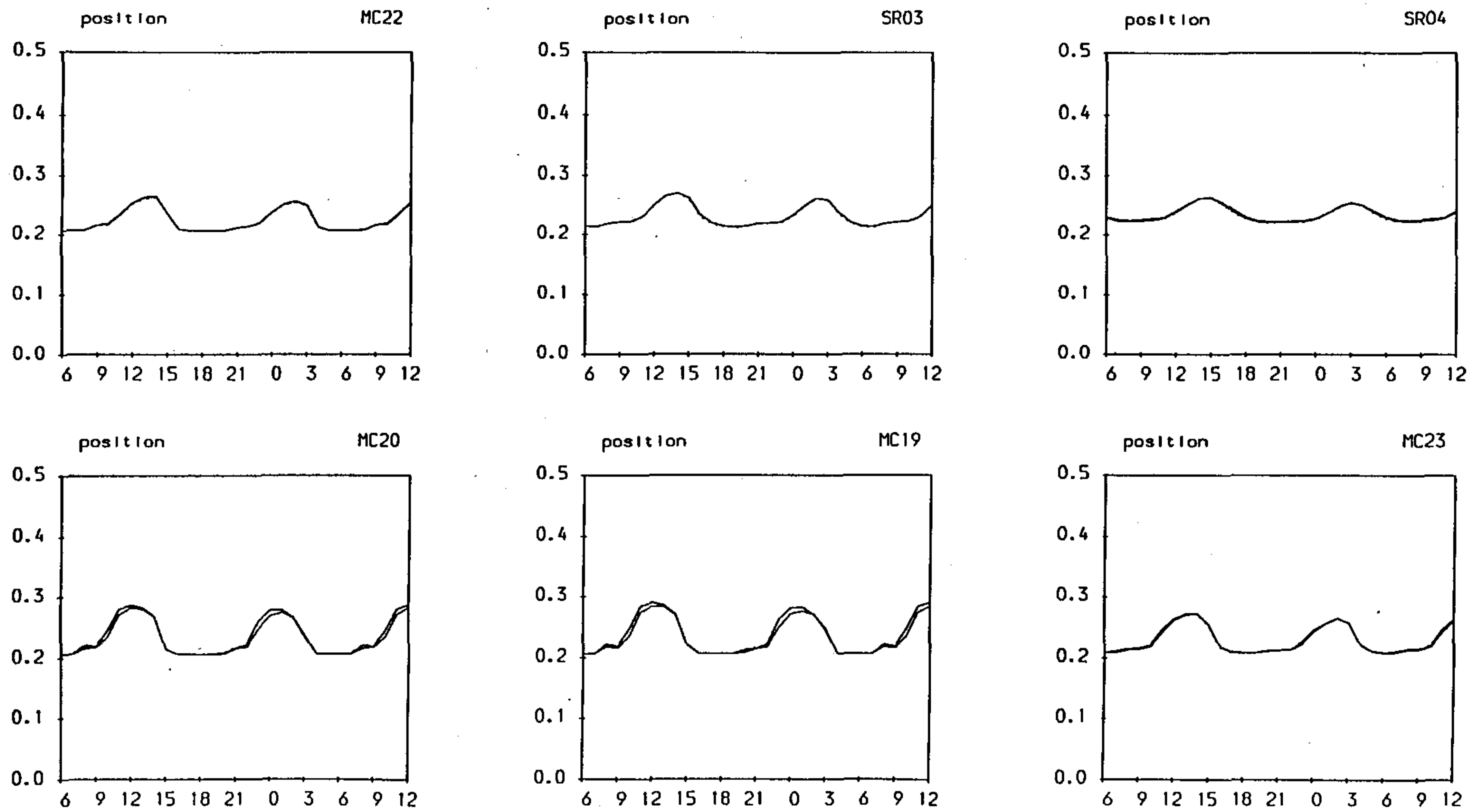


TK+Sham Tseng Dry Neap CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 ——— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

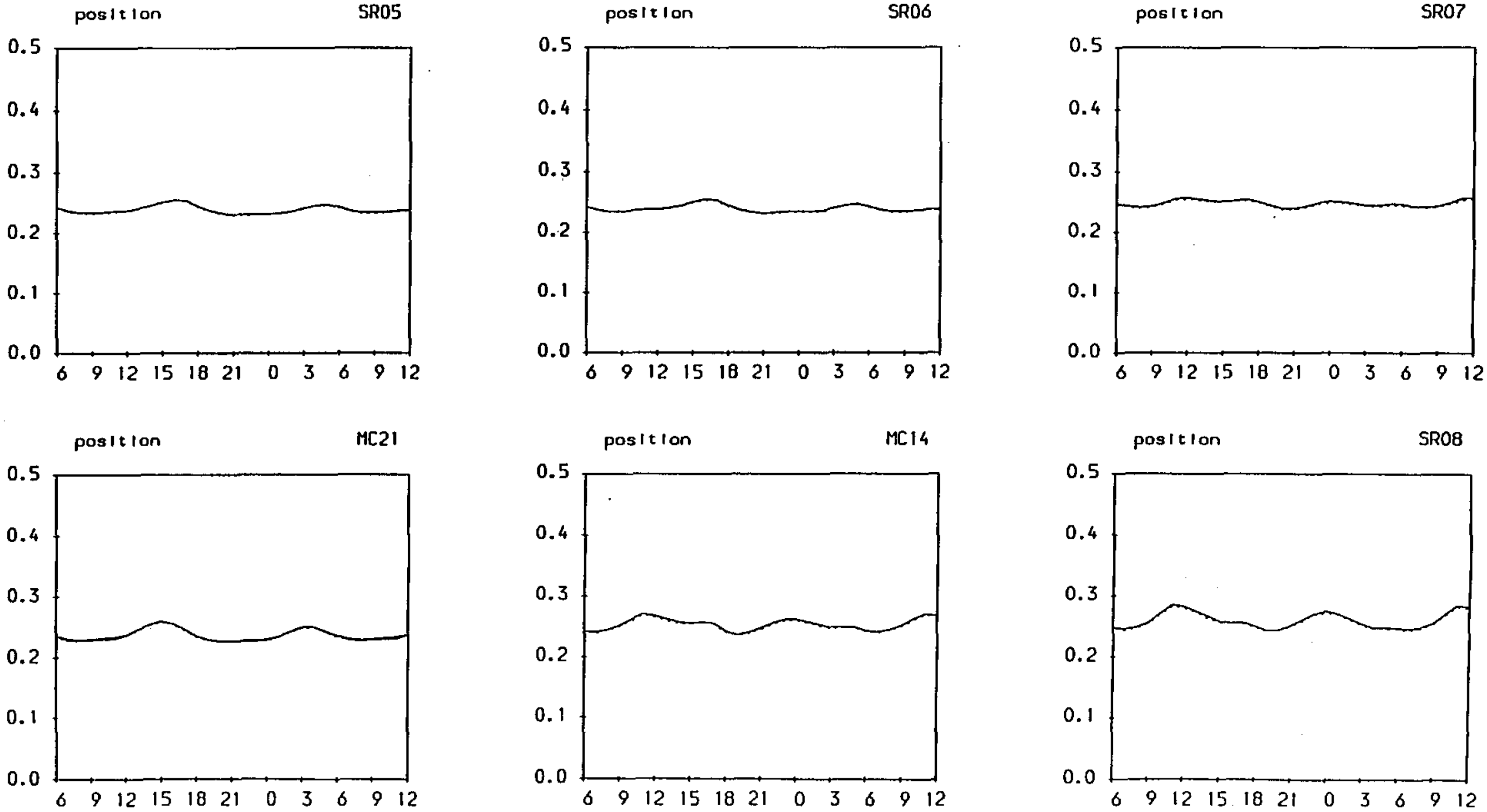


TK+Sham Tseng Dry Neap CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

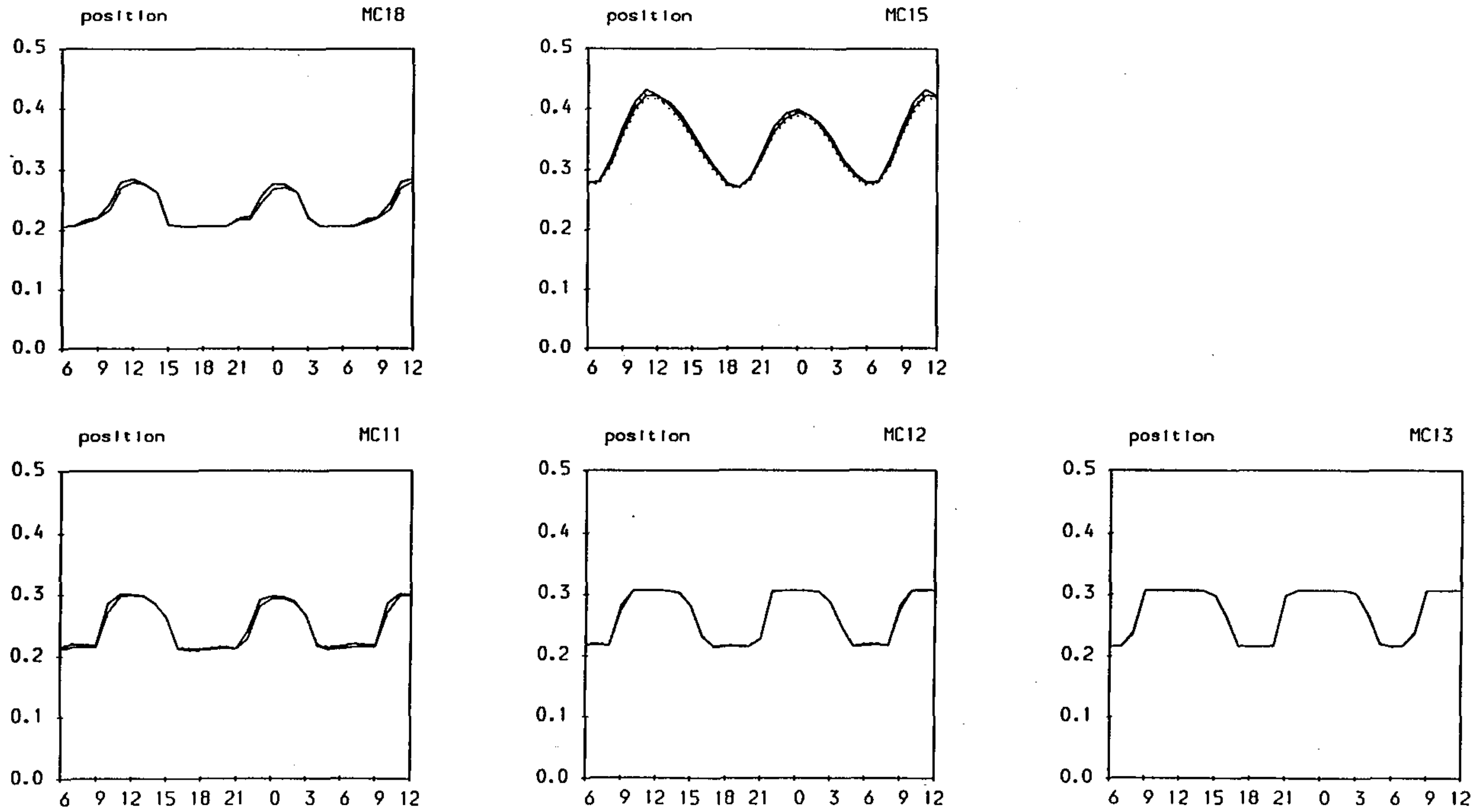


TK+Sham Tseng Dry Neap   CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

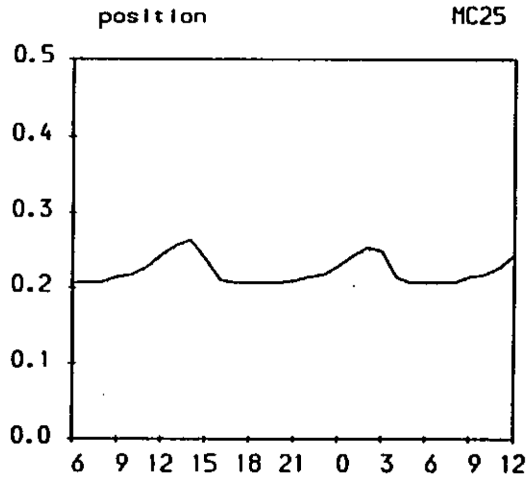


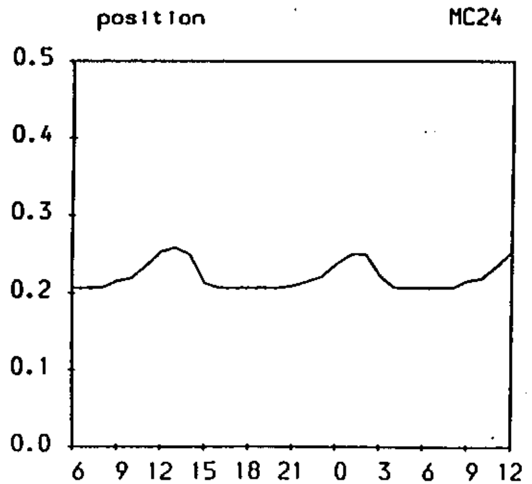
TK+Sham Tseng Dry Neap CJV v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



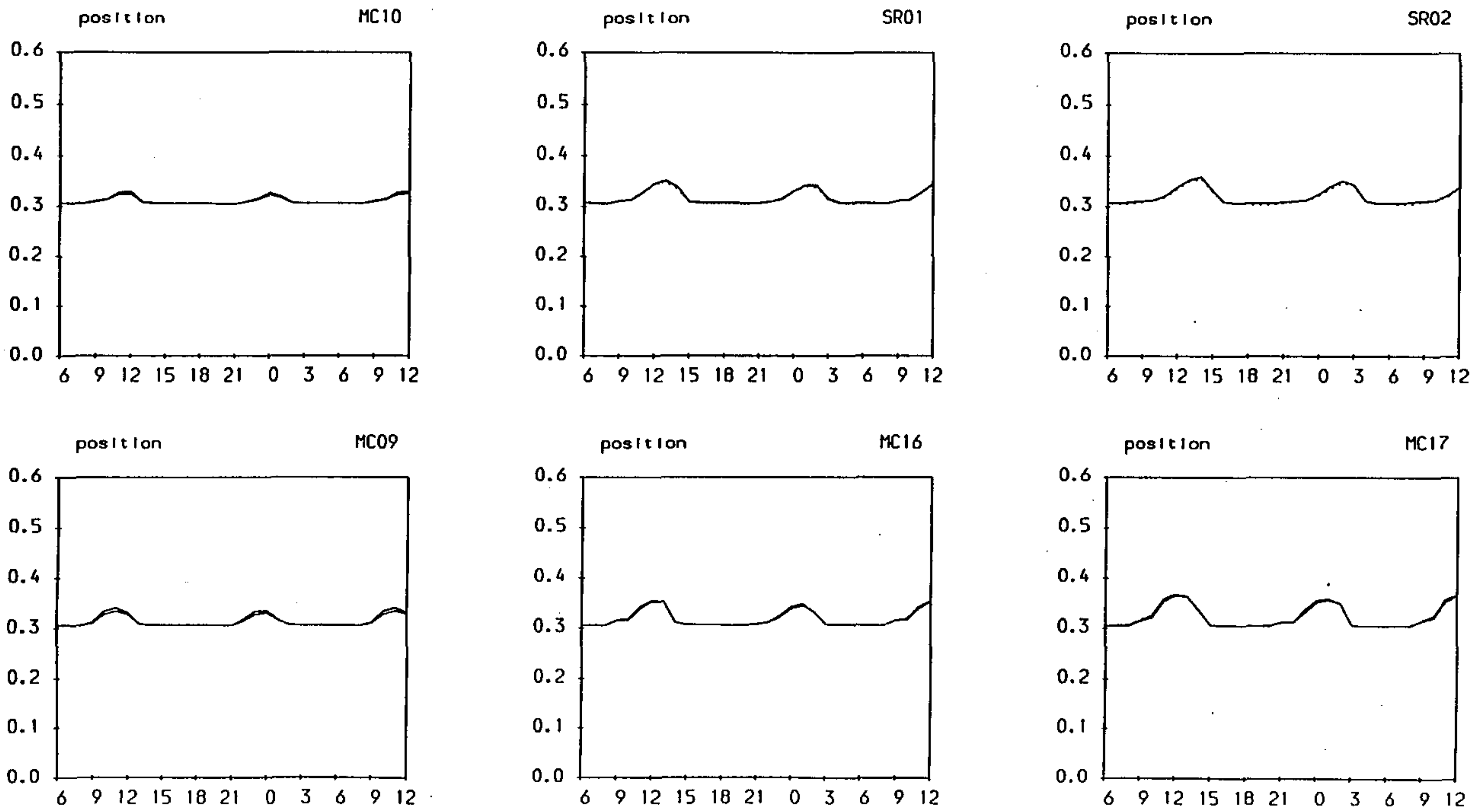


TK+Sham Tseng Dry Neap   CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 2/03/95   ——— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

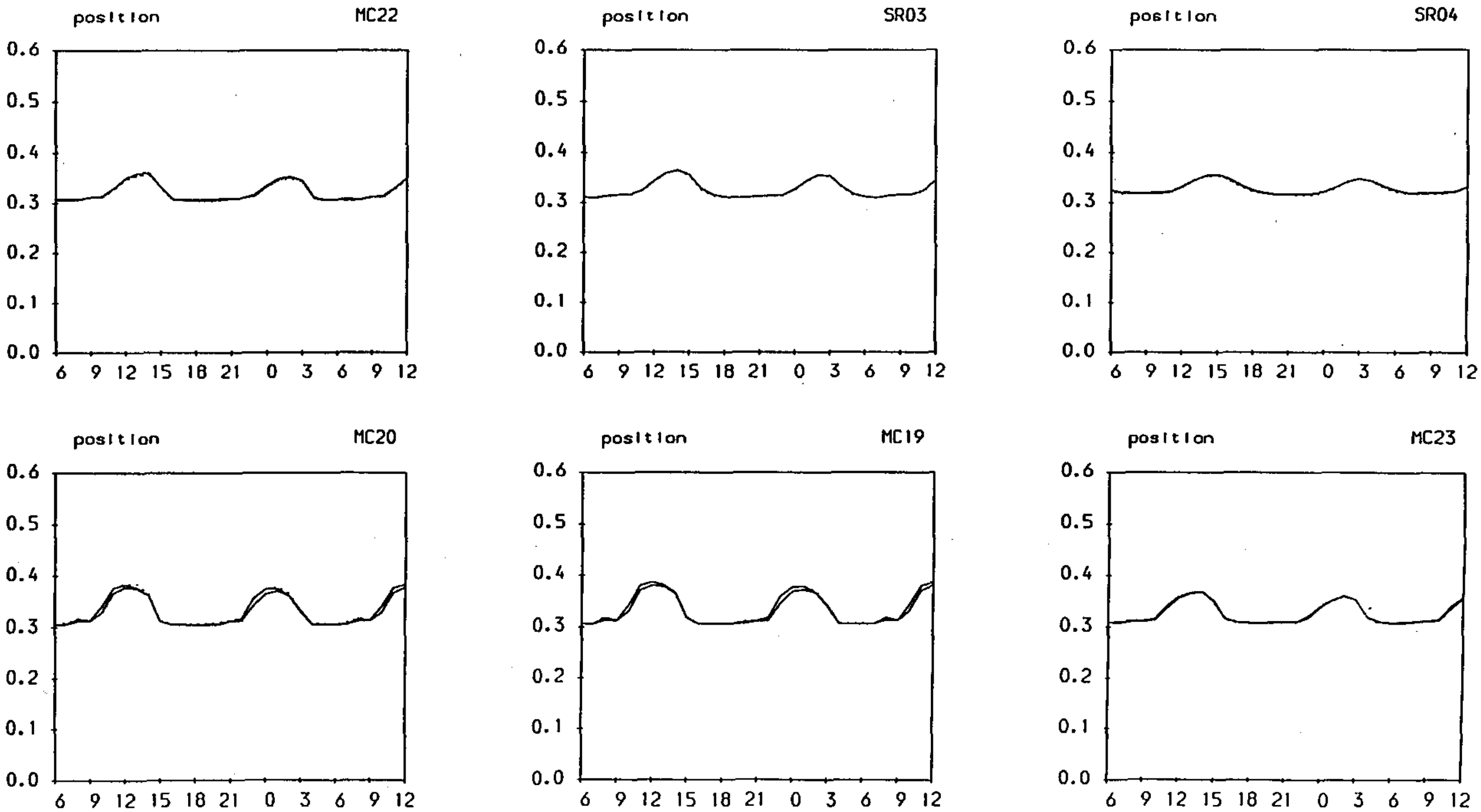


TK+Sham Tseng Dry Neap   CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

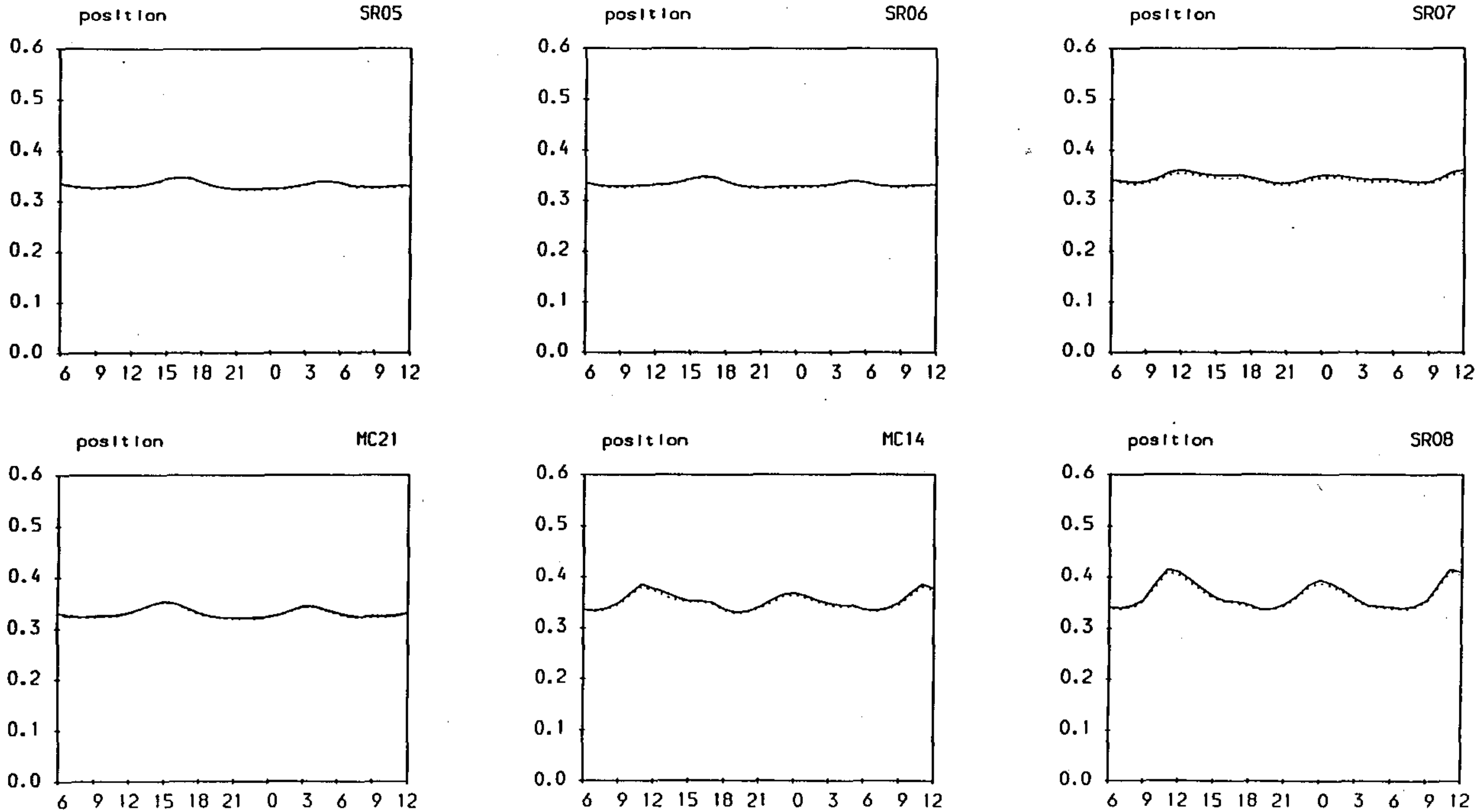


TK+Sham Tseng Dry Neap   CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

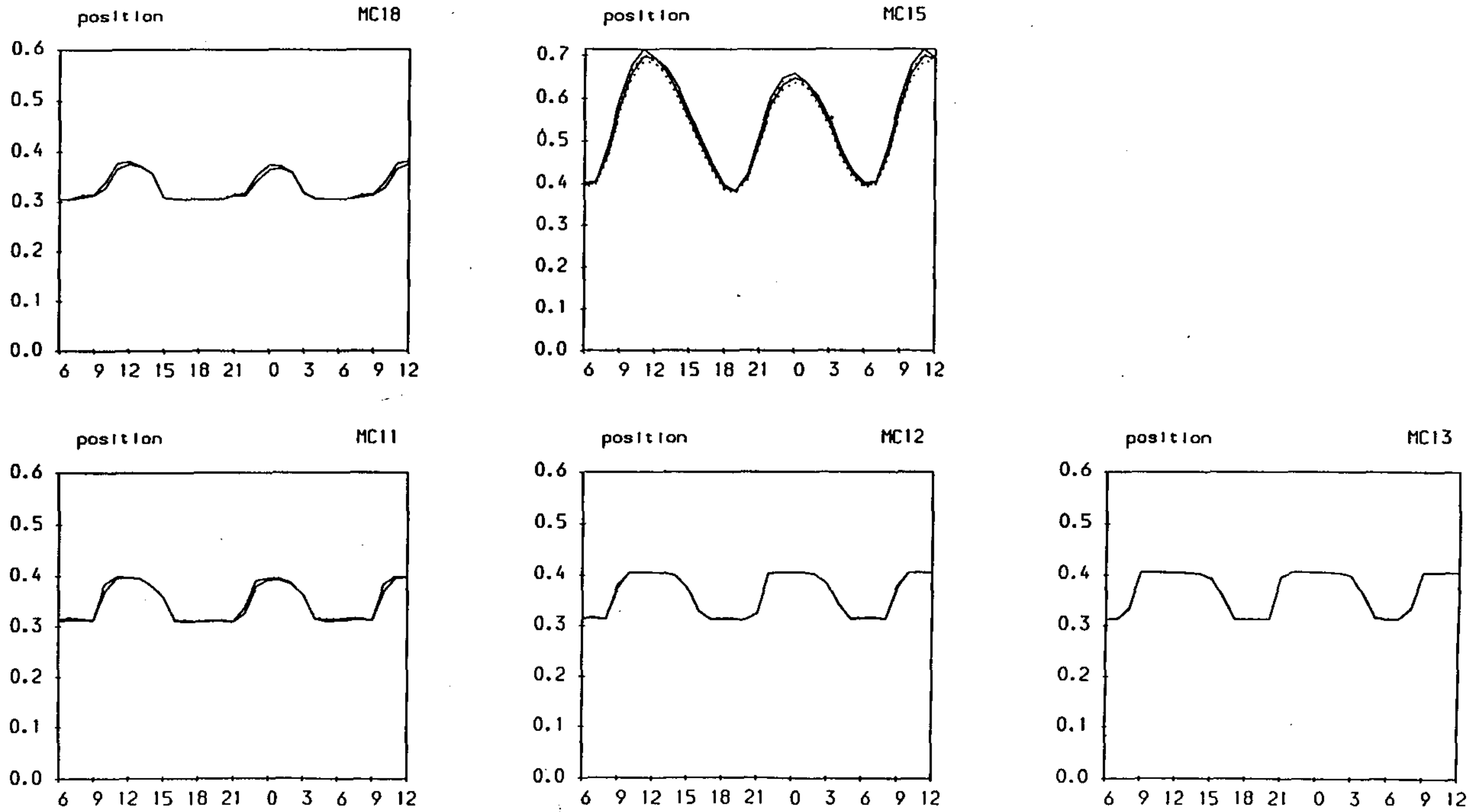


TK+Sham Tseng Dry Neap   CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

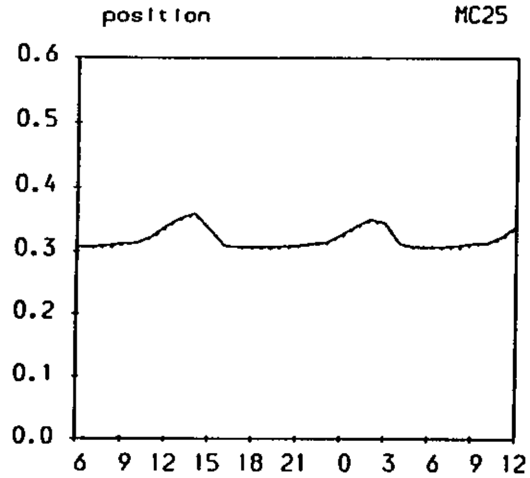


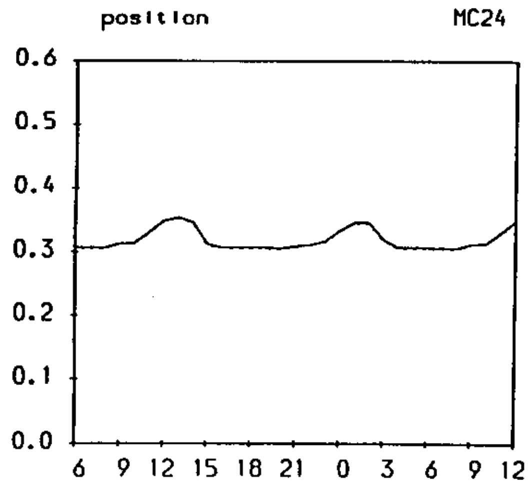
TK+Sham Tseng Dry Neap CJV v LSO

Total Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



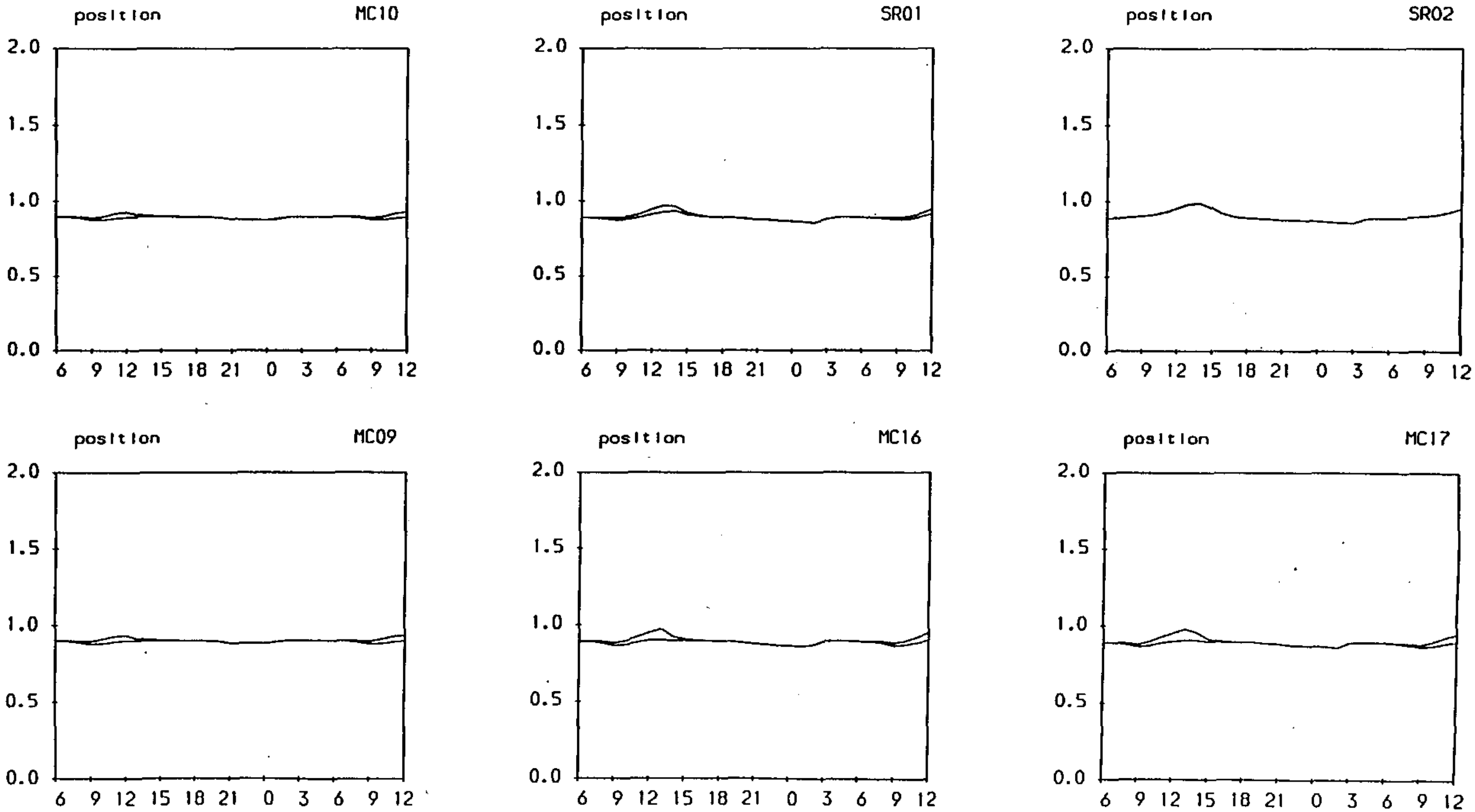


TK+Sham Tseng Dry Neap   CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

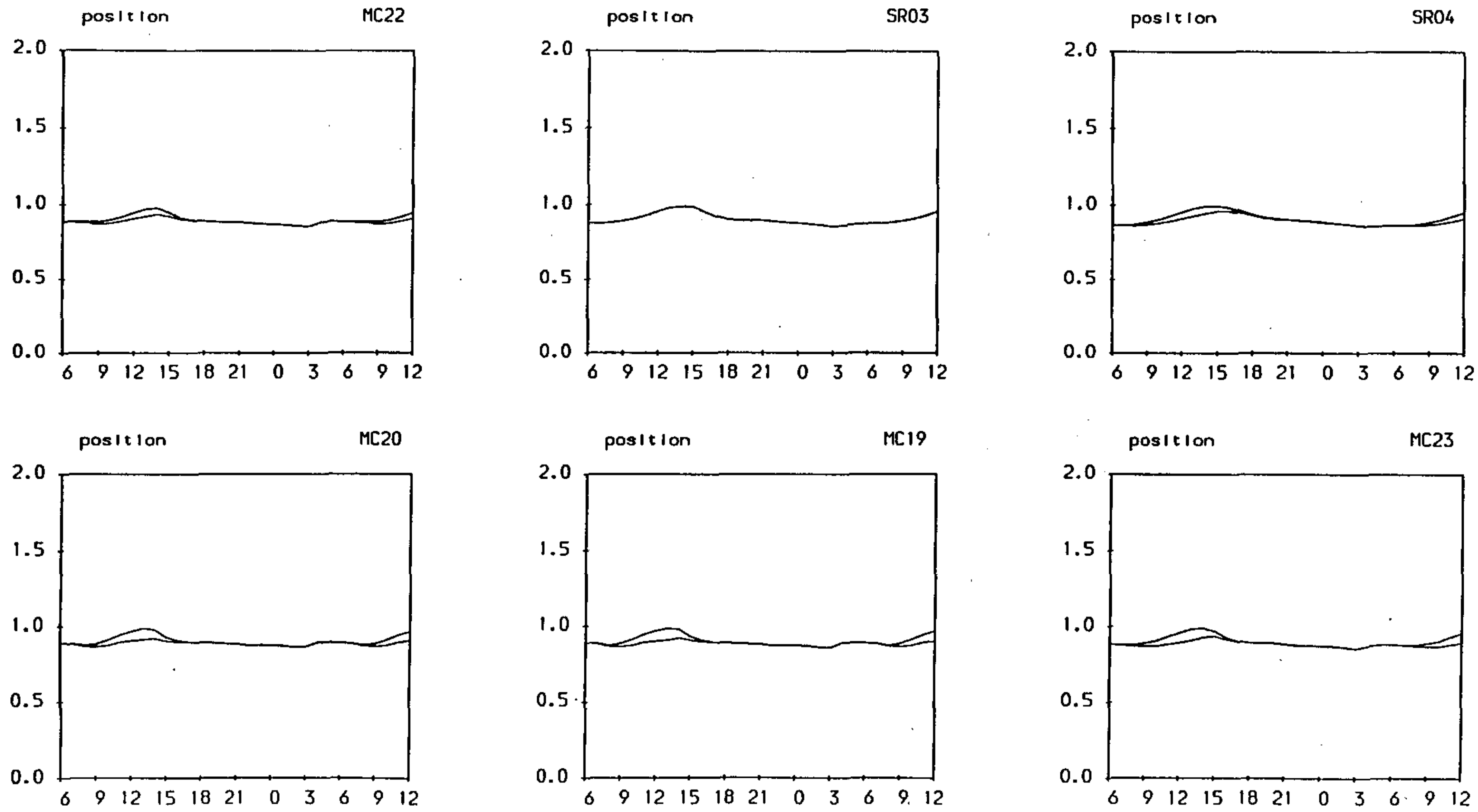


TK+Sham Tseng Dry Neap CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV .... LongSO

Observed symbols: * Upper layer, △ Lower layer

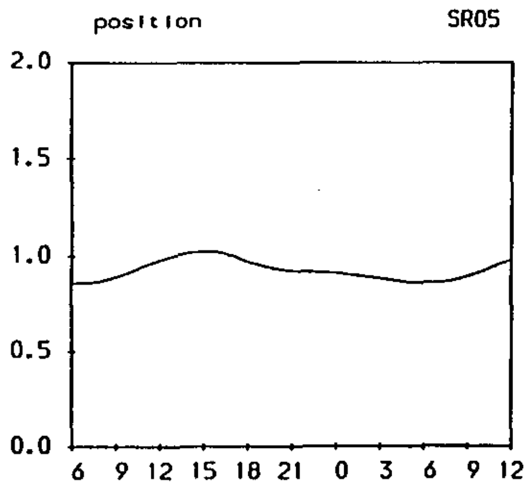


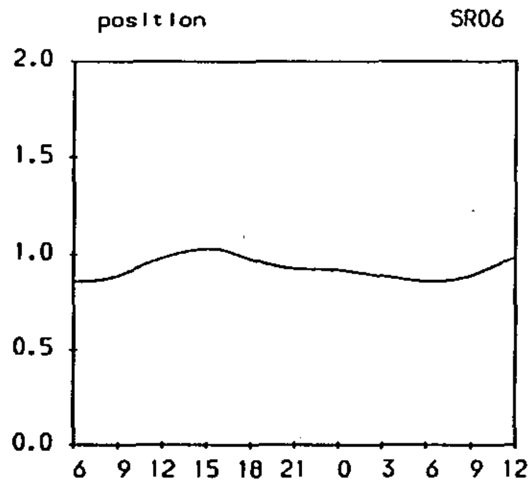
TK+Sham Tseng Dry Neap CJV v LSO

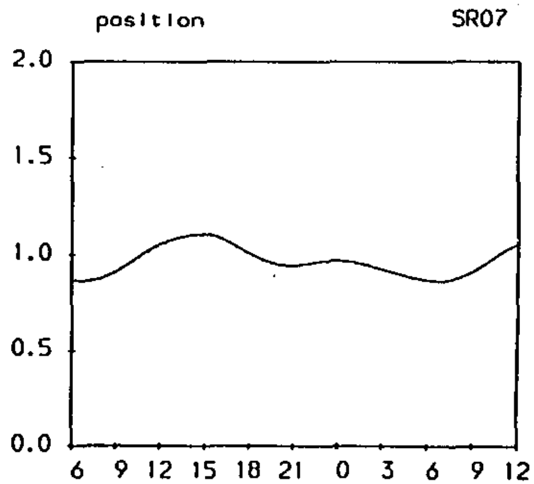
Chlorophyll (ug/l) against time

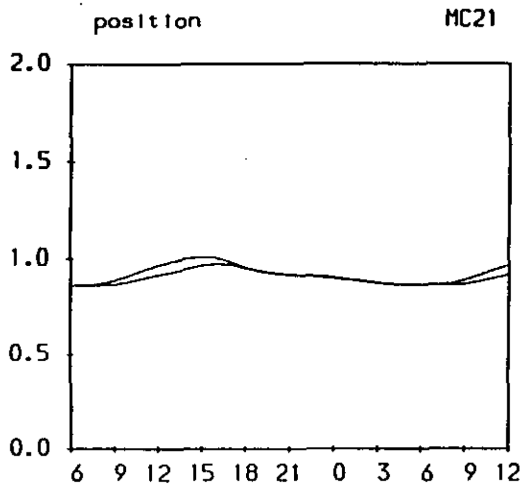
2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

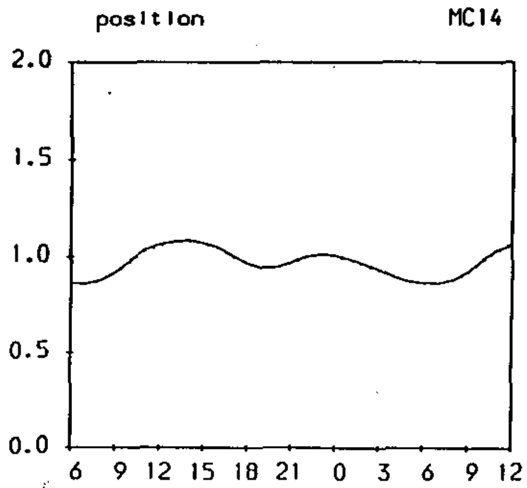
Observed symbols: * Upper layer, ∆ Lower layer

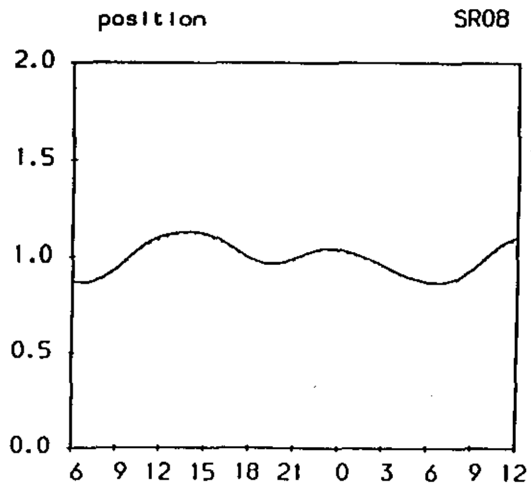










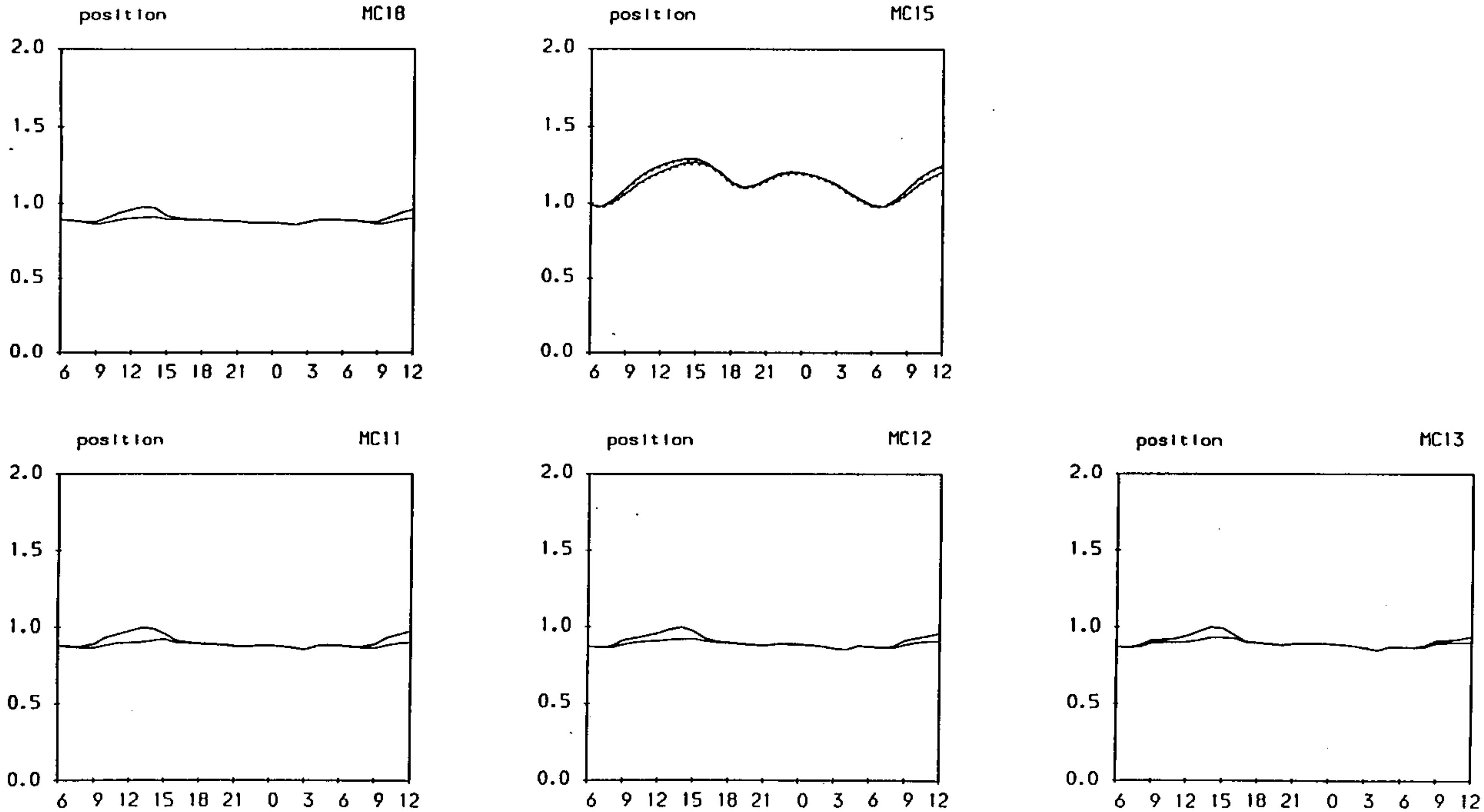


TK+Sham Tseng Dry Neap   CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid   DM 2/03/95   —— TKCJV   ········ LongSO

Observed symbols: * Upper layer, ∆ Lower layer

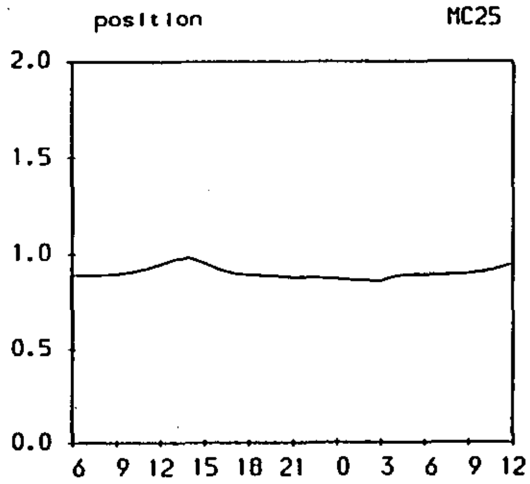


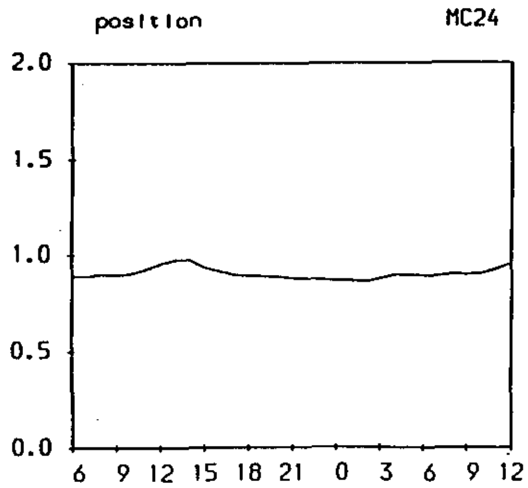
TK+Sham Tseng Dry Neap CJV v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 2/03/95 —— TKCJV ········ LongSO

Observed symbols: * Upper layer, △ Lower layer





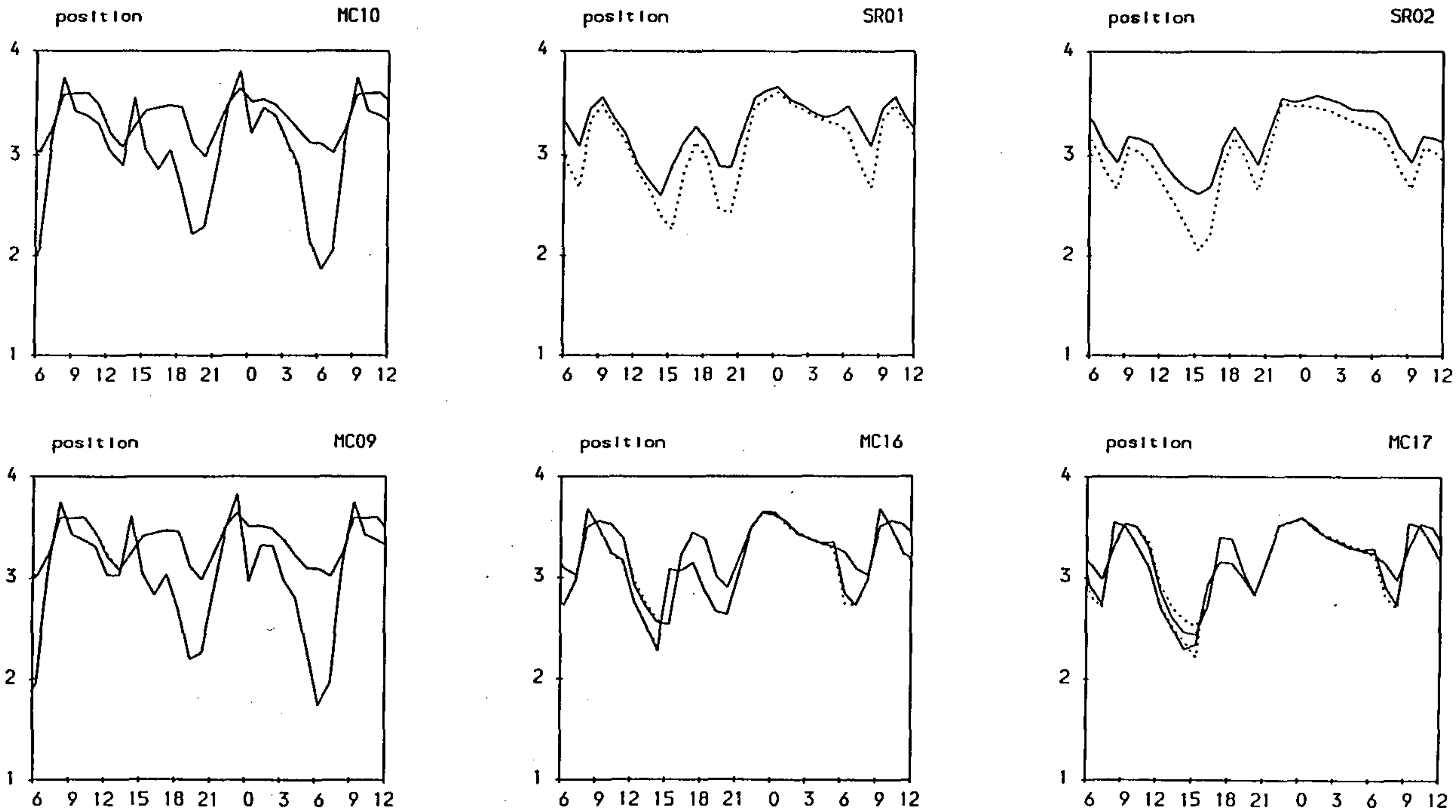
APPENDIX 3
RESULTS OF THE SIMULATION OF WET AND DRY SEASON SPRING TIDE WATER QUALITY

TK+Sham Tseng Wet Spring Original v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

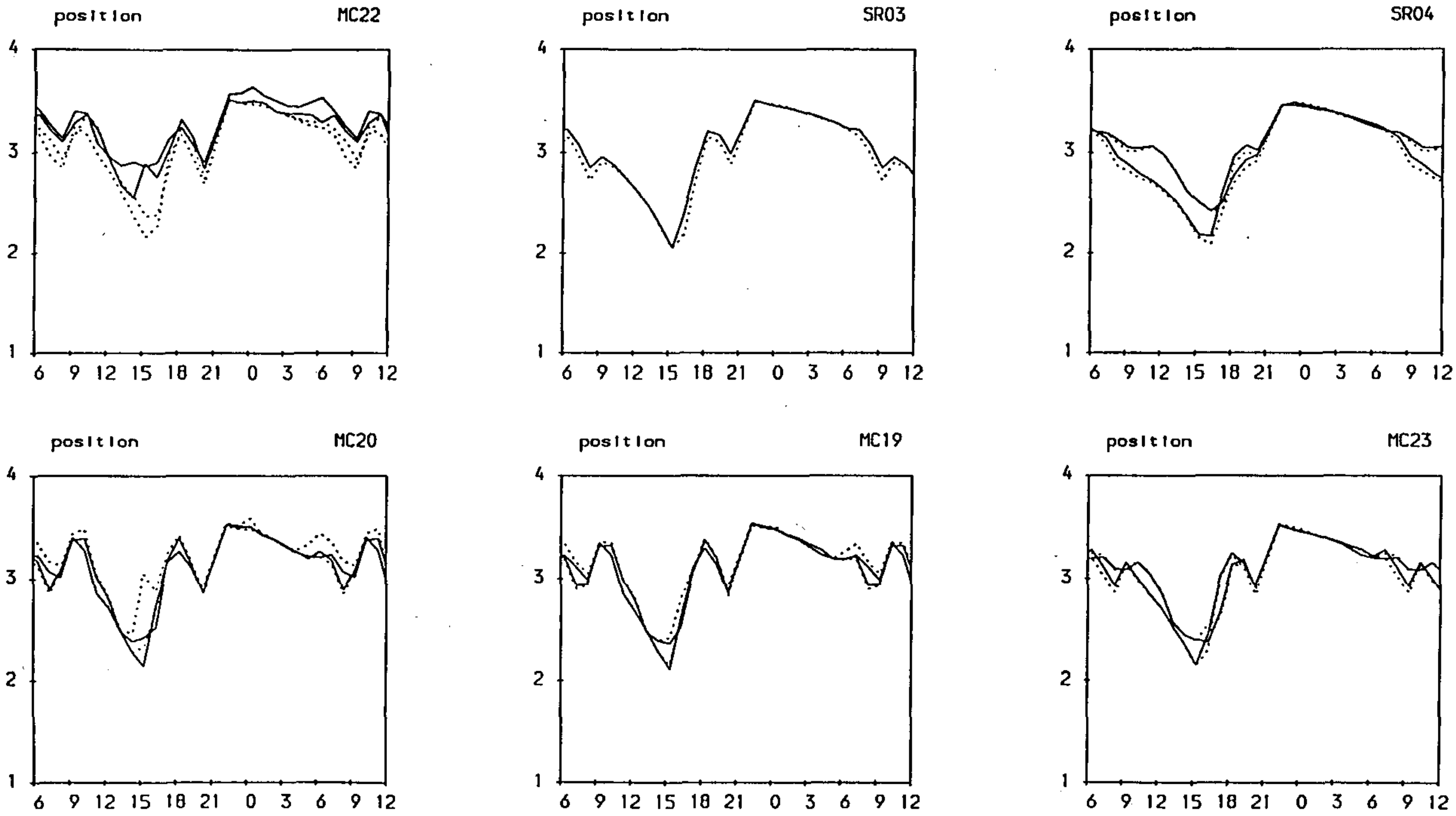


TK+Sham Tseng Wet Spring Original v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ∆ Lower layer

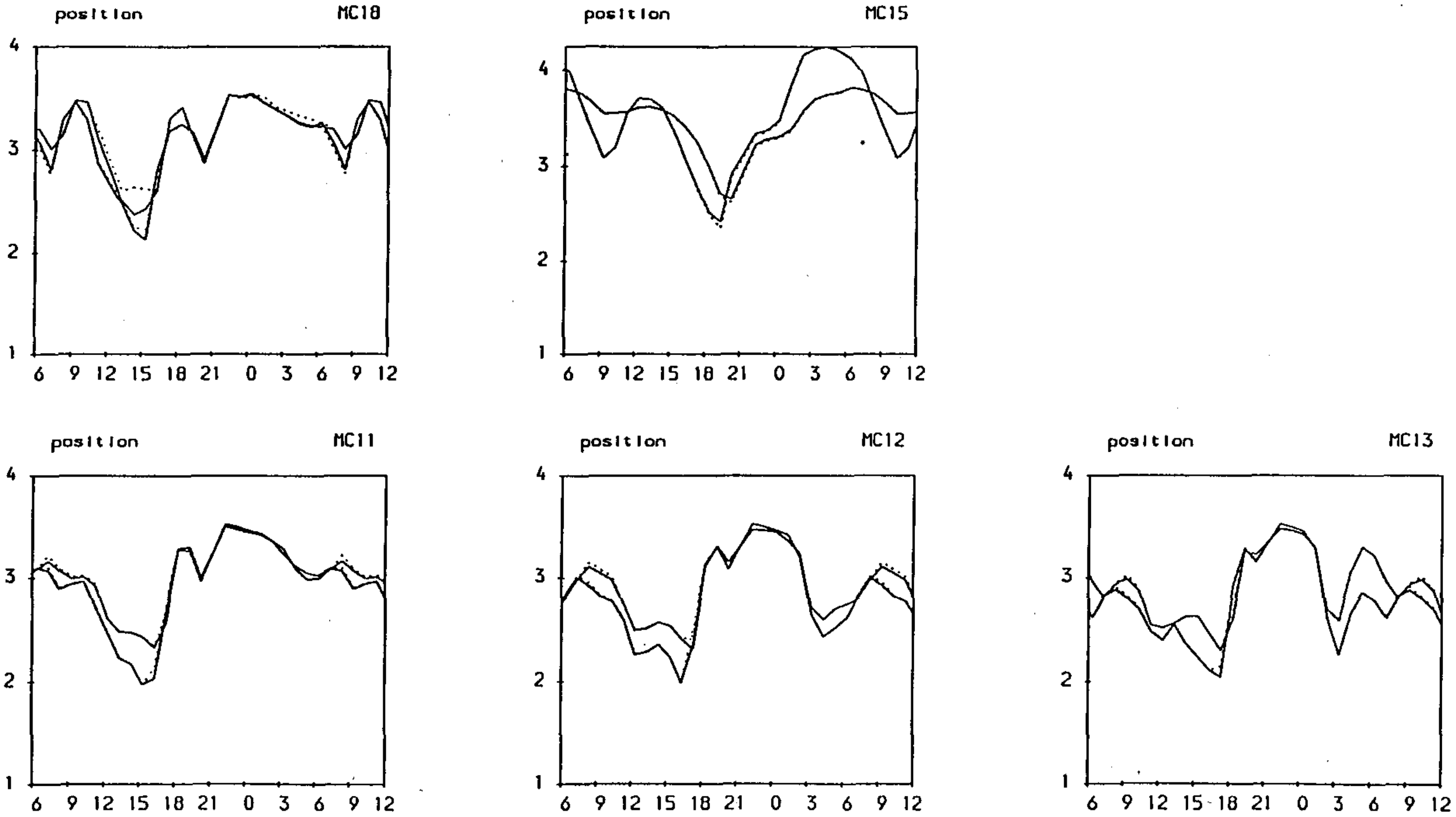


TK+Sham Tseng Wet Spring Original v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

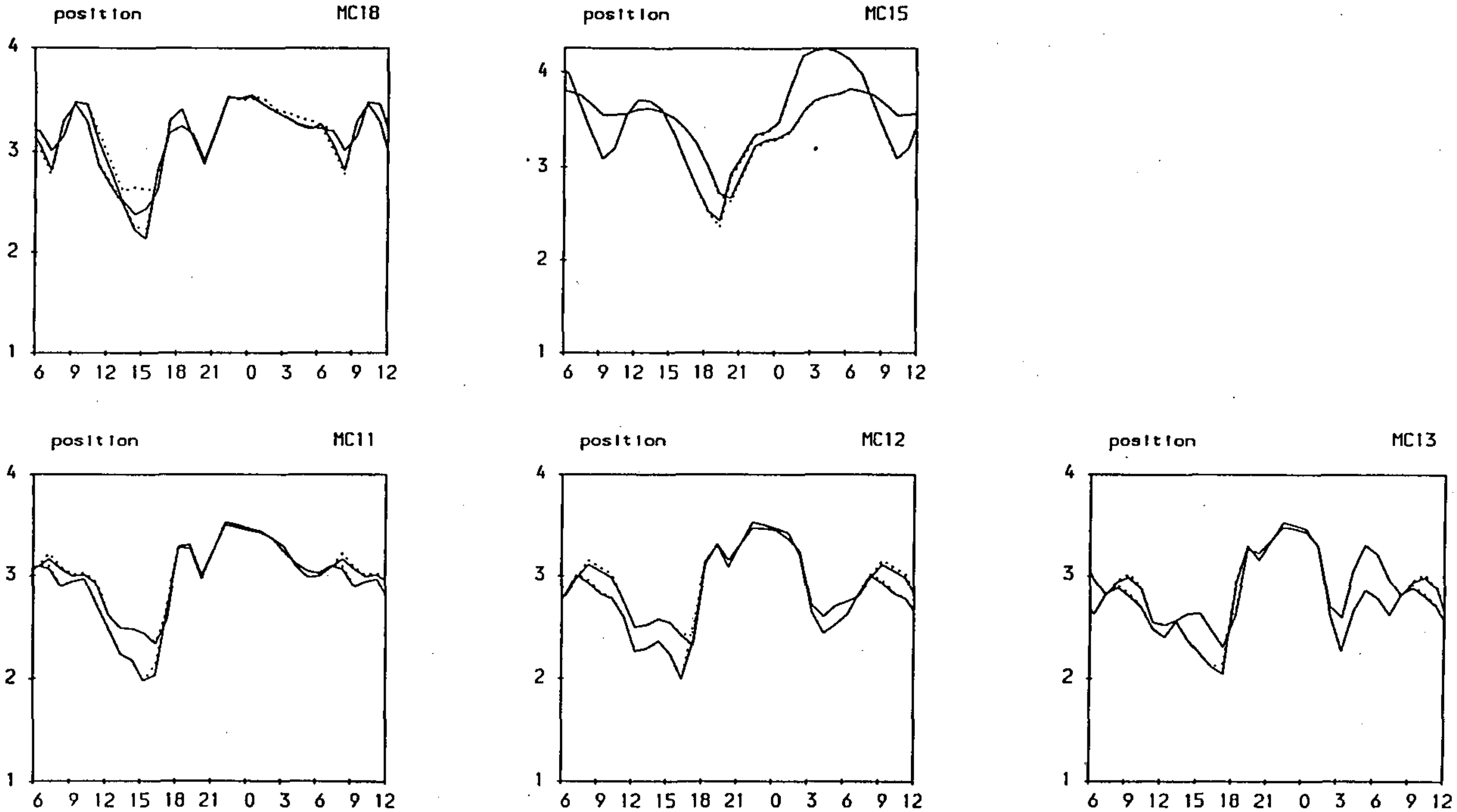


TK+Sham Tseng Wet Spring Original v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: ∗ Upper layer, △ Lower layer

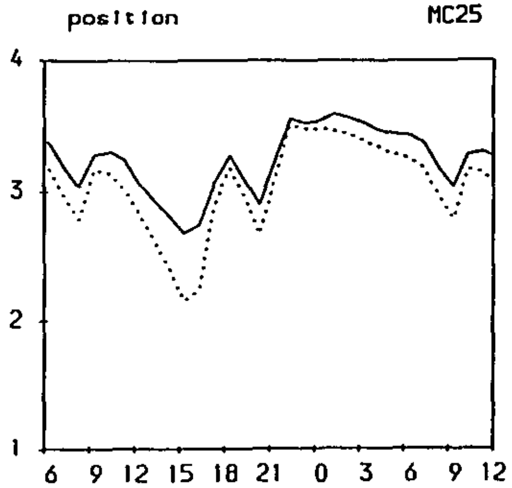


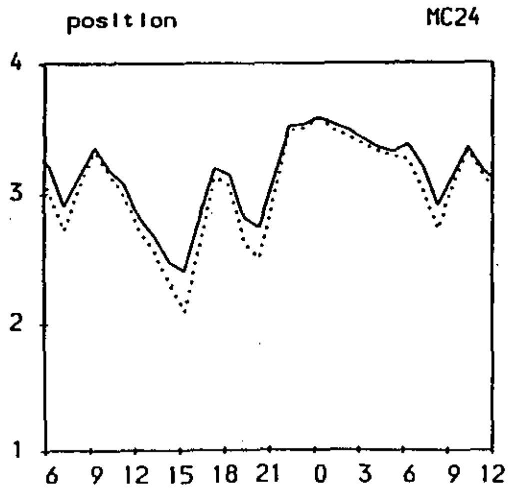
TK+Sham Tseng Wet Spring Original v LSO

E.Coli (no/100ml) against time   (log to base 10 on y-axis)

2 Layer, 50m grid   DM 17/05/95   —— Original   ········ LongSO

Observed symbols: * Upper layer, △   Lower layer



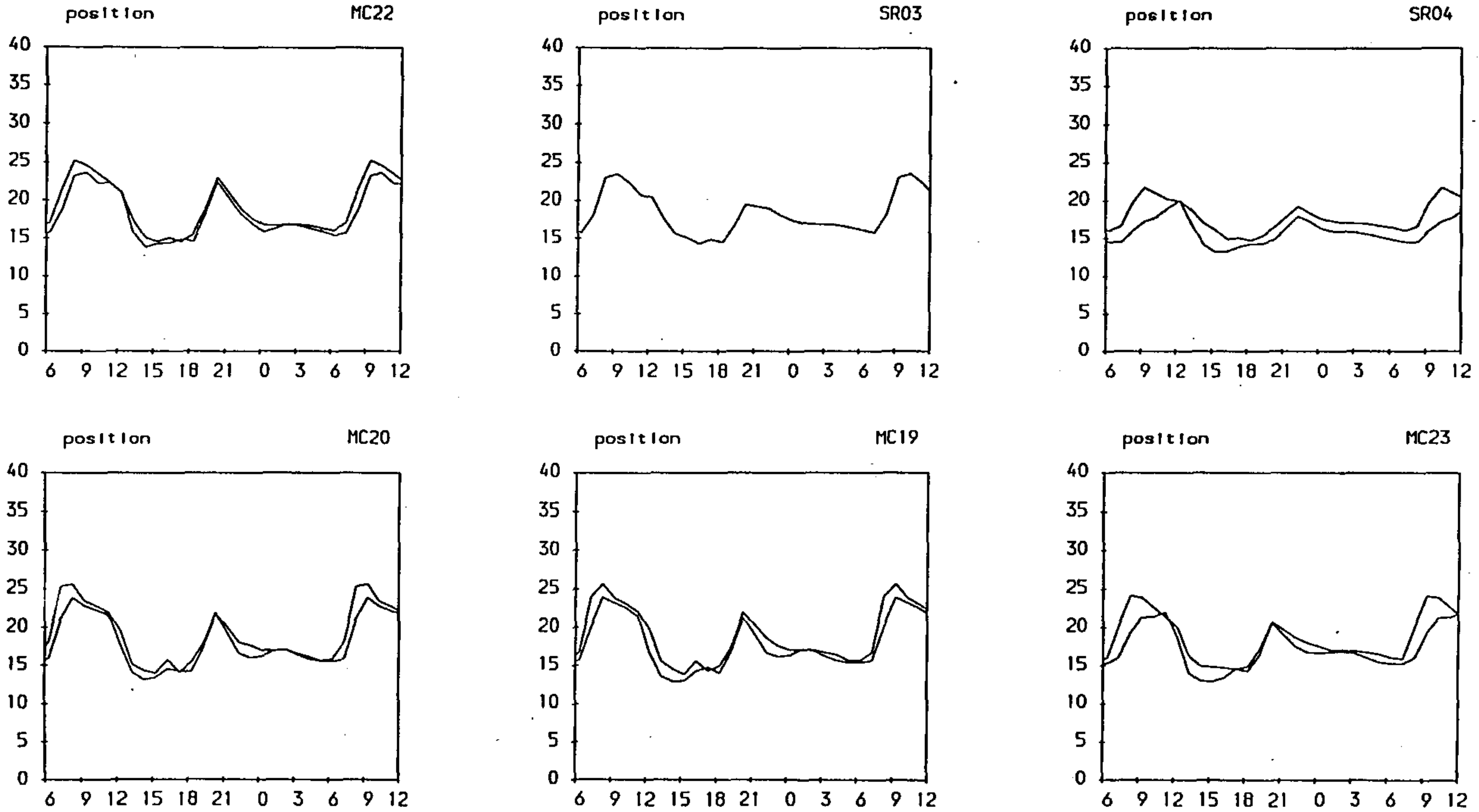


TK+Sham Tseng Wet Spring Original v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

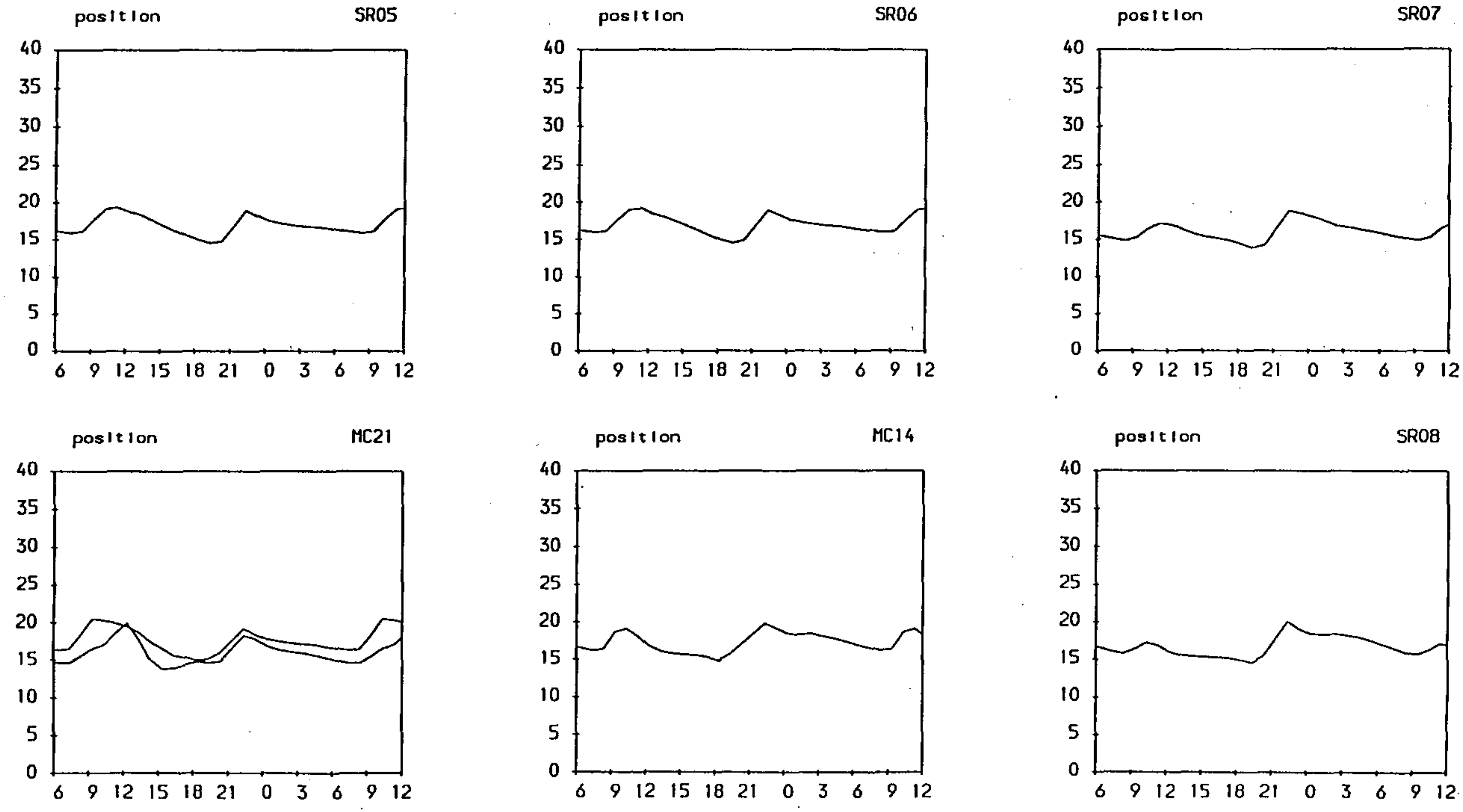


TK+Sham Tseng Wet Spring Original v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

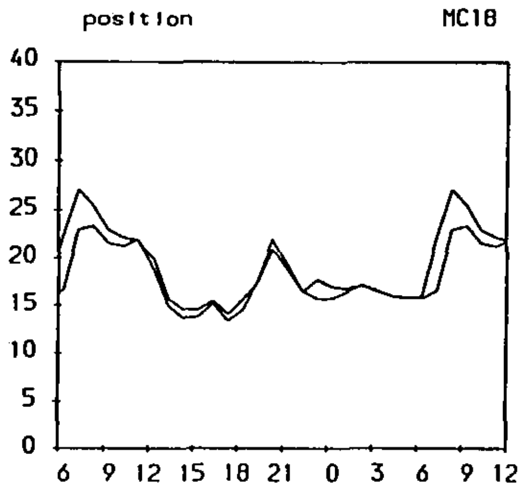


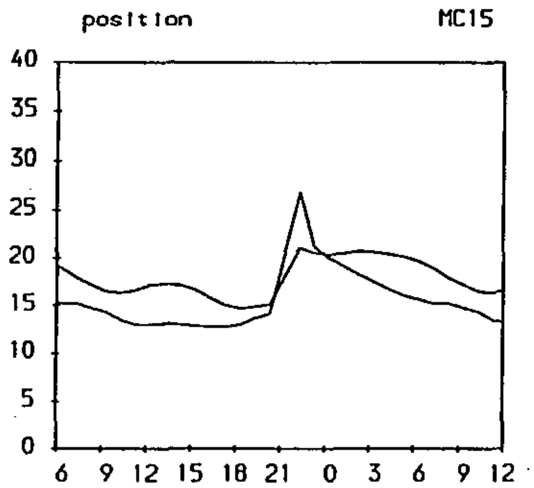
TK+Sham Tseng Wet Spring Original v LSO

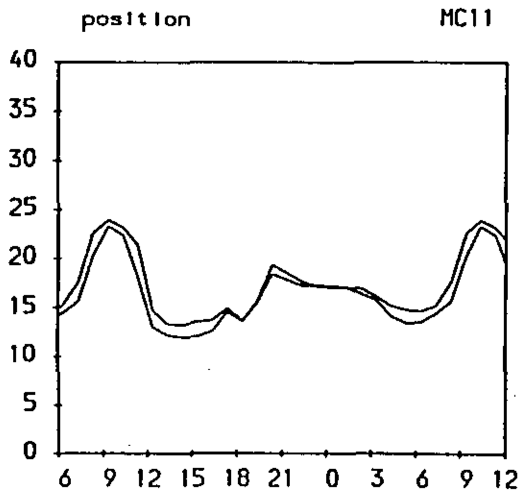
Suspended Solids (mg/l) against time

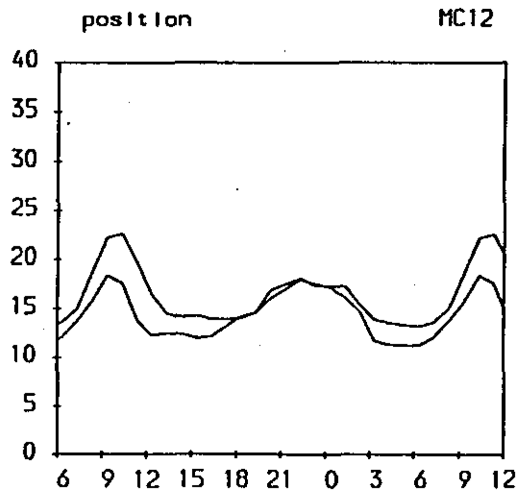
2 Layer, 50m grid DM 17/05/95 ——— Original .... LongSO

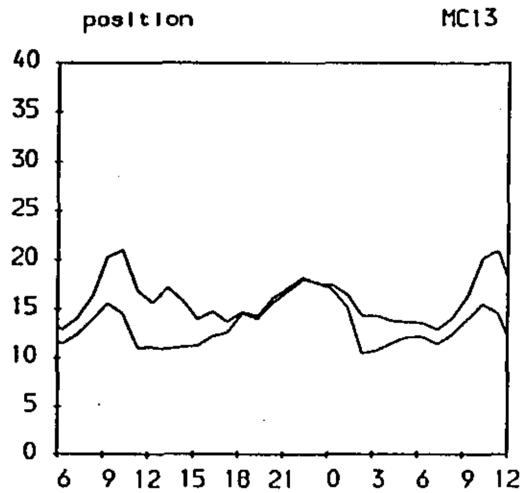
Observed symbols: * Upper layer, Δ Lower layer









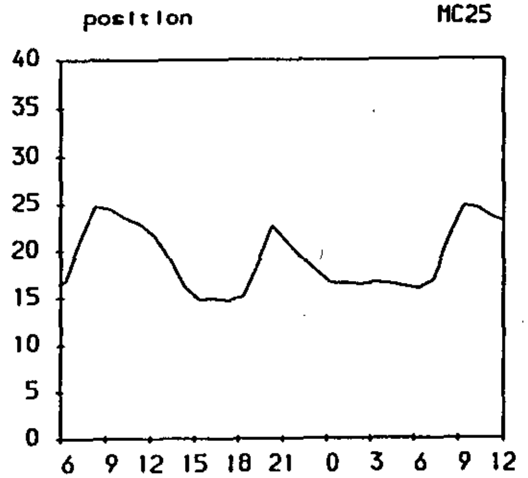


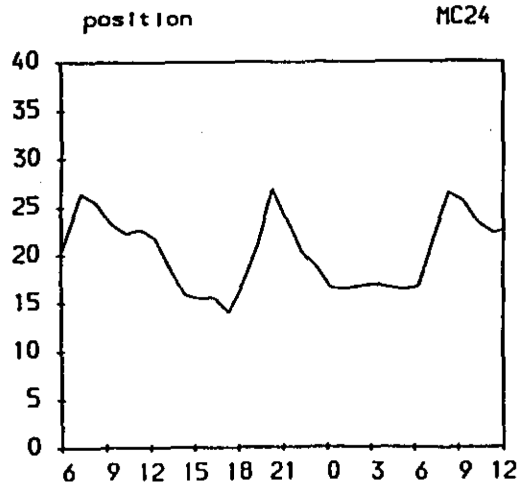
TK+Sham Tseng Wet Spring Original v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 17/05/95 ——— Original ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



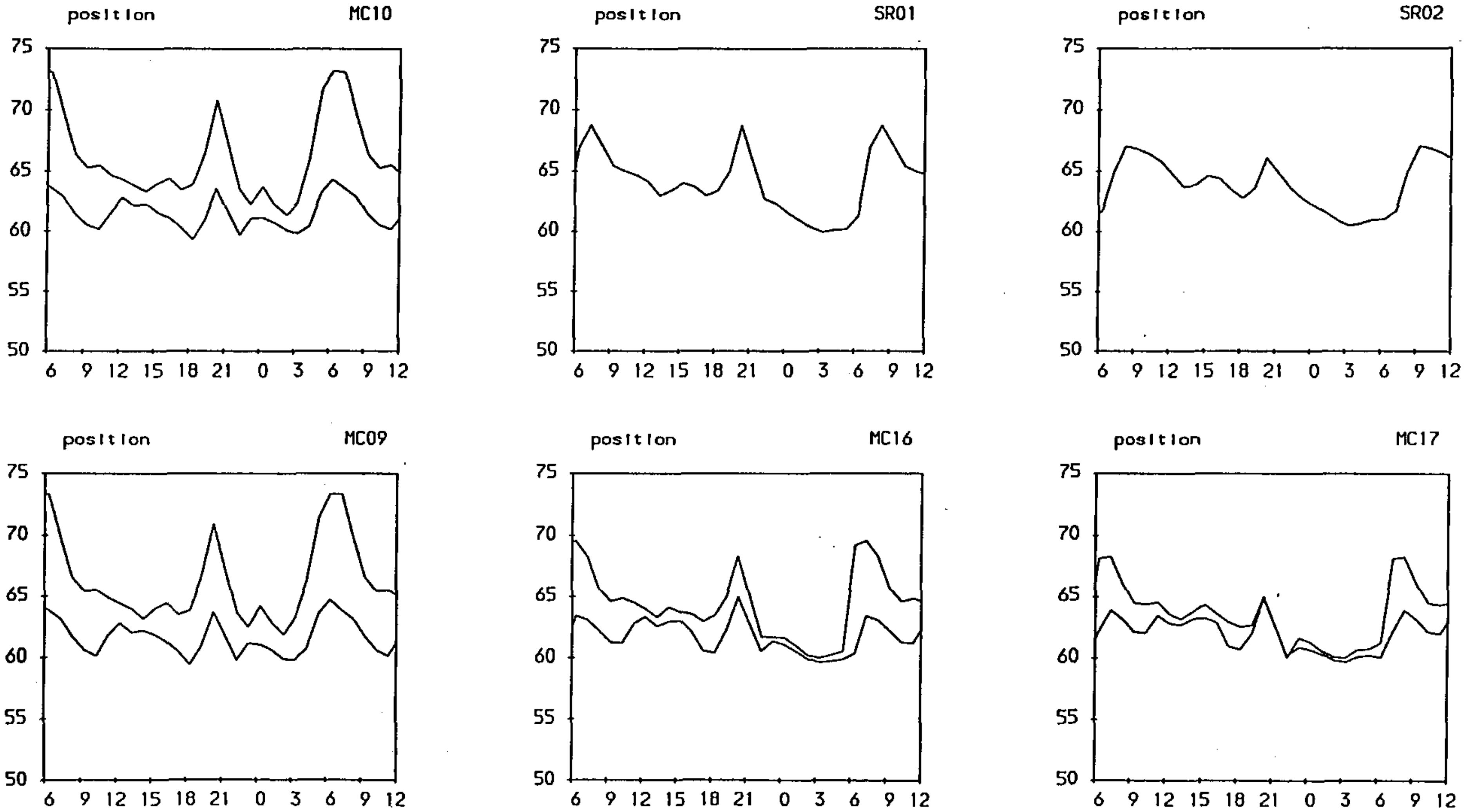


TK+Sham Tseng Wet Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

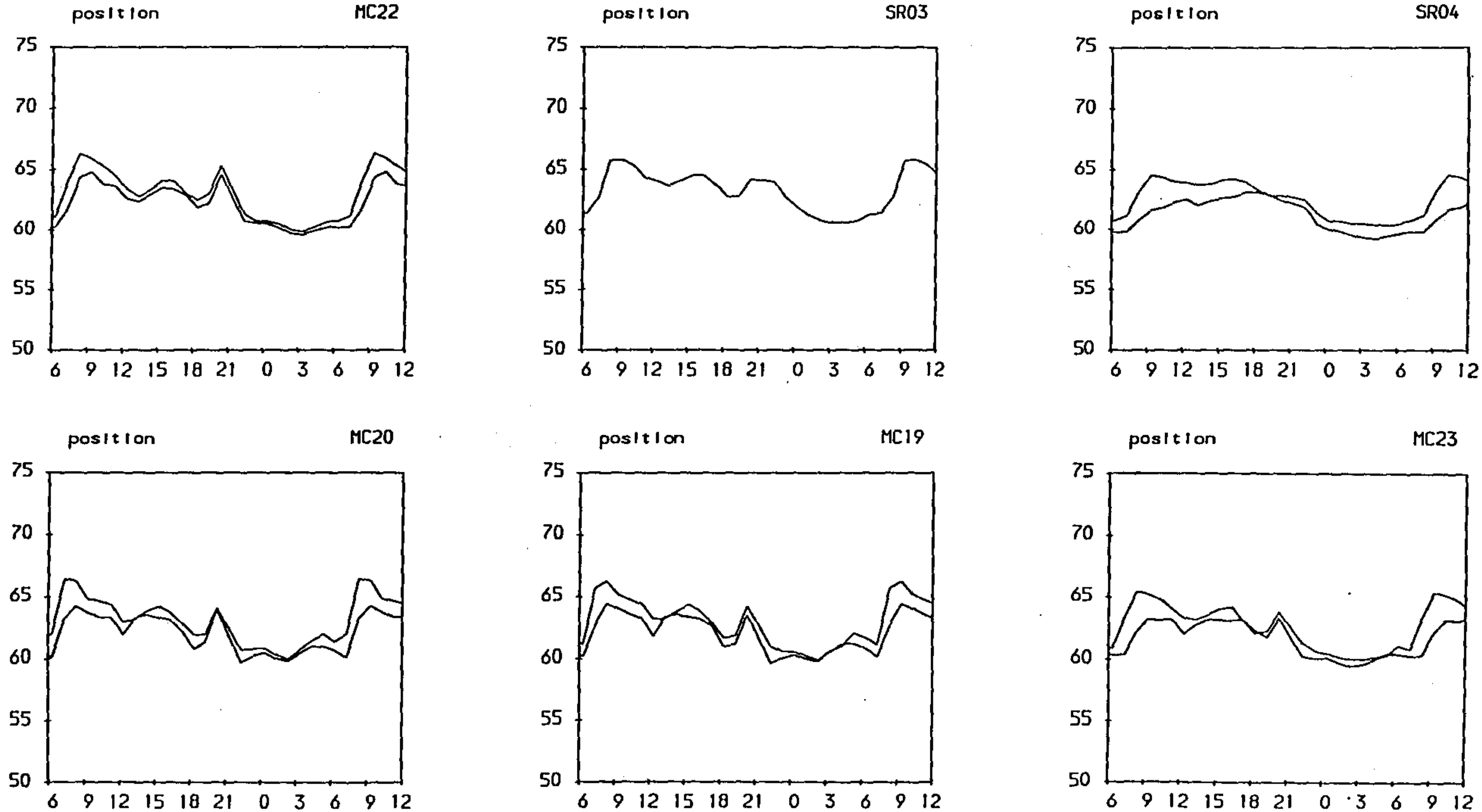


TK+Sham Tseng Wet Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

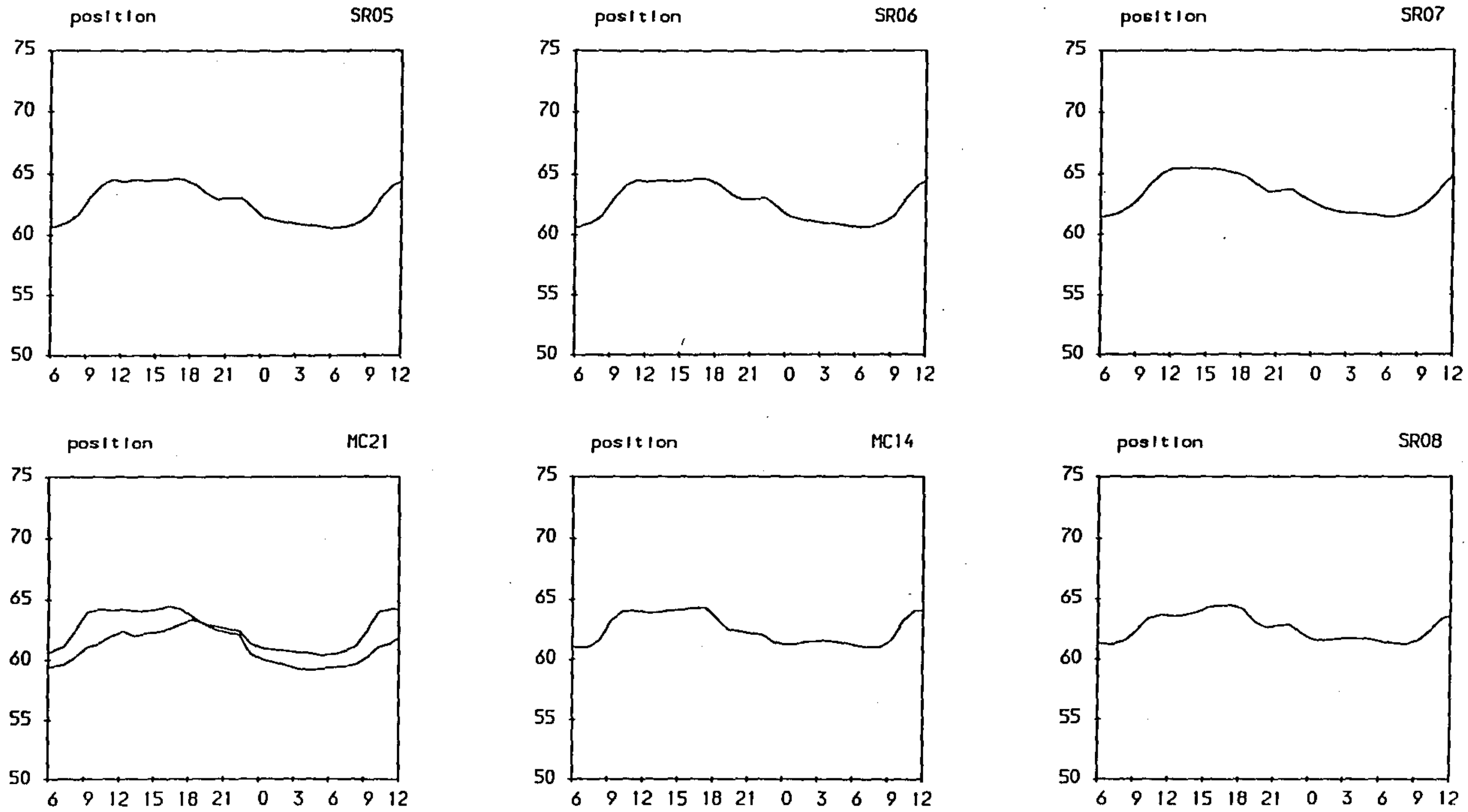


TK+Sham Tseng Wet Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

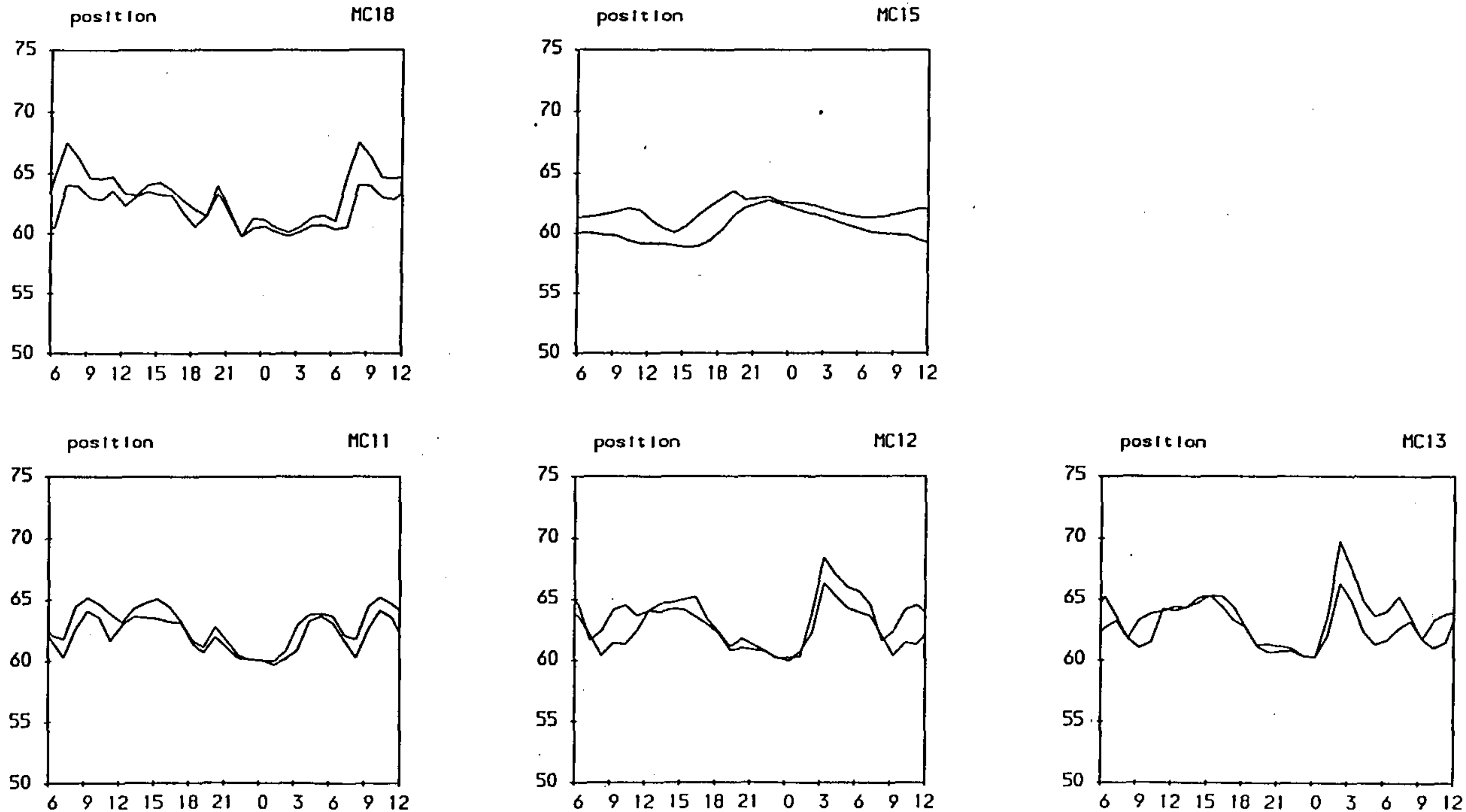


TK+Sham Tseng Wet Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

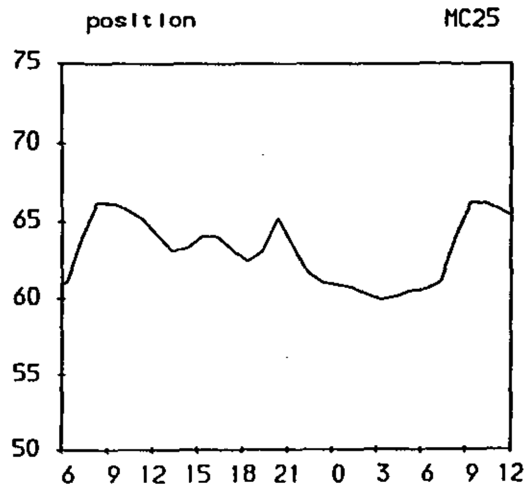


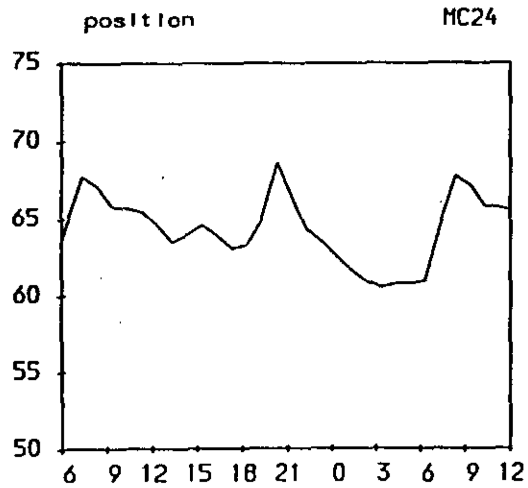
TK+Sham Tseng Wet Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, ∆ Lower layer



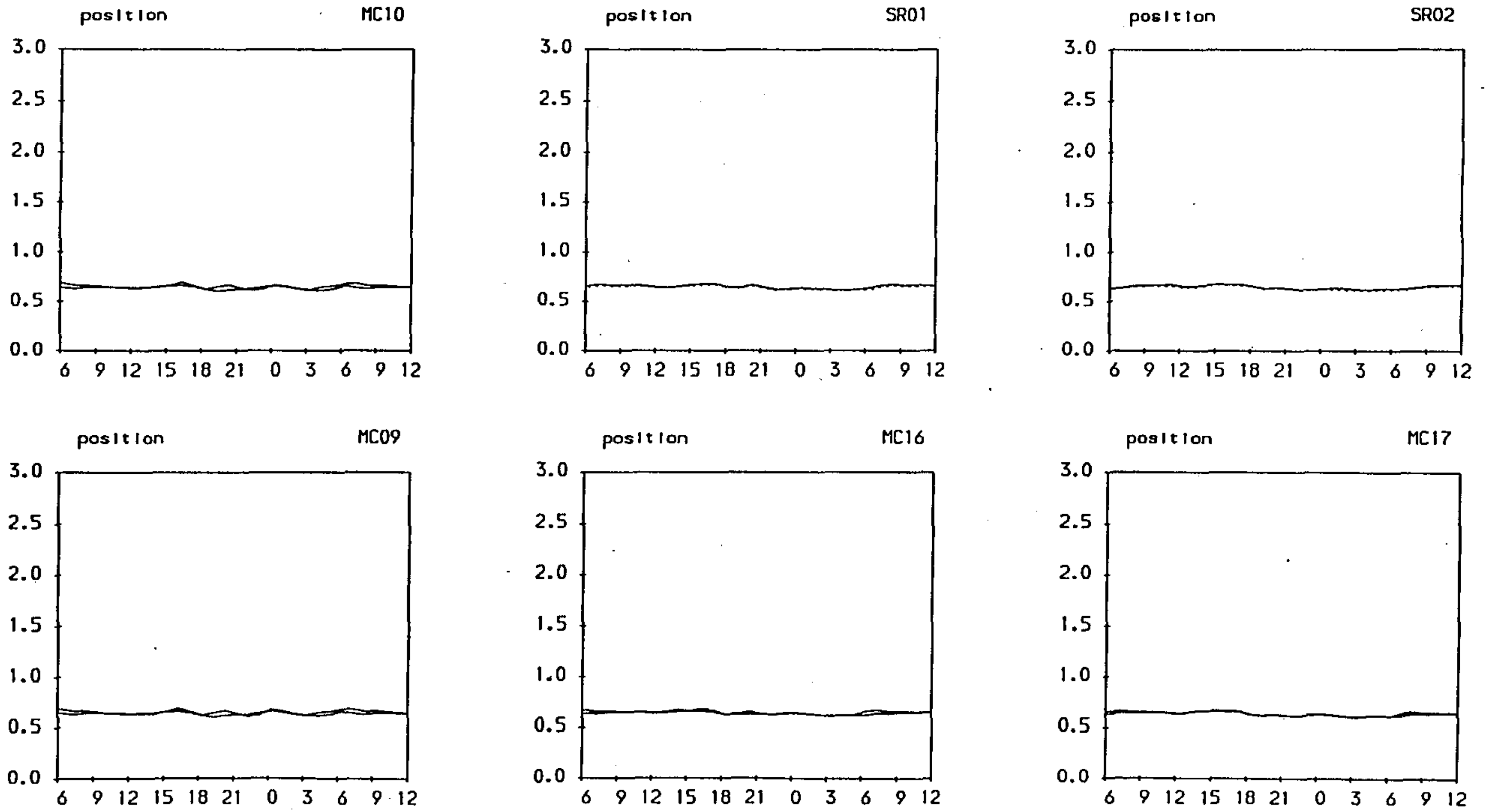


TK+Sham Tseng Wet Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ∆ Lower layer

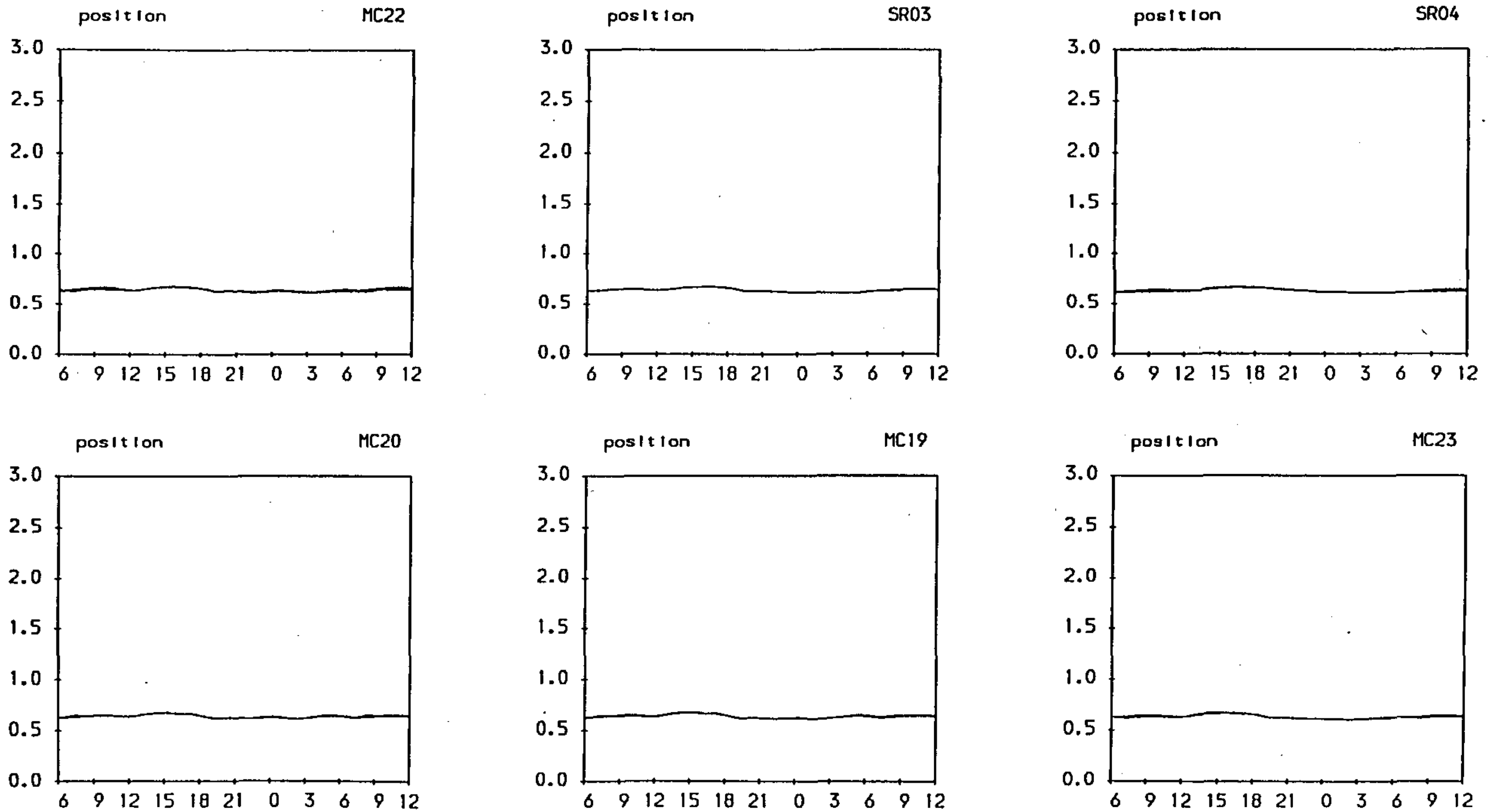


TK+Sham Tseng Wet Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: ∗ Upper layer, ▵ Lower layer

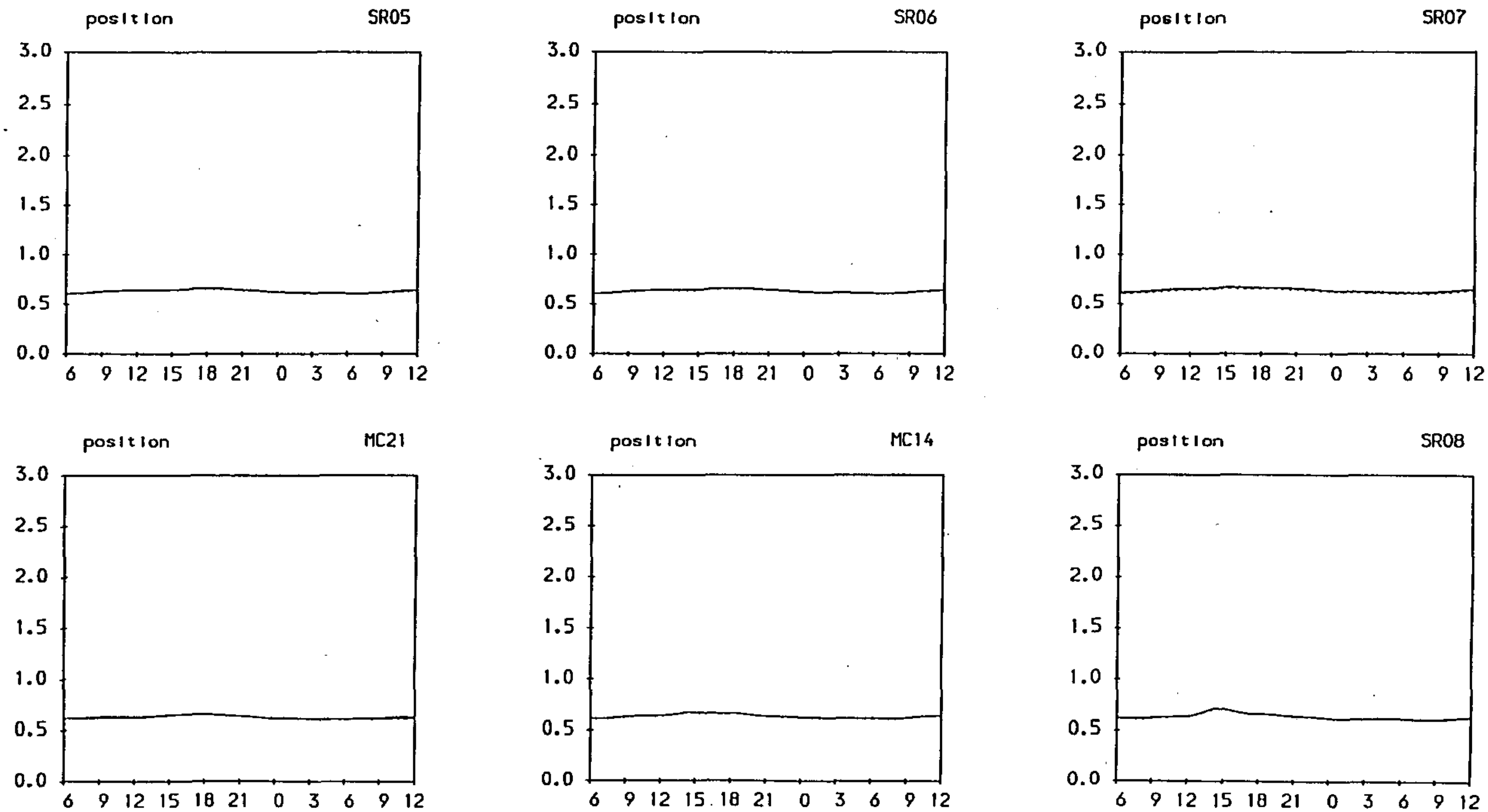


TK+Sham Tseng Wet Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

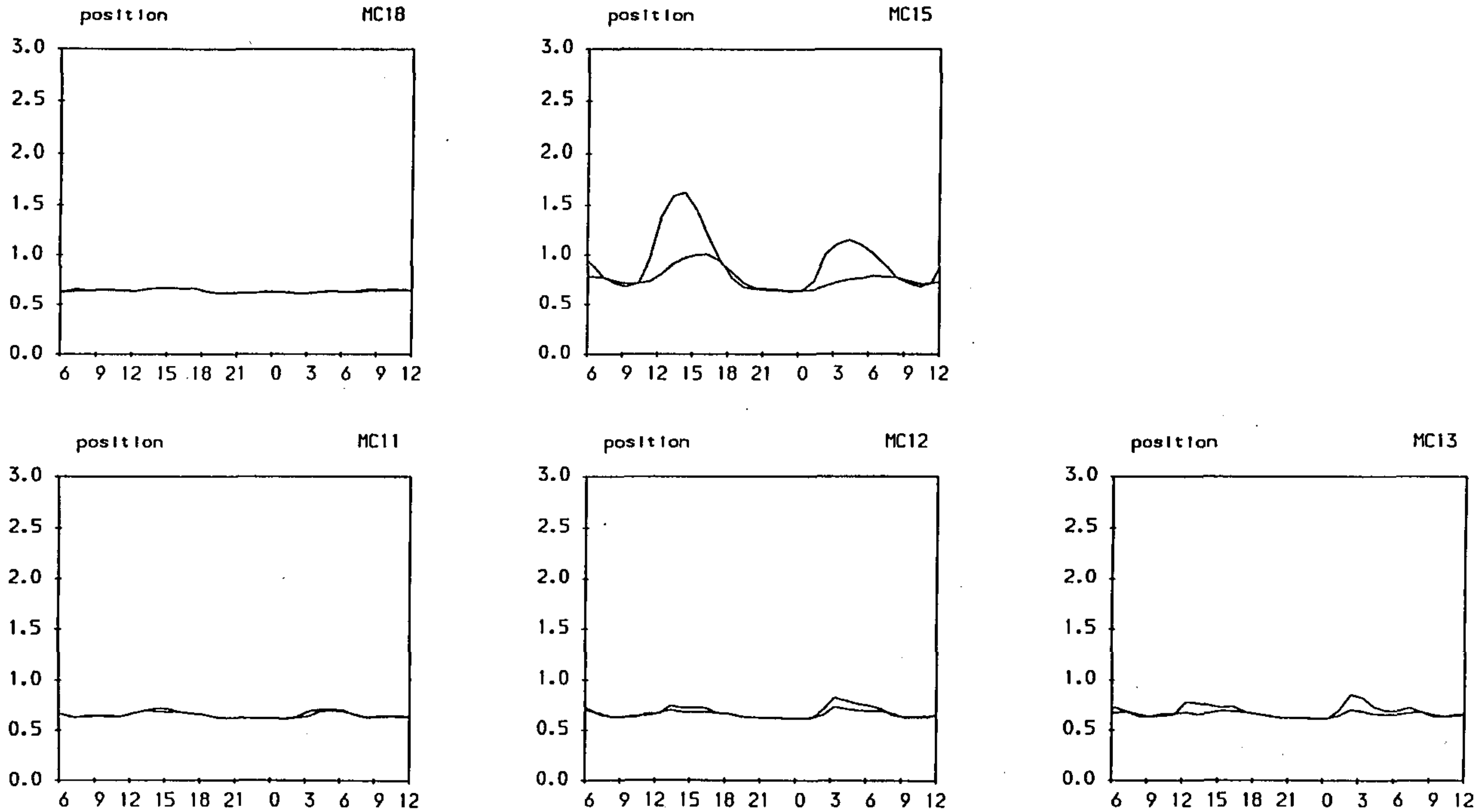


TK+Sham Tseng Wet Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, ∆ Lower layer

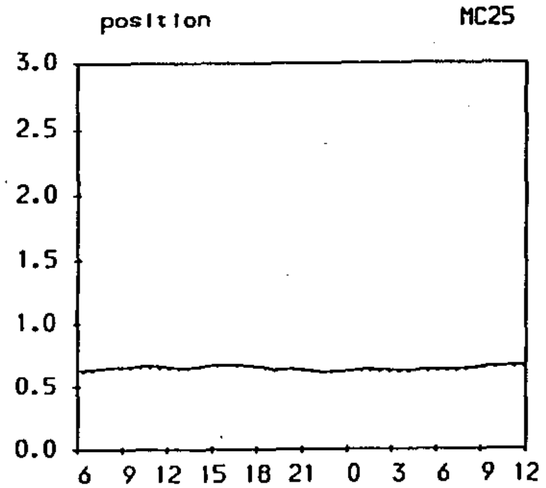


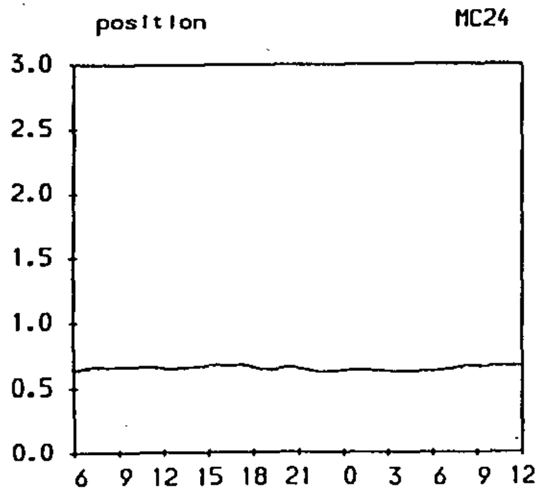
TK+Sham Tseng Wet Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



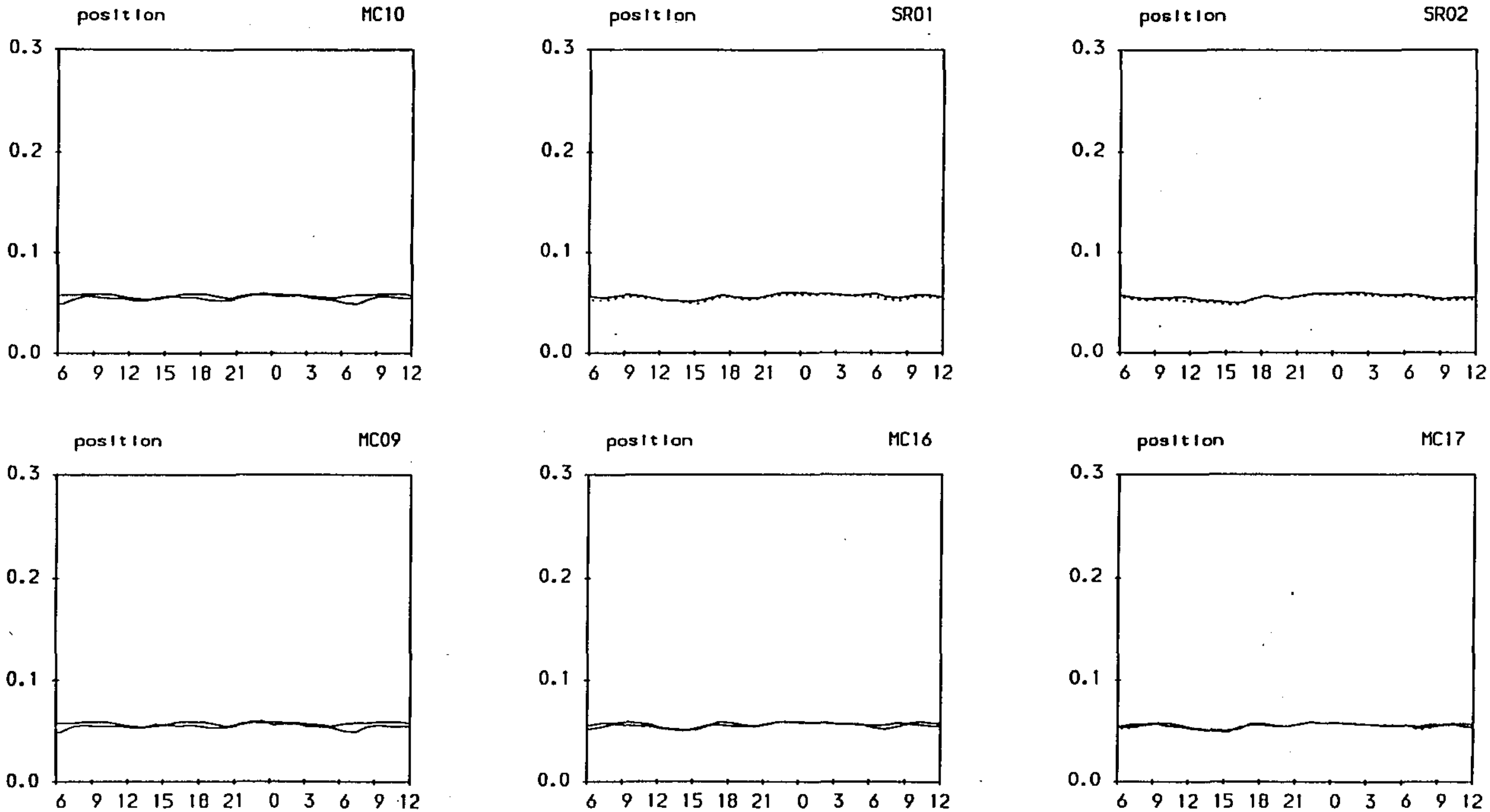


TK+Sham Tseng Wet Spring Original v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 17/05/95   —— Original   ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer

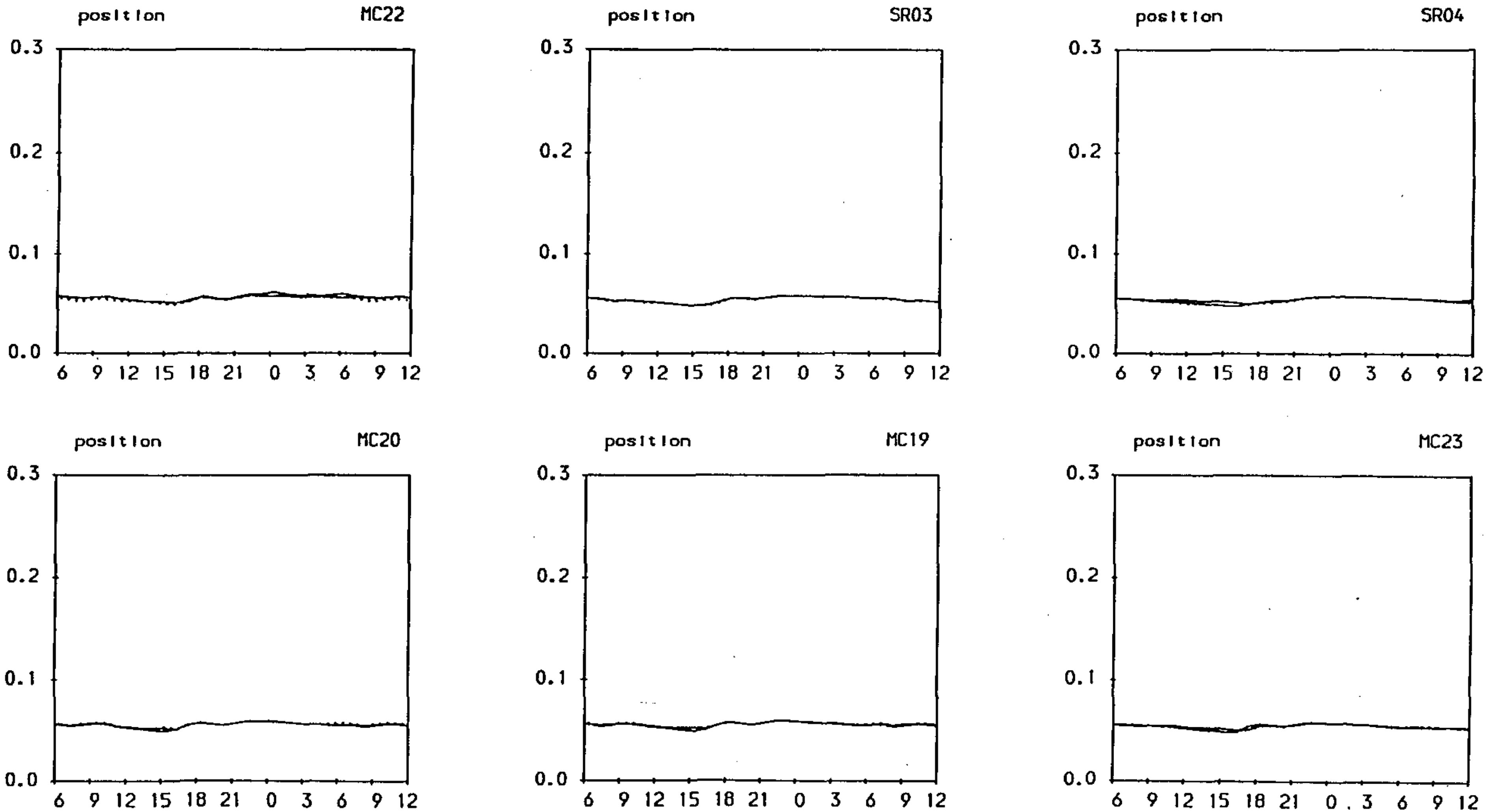


TK+Sham Tseng Wet Spring Original v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 17/05/95   ——— Original   .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

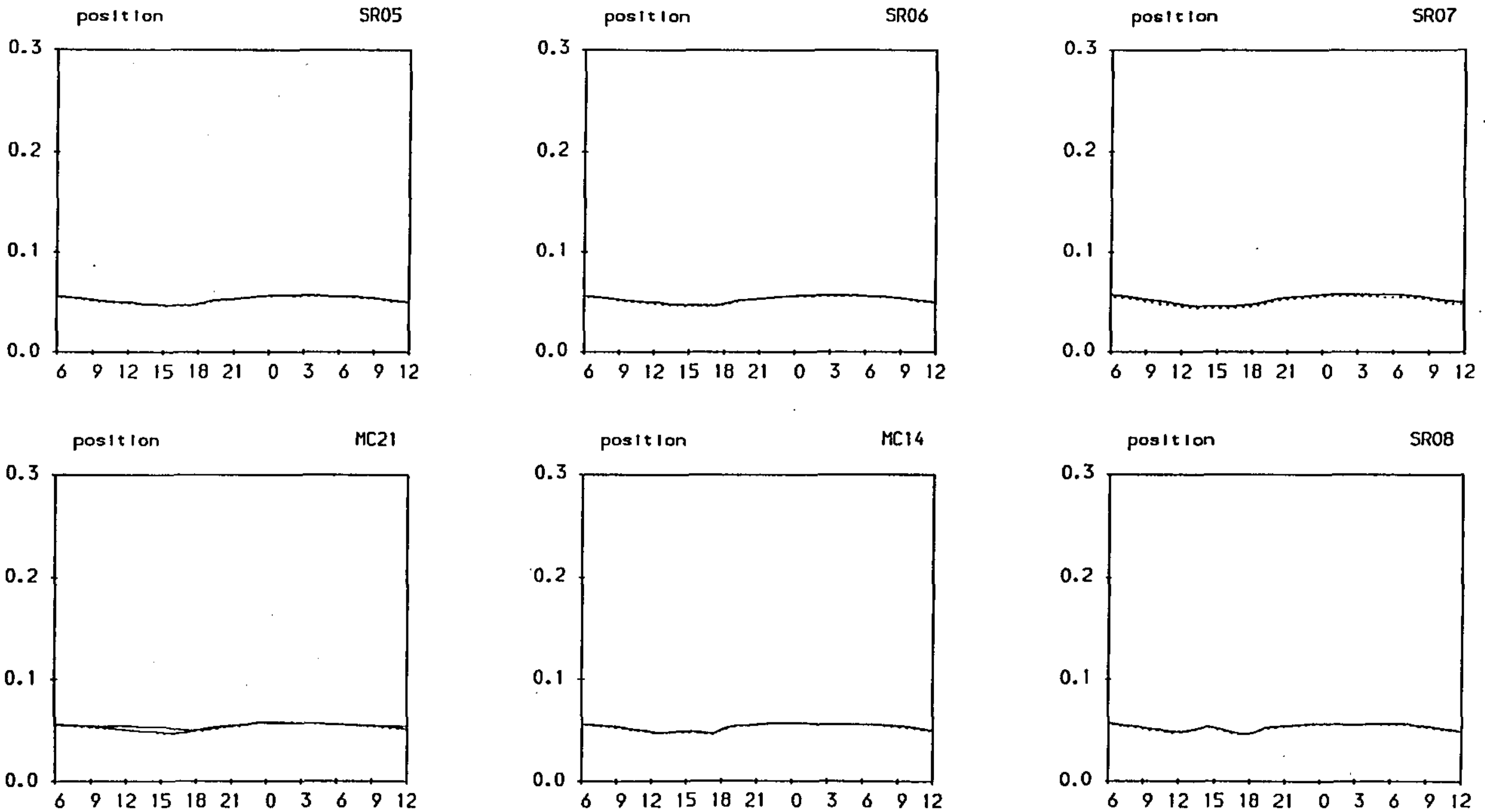


TK+Sham Tseng Wet Spring Original v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 ——— Original .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

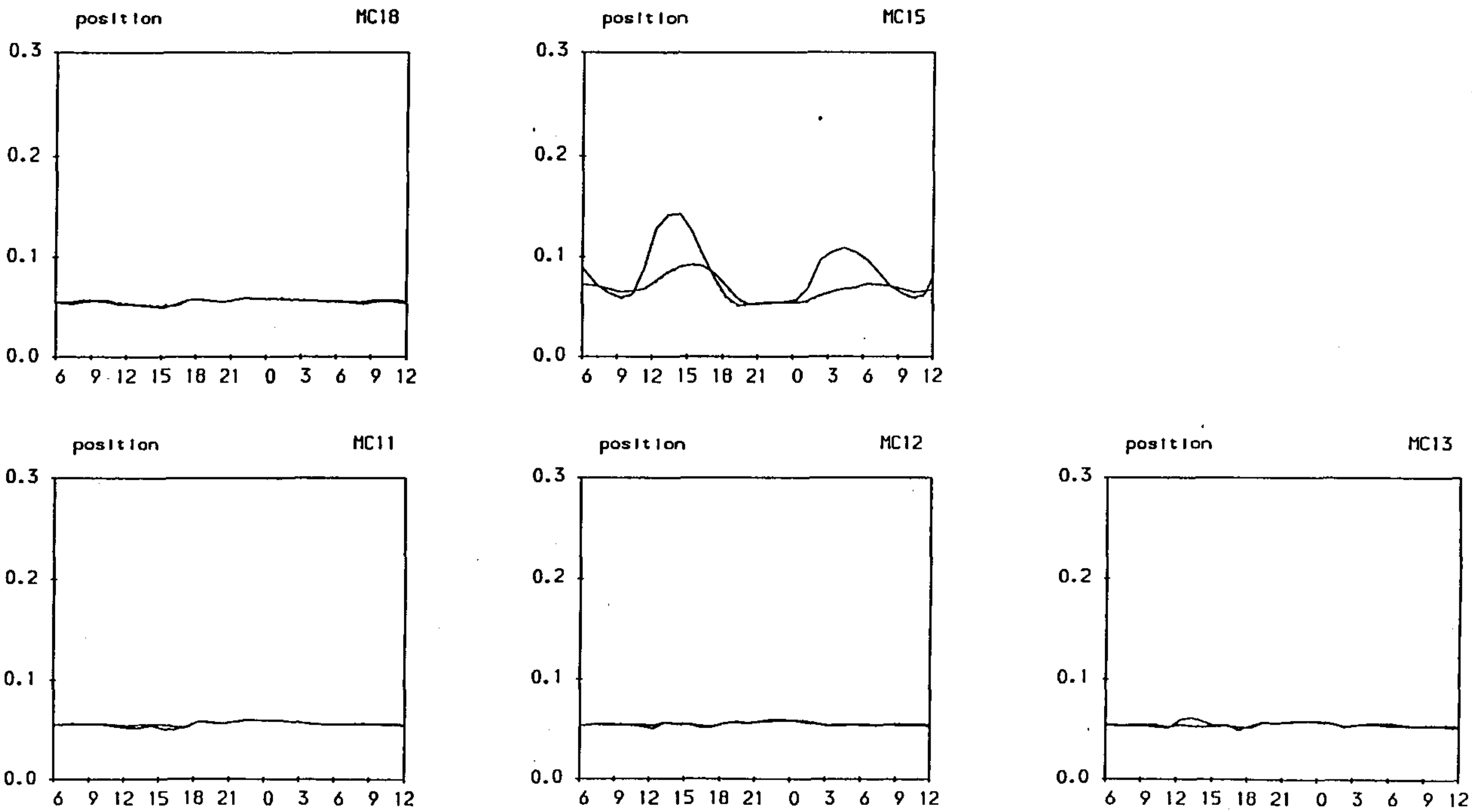


TK+Sham Tseng Wet Spring Original v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

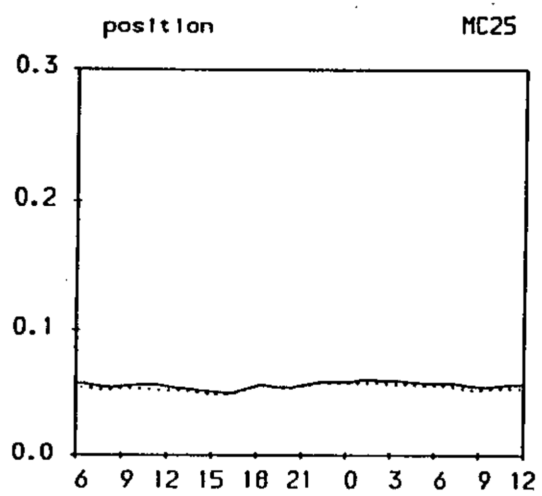


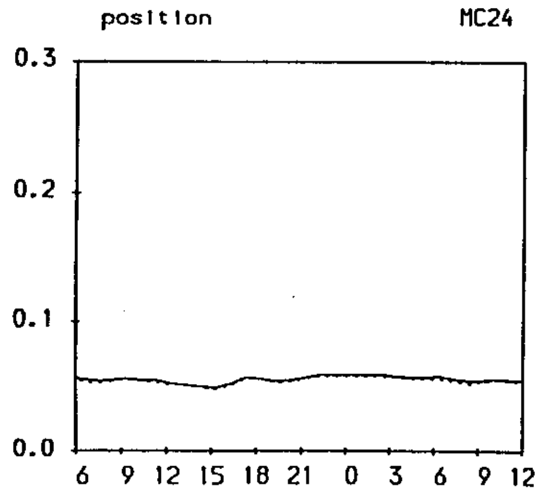
TK+Sham Tseng Wet Spring Original v LSO

Ammoniacal Nitrogen (mg N/L) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



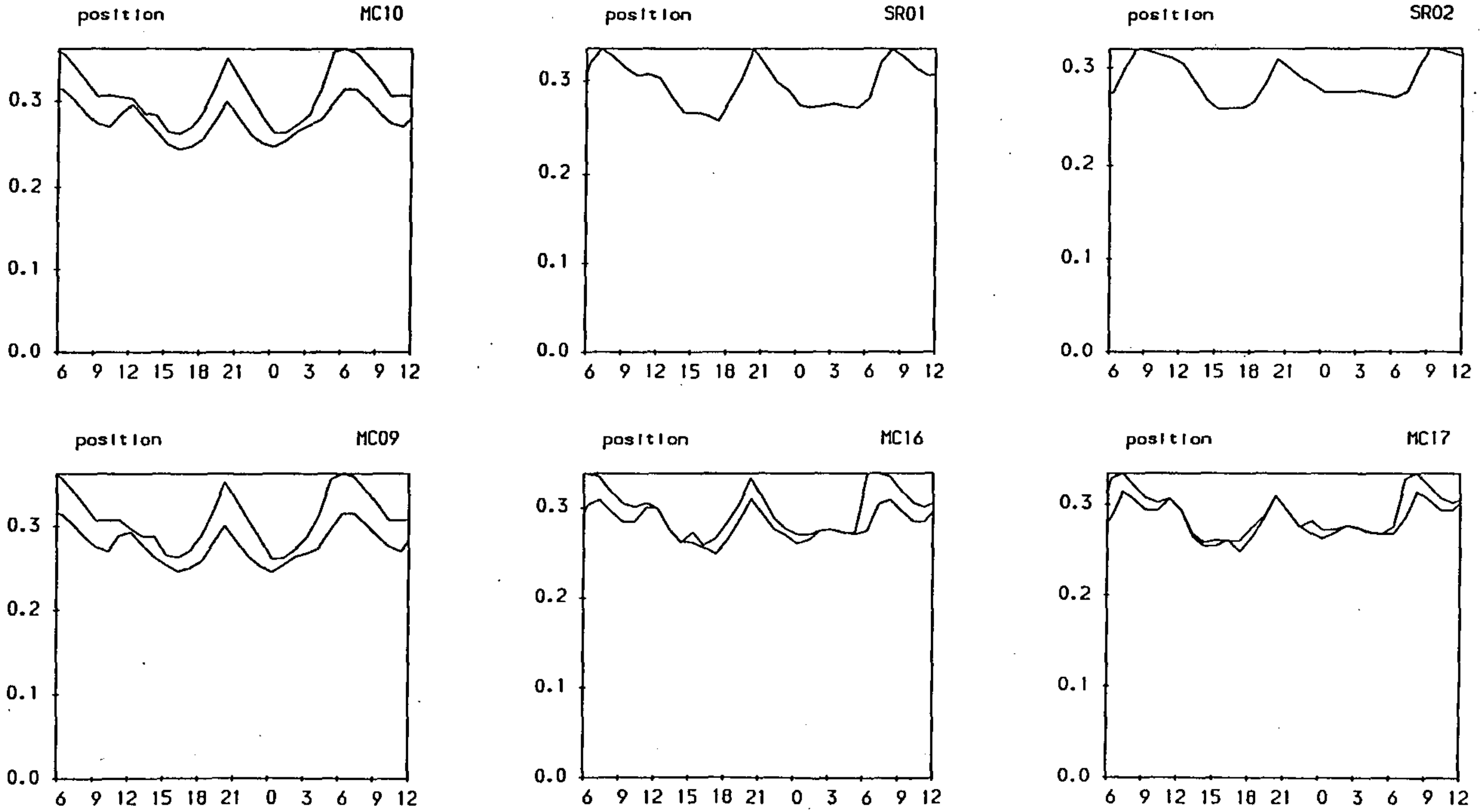


TK+Sham Tseng Wet Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

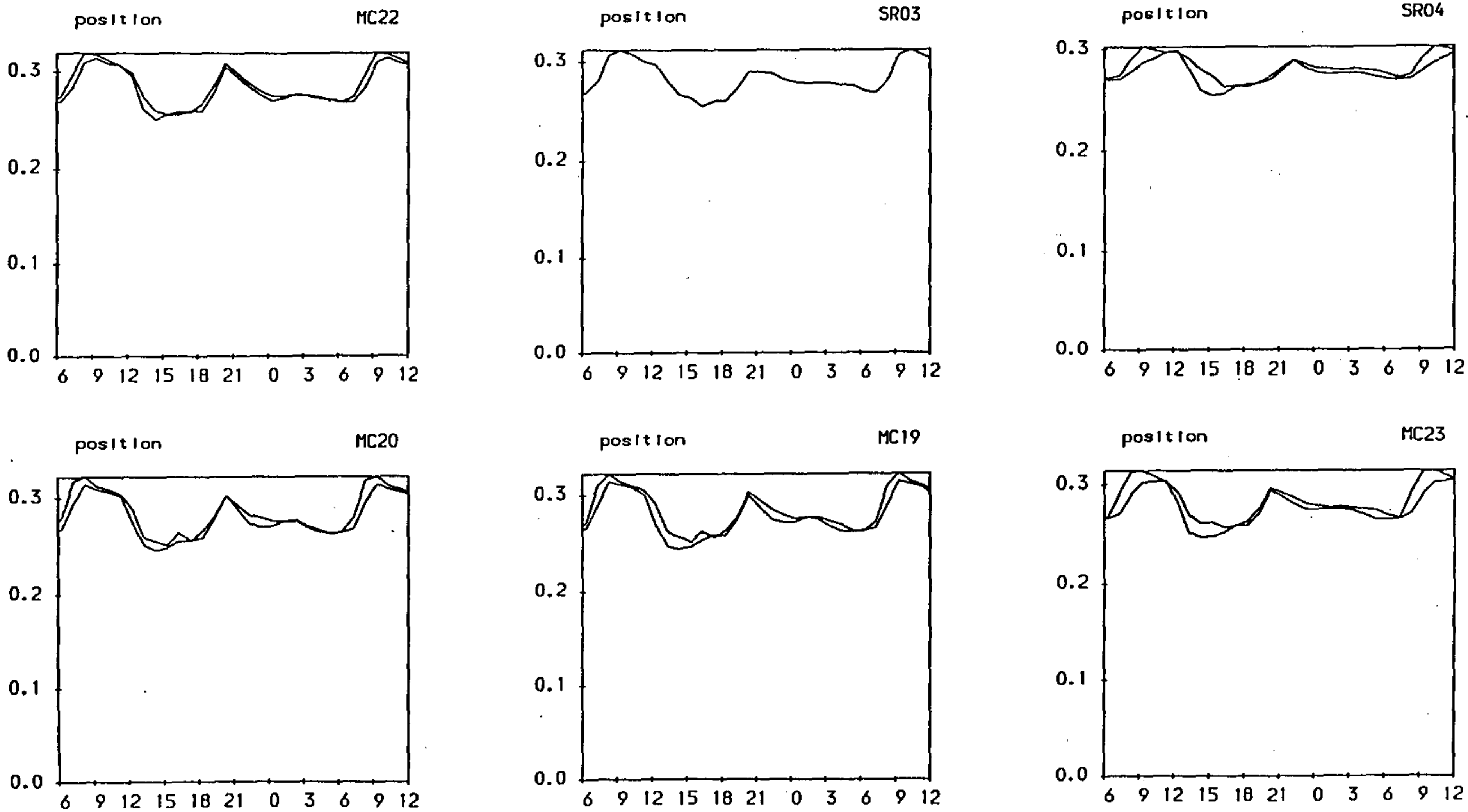


TK+Sham Tseng Wet Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

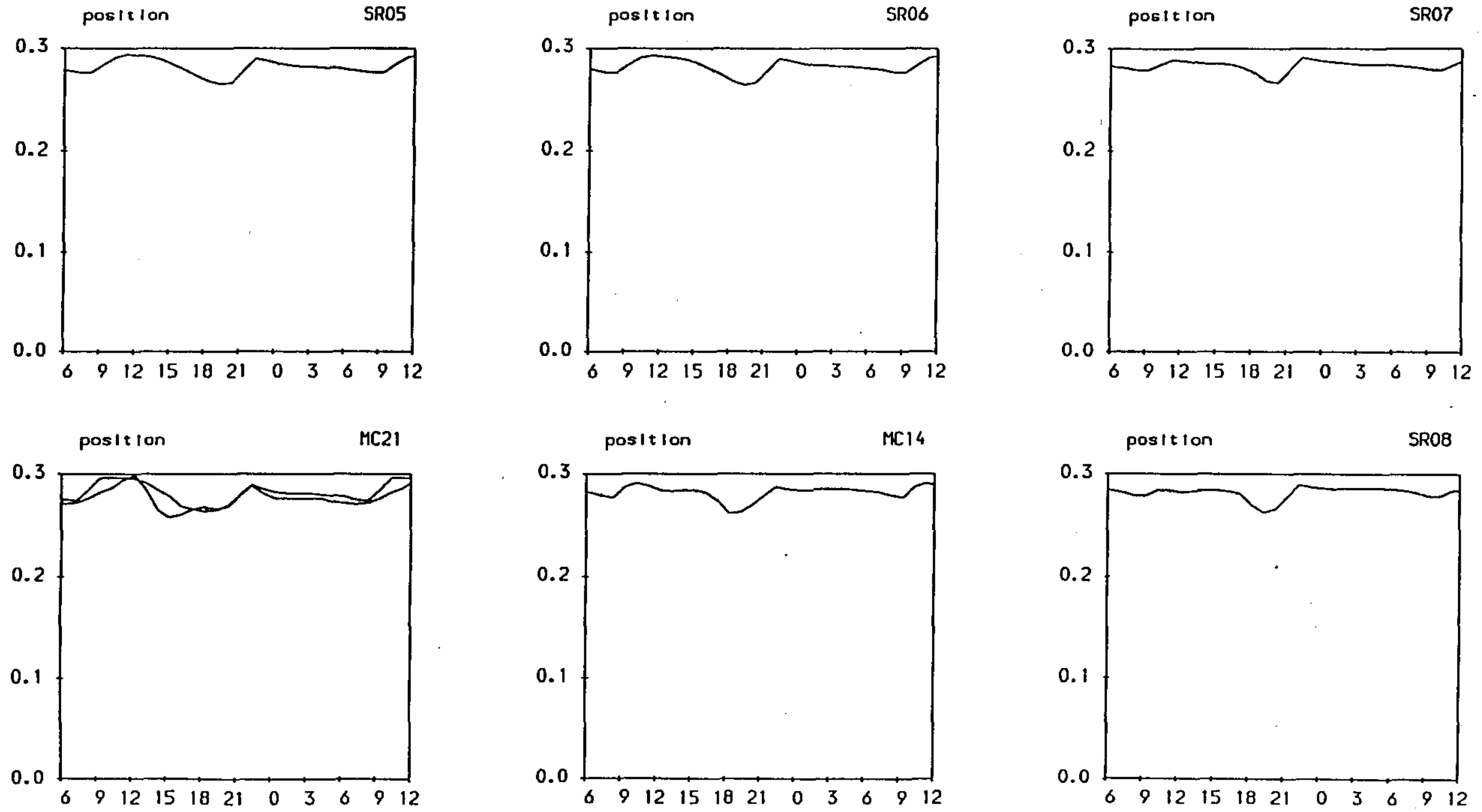


TK+Sham Tseng Wet Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

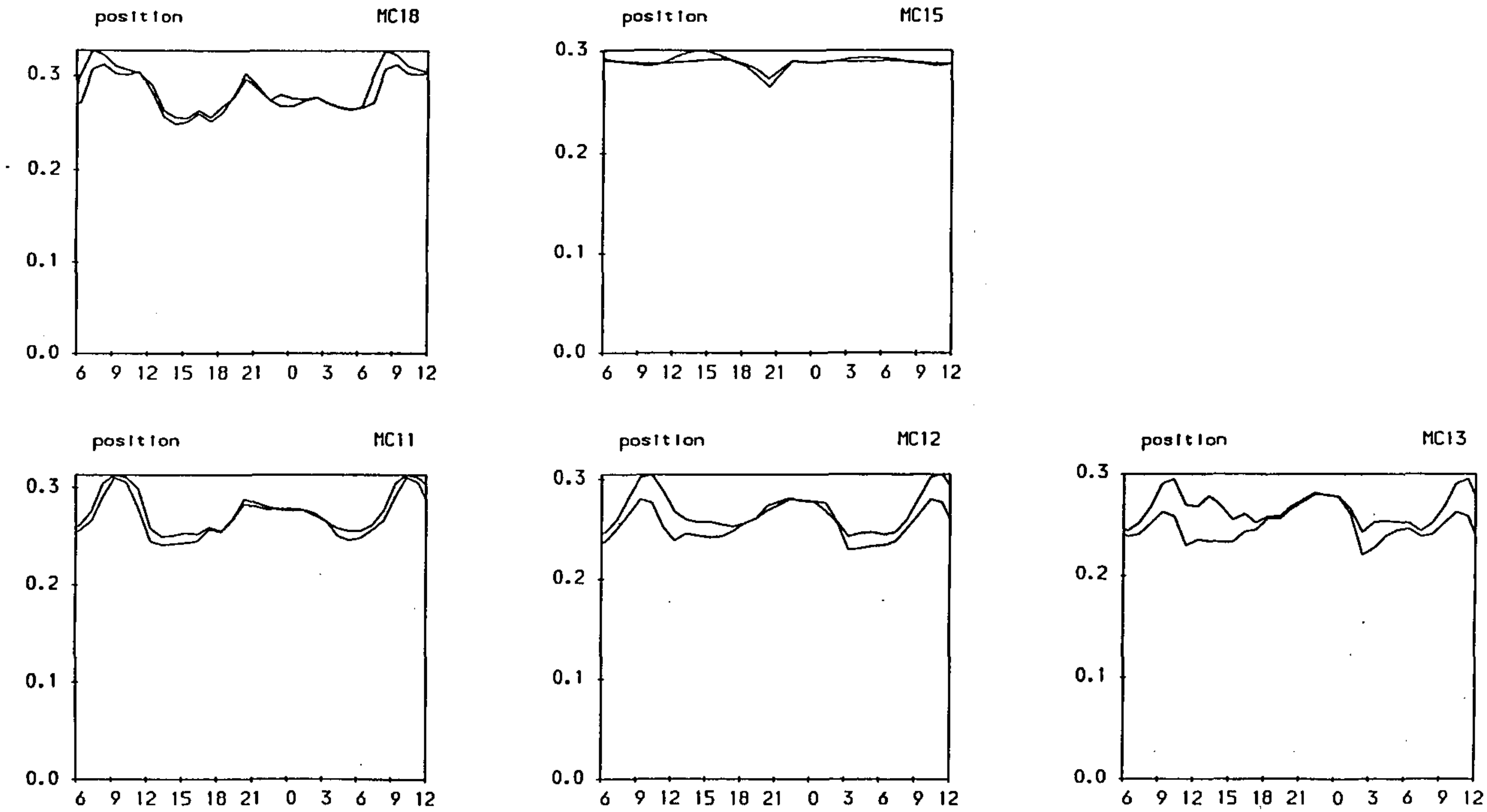


TK+Sham Tseng Wet Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

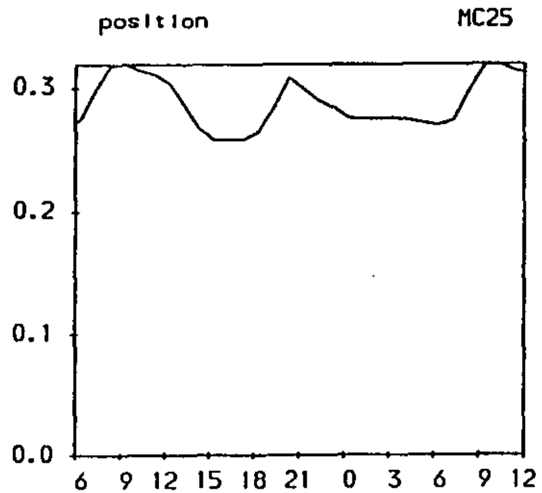


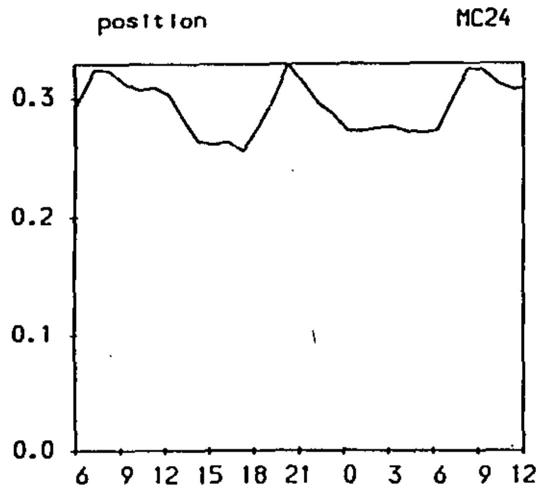
TK+Sham Tseng Wet Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



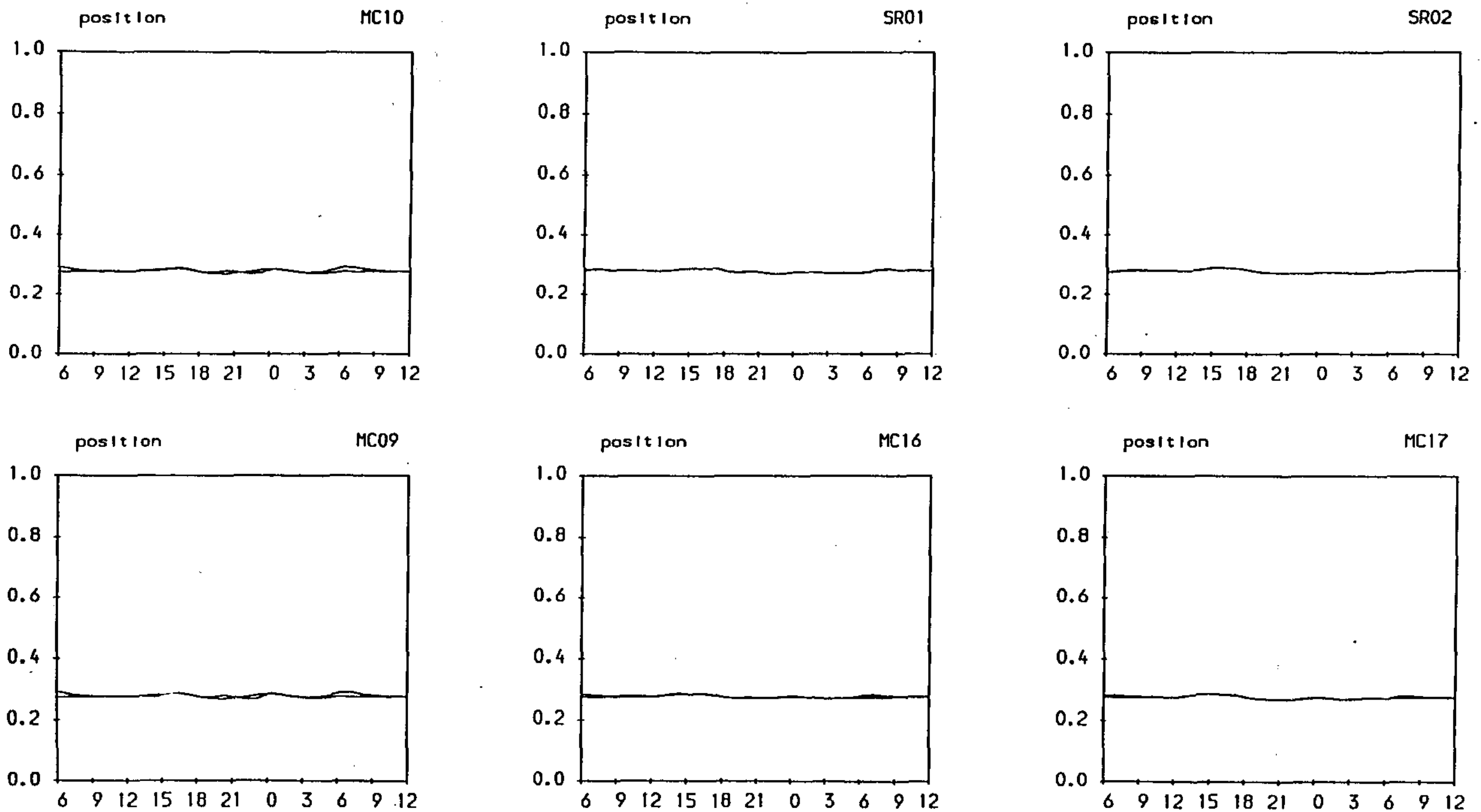


TK+Sham Tseng Wet Spring Original v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

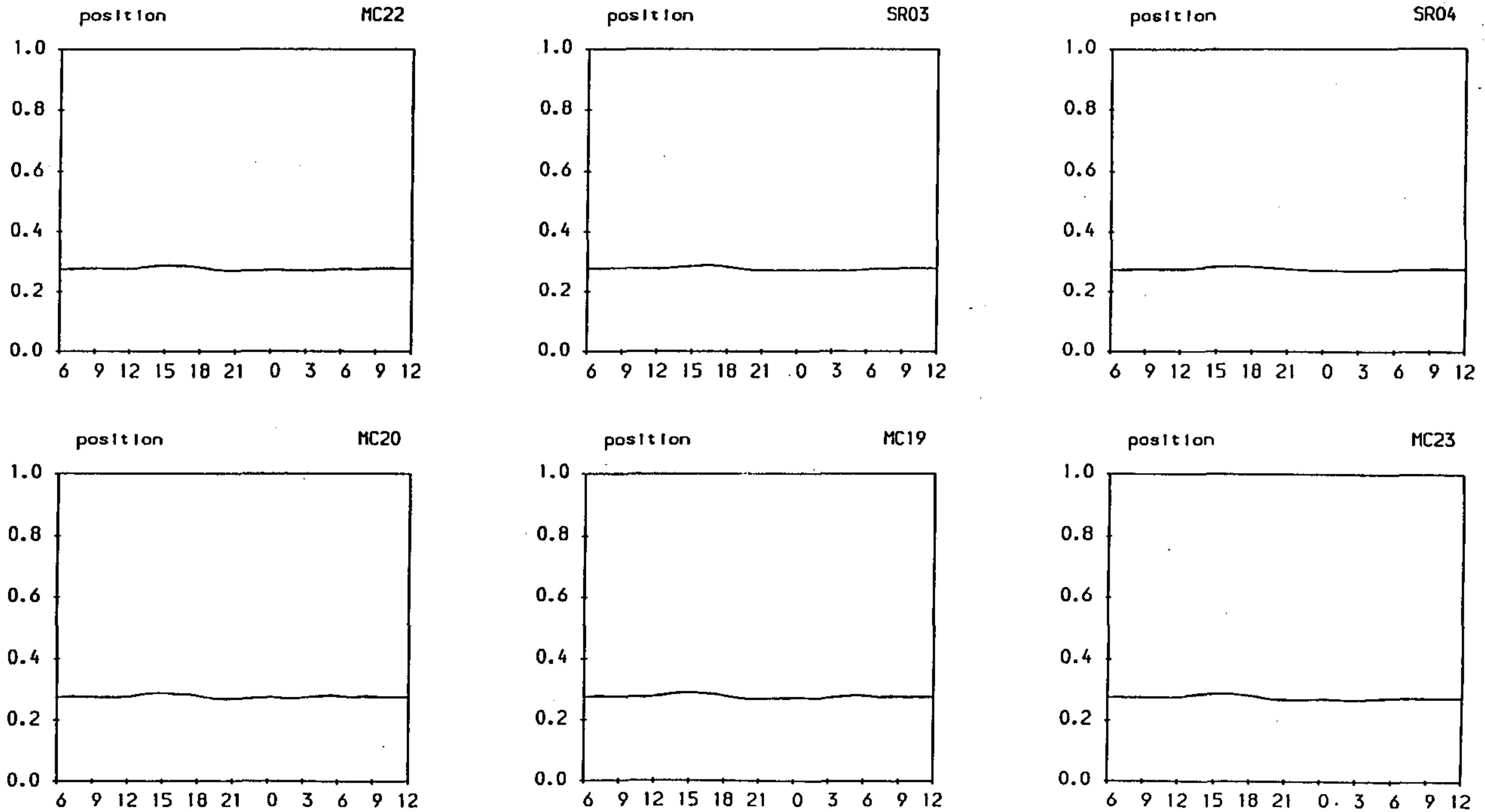


TK+Sham Tseng Wet Spring Original v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

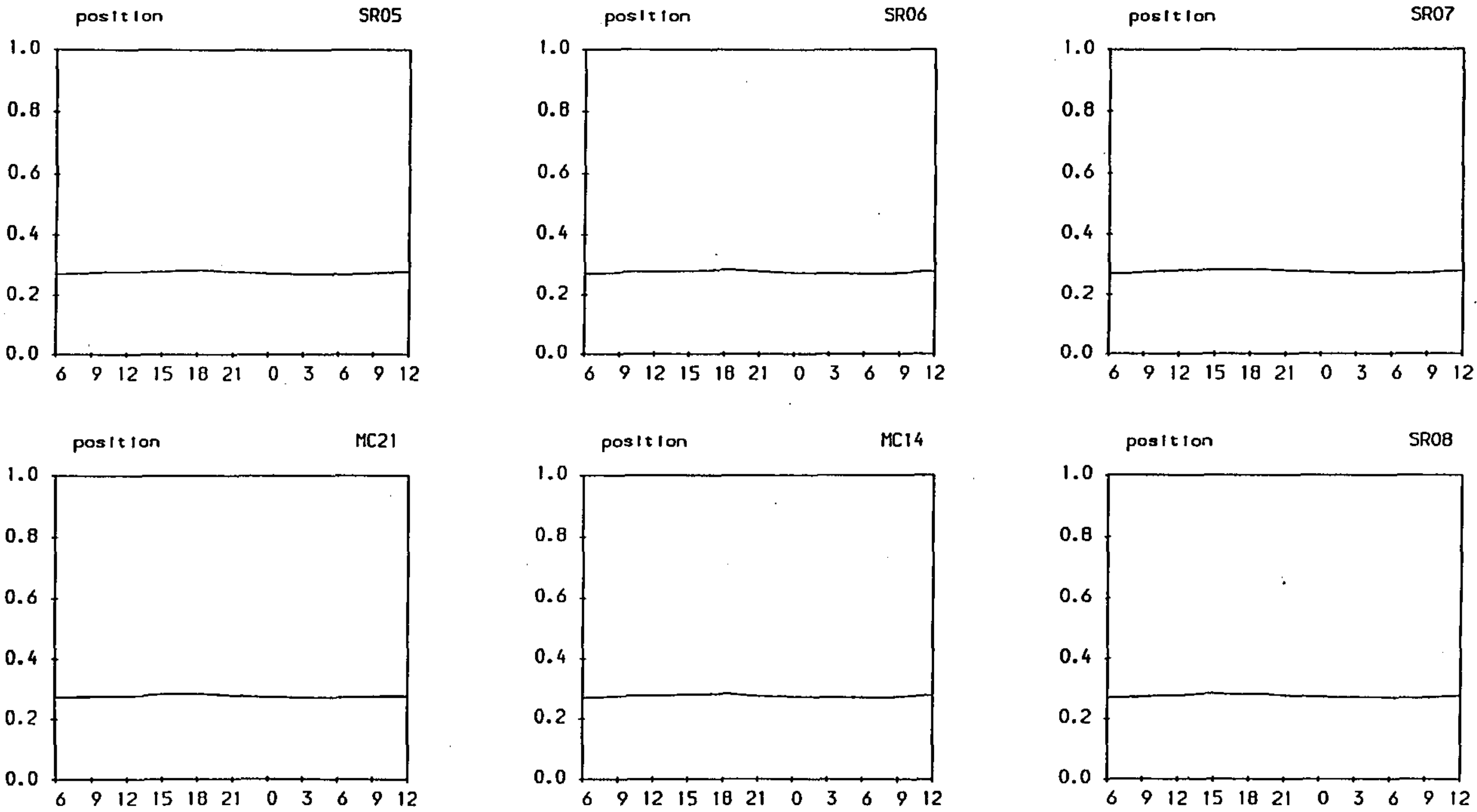


TK+Sham Tseng Wet Spring Original v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

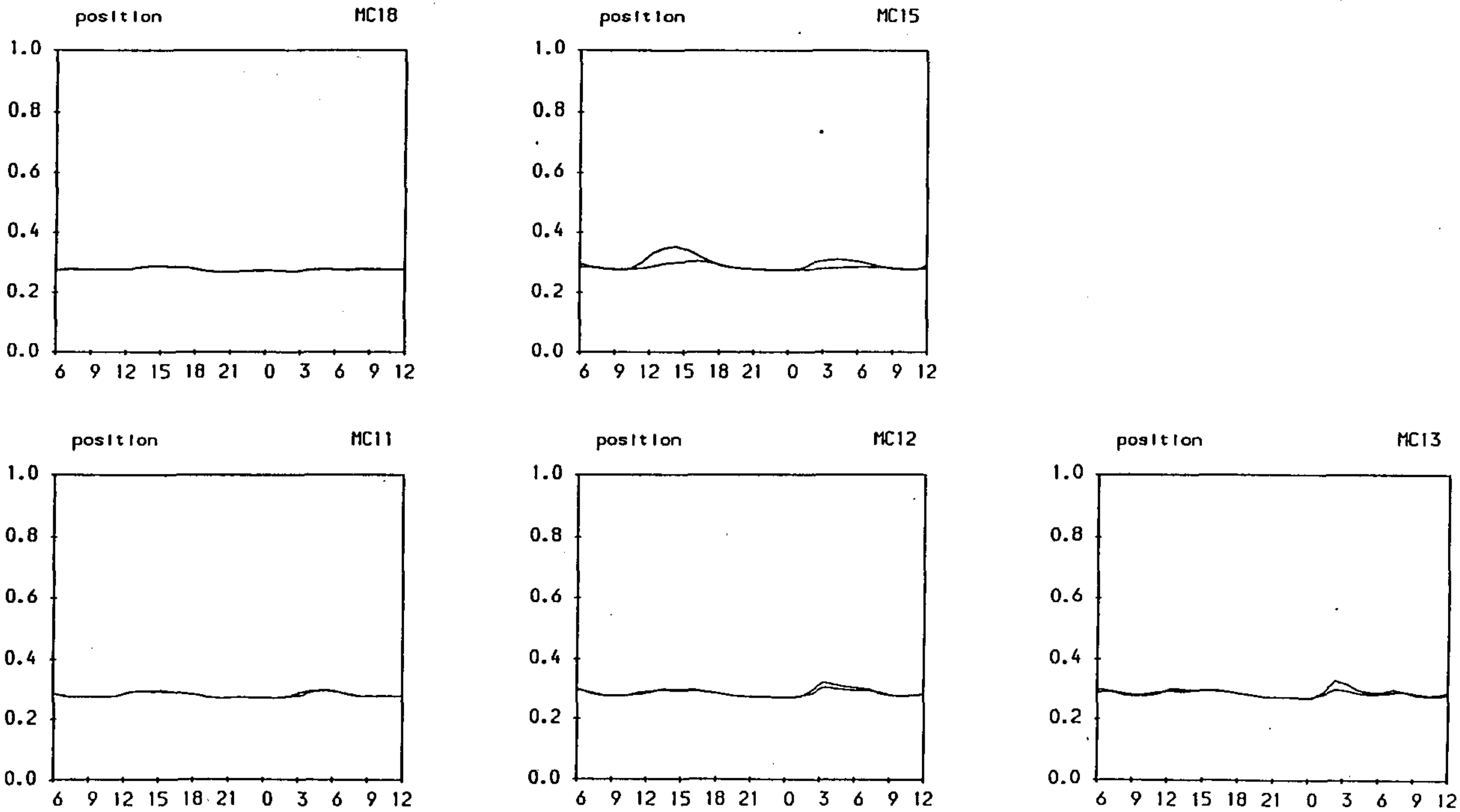


TK+Sham Tseng Wet Spring Original v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

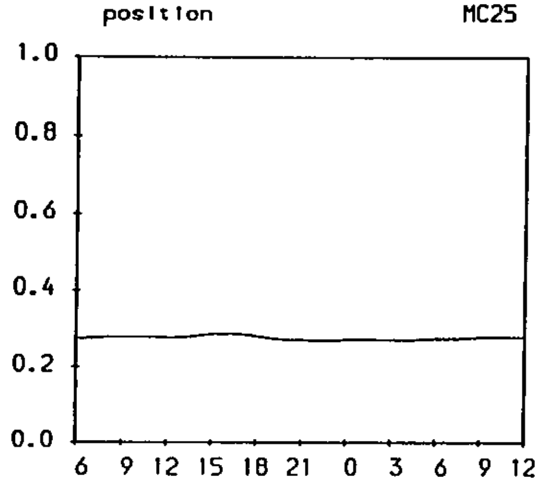


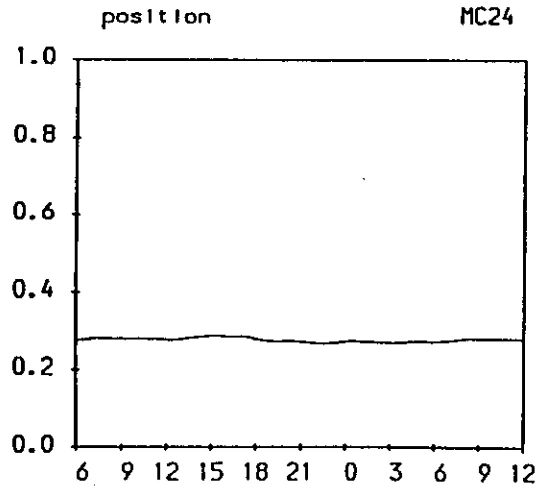
TK+Sham Tseng Wet Spring Original v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer



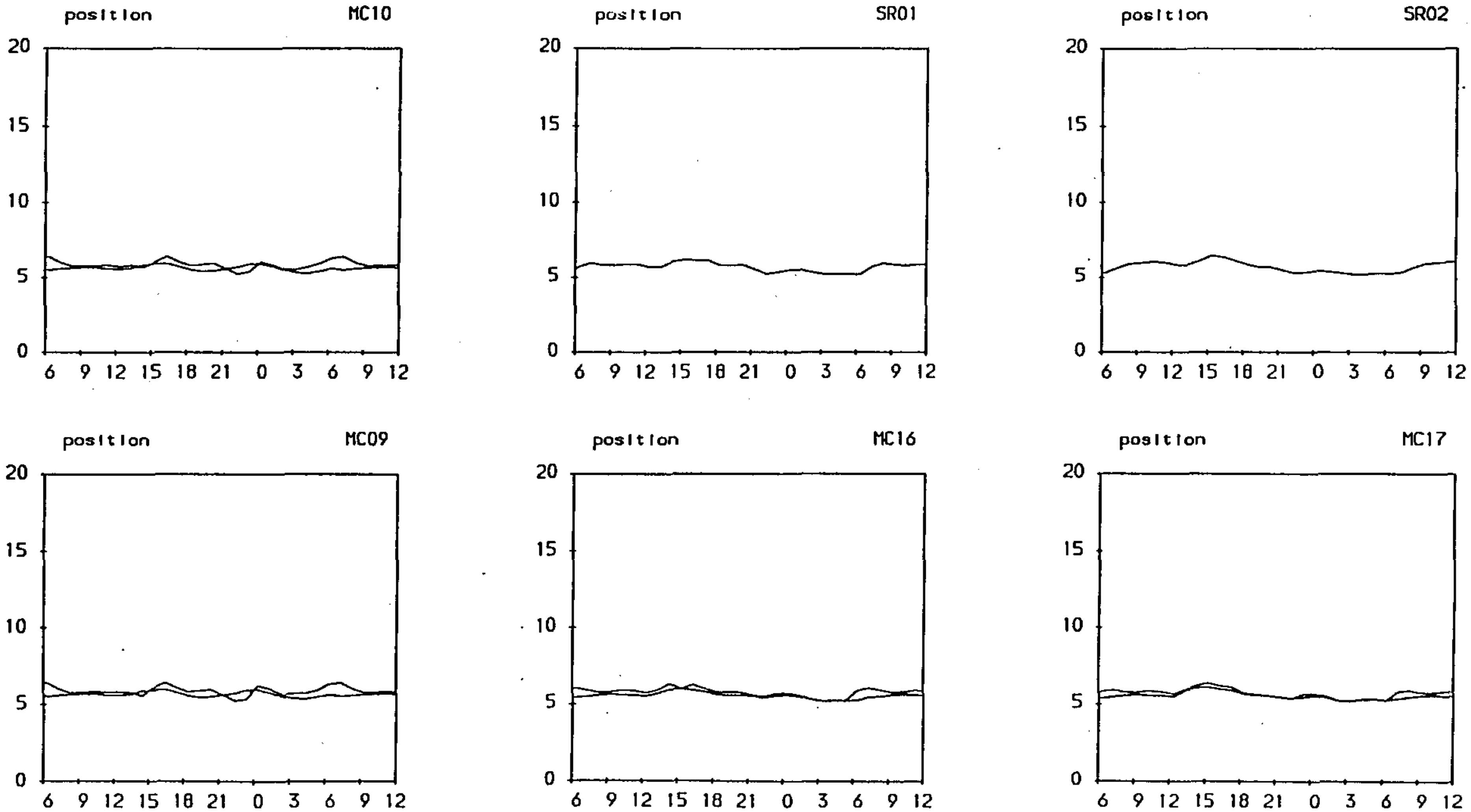


TK+Sham Tseng Wet Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

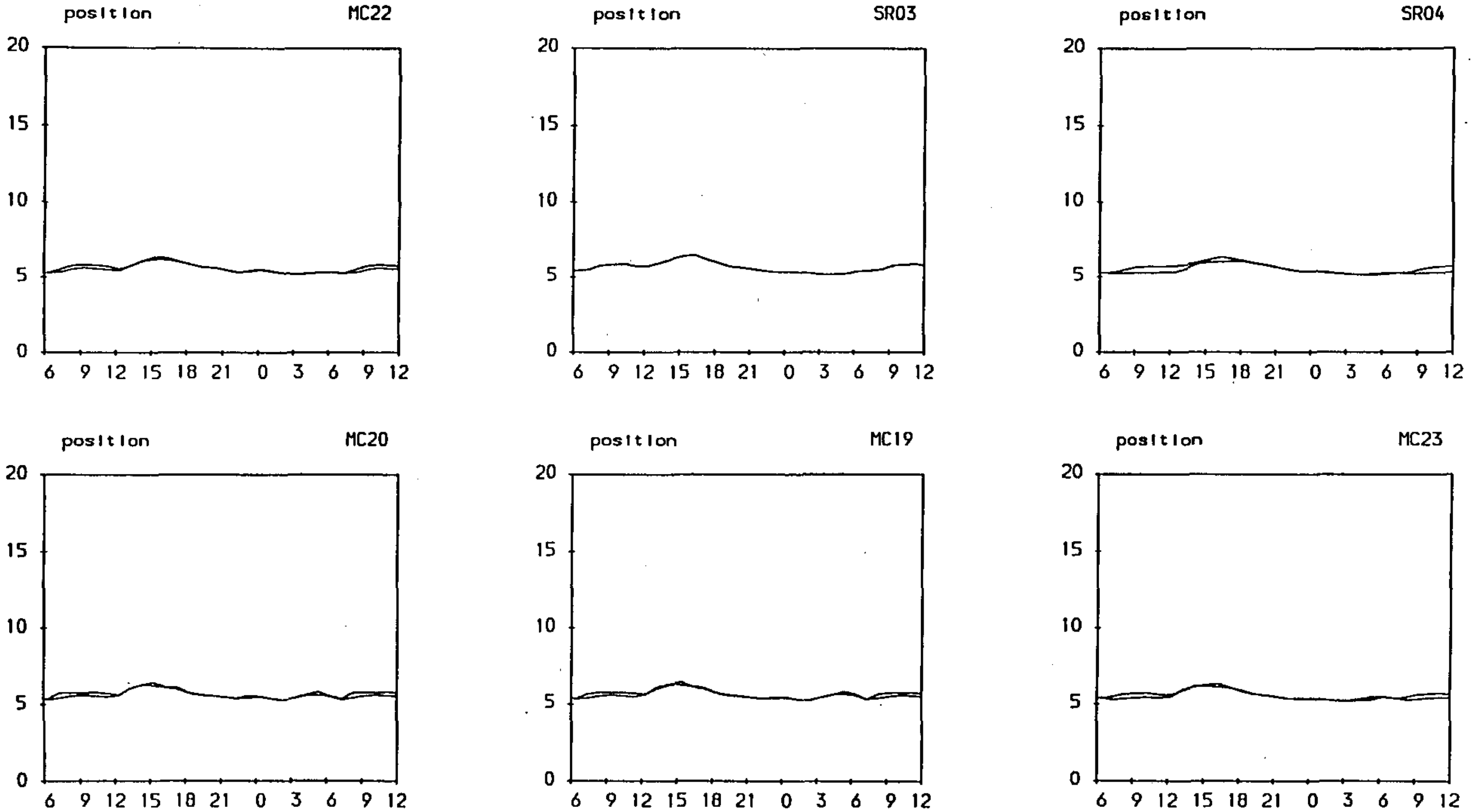


TK+Sham Tseng Wet Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

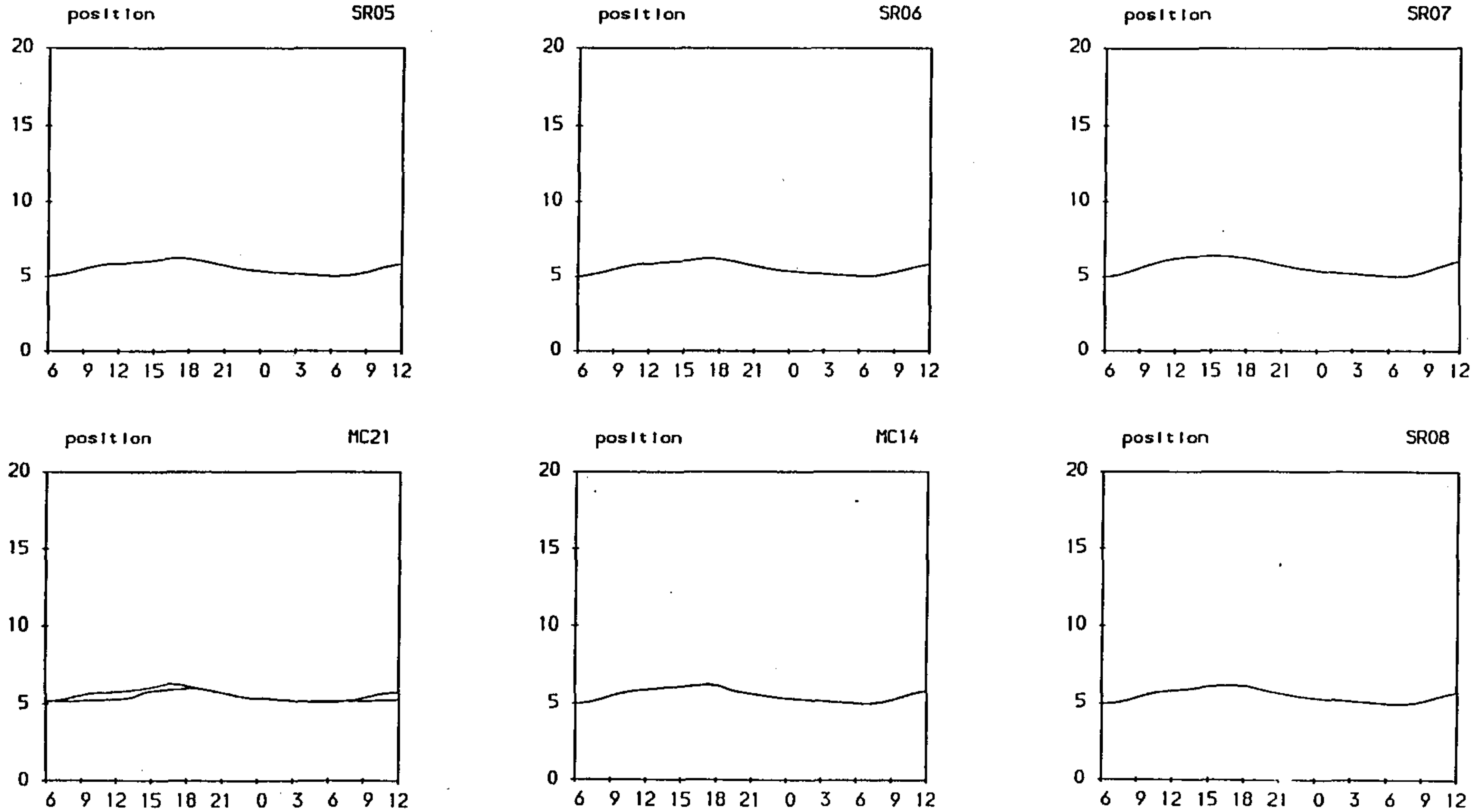


TK+Sham Tseng Wet Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

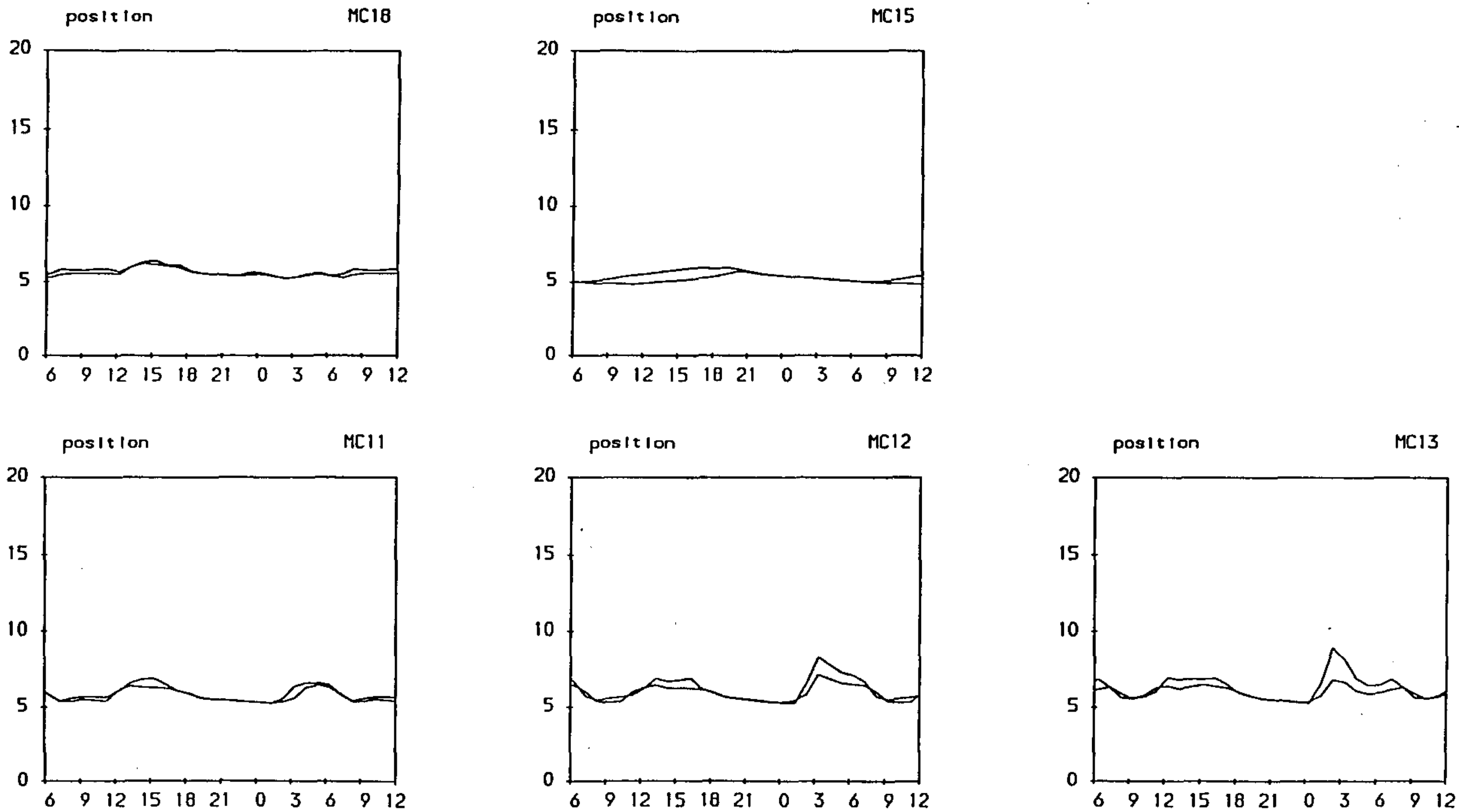


TK+Sham Tseng Wet Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

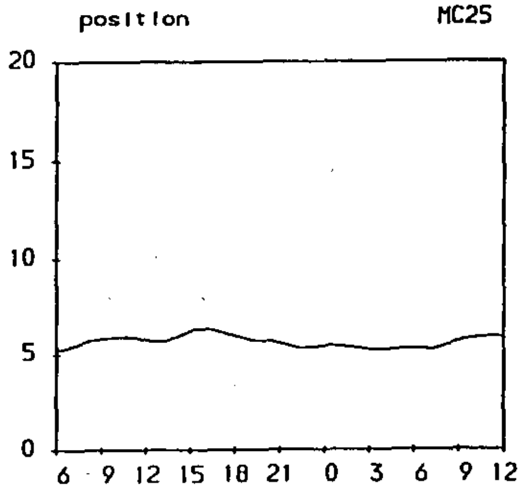


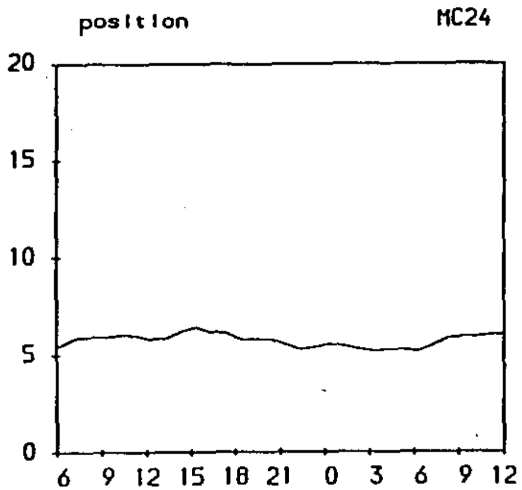
TK+Sham Tseng Wet Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



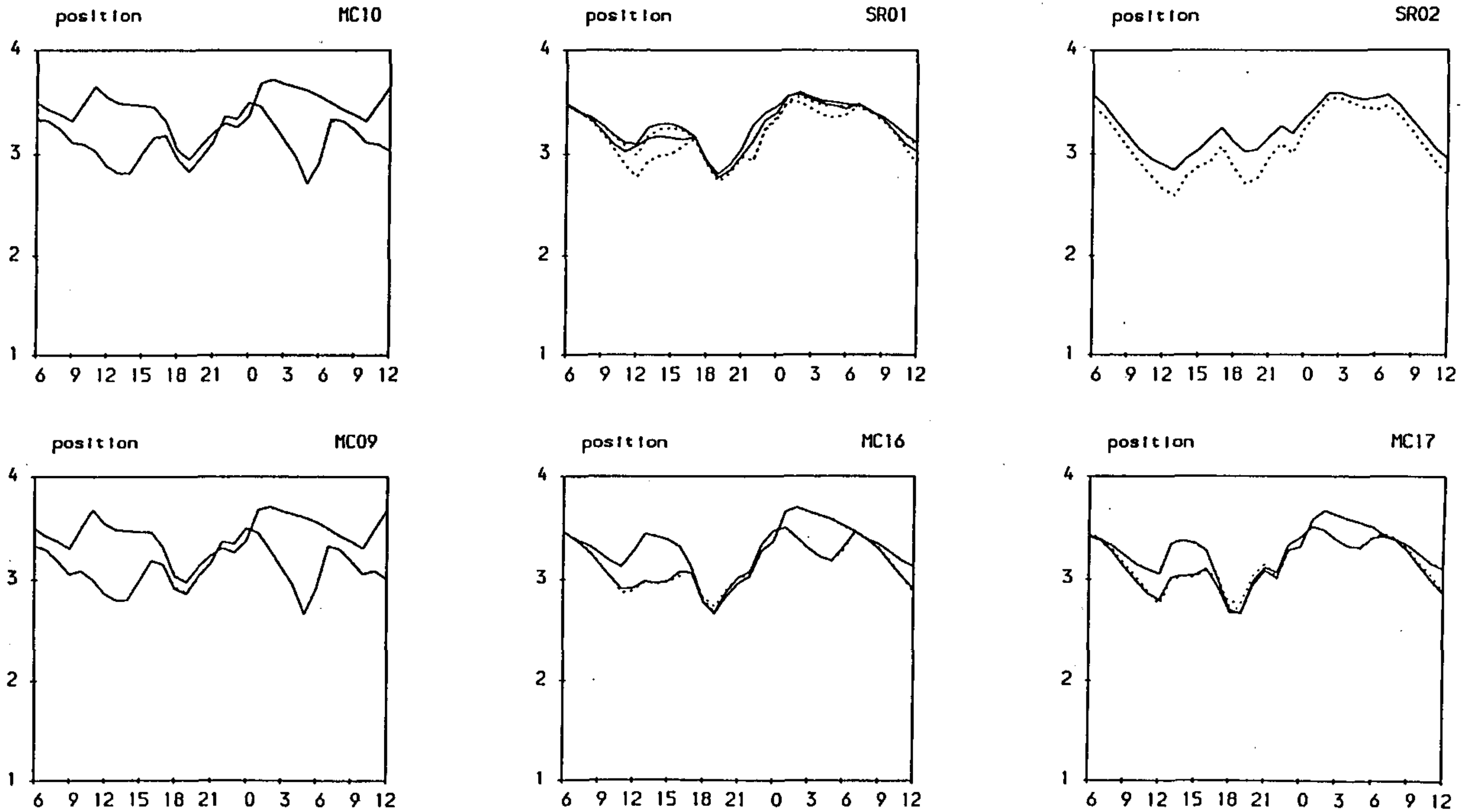


TK+Sham Tseng Dry Spring Original v LSO

E.Coli (no/100ml) against time   (log to base 10 on y-axis)

2 Layer, 50m grid   DM 17/05/95   —— Original   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

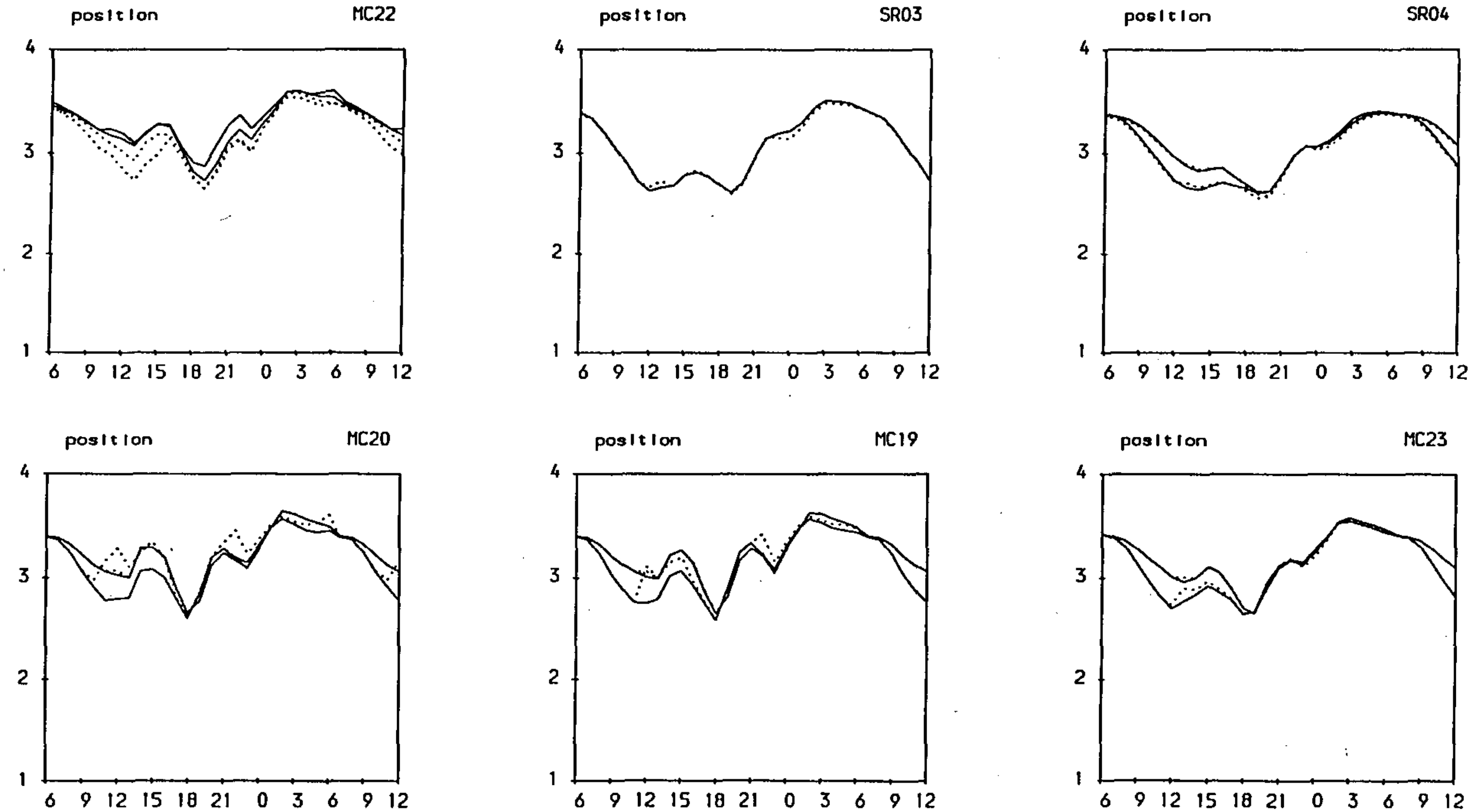


TK+Sham Tseng Dry Spring Original v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer

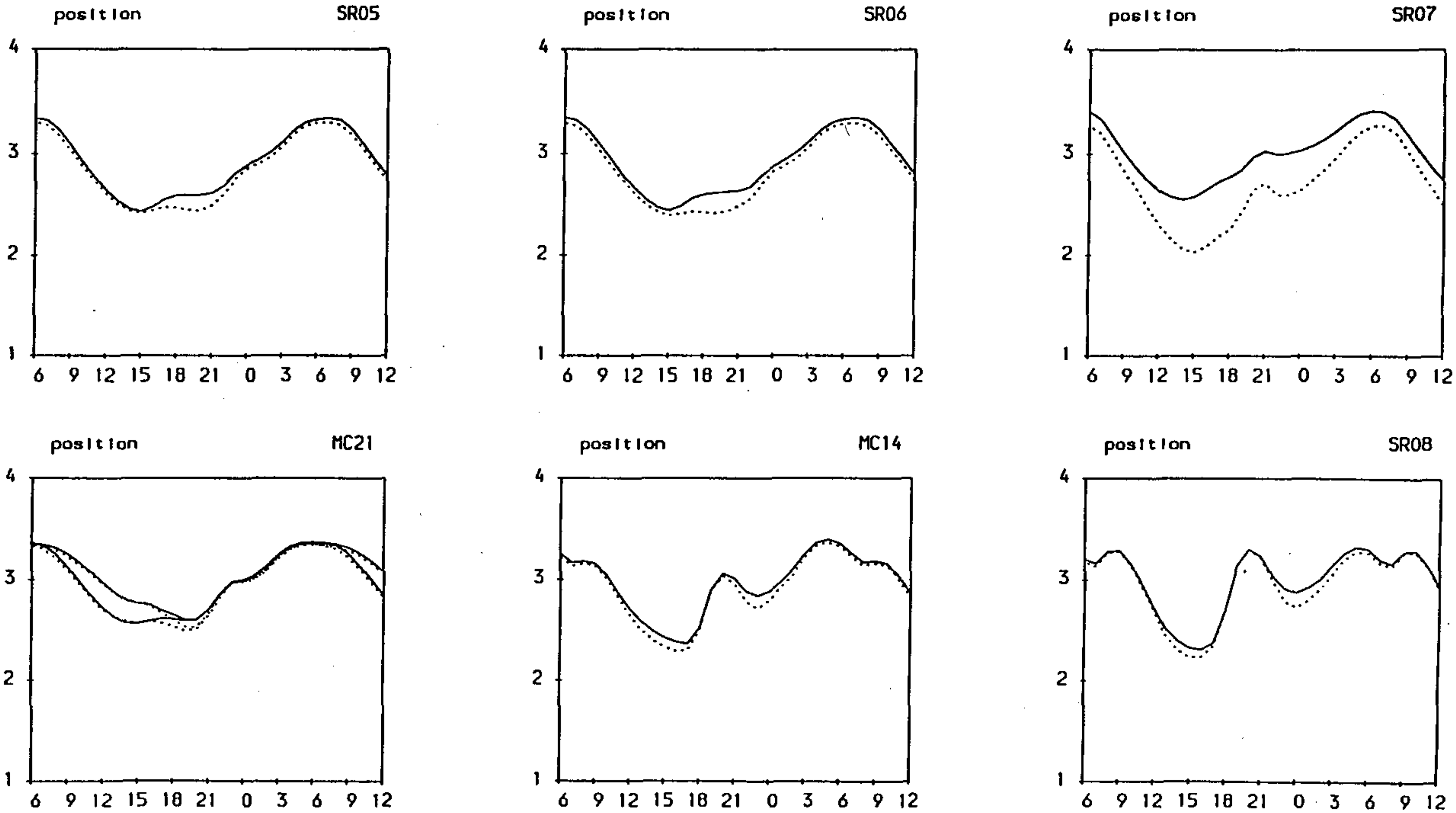


TK+Sham Tseng Dry Spring Original v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 17/05/95 ——— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

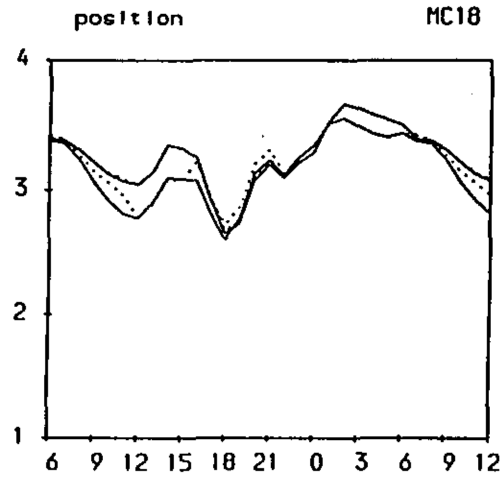


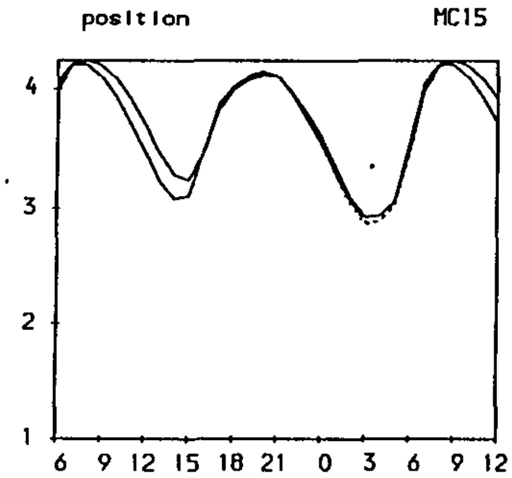
TK+Sham Tseng Dry Spring Original v LSO

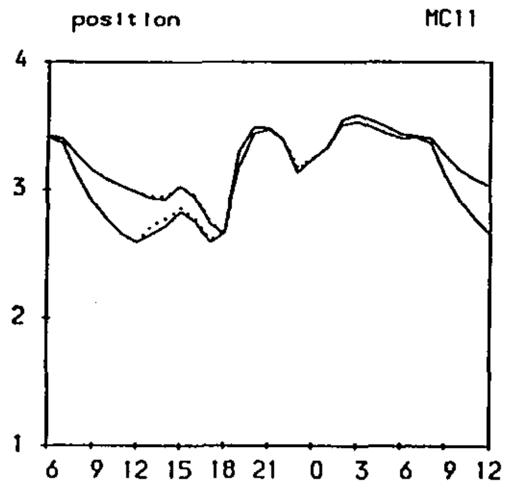
E.Coli (no/100ml) against time (log to base 10 on y-axis)

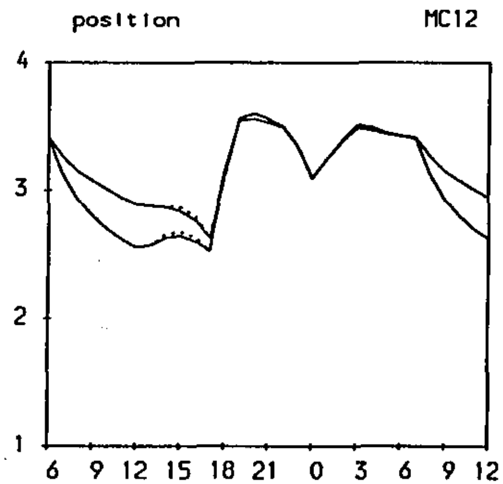
2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

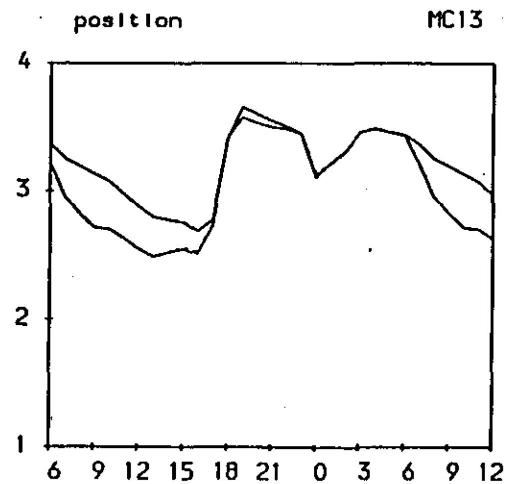
Observed symbols: * Upper layer, △ Lower layer









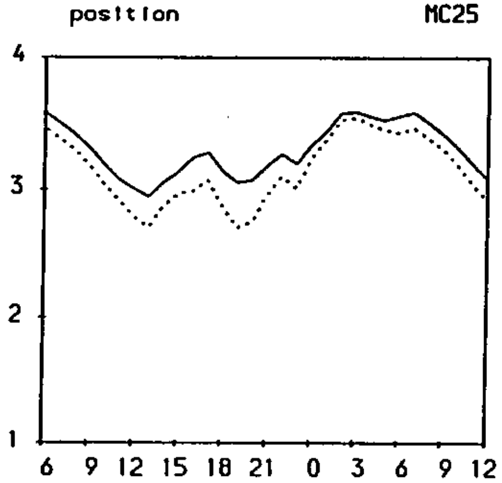


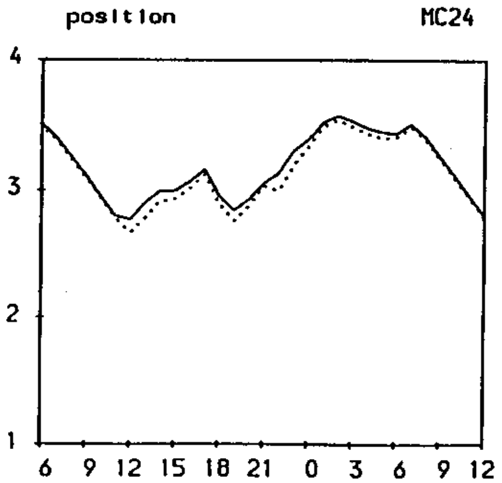
TK+Sham Tseng Dry Spring Original v LSO

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



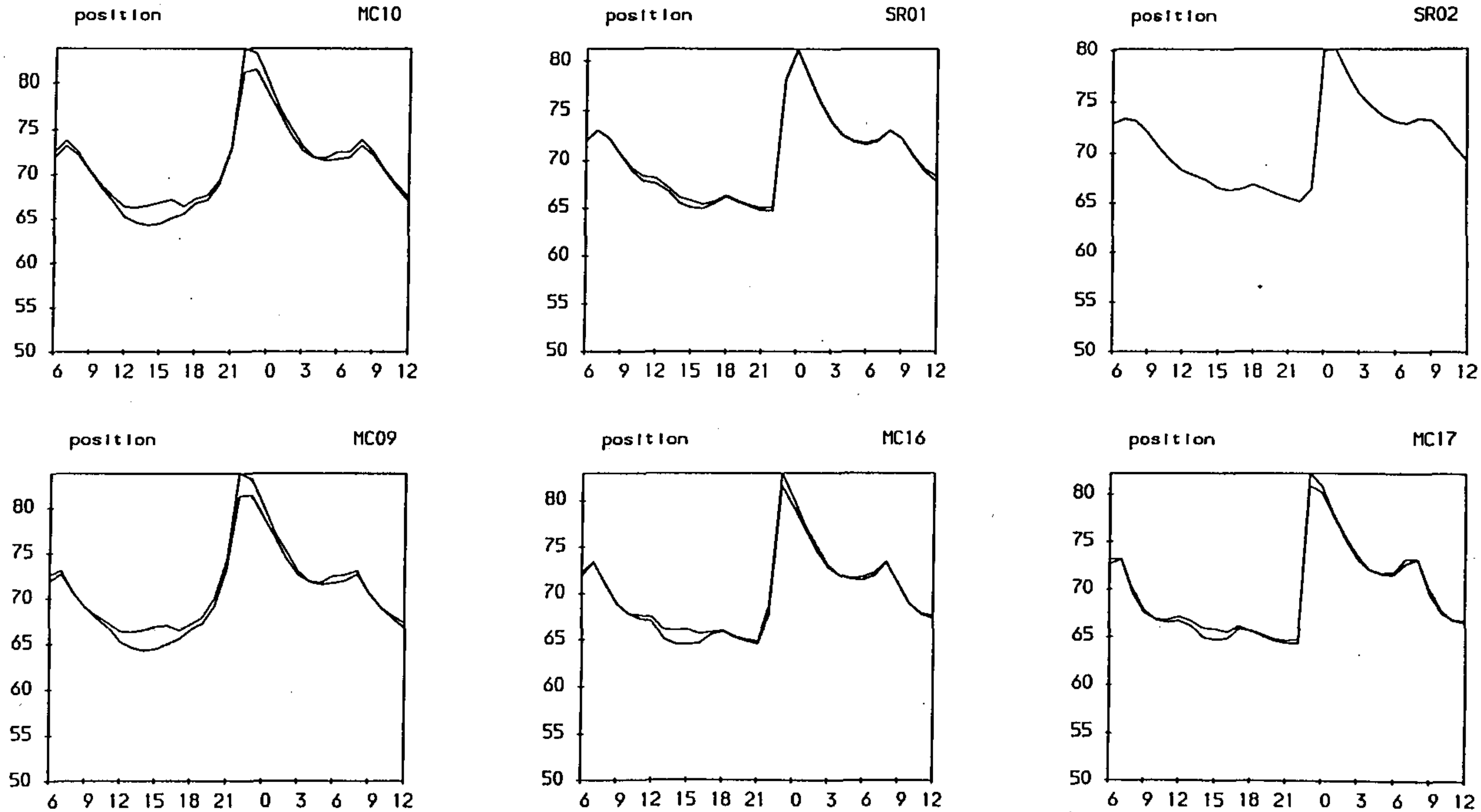


TK+Sham Tseng Dry Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid   DM 17/05/95   —— Original   ········ LongSO

Observed symbols: * Upper layer, ∆ Lower layer

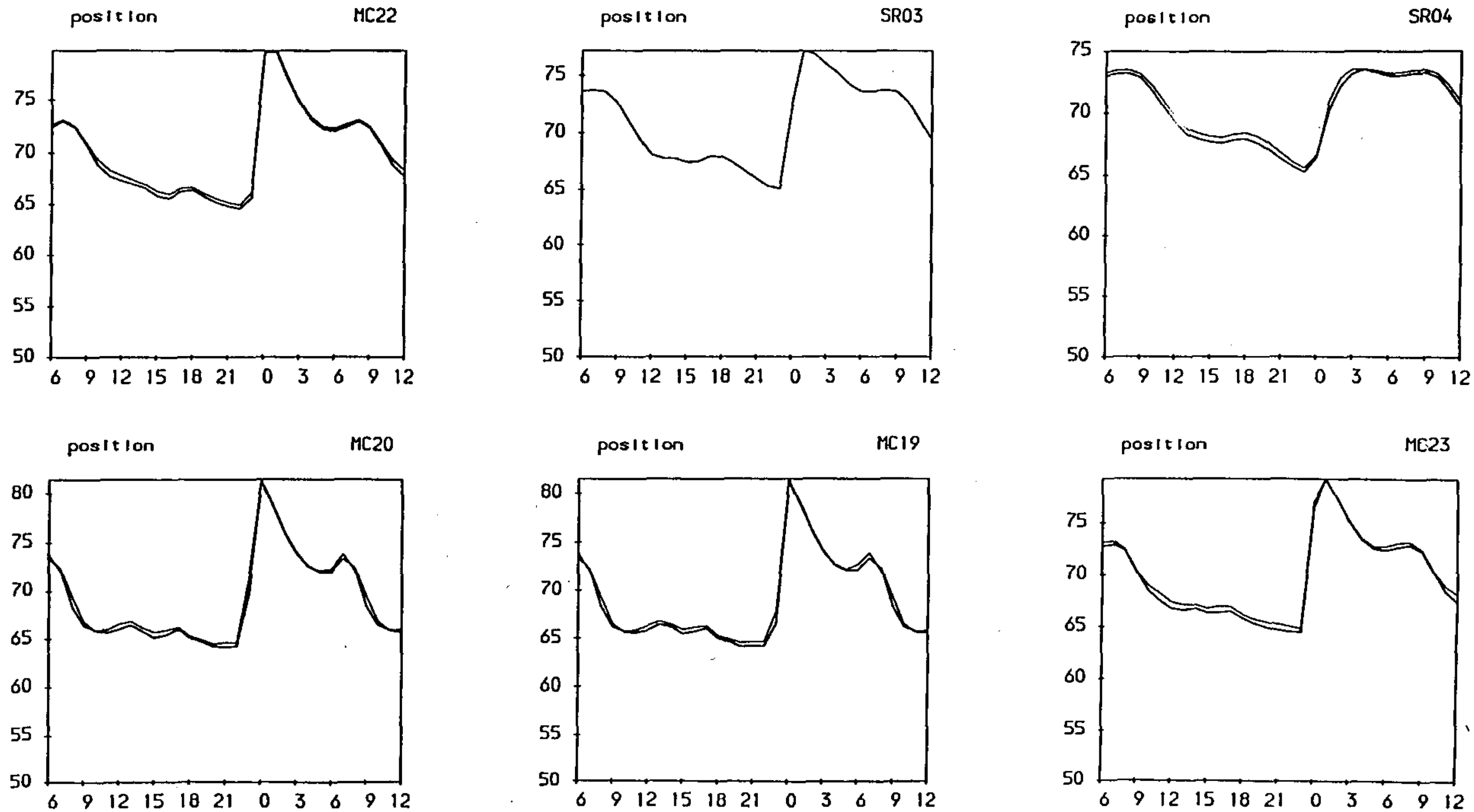


TK+Sham Tseng Dry Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

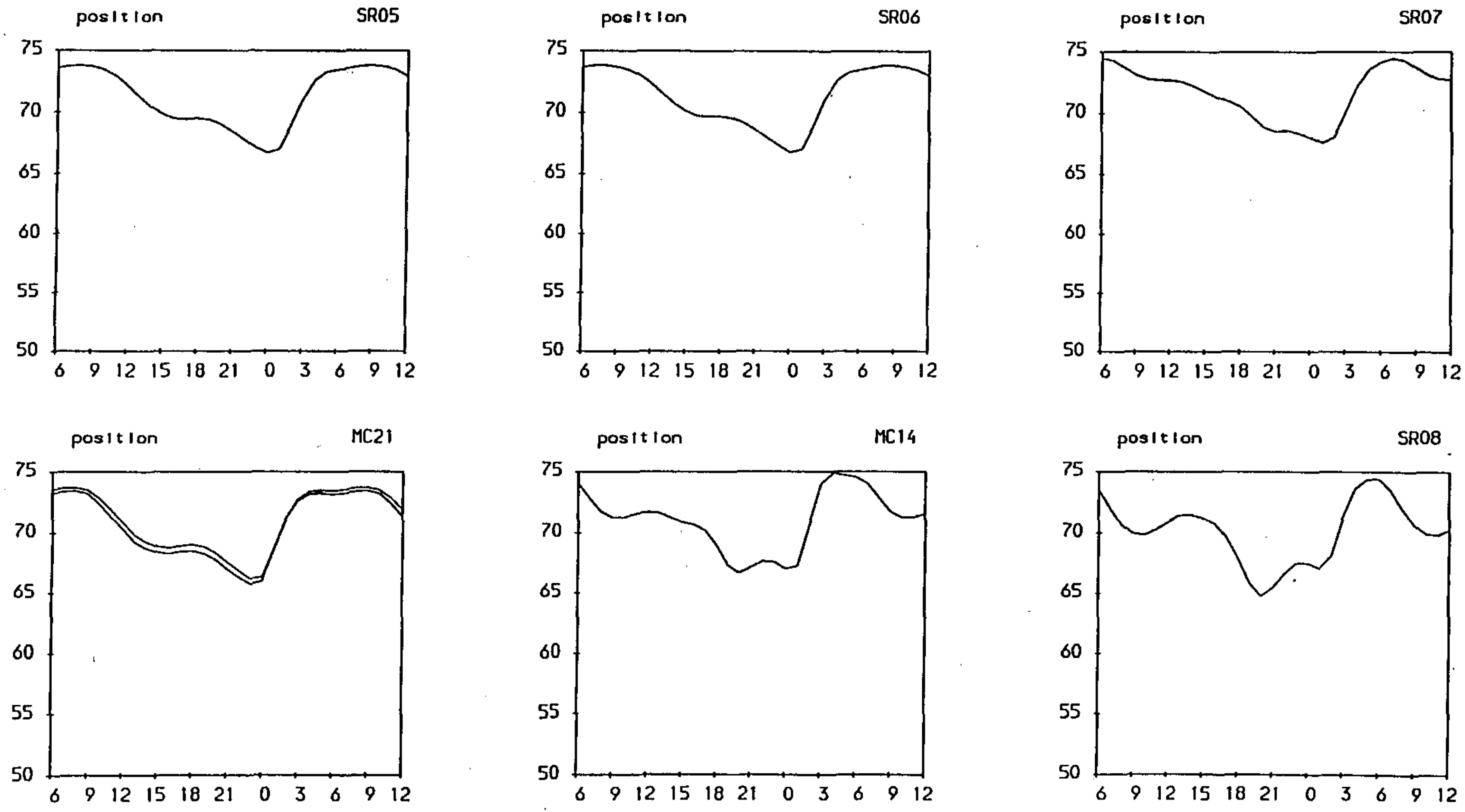


TK+Sham Tseng Dry Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

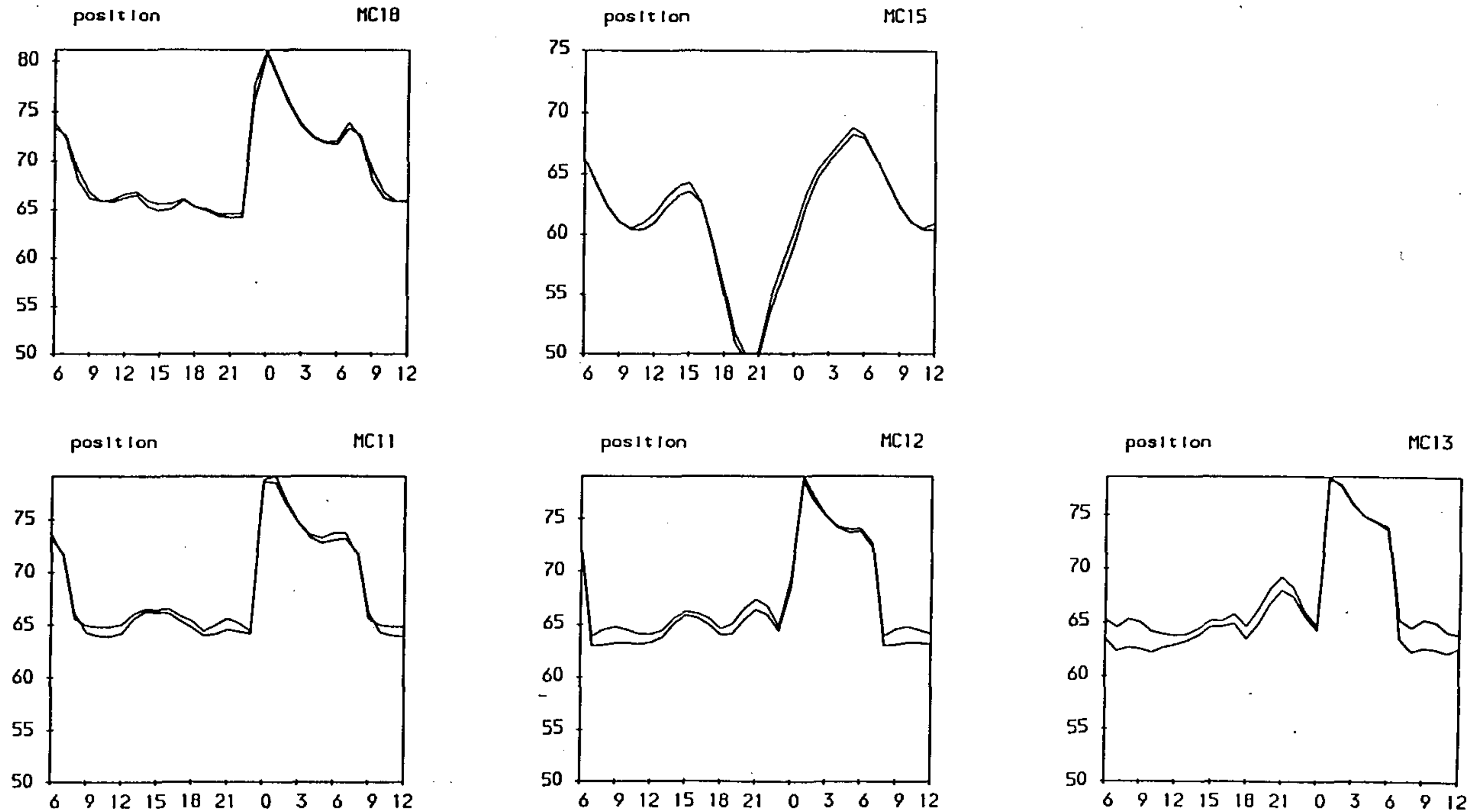


TK+Sham Tseng Dry Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

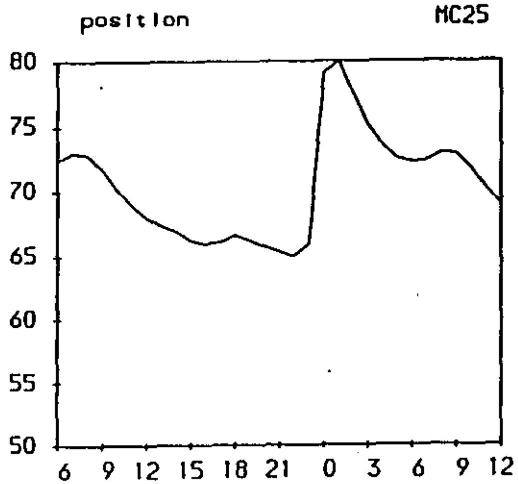


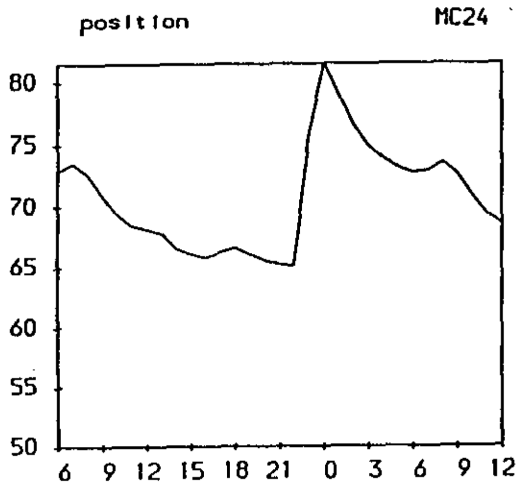
TK+Sham Tseng Dry Spring Original v LSO

Dissolved Oxygen (% saturation) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, ∆ Lower layer



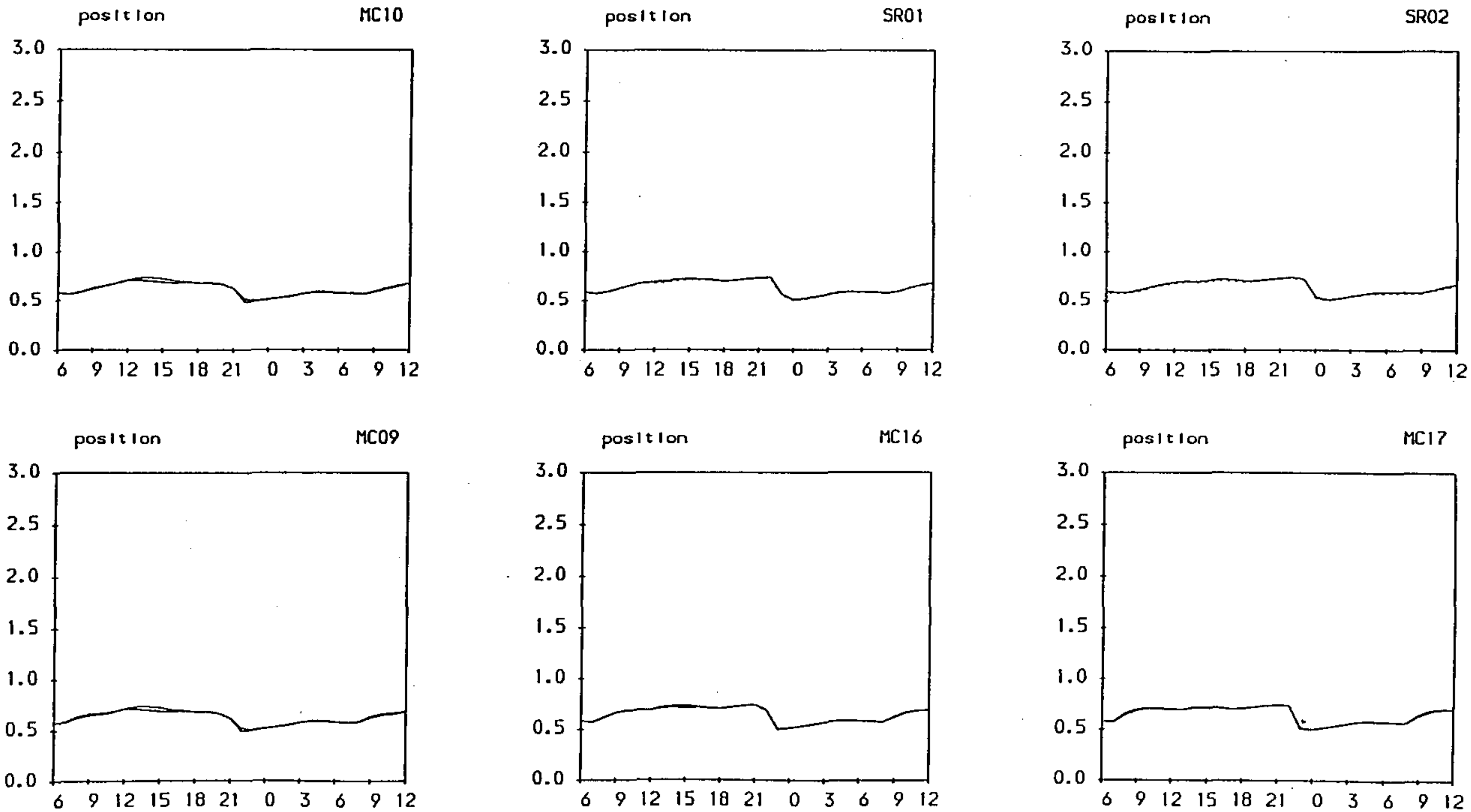


TK+Sham Tseng Dry Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, Δ Lower layer

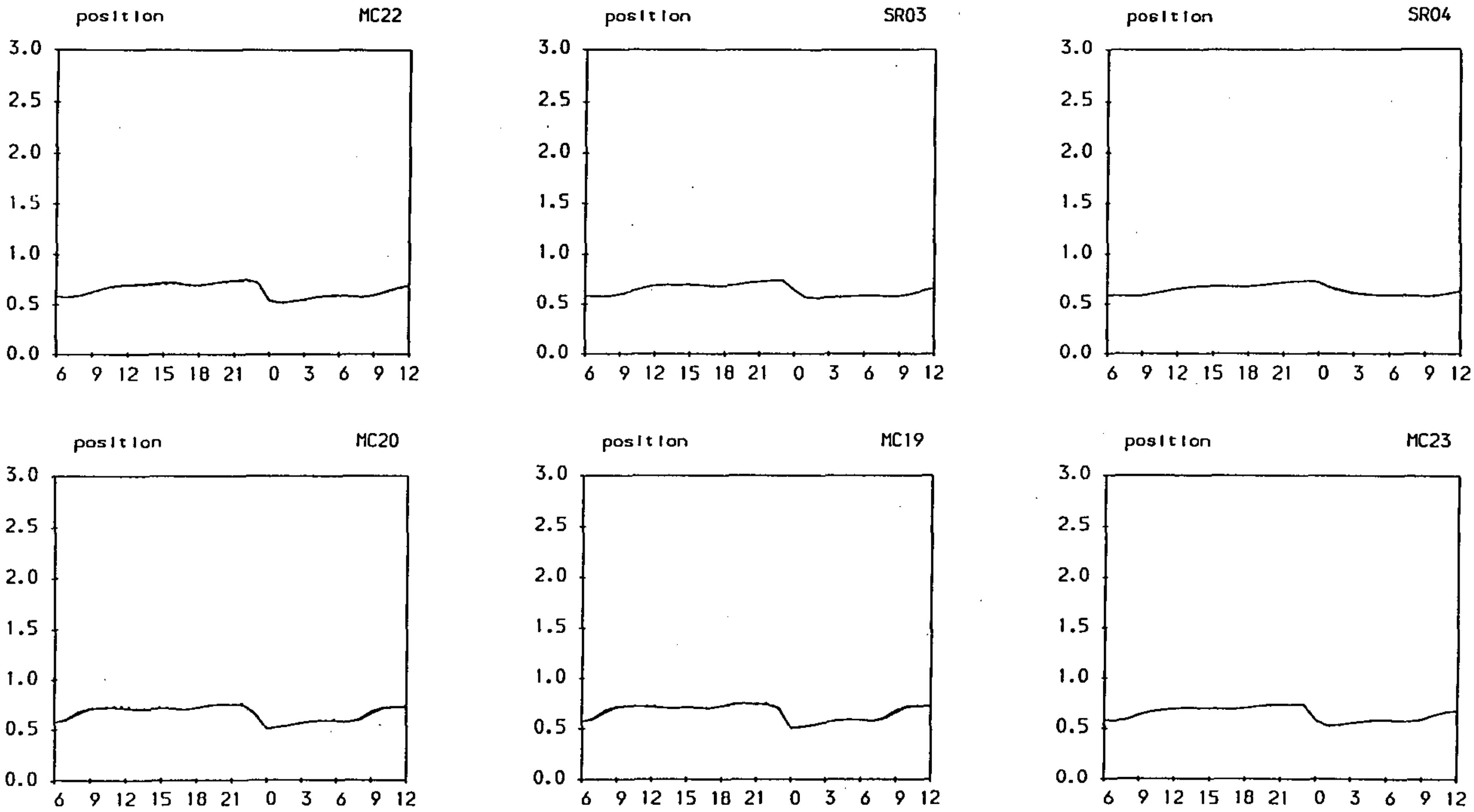


TK+Sham Tseng Dry Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

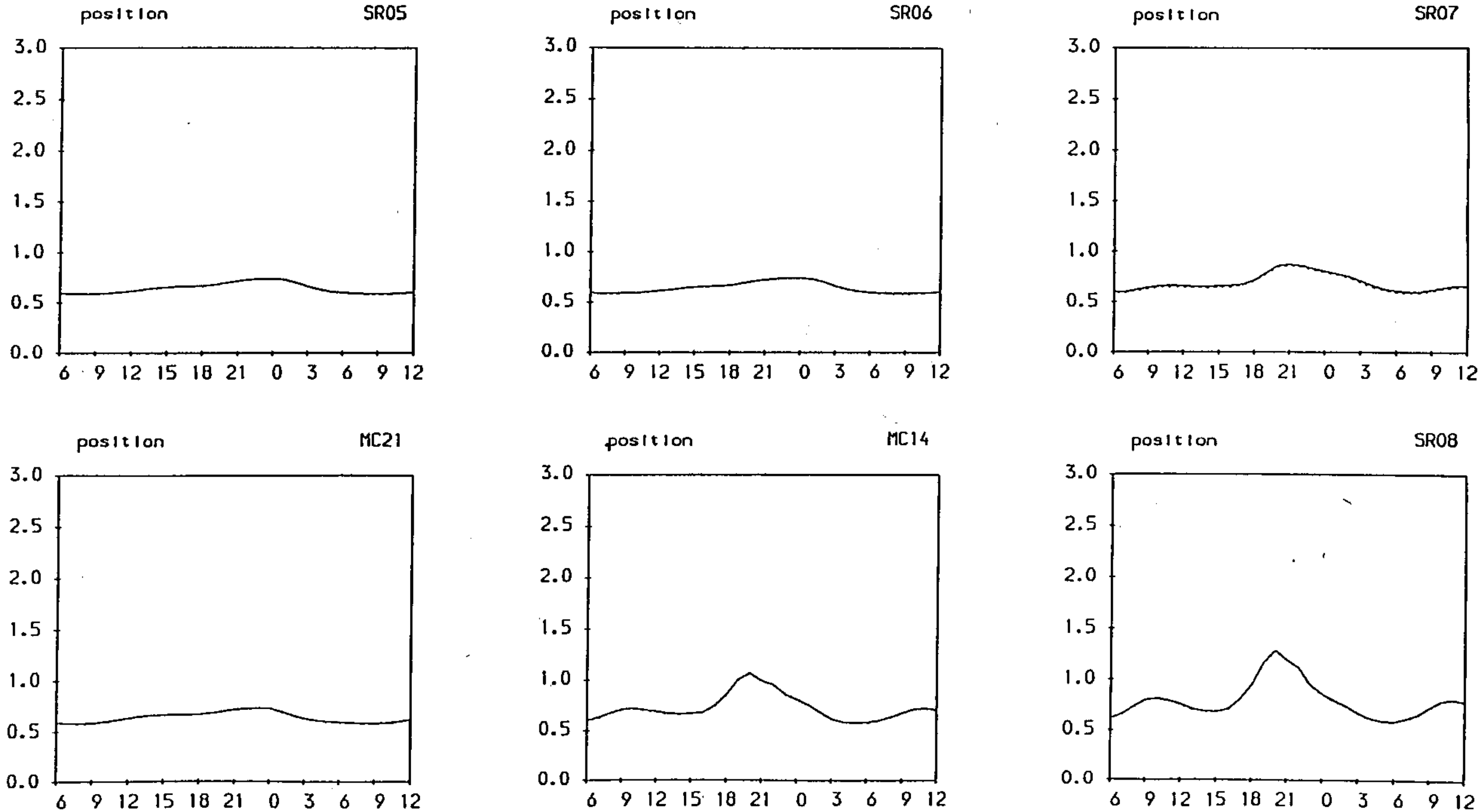


TK+Sham Tseng Dry Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid   DM 17/05/95   —— Original   .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

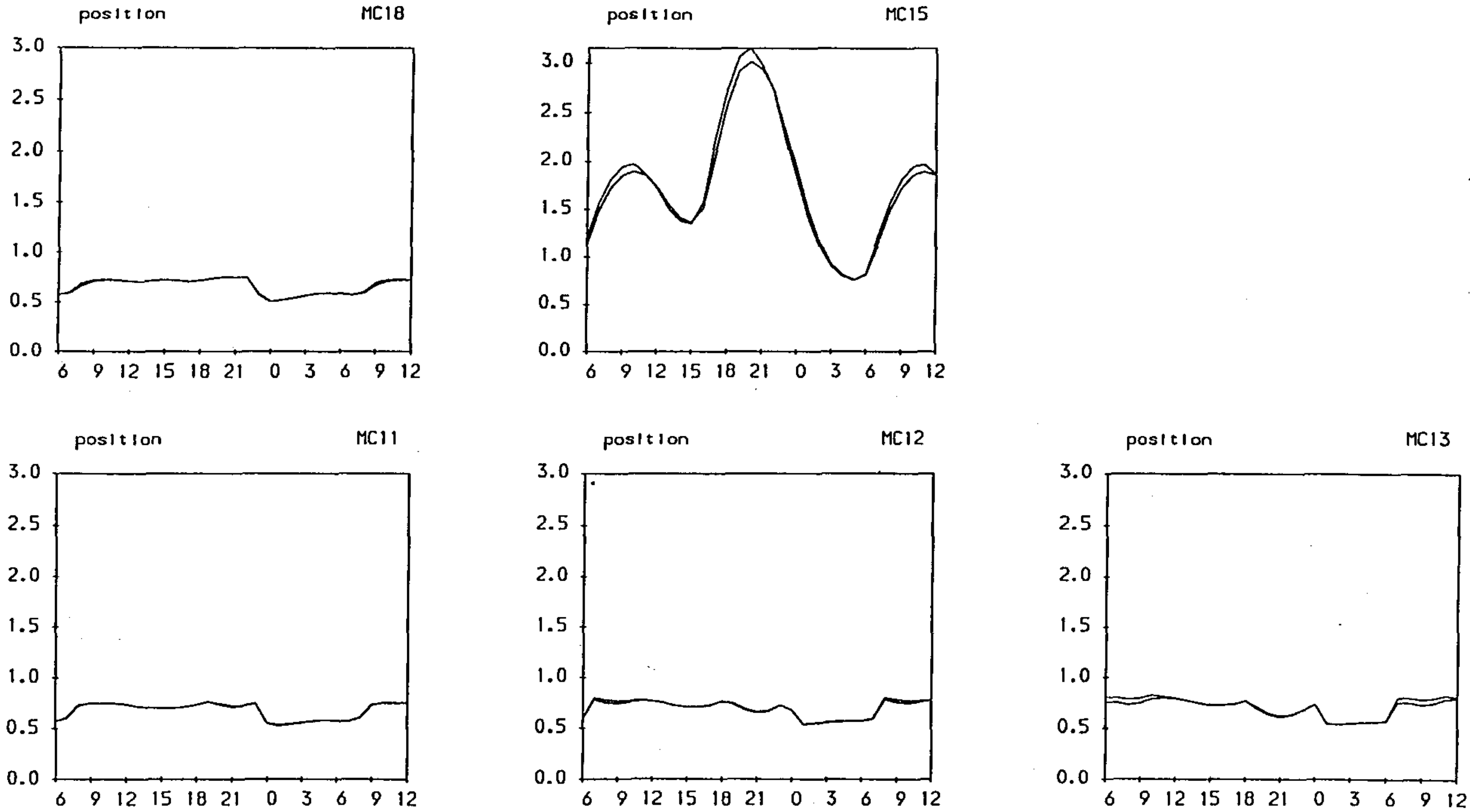


TK+Sham Tseng Dry Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid DM 17/05/95 ——— Original ········· LongSO

Observed symbols: * Upper layer, △ Lower layer

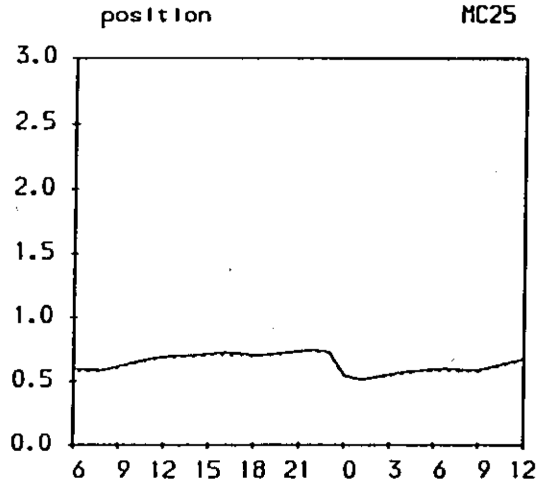


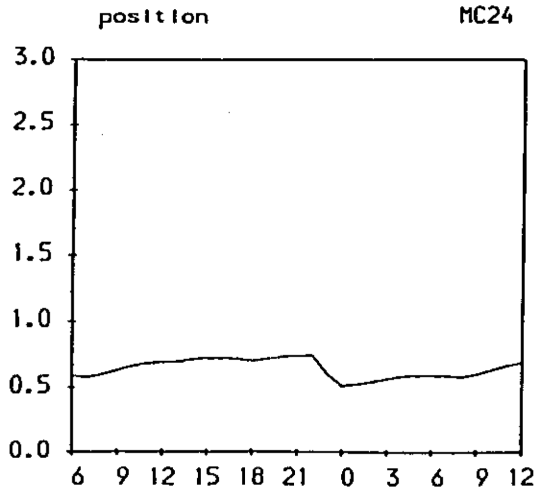
TK+Sham Tseng Dry Spring Original v LSO

BOD (mg/l) against time

2 Layer, 50m grid   DM 17/05/95   —— Original   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



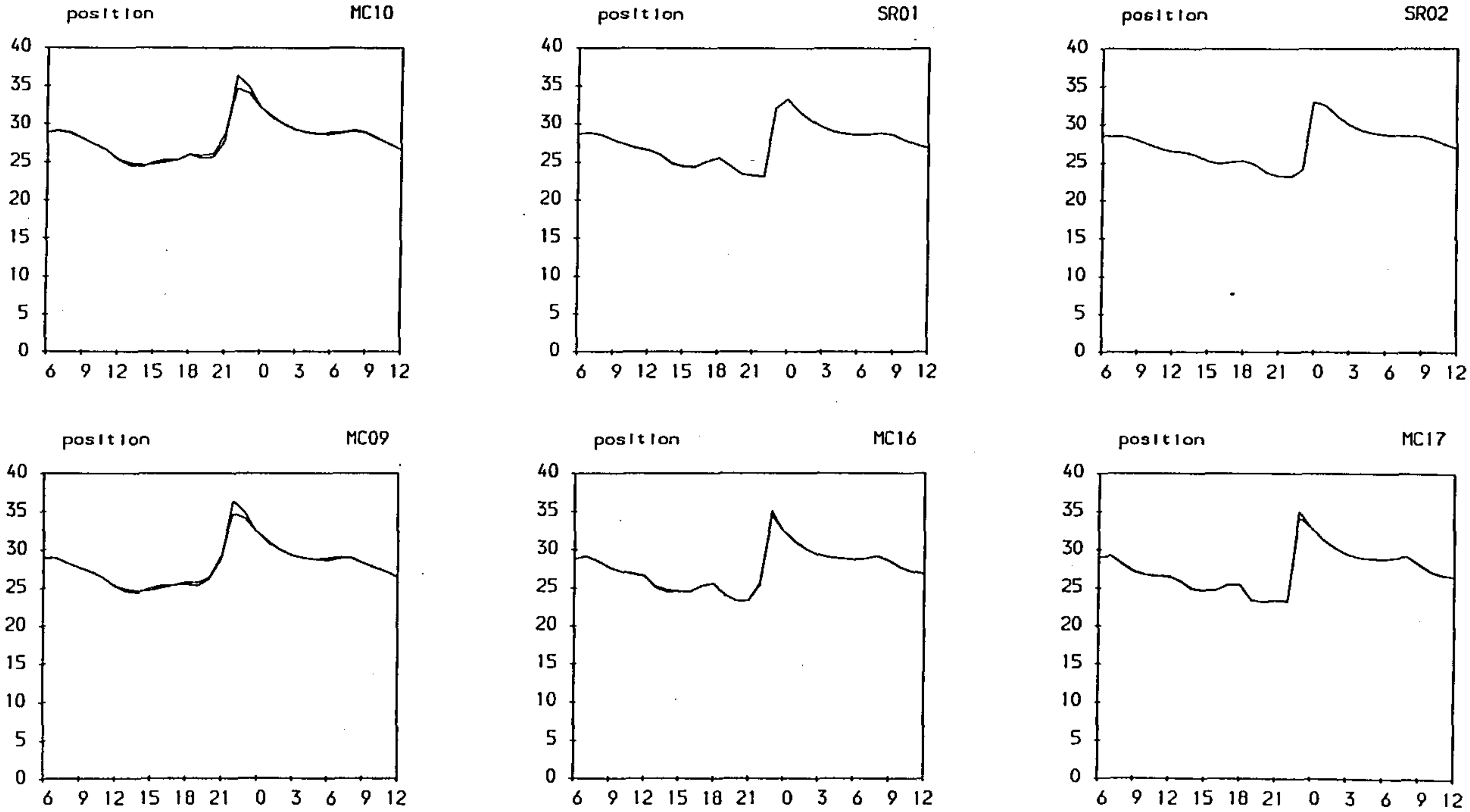


TK+Sham Tseng Dry Spring Original v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

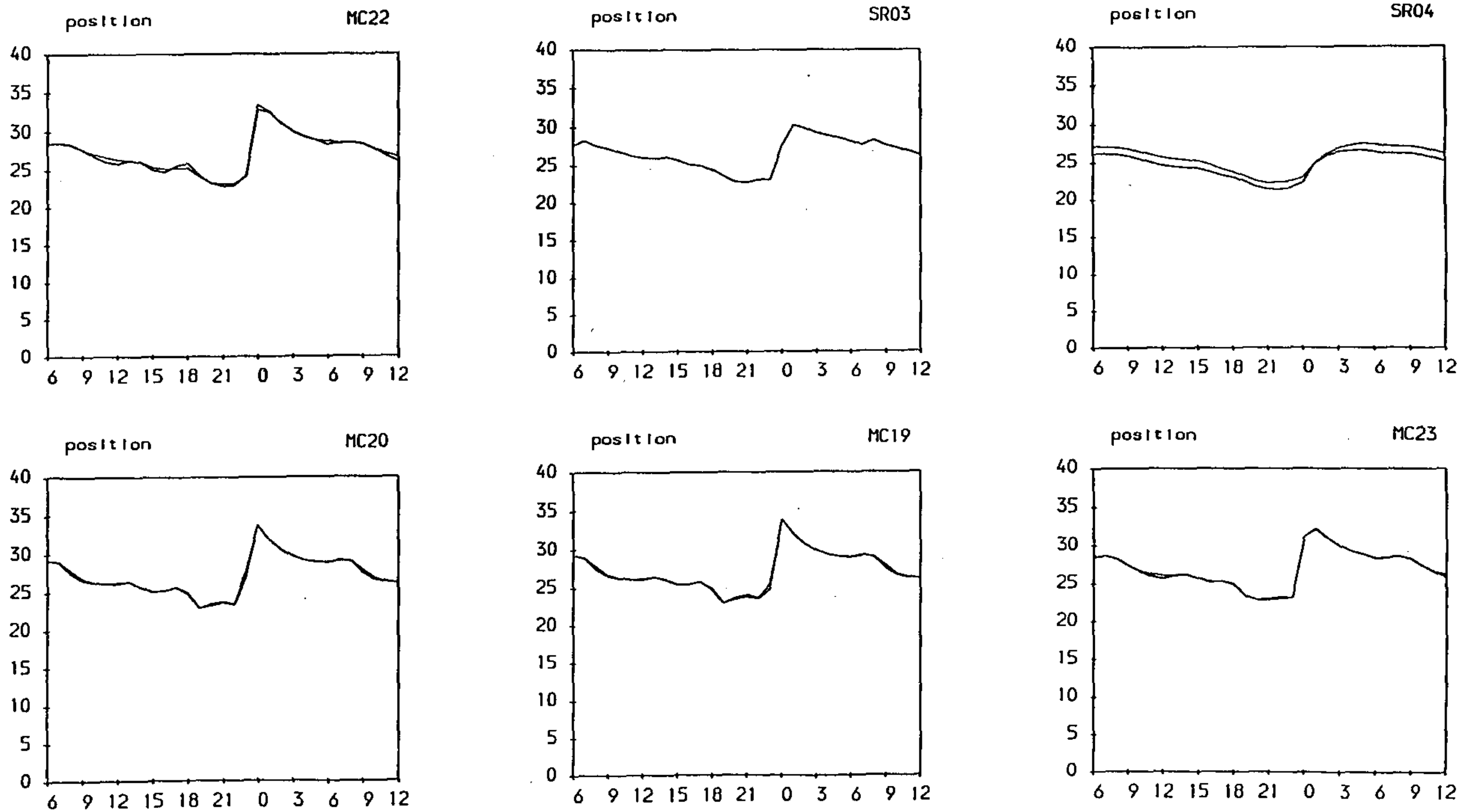


TK+Sham Tseng Dry Spring Original v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid   DM 17/05/95   —— Original   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

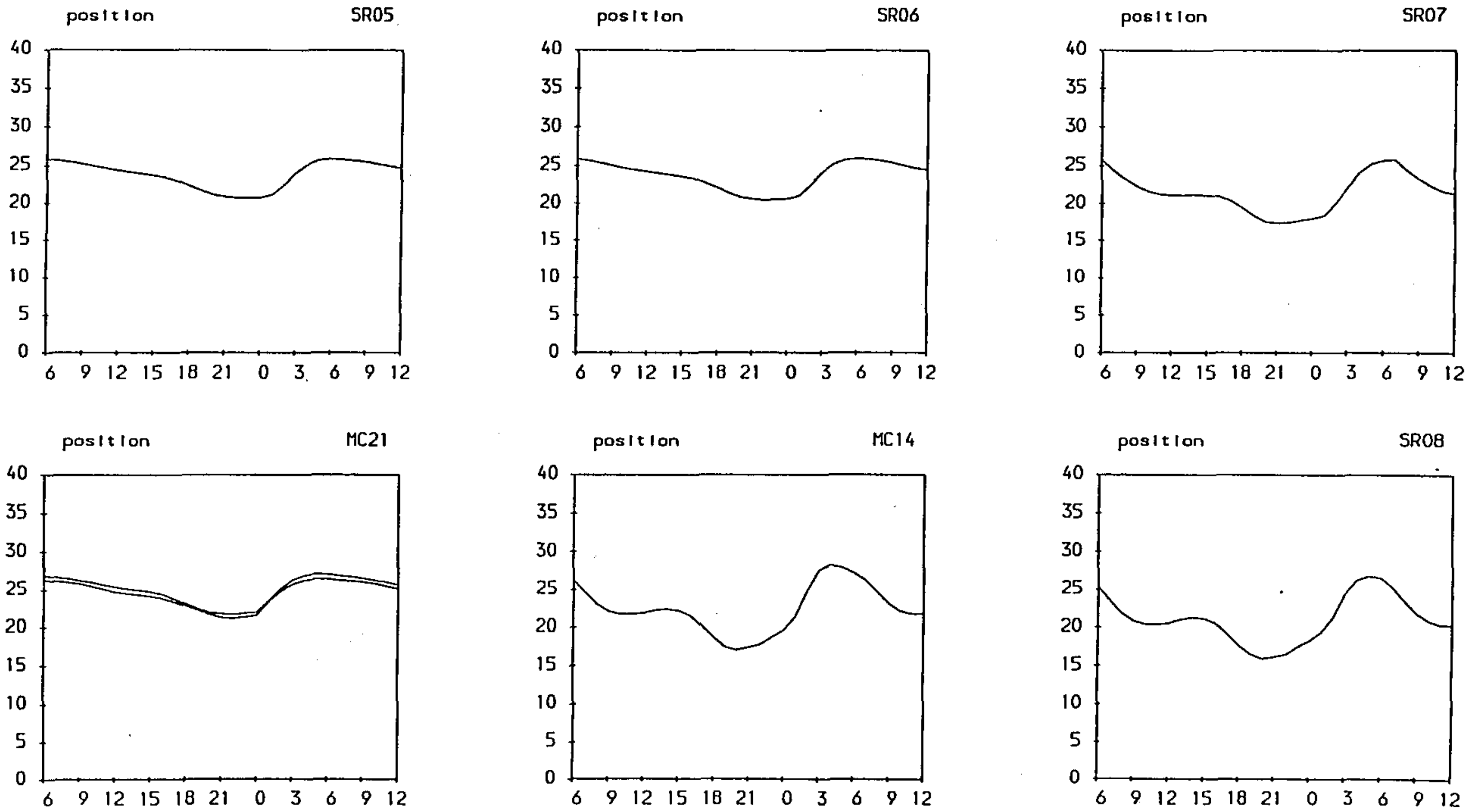


TK+Sham Tseng Dry Spring Original v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 17/05/95 ——— Original .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

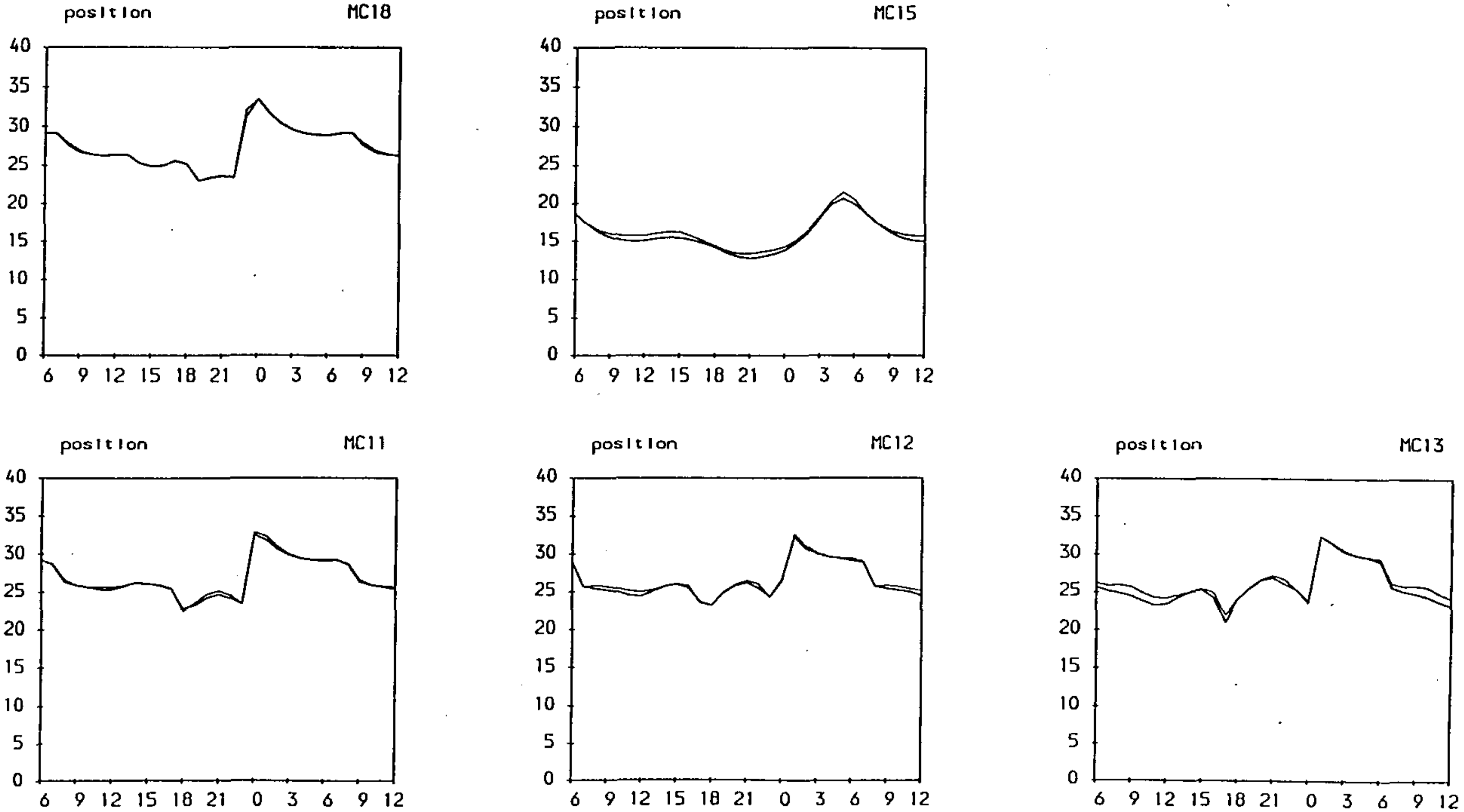


TK+Sham Tseng Dry Spring Original v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

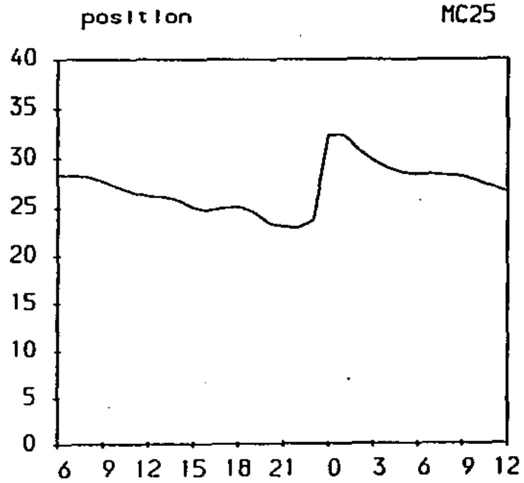


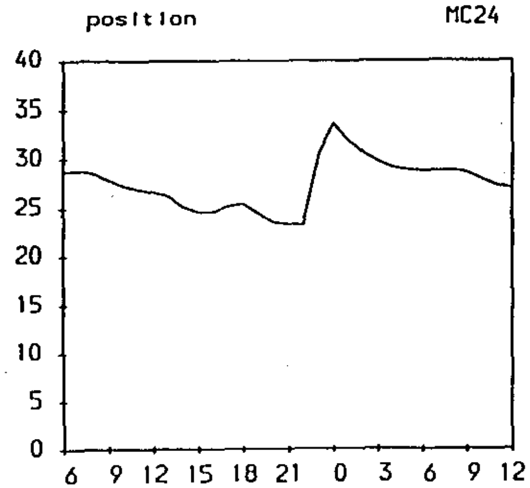
TK+Sham Tseng Dry Spring Original v LSO

Suspended Solids (mg/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, Δ Lower layer



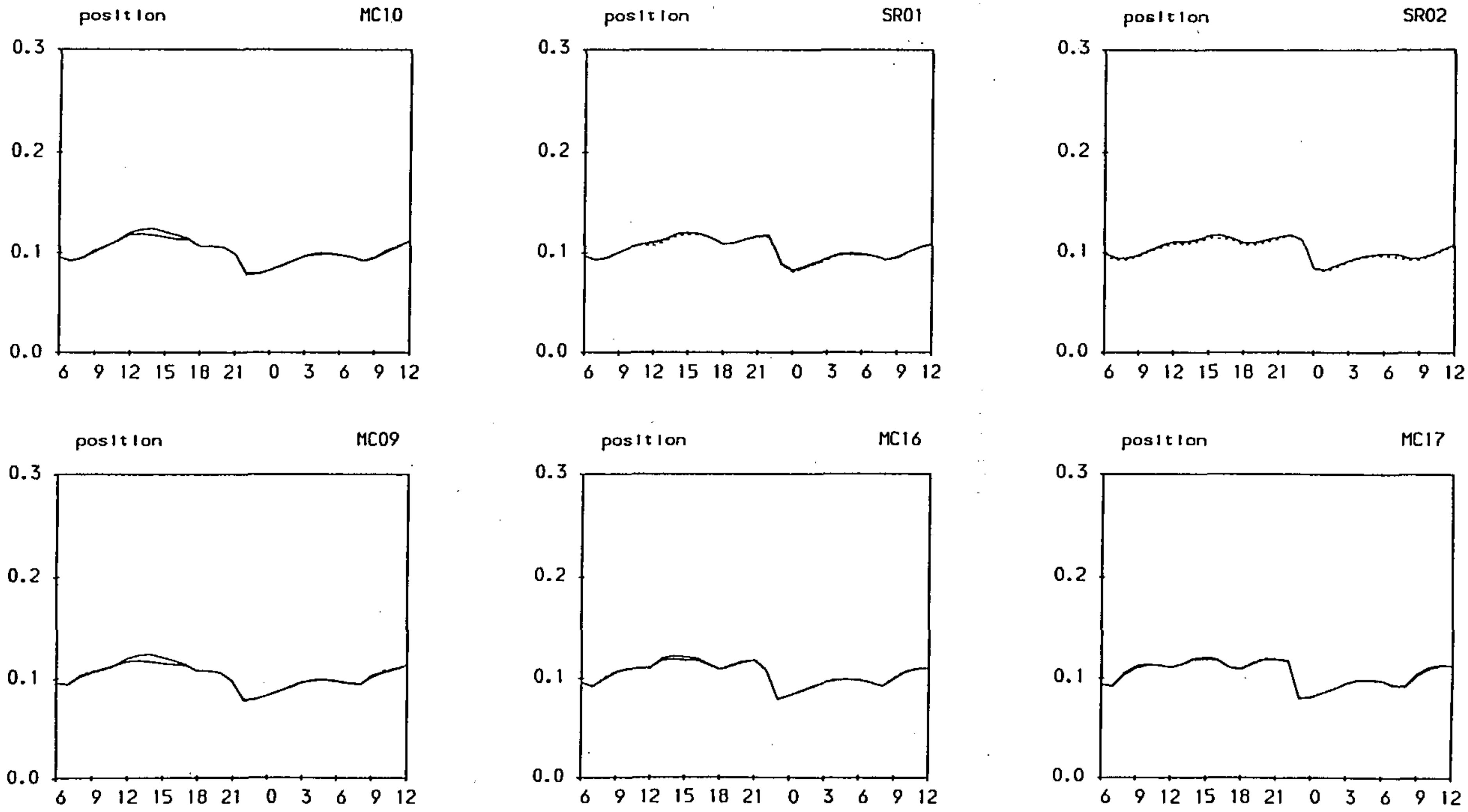


TK+Sham Tseng Dry Spring Original v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, Δ Lower layer

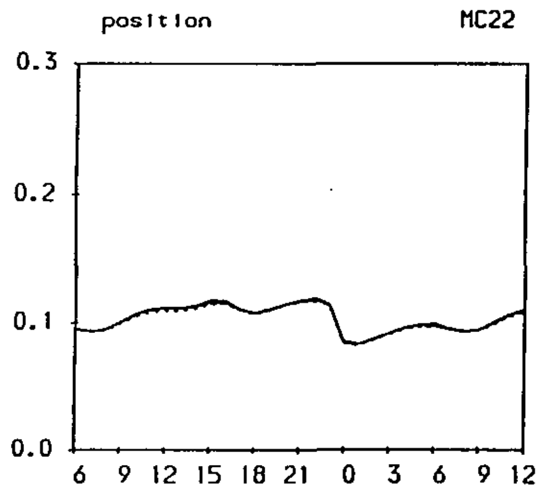


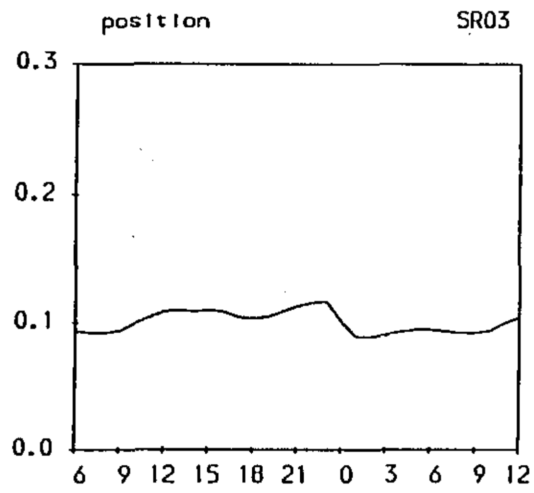
TK+Sham Tseng Dry Spring Original v LSO

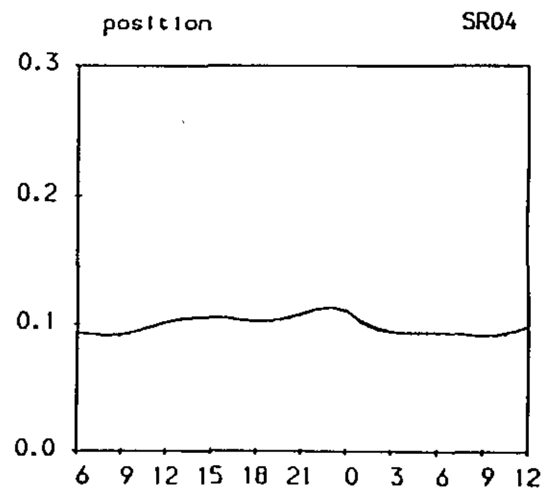
Ammoniacal Nitrogen (mg N/l) against time

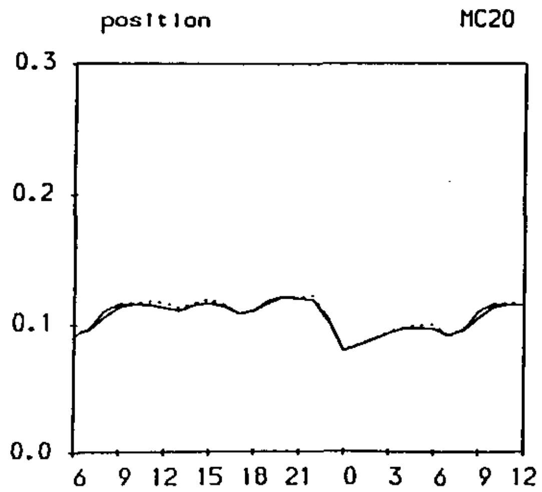
2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

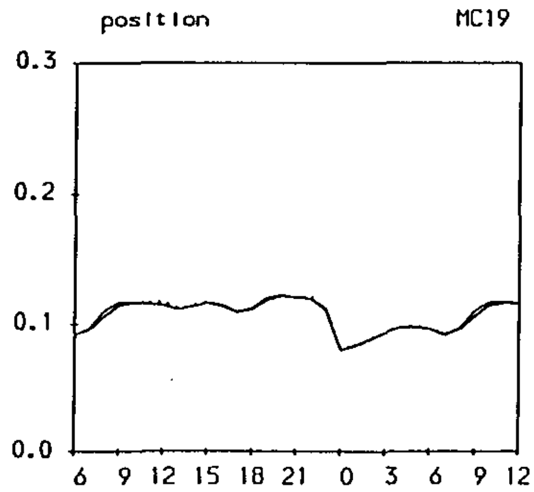
Observed symbols: * Upper layer, △ Lower layer

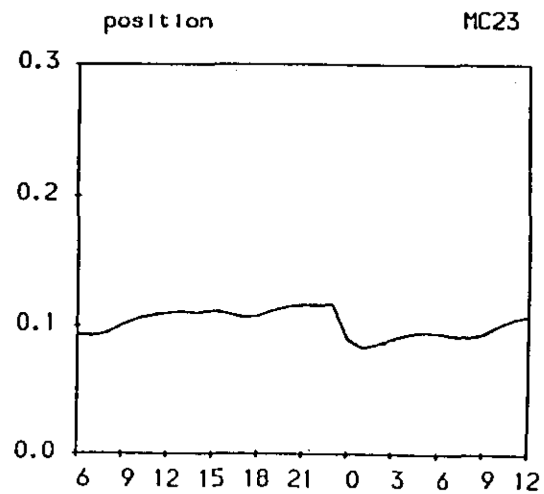










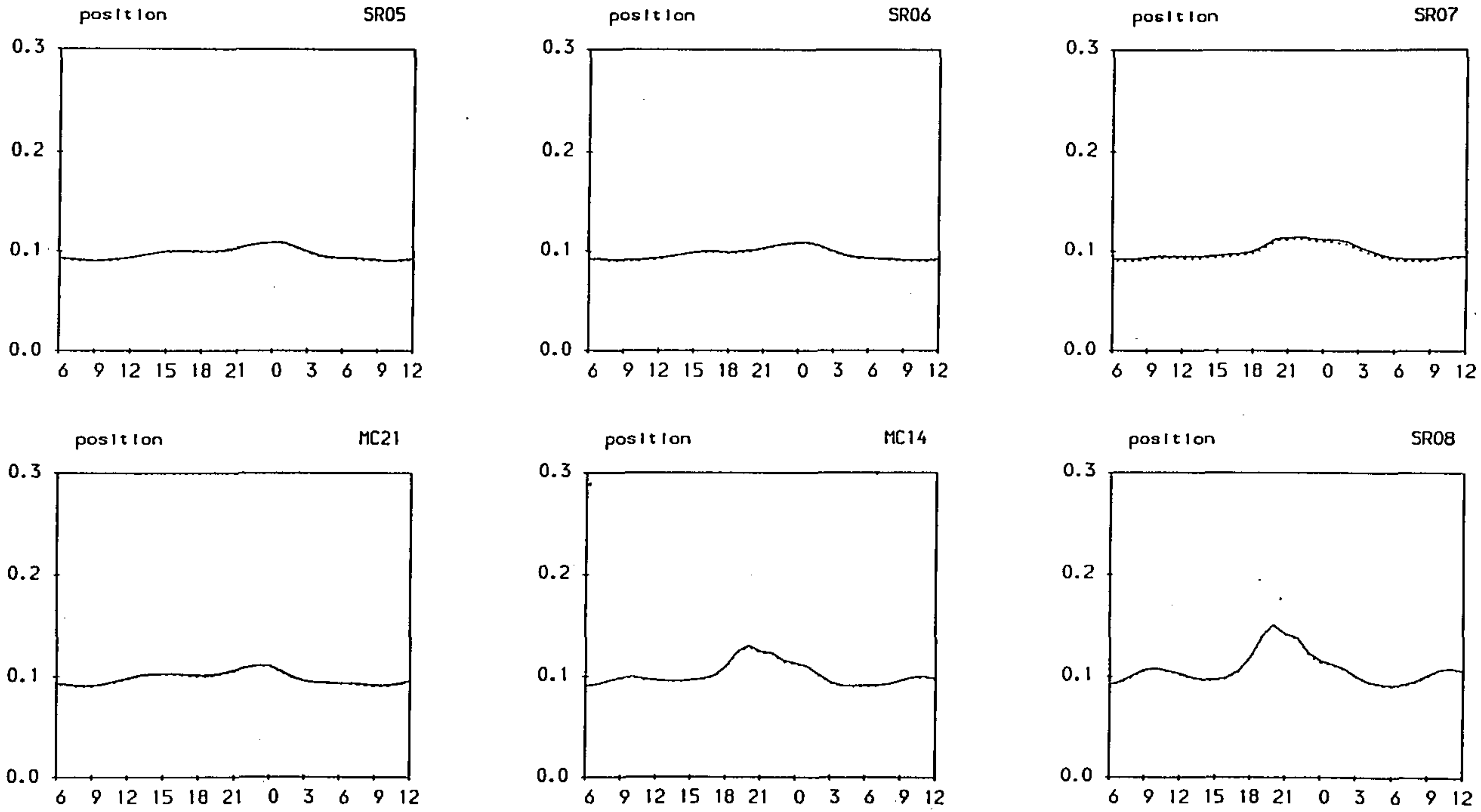


TK+Sham Tseng Dry Spring Original v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

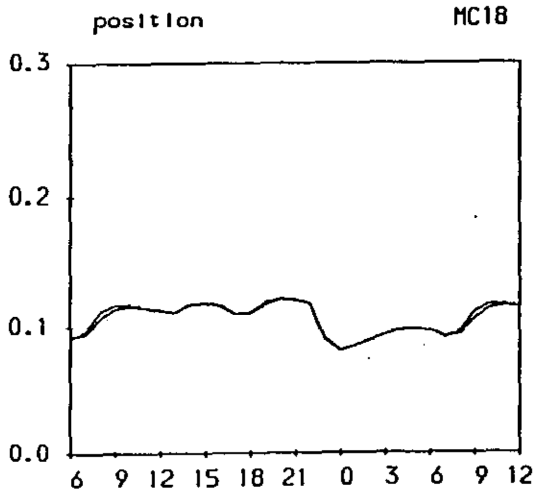


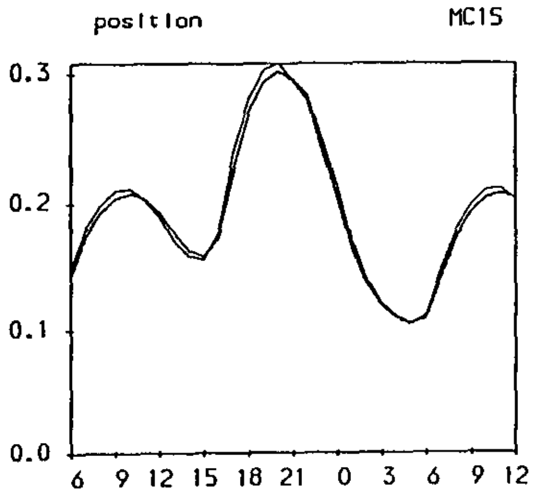
TK+Sham Tseng Dry Spring Original v LSO

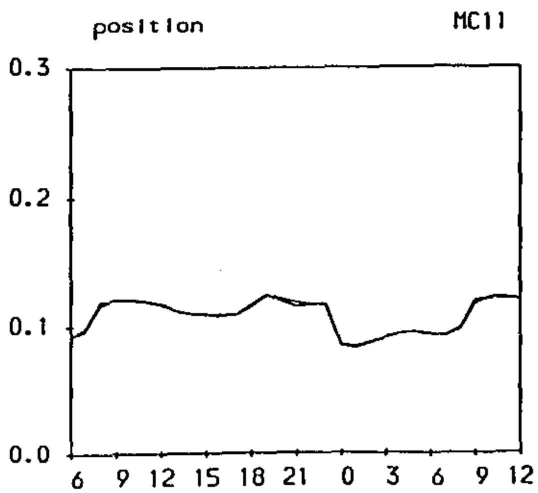
Ammoniacal Nitrogen (mg N/l) against time

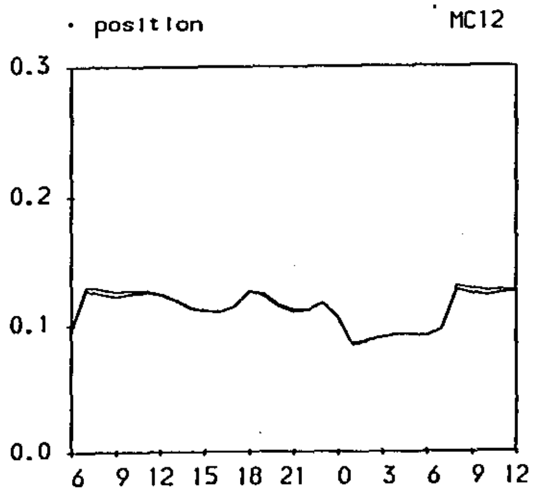
2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

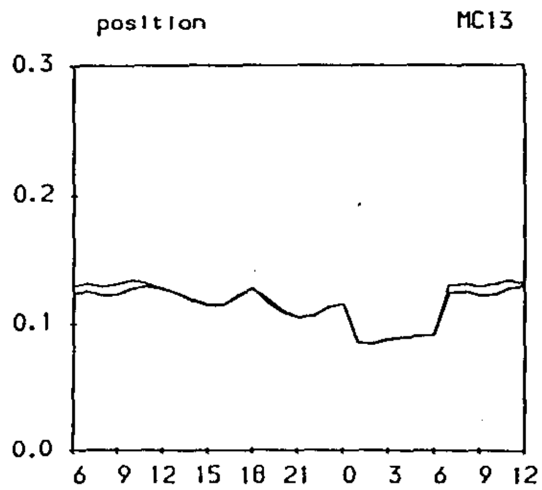
Observed symbols: * Upper layer, △ Lower layer









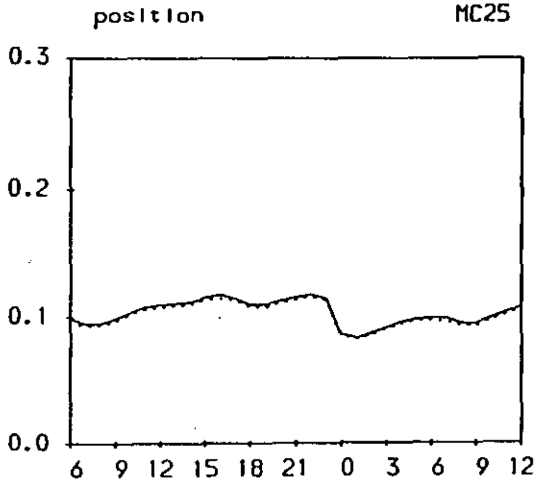


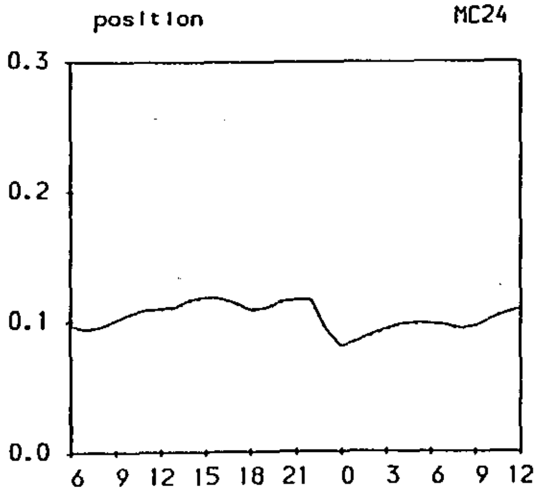
TK+Sham Tseng Dry Spring Original v LSO

Ammoniacal Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer



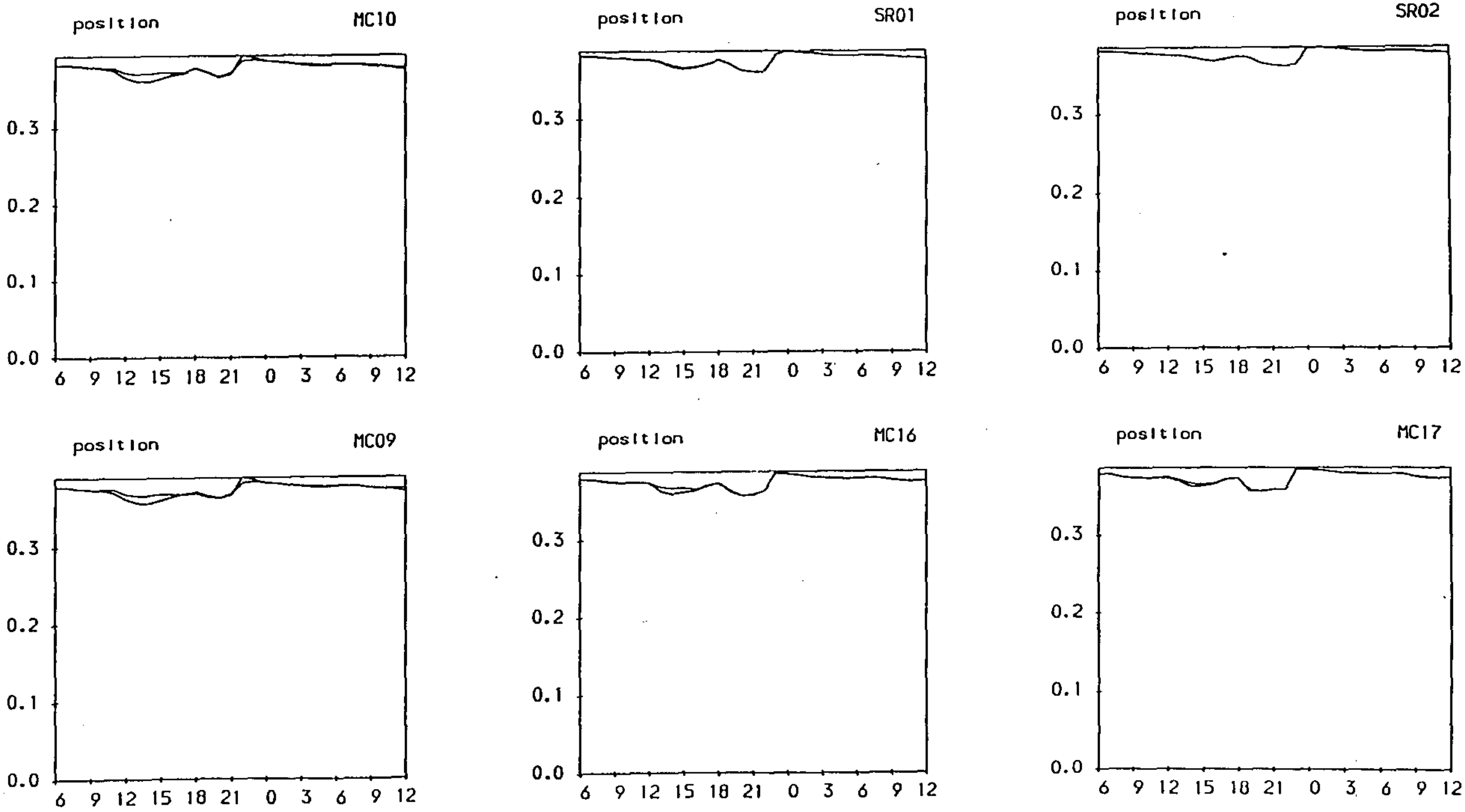


TK+Sham Tseng Dry Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

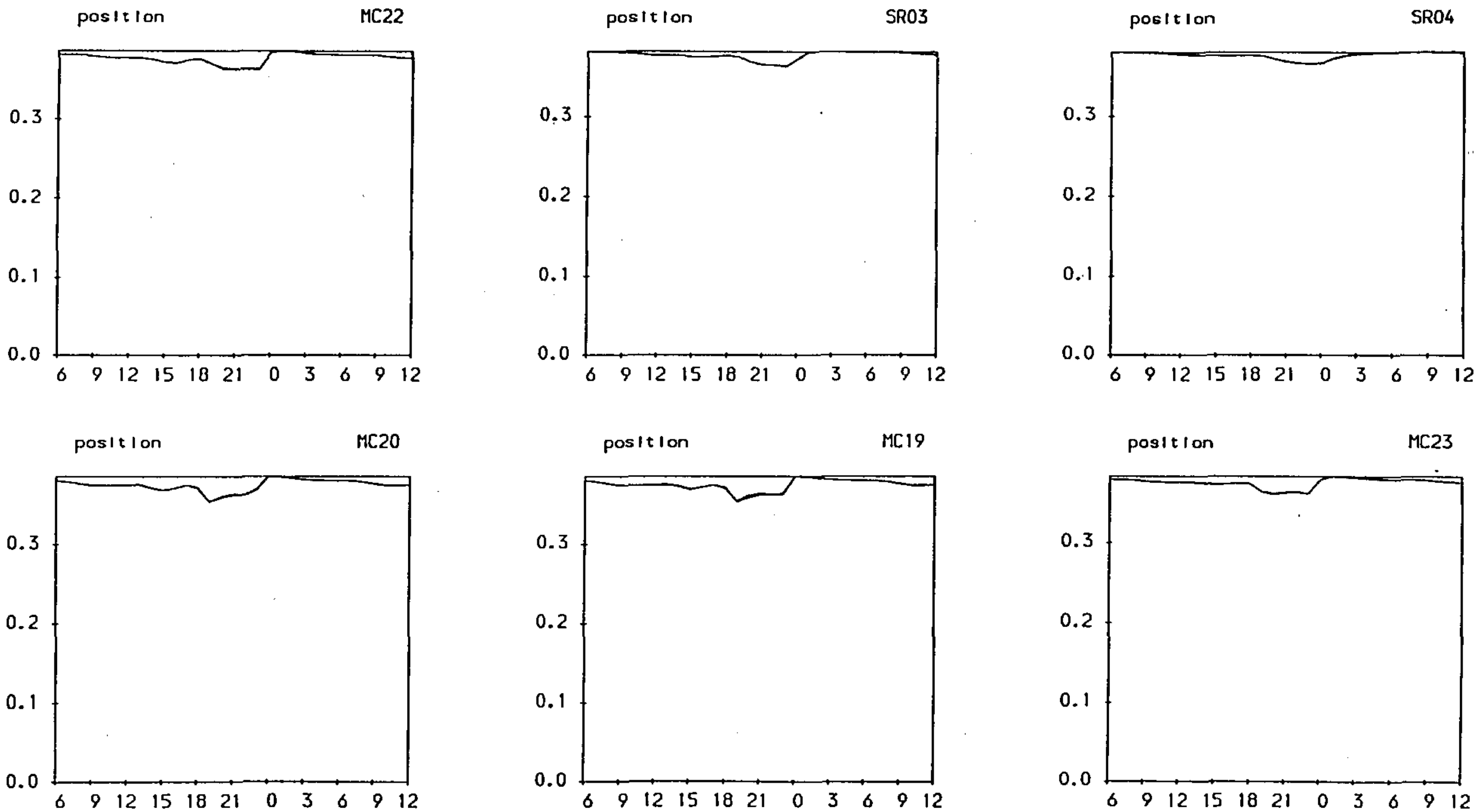


TK+Sham Tseng Dry Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

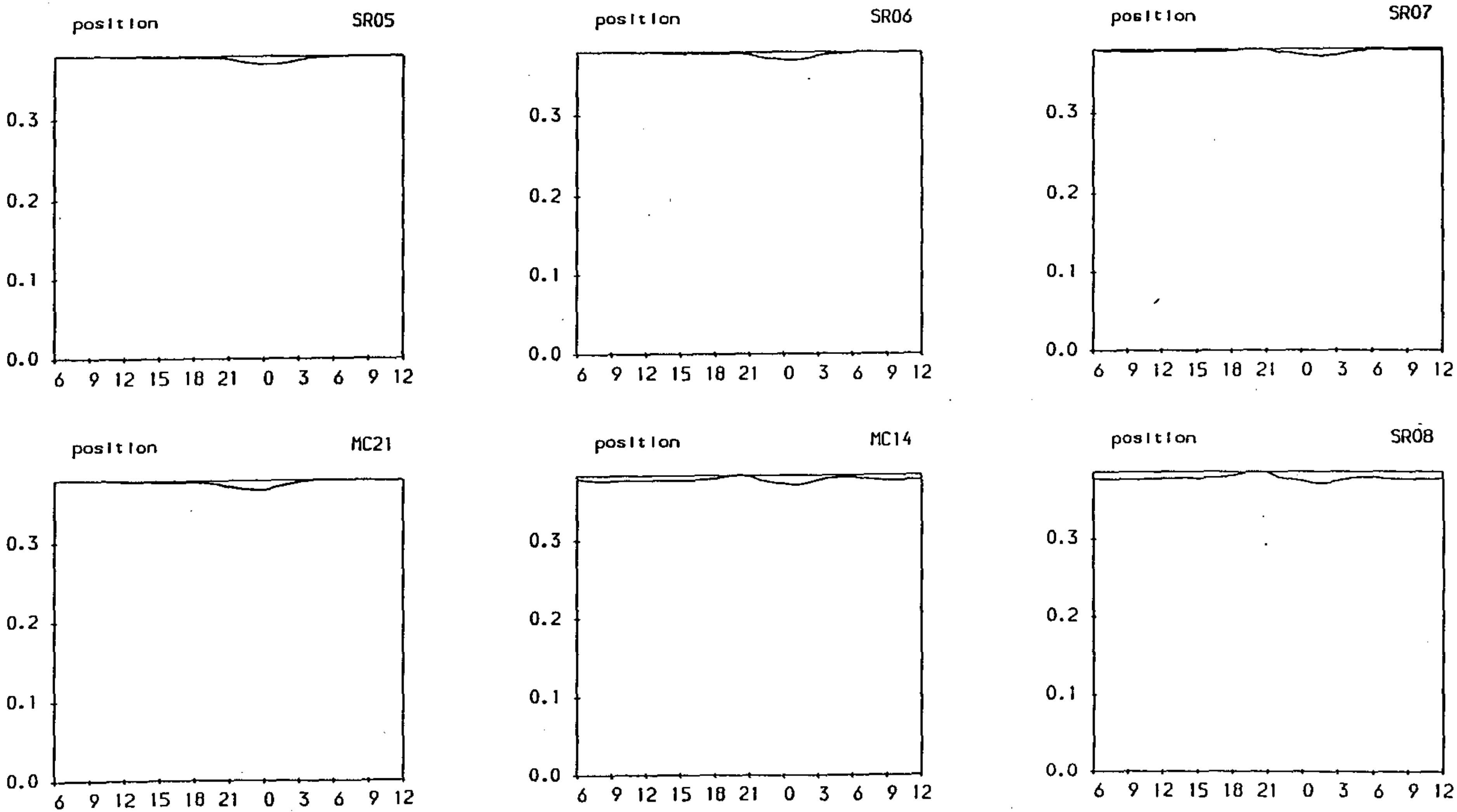


TK+Sham Tseng Dry Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 17/05/95   —— Original   .... LongSO

Observed symbols: * Upper layer, △ Lower layer

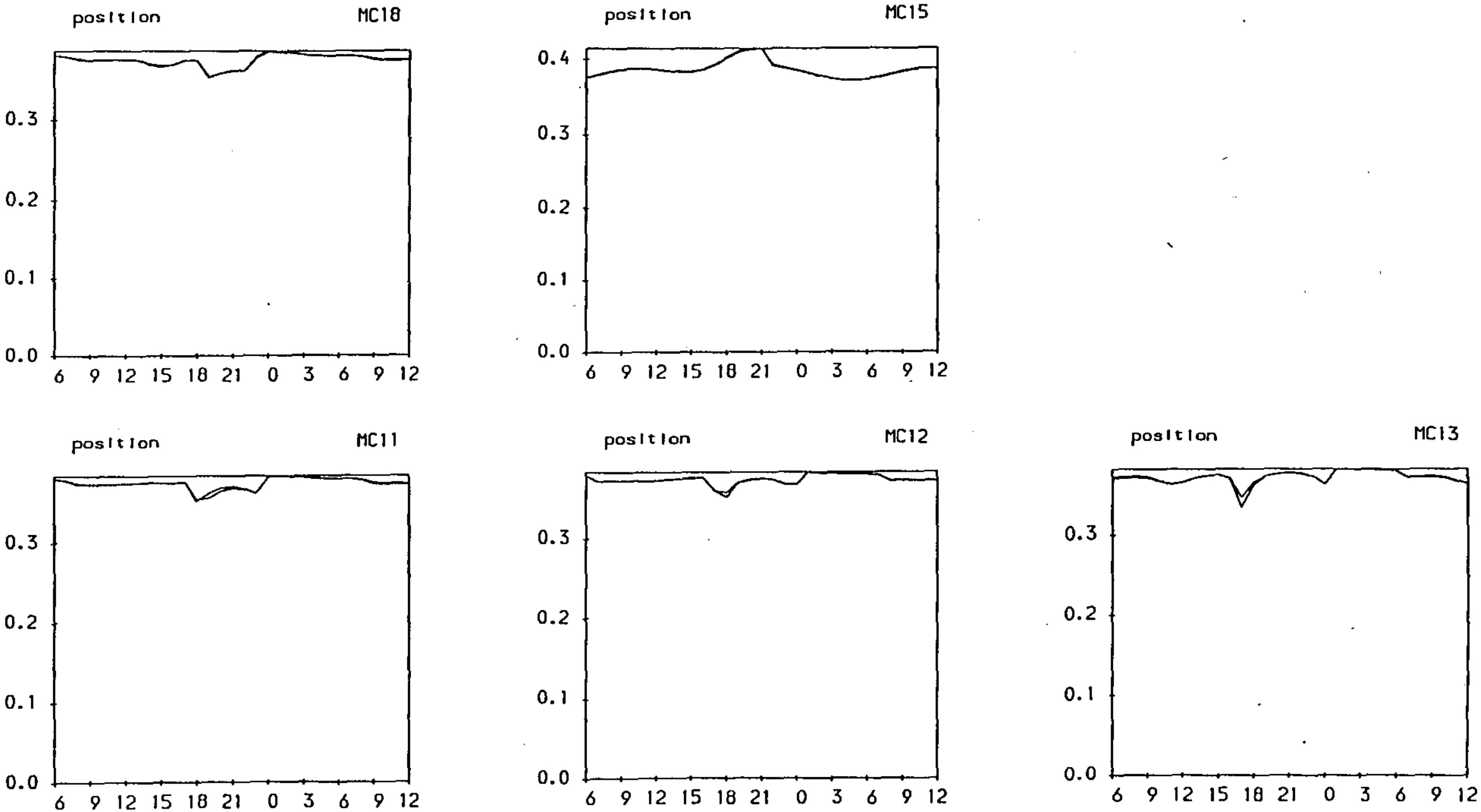


TK+Sham Tseng Dry Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer

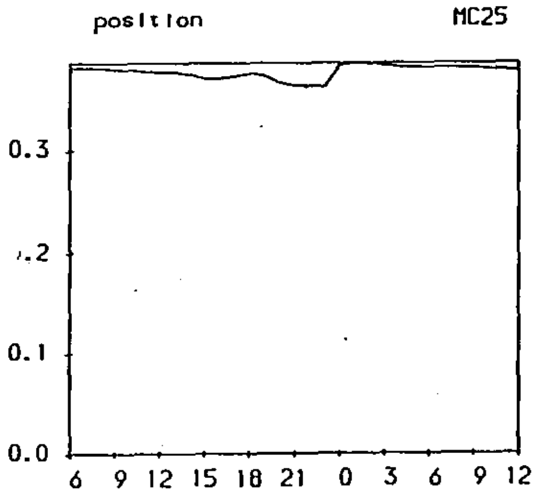


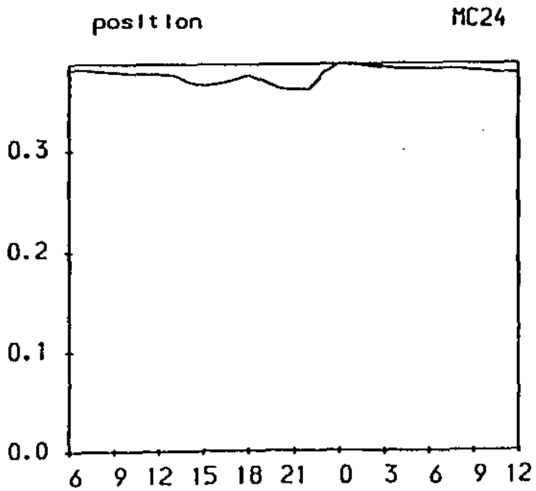
TK+Sham Tseng Dry Spring Original v LSO

Oxidised Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer



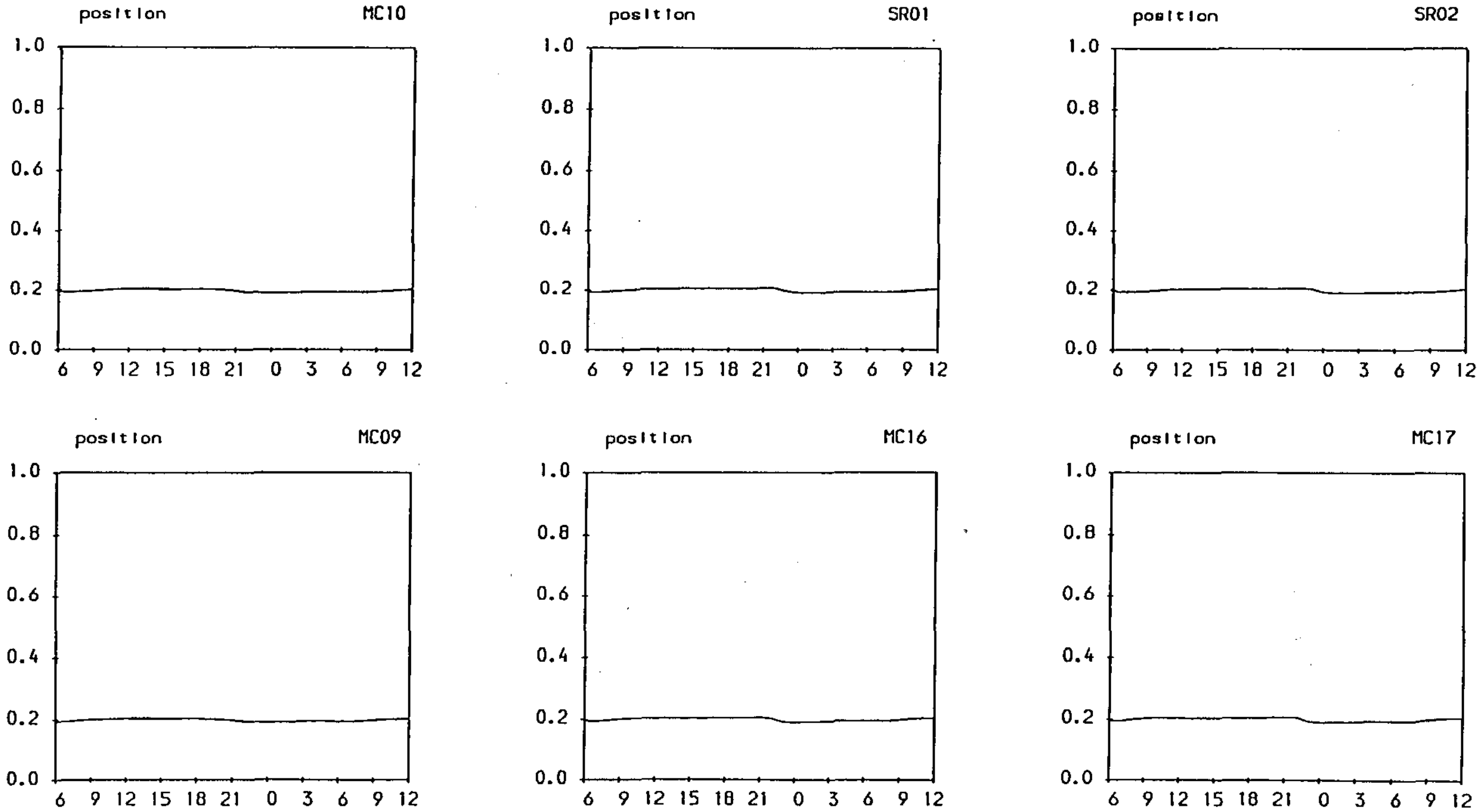


TK+Sham Tseng Dry Spring Original v LSO

Organic Nitrogen (mg N/L) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, △ Lower layer

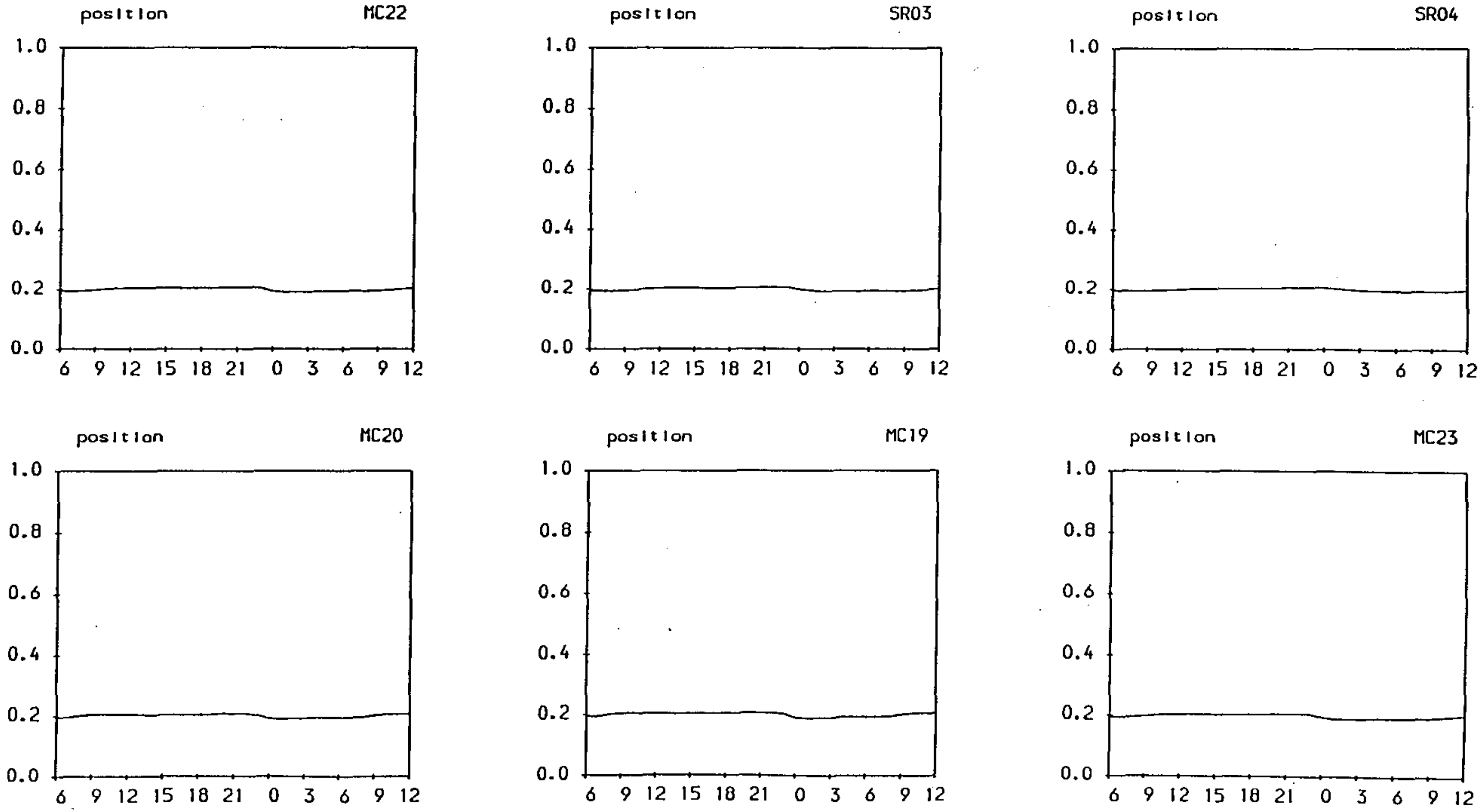


TK+Sham Tseng Dry Spring Original v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

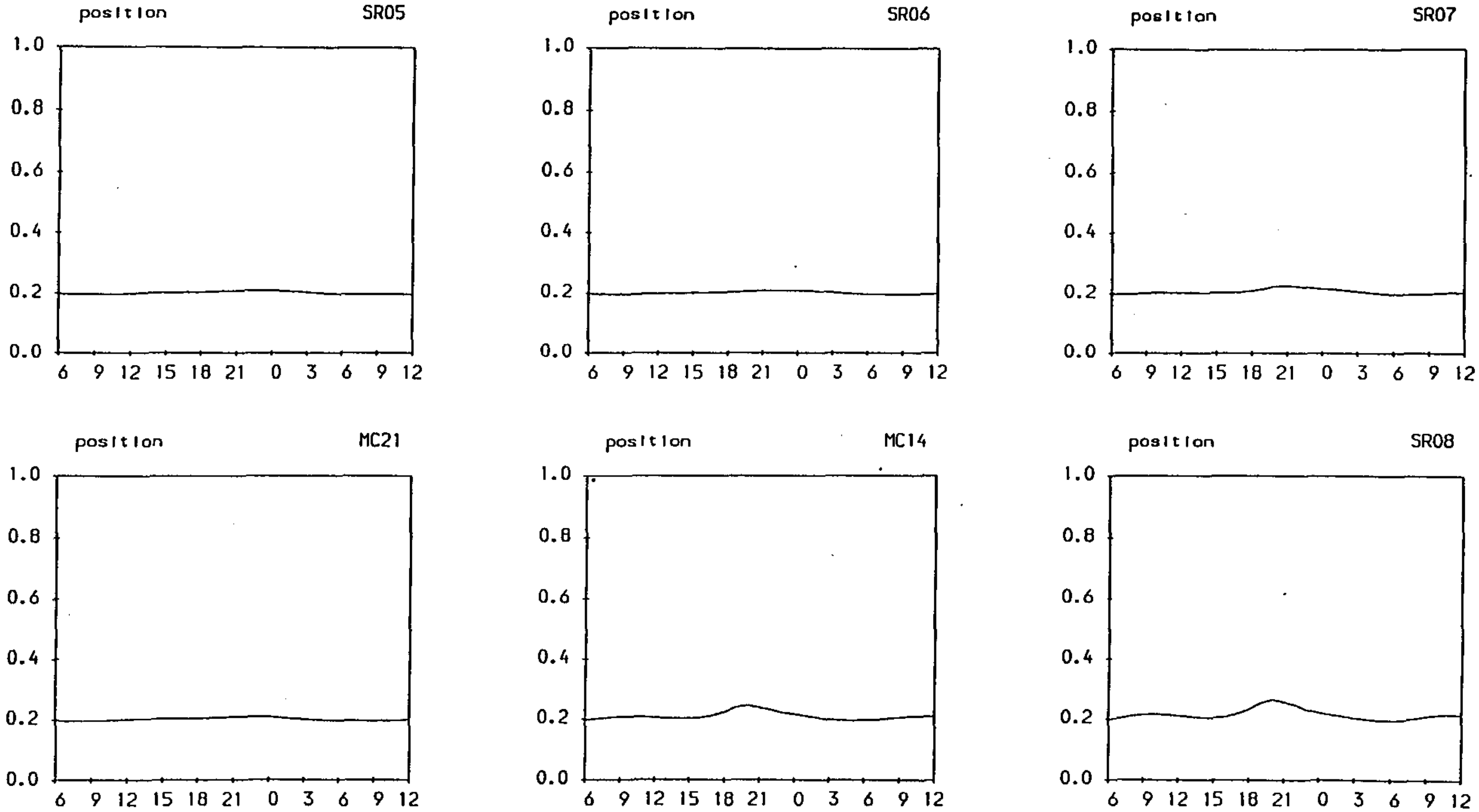


TK+Sham Tseng Dry Spring Original v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

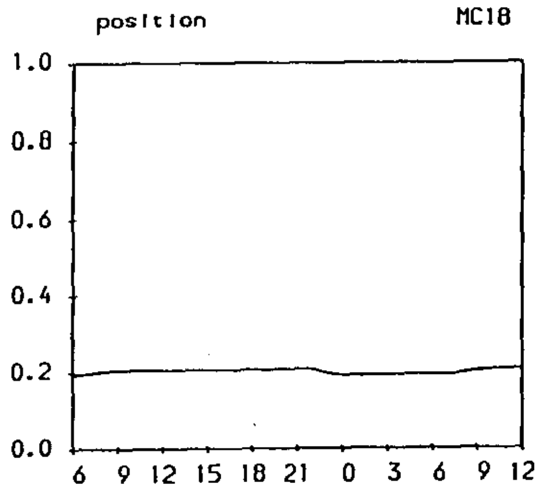


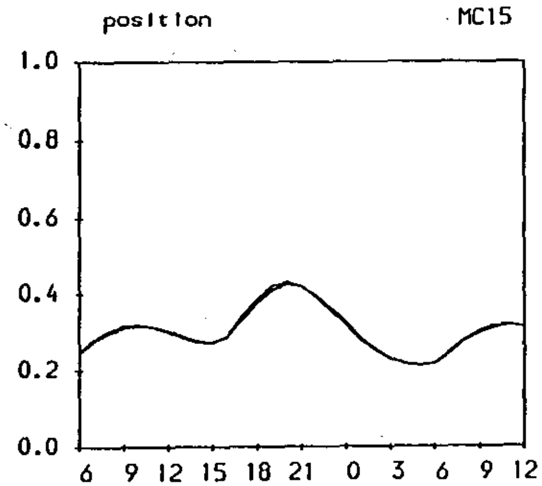
TK+Sham Tseng Dry Spring Original v LSO

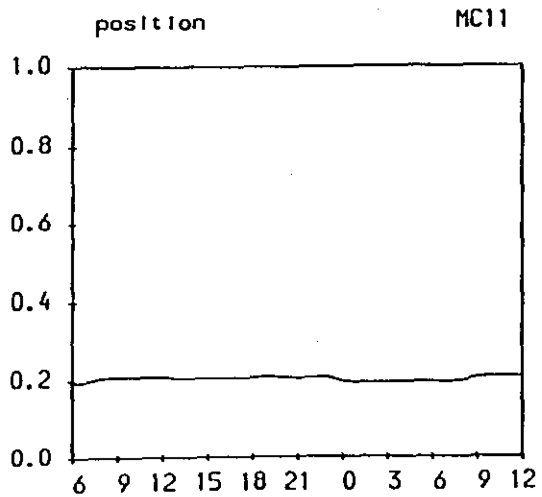
Organic Nitrogen (mg N/l) against time

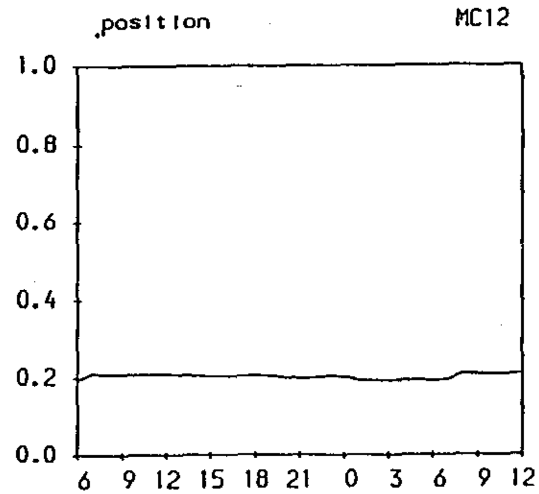
2 Layer, 50m grid DM 17/05/95 ——— Original ········ LongSO

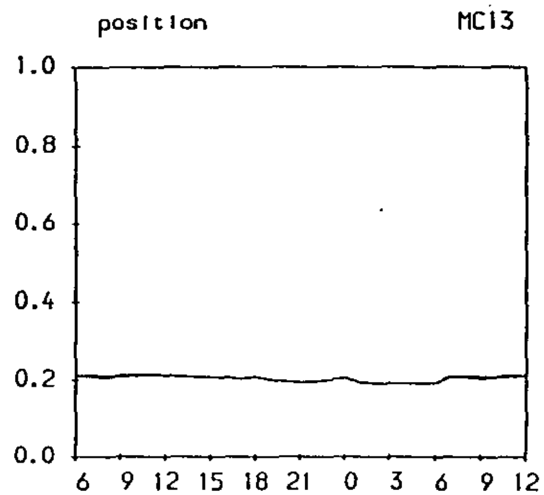
Observed symbols: * Upper layer, △ Lower layer









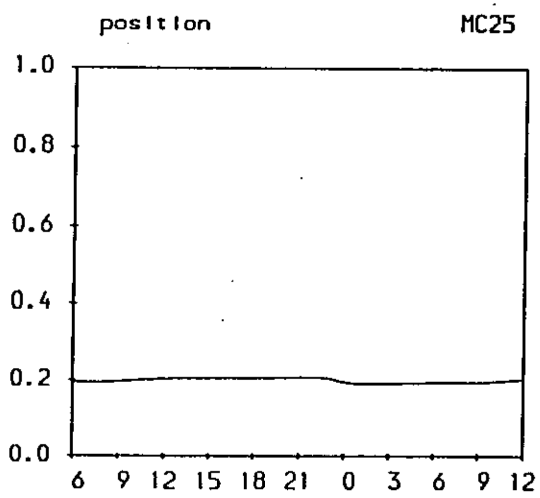


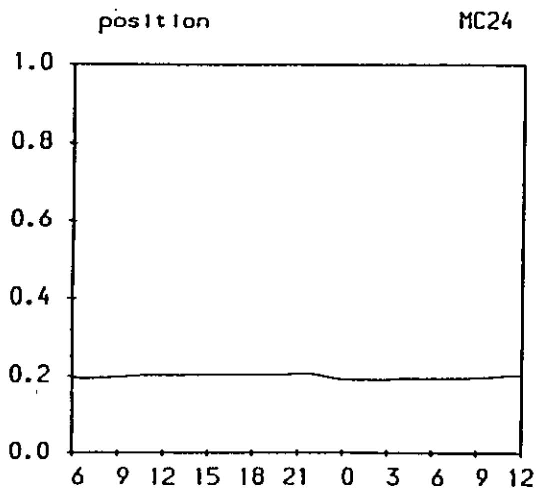
TK+Sham Tseng Dry Spring Original v LSO

Organic Nitrogen (mg N/l) against time

2 Layer, 50m grid   DM 17/05/95   —— Original   ········ LongSO

Observed symbols: * Upper layer, △ Lower layer



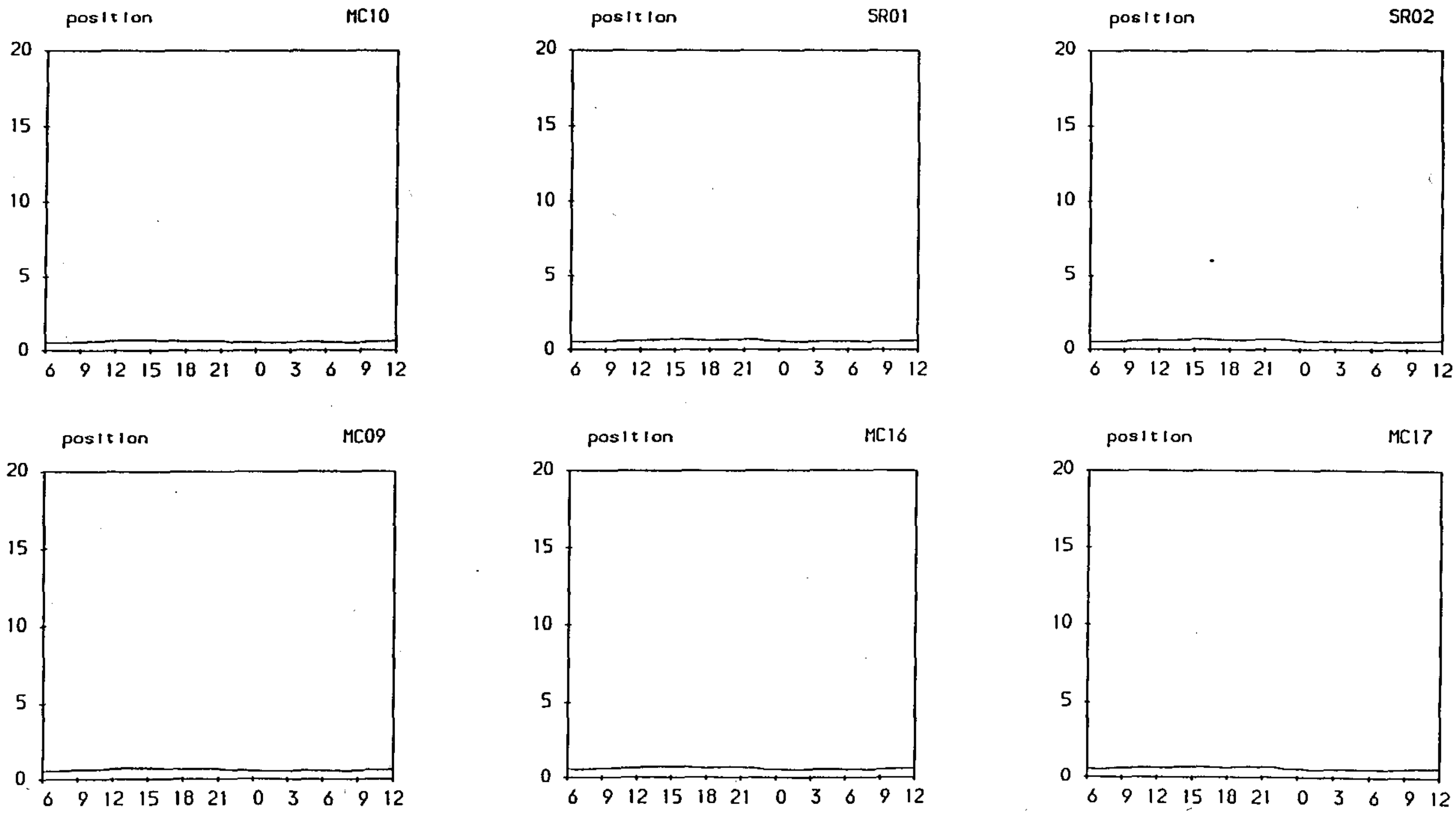


TK+Sham Tseng Dry Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

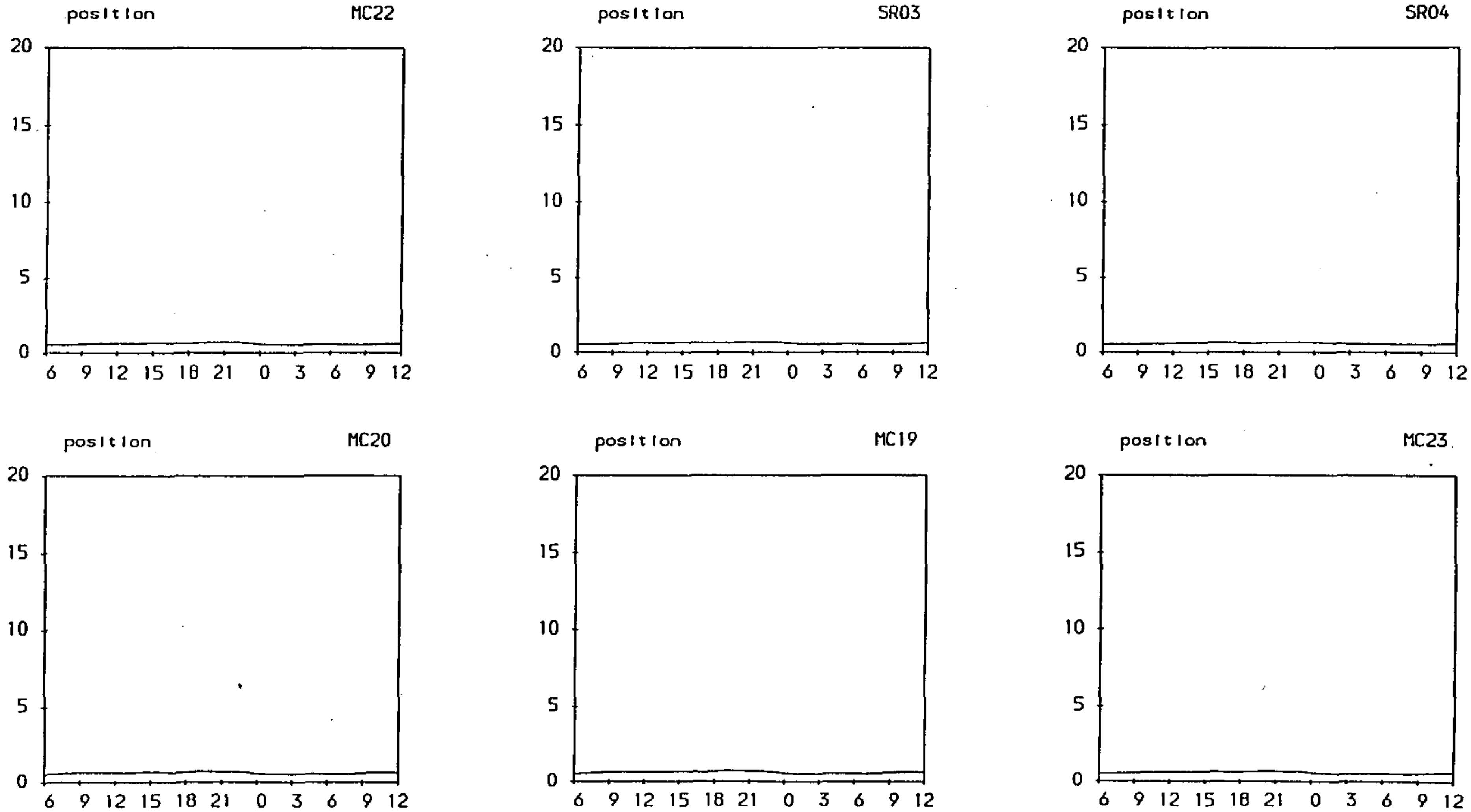


TK+Sham Tseng Dry Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, ▵ Lower layer

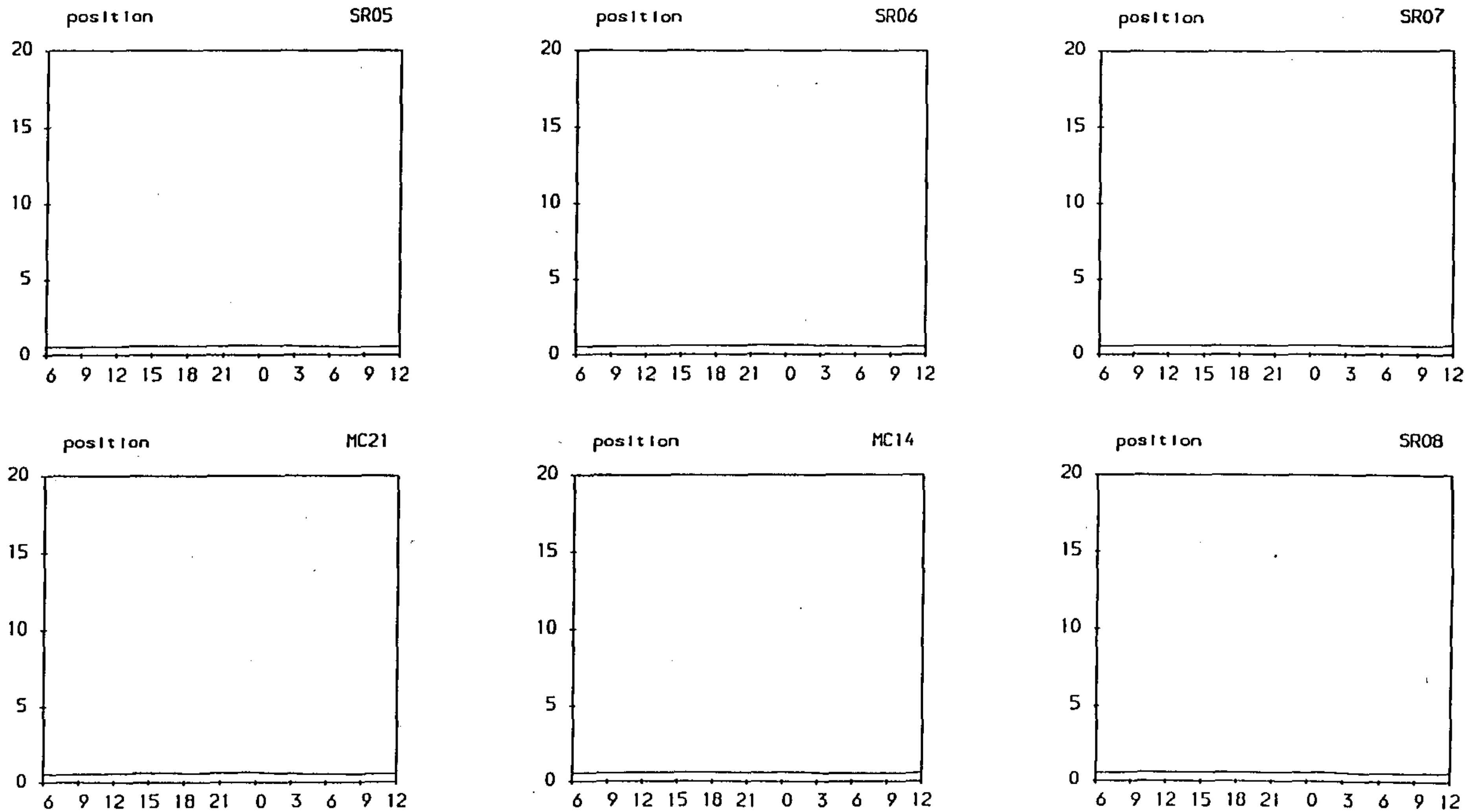


TK+Sham Tseng Dry Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

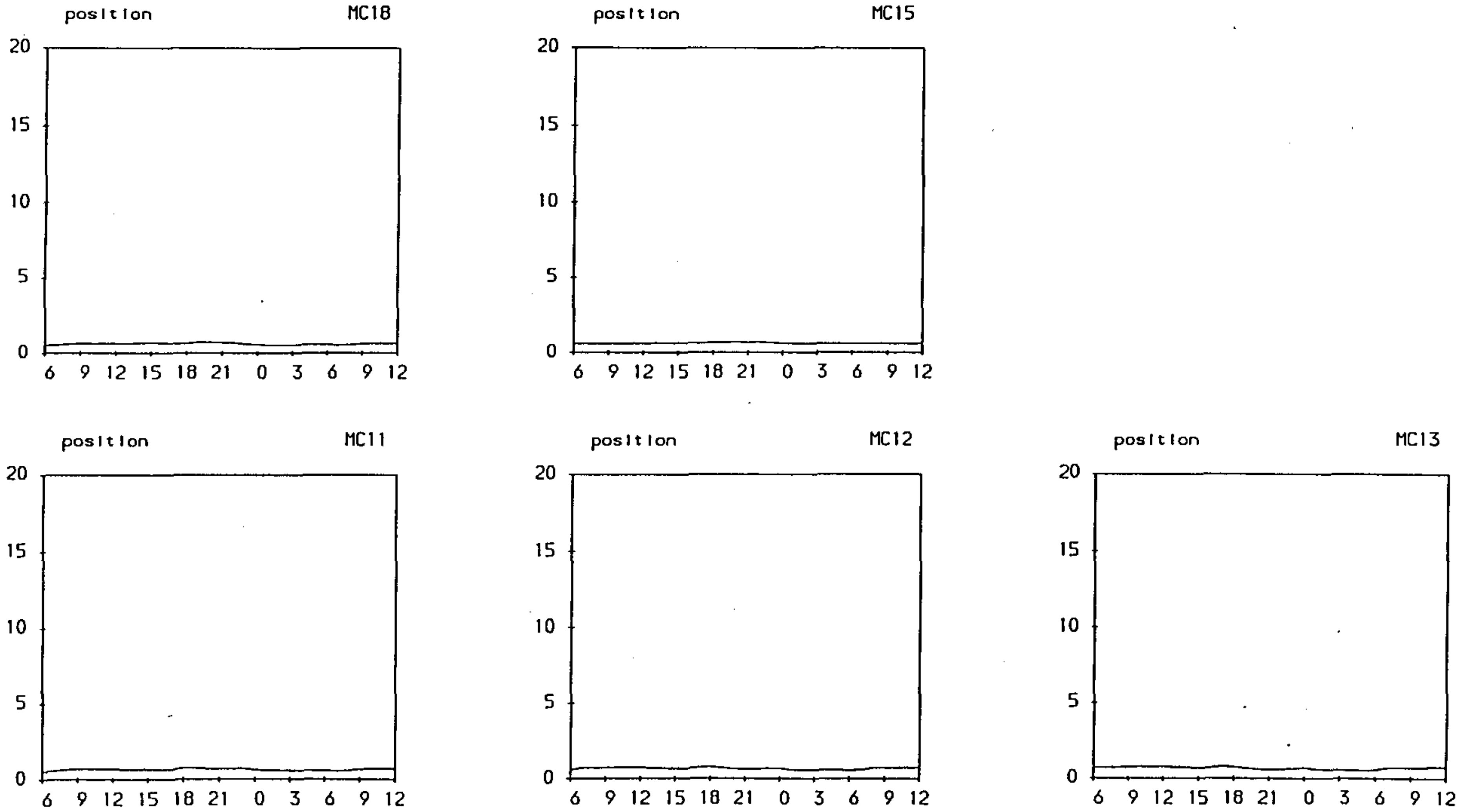


TK+Sham Tseng Dry Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original .... LongSO

Observed symbols: * Upper layer, △ Lower layer

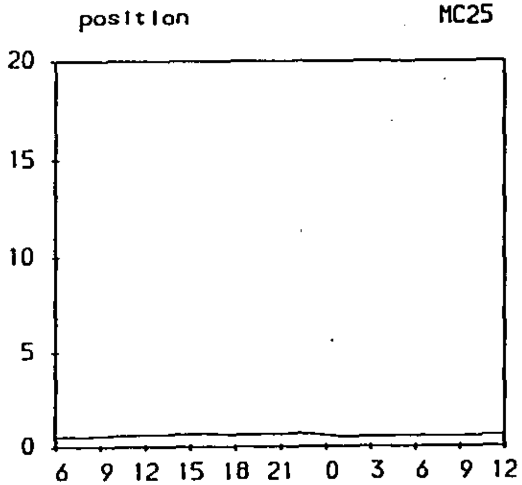


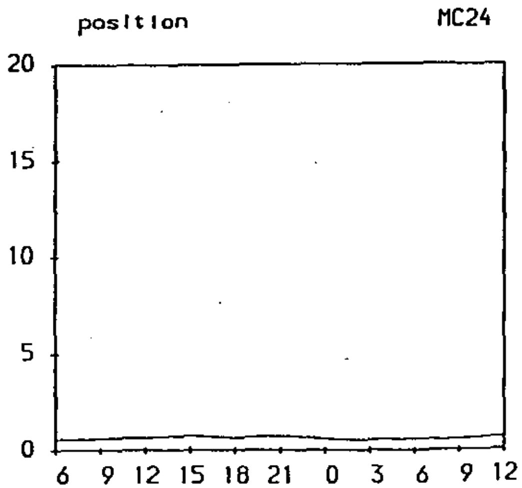
TK+Sham Tseng Dry Spring Original v LSO

Chlorophyll (ug/l) against time

2 Layer, 50m grid DM 17/05/95 —— Original ········ LongSO

Observed symbols: * Upper layer, ▵ Lower layer





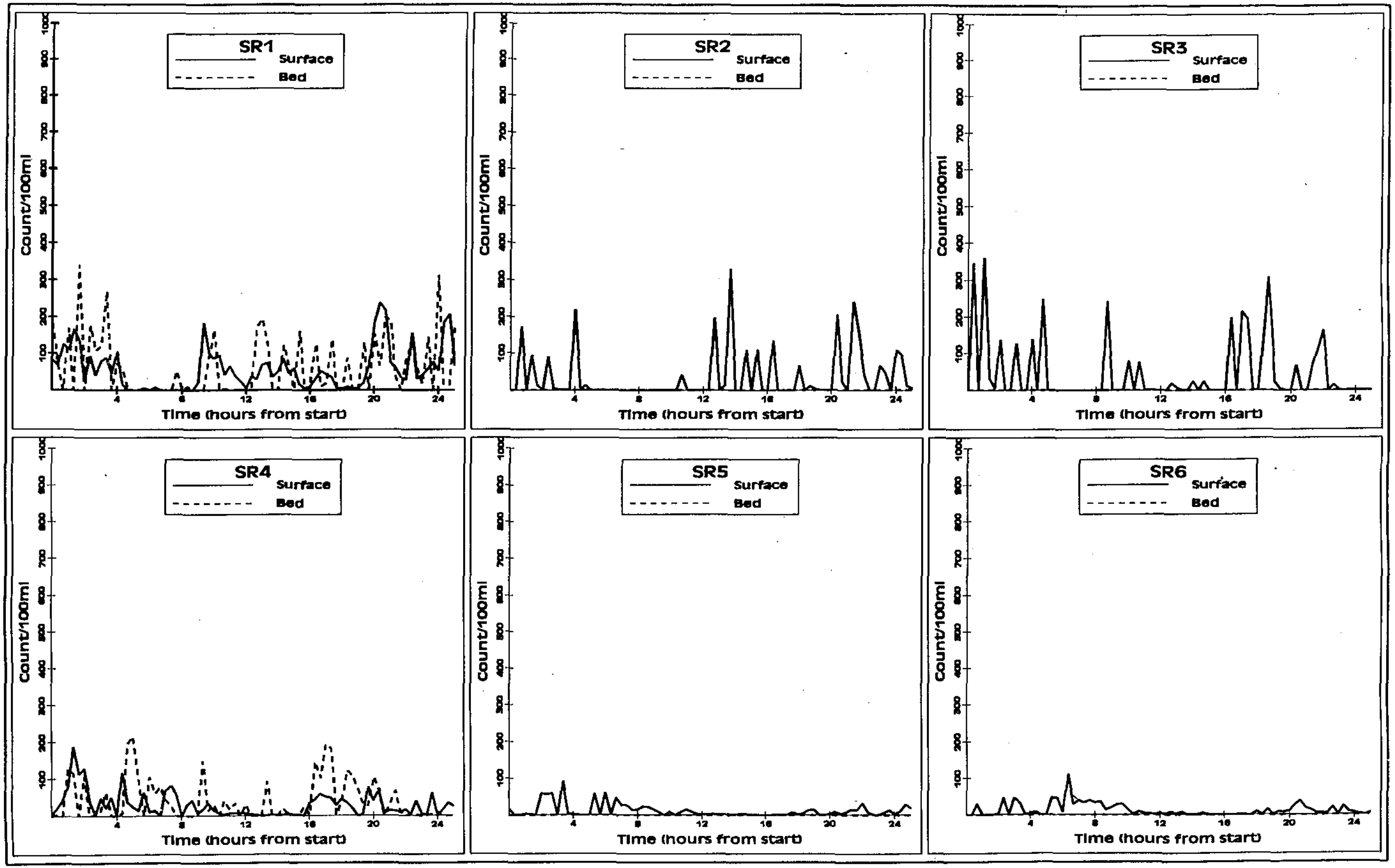


FIGURE 1 LONG OUTFALL, DRY SEASON SPRING TIDE (Run No. 1)

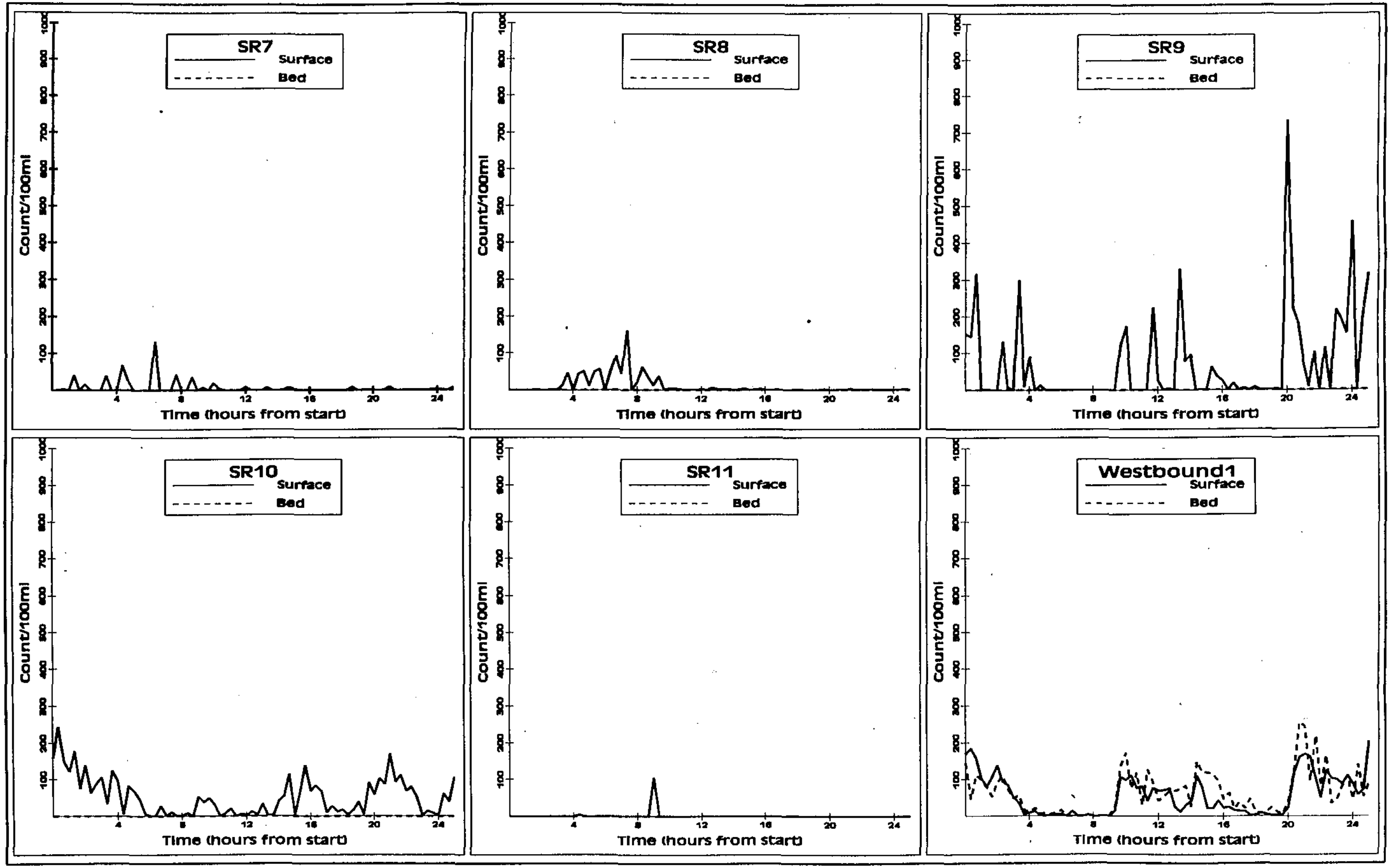


FIGURE 1 LONG OUTFALL, DRY SEASON SPRING TIDE (Run No. 1)

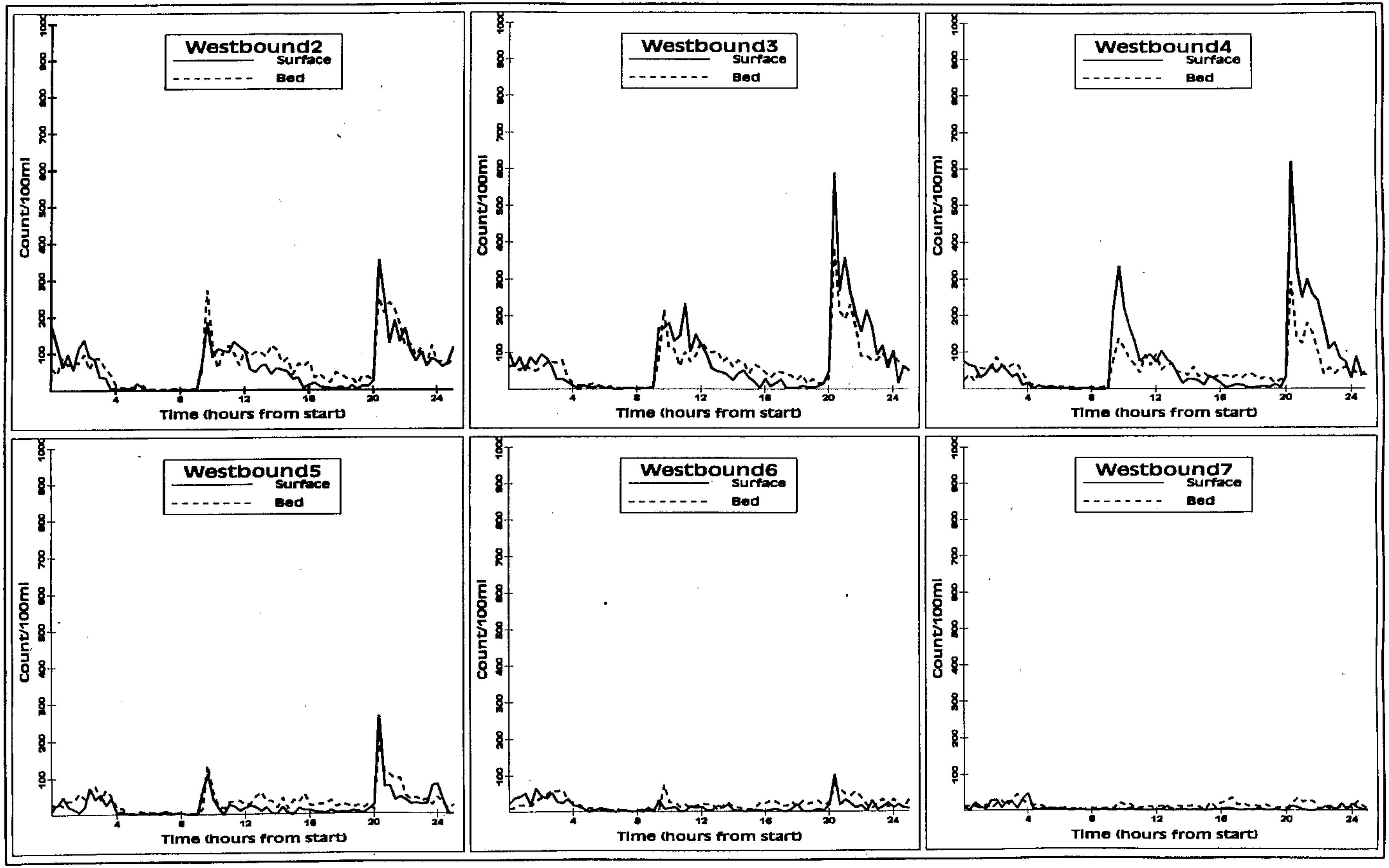


FIGURE 1 LONG OUTFALL, DRY SEASON SPRING TIDE (Run No. 1)

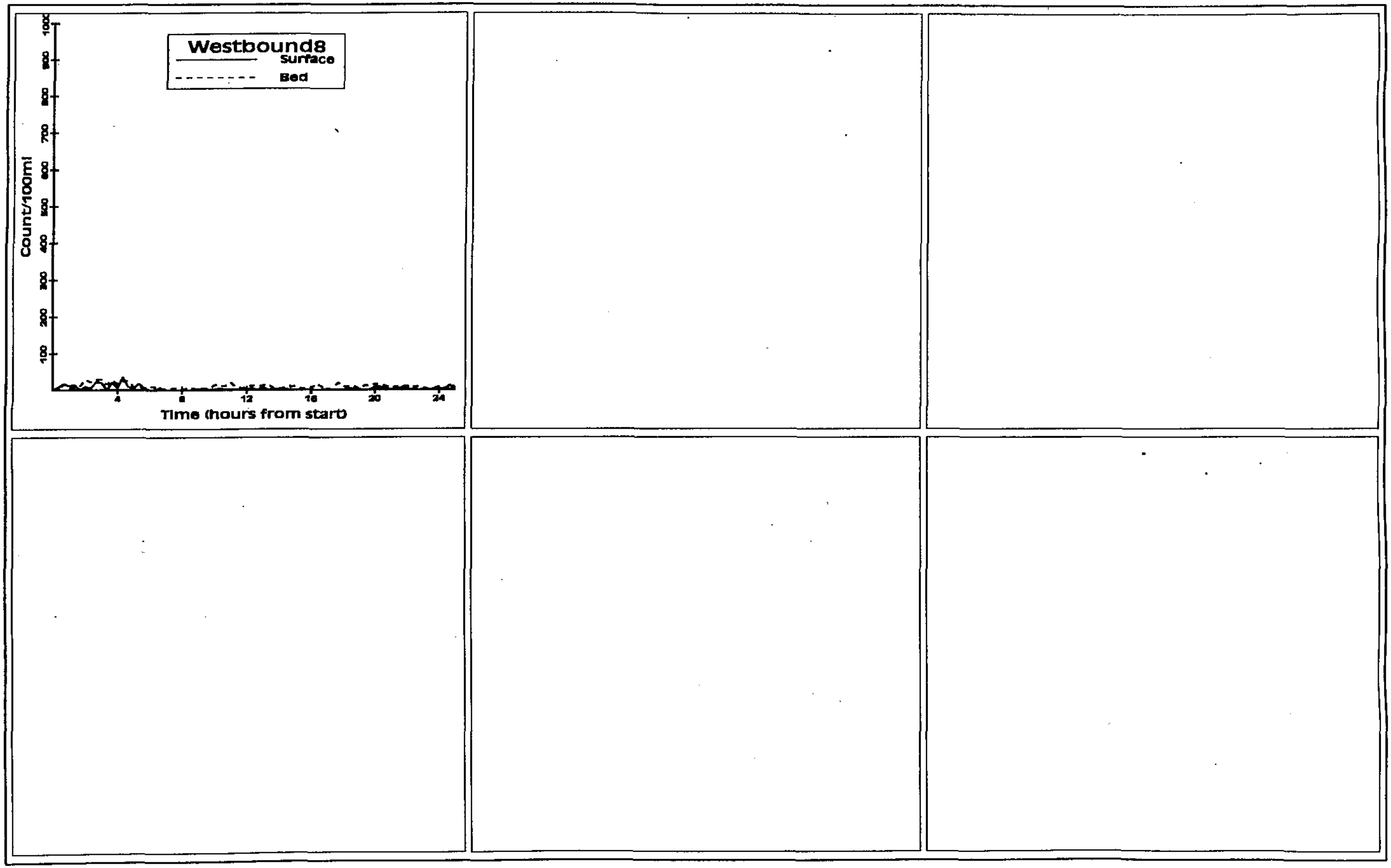


FIGURE 1 LONG OUTFALL, DRY SEASON SPRING TIDE (Run No. 1)

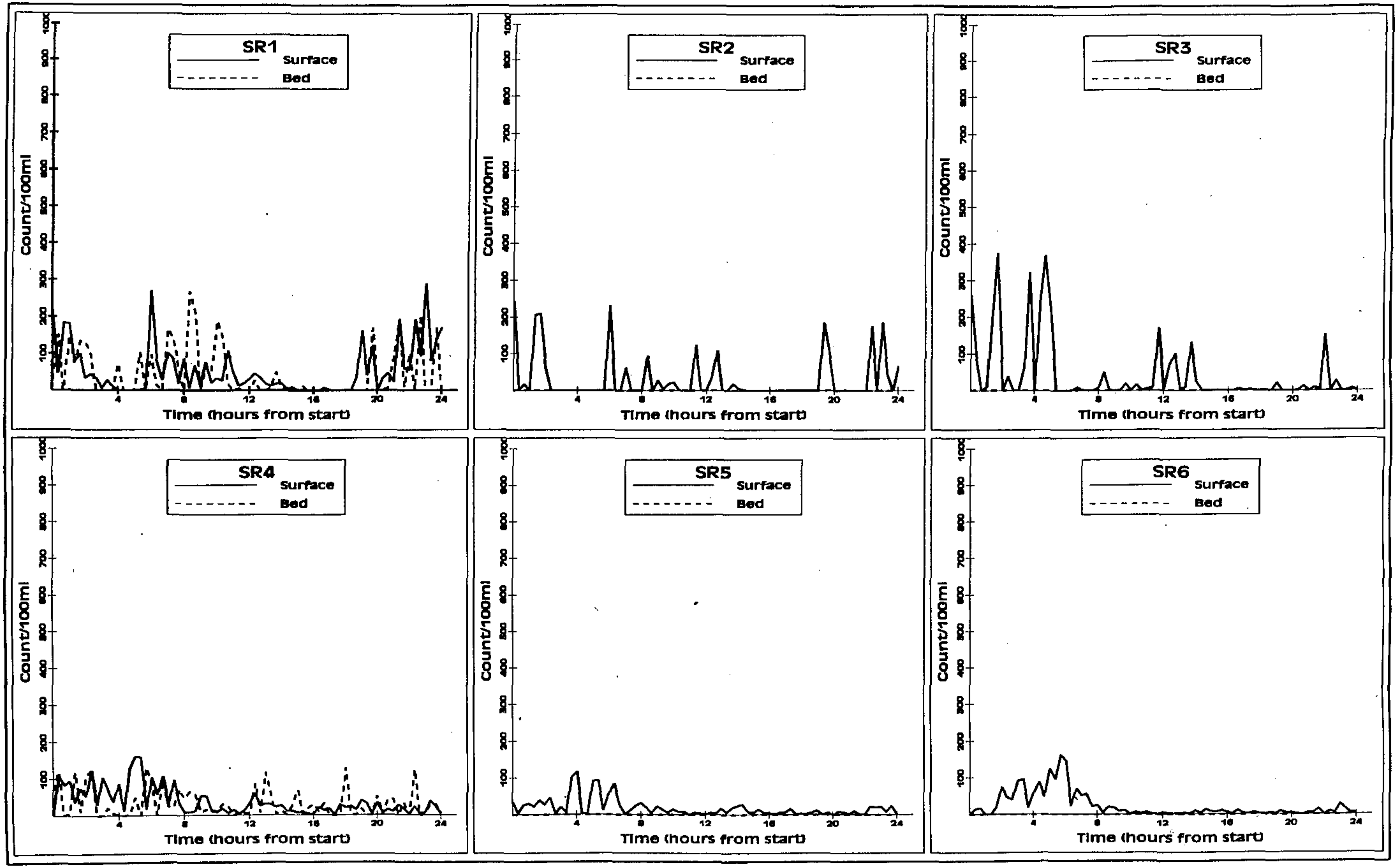


FIGURE 2 LONG OUTFALL DRY SEASON NEAP TIDE (Run No. 2)

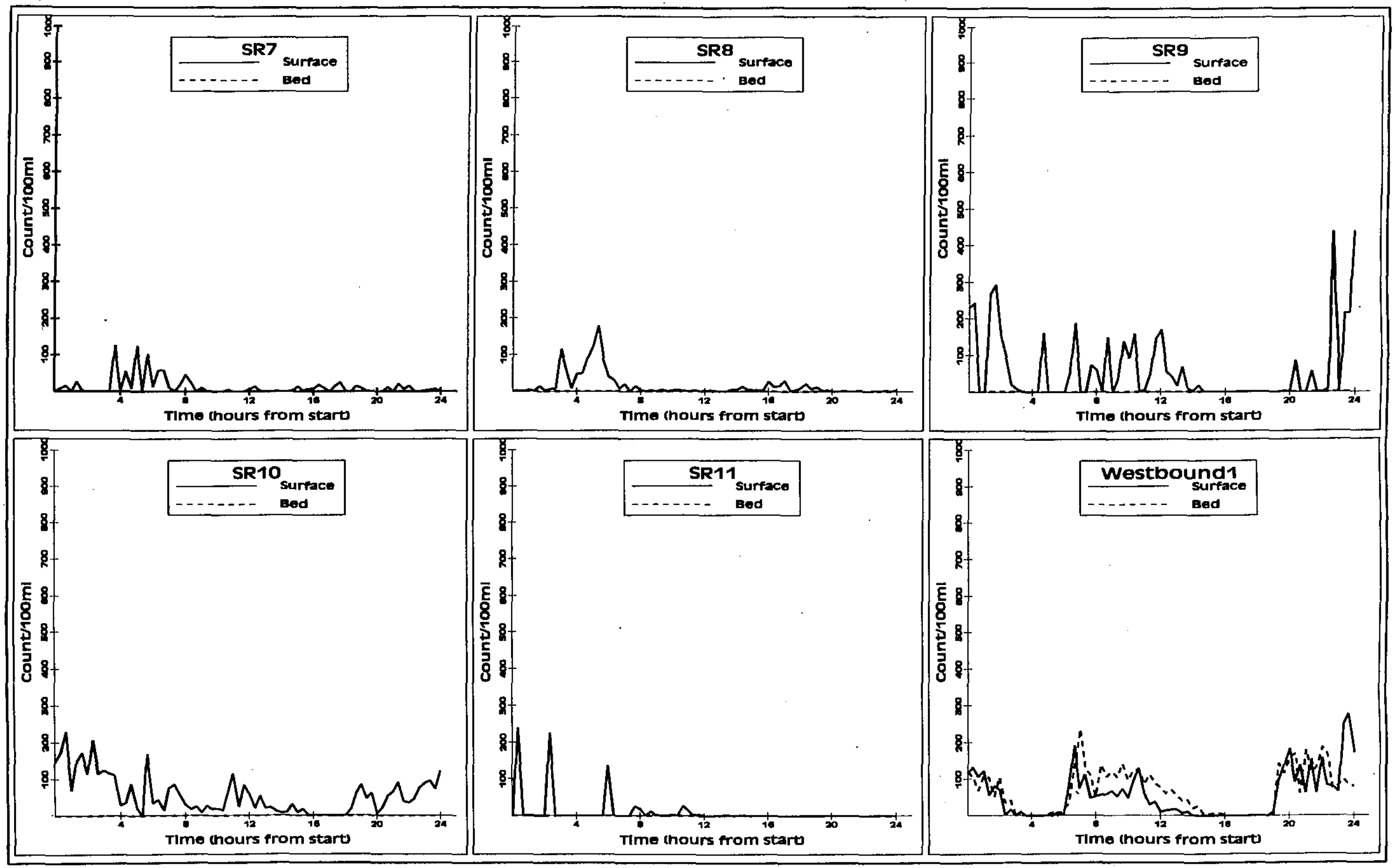


FIGURE 2 LONG OUTFALL DRY SEASON NEAP TIDE (Run No. 2)

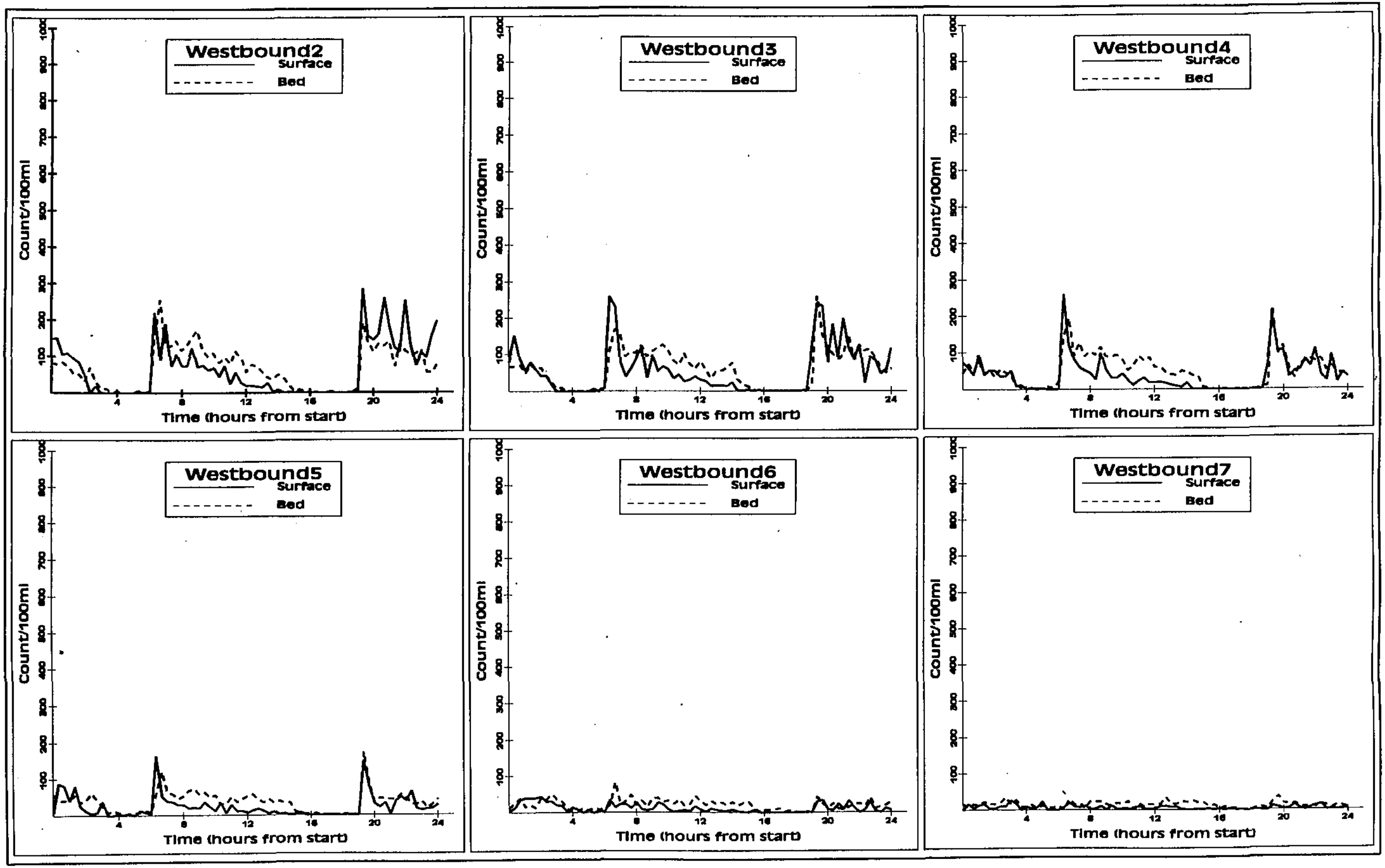


FIGURE 2 LONG OUTFALL DRY SEASON NEAP TIDE (Run No. 2)

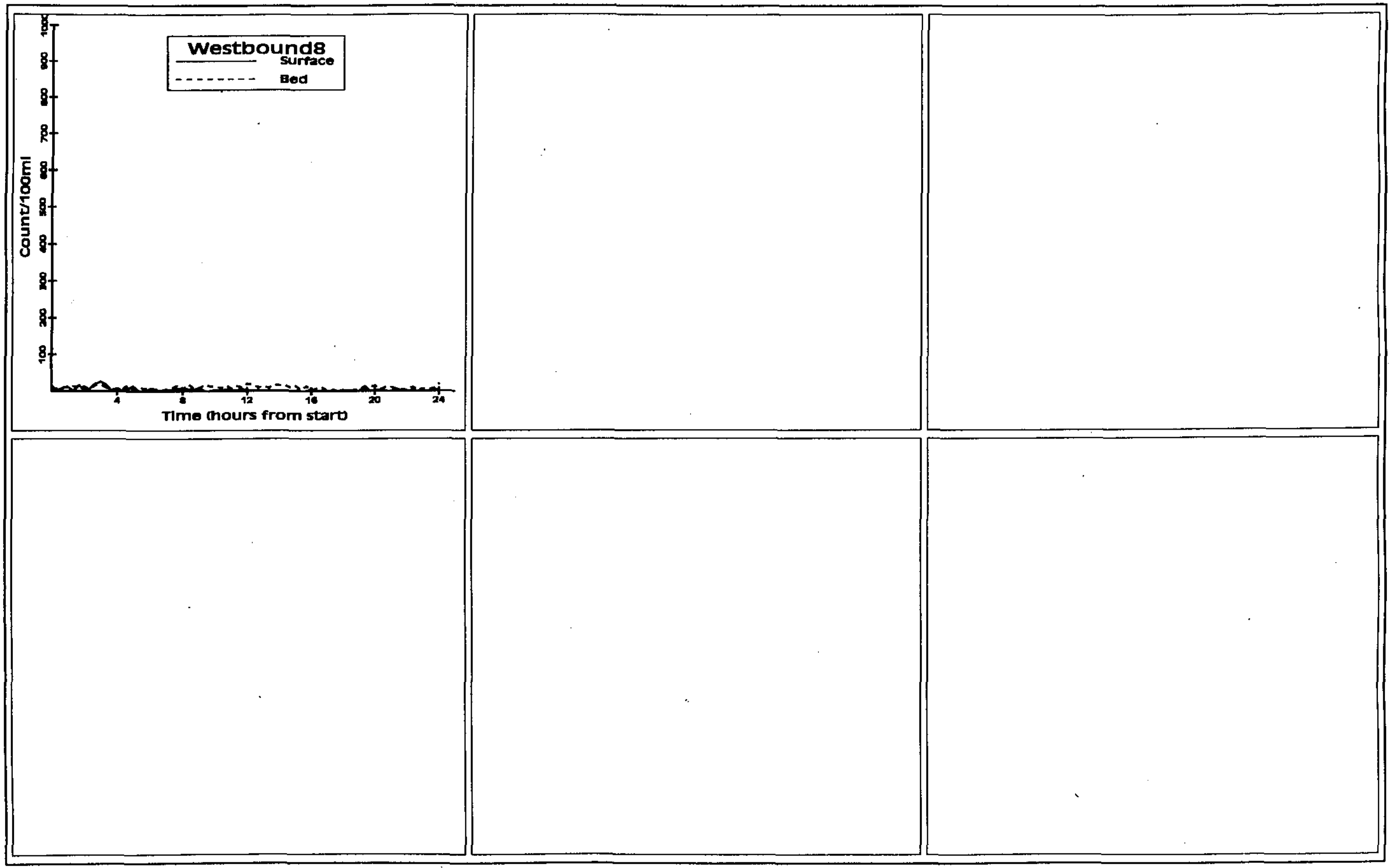


FIGURE 2 LONG OUTFALL DRY SEASON NEAP TIDE (Run No. 2)

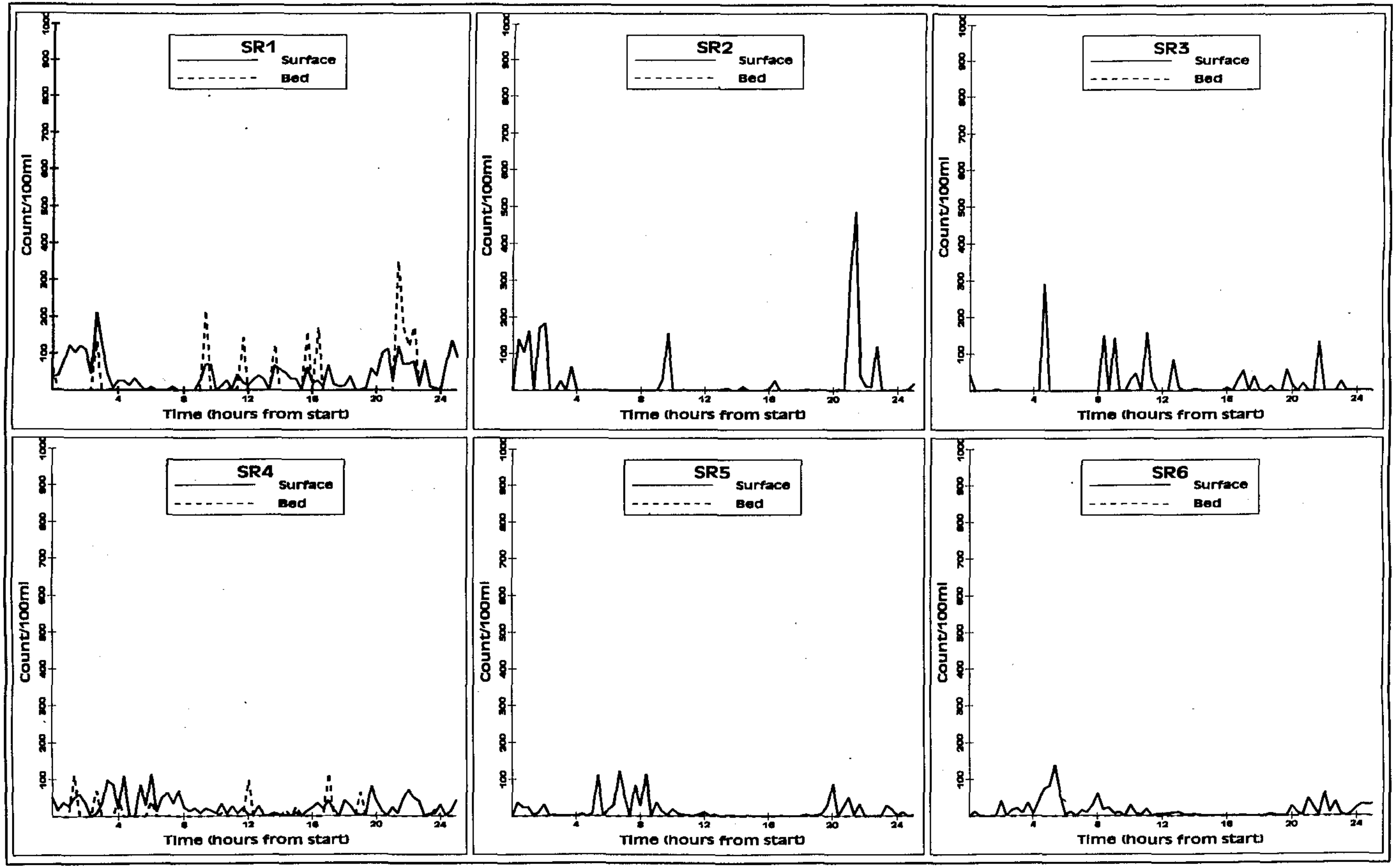


FIGURE 3 LONG OUTFALL, INTERMEDIATE SEASON SPRING TIDE (Run No. 3)

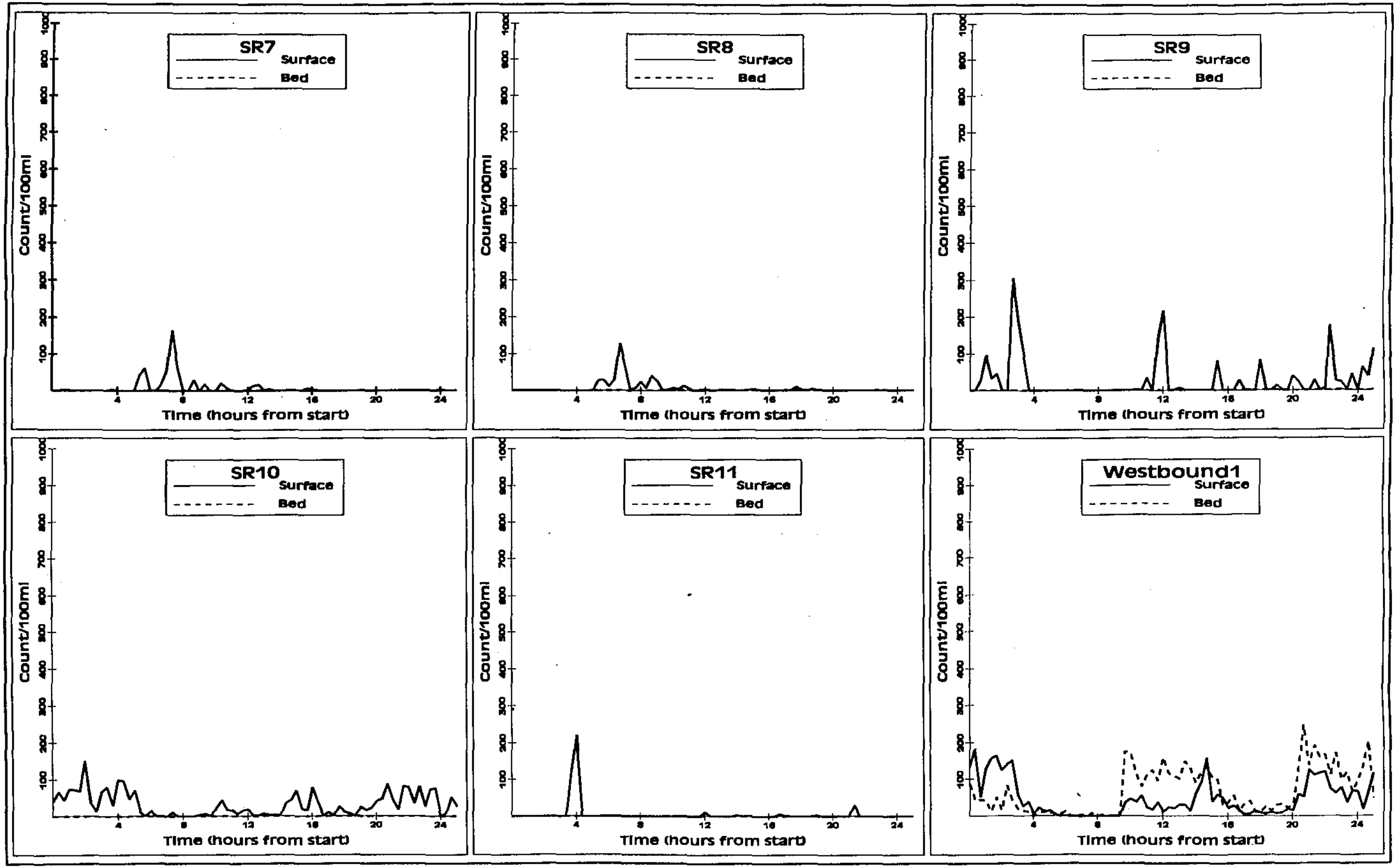


FIGURE 3 LONG OUTFALL, INTERMEDIATE SEASON SPRING TIDE (Run No. 3)

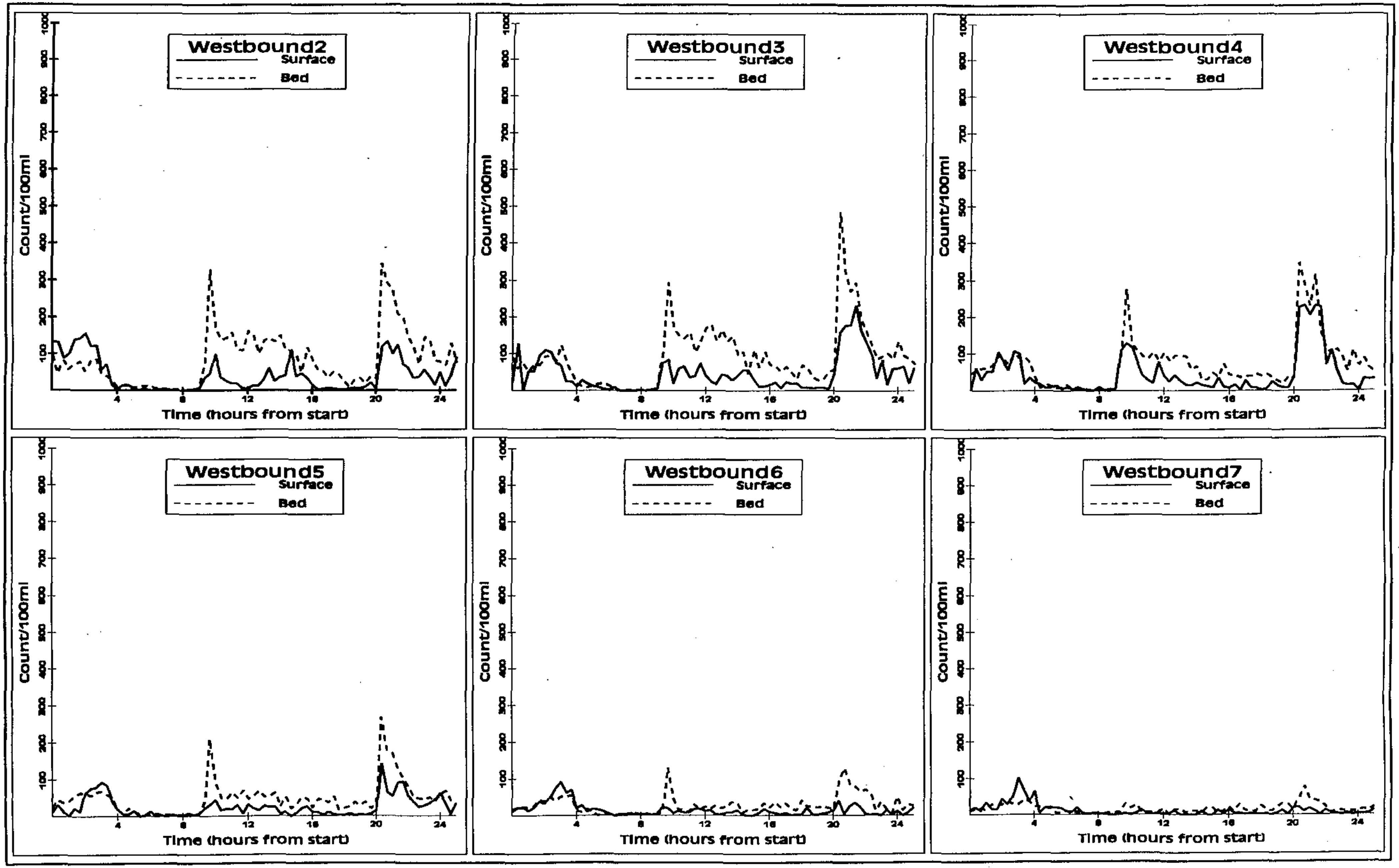


FIGURE 3 LONG OUTFALL, INTERMEDIATE SEASON SPRING TIDE (Run No. 3)

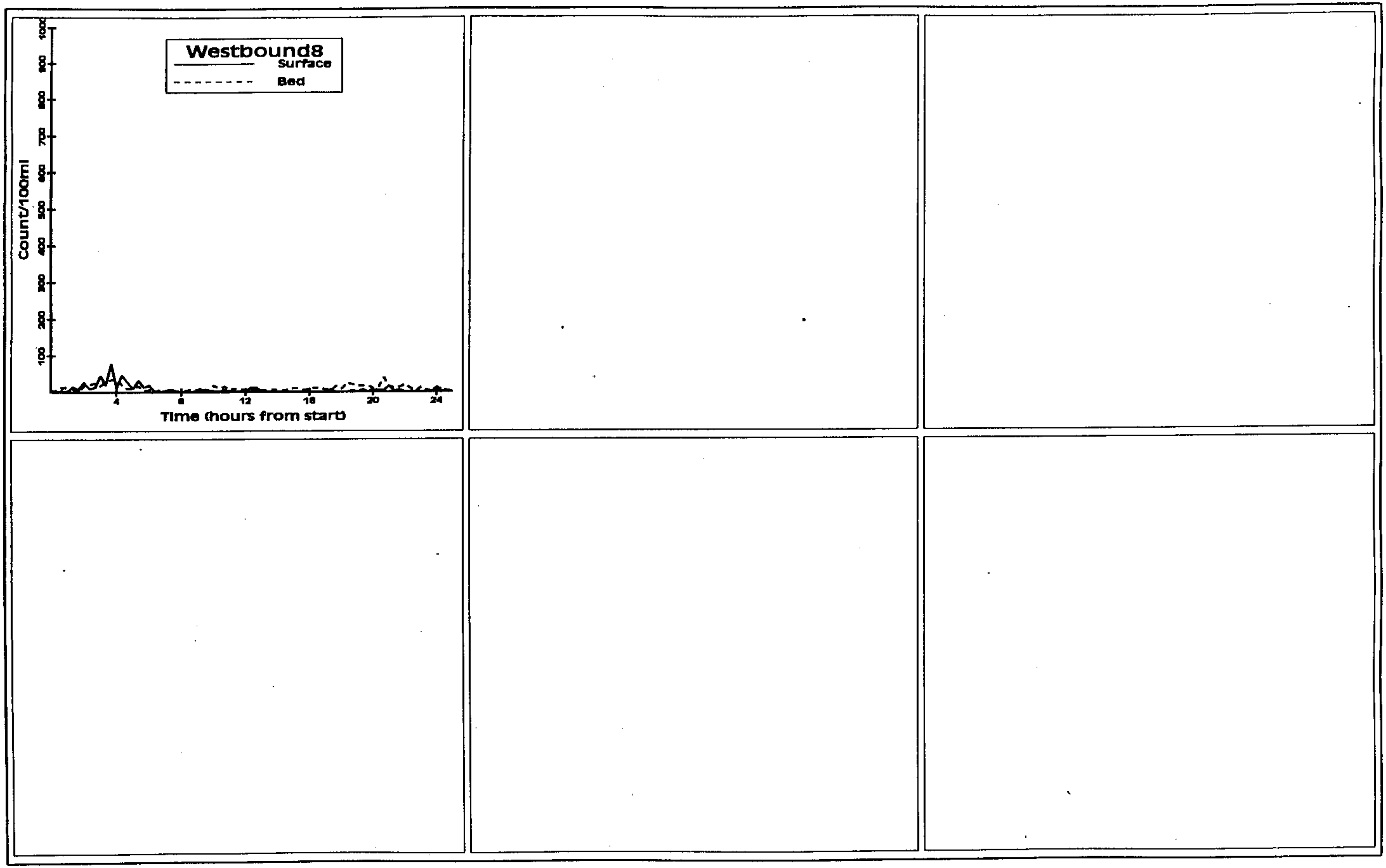


FIGURE 3 LONG OUTFALL, INTERMEDIATE SEASON SPRING TIDE (Run No. 3)

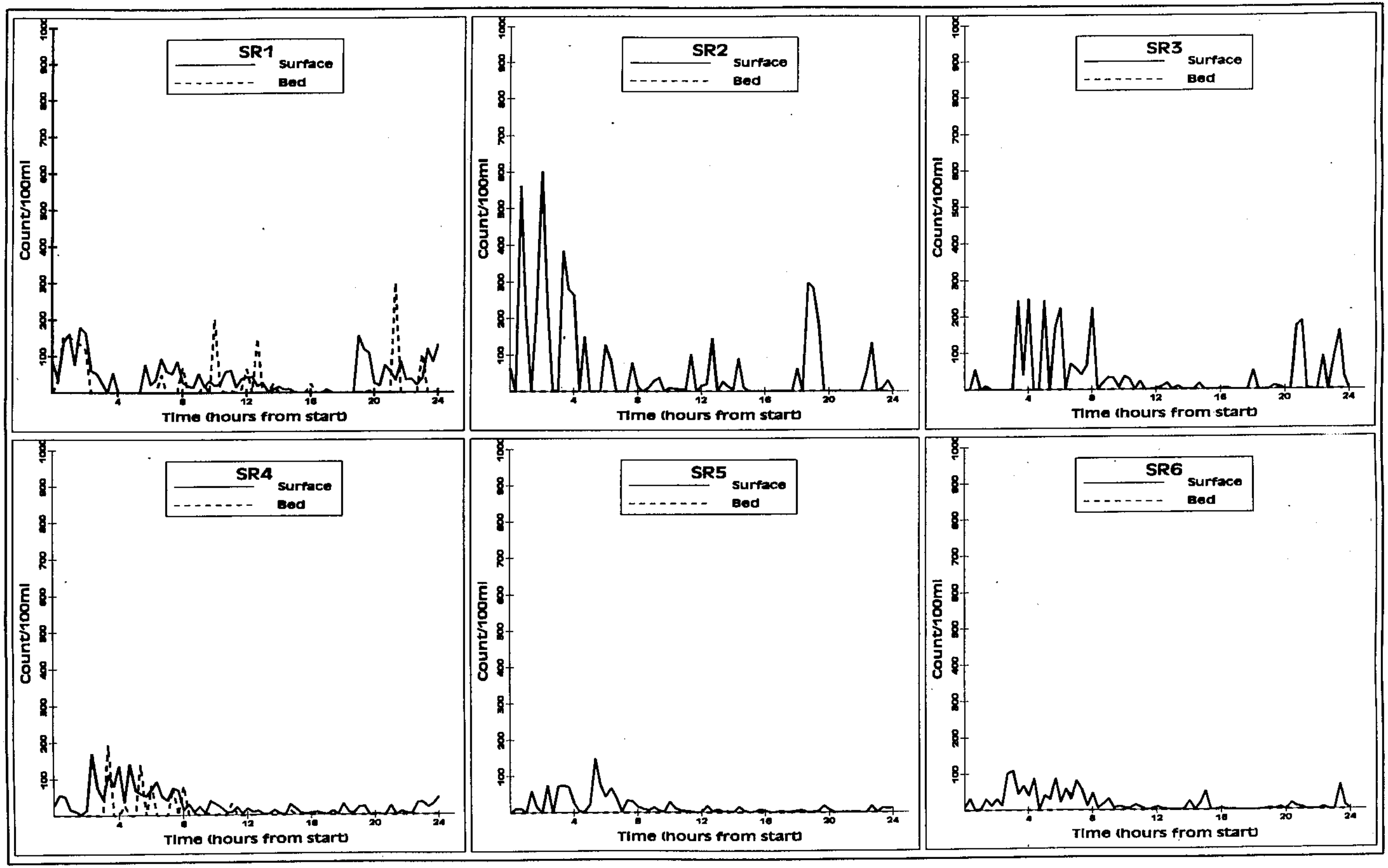


FIGURE 4 LONG OUTFALL, INTERMEDIATE SEASON NEAP TIDE (Run No. 4)

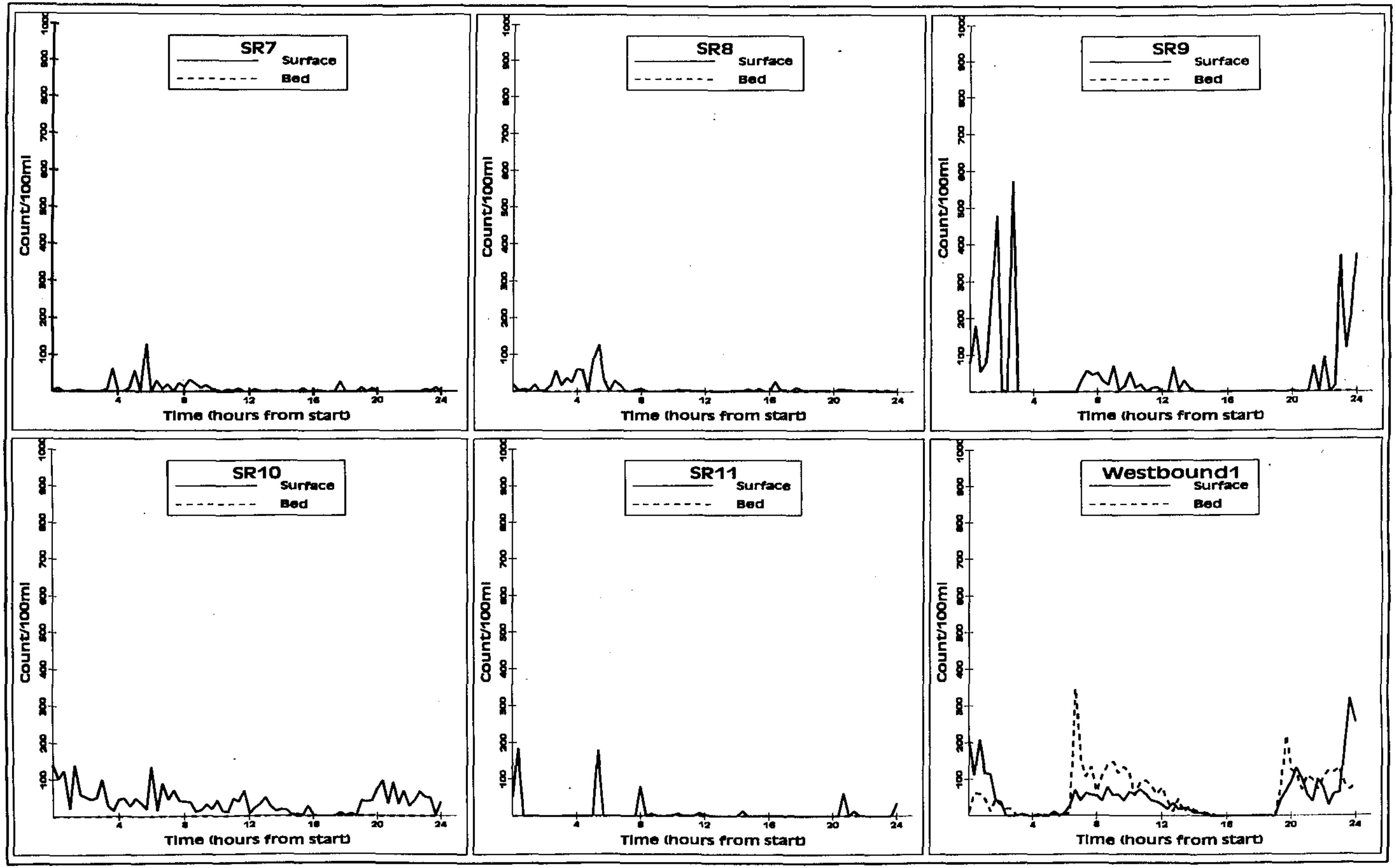


FIGURE 4 LONG OUTFALL, INTERMEDIATE SEASON NEAP TIDE (Run No. 4)

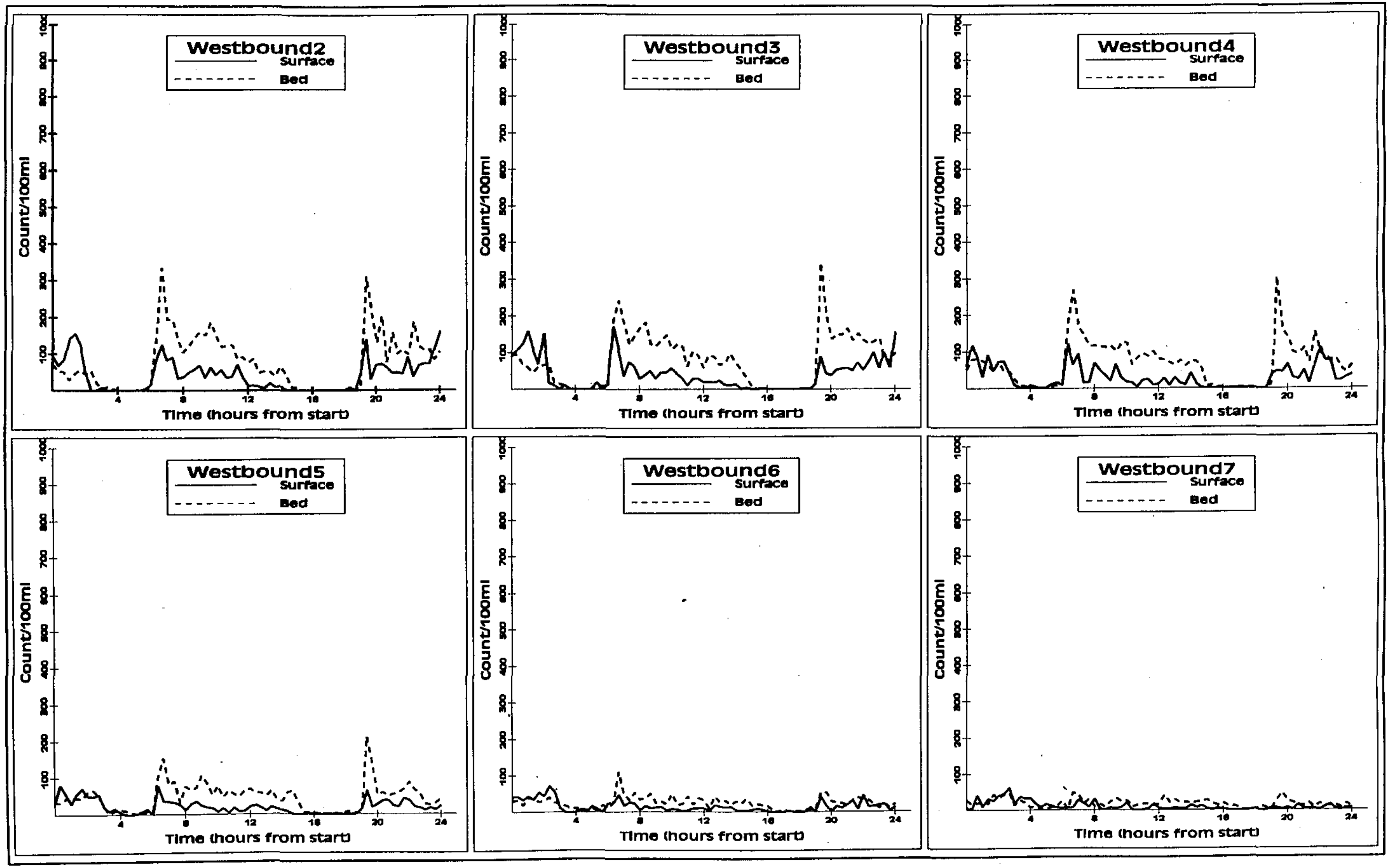


FIGURE 4 LONG OUTFALL, INTERMEDIATE SEASON NEAP TIDE (Run No. 4)

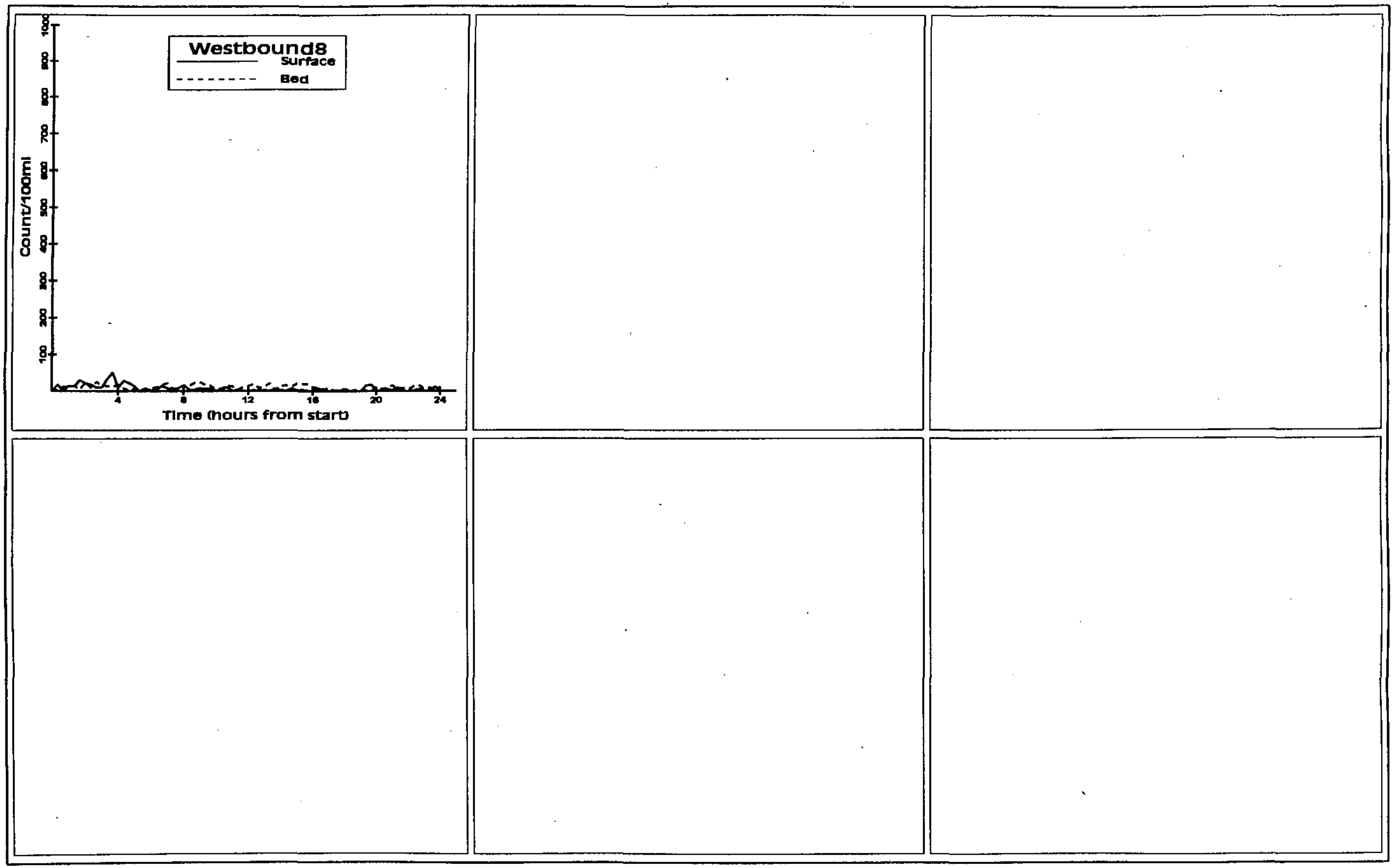


FIGURE 4 LONG OUTFALL, INTERMEDIATE SEASON NEAP TIDE (Run No. 4)

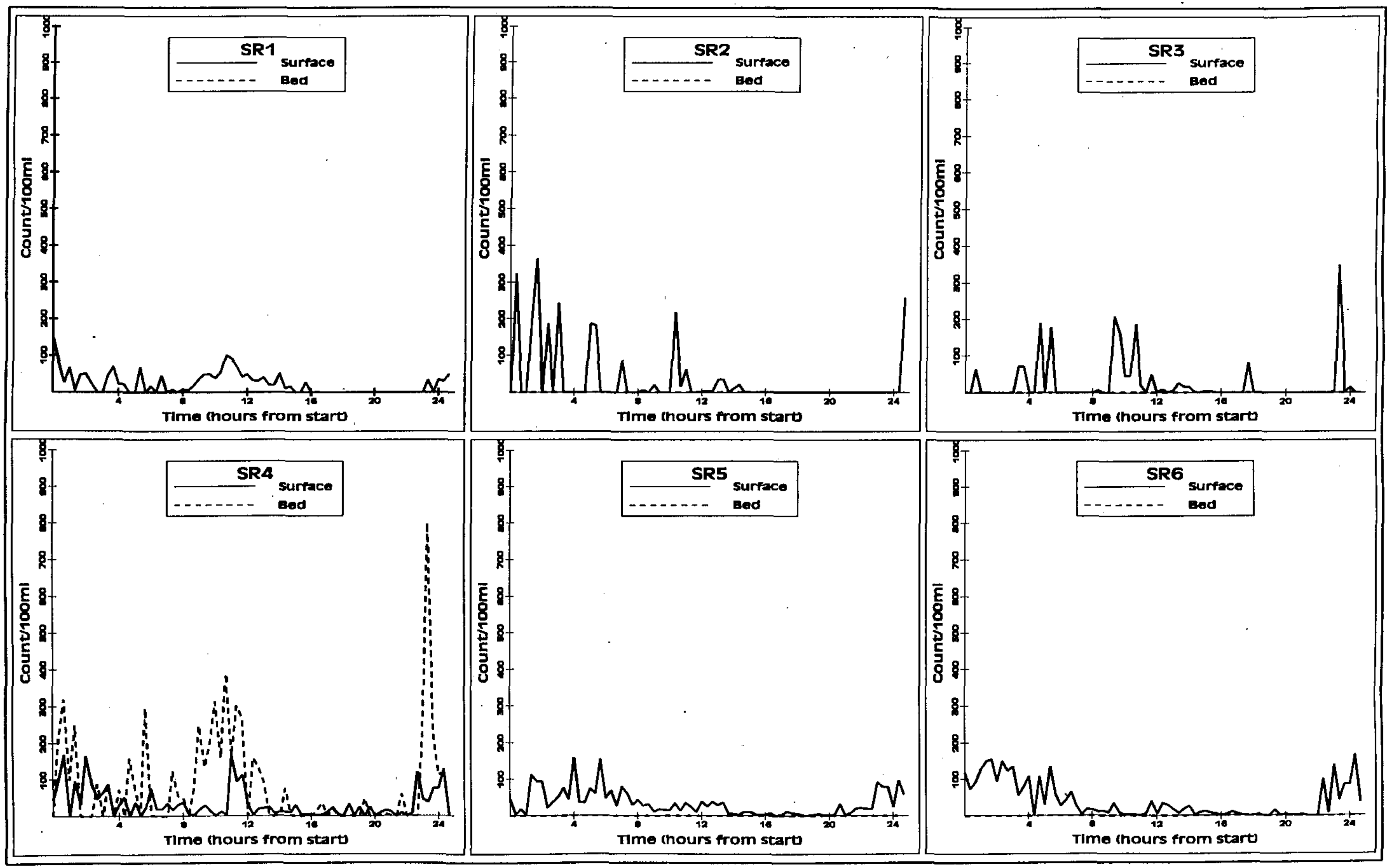


FIGURE 5 LONG OUTFALL, WET SEASON SPRING TIDE (Run No. 5)

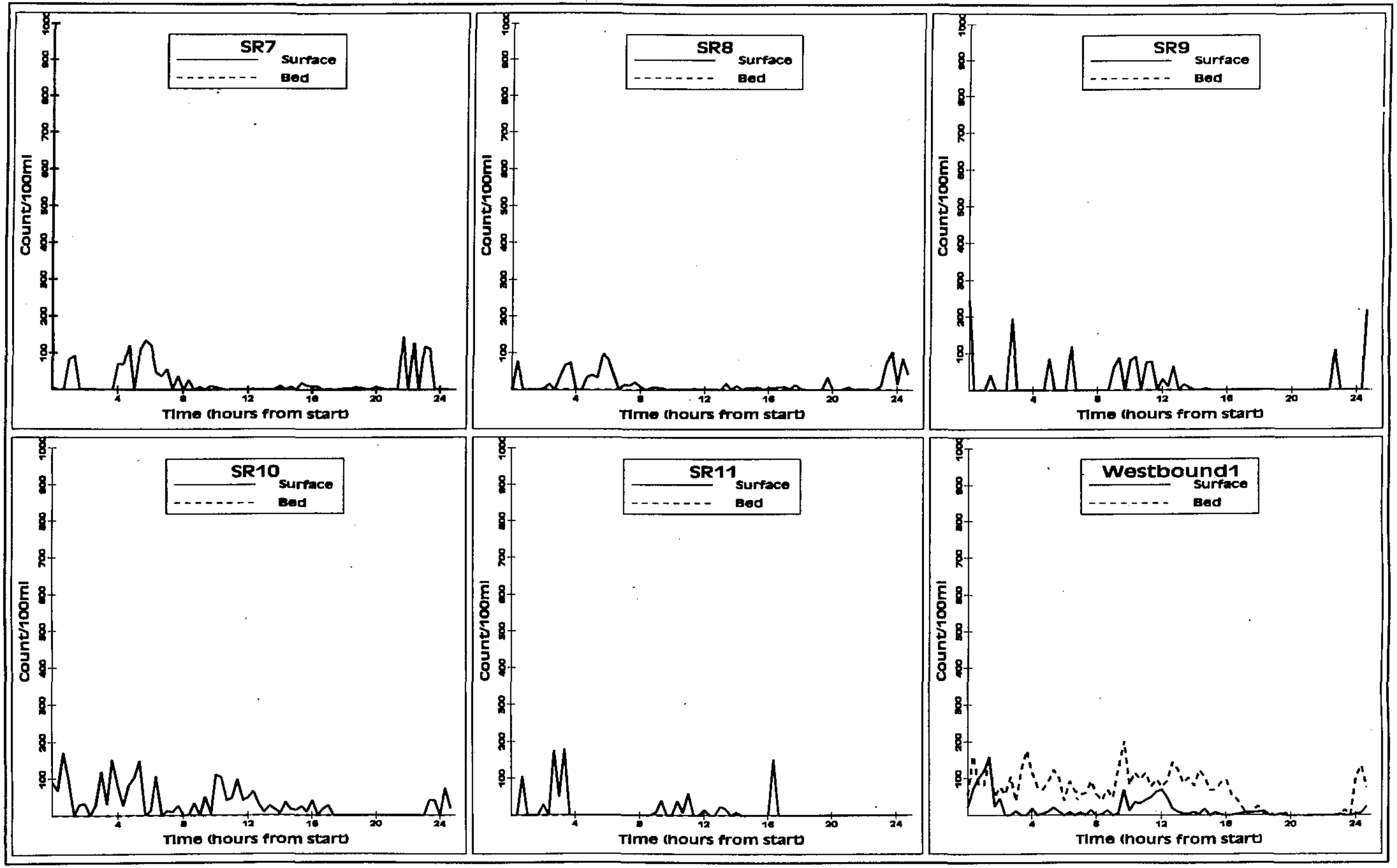


FIGURE 5 LONG OUTFALL, WET SEASON SPRING TIDE (Run No. 5)

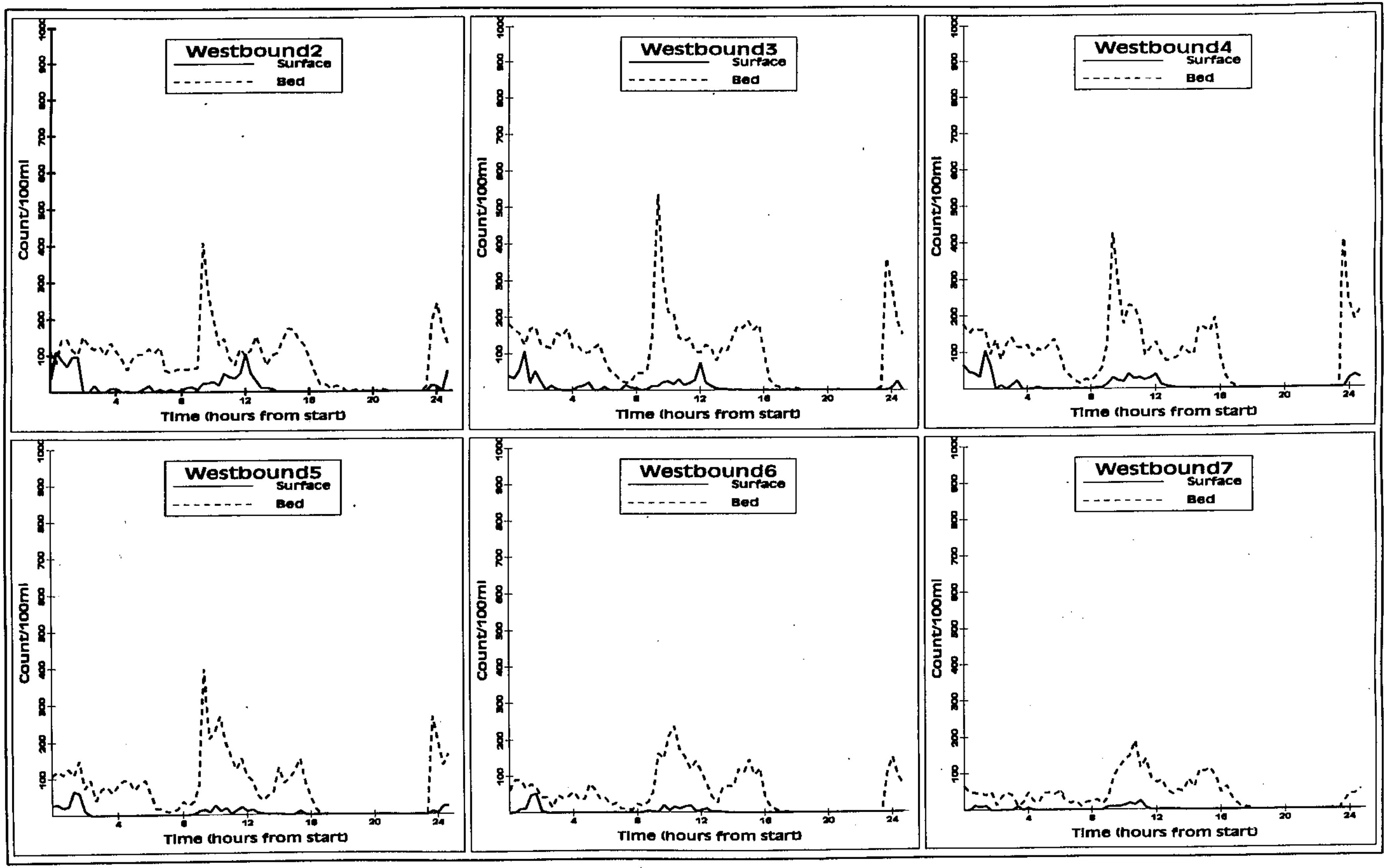


FIGURE 5 LONG OUTFALL, WET SEASON SPRING TIDE (Run No. 5)

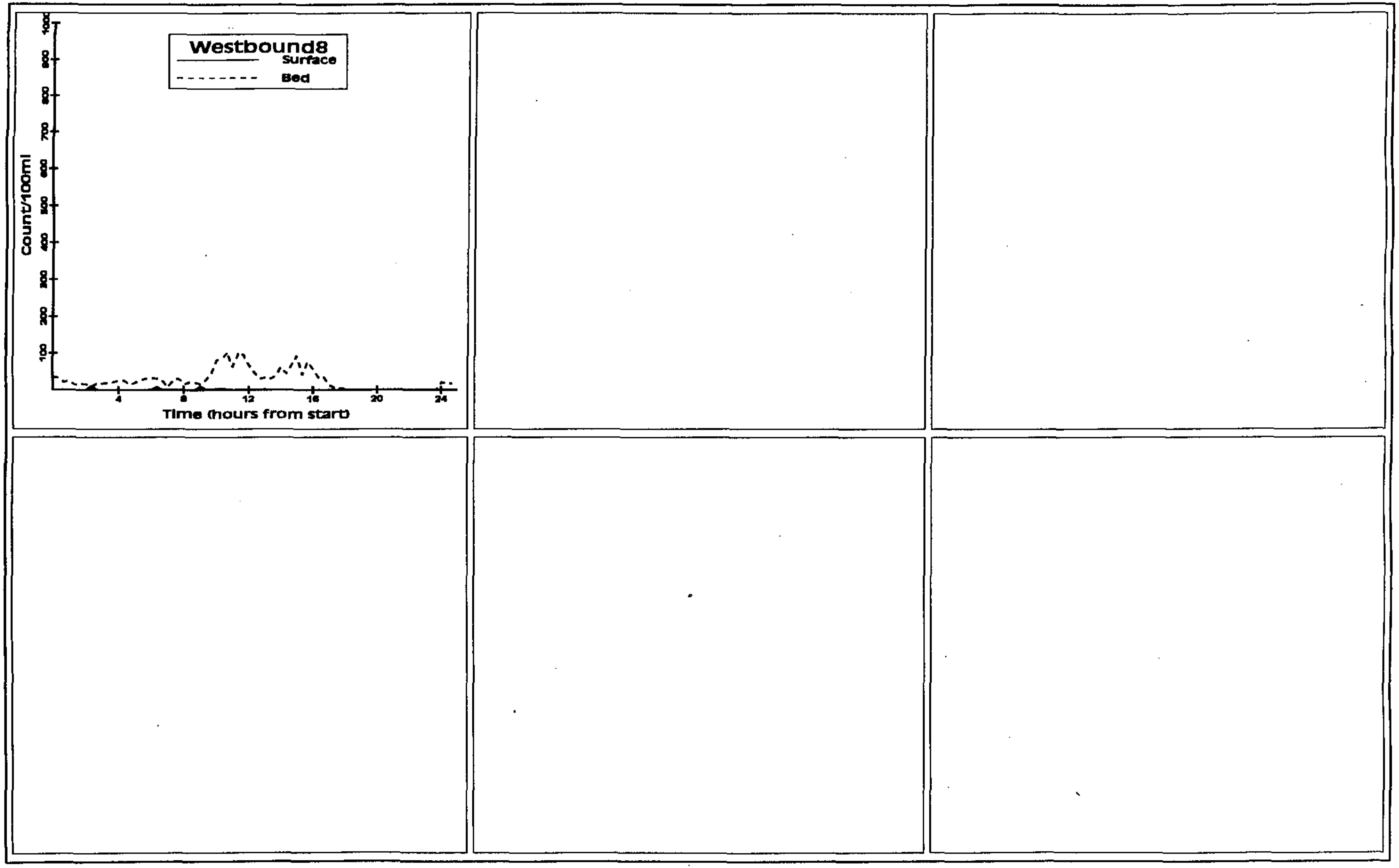


FIGURE 5 LONG OUTFALL, WET SEASON SPRING TIDE (Run No. 5)

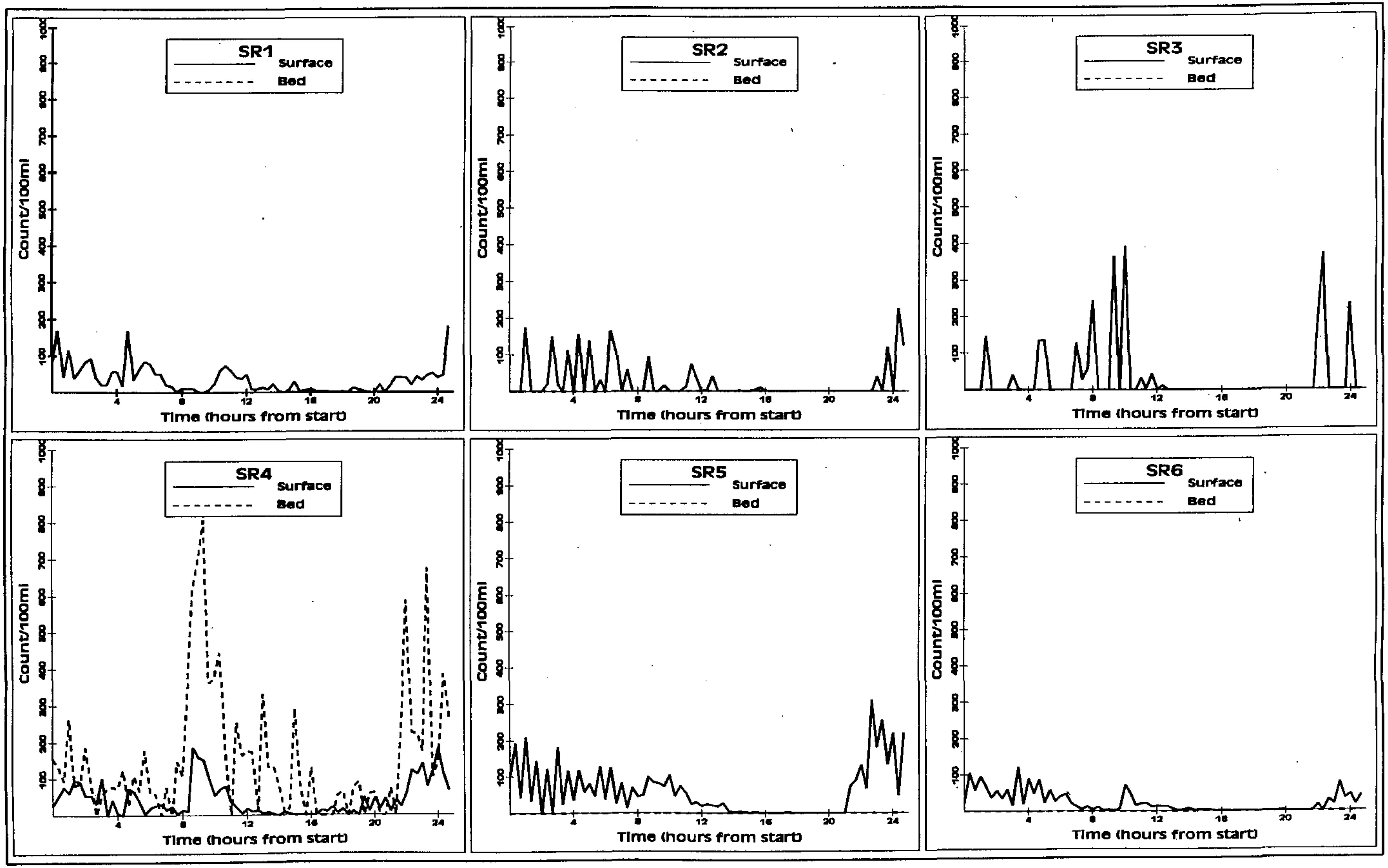


FIGURE 6 LONG OUTFALL, WET SEASON NEAP TIDE (Run No. 6)

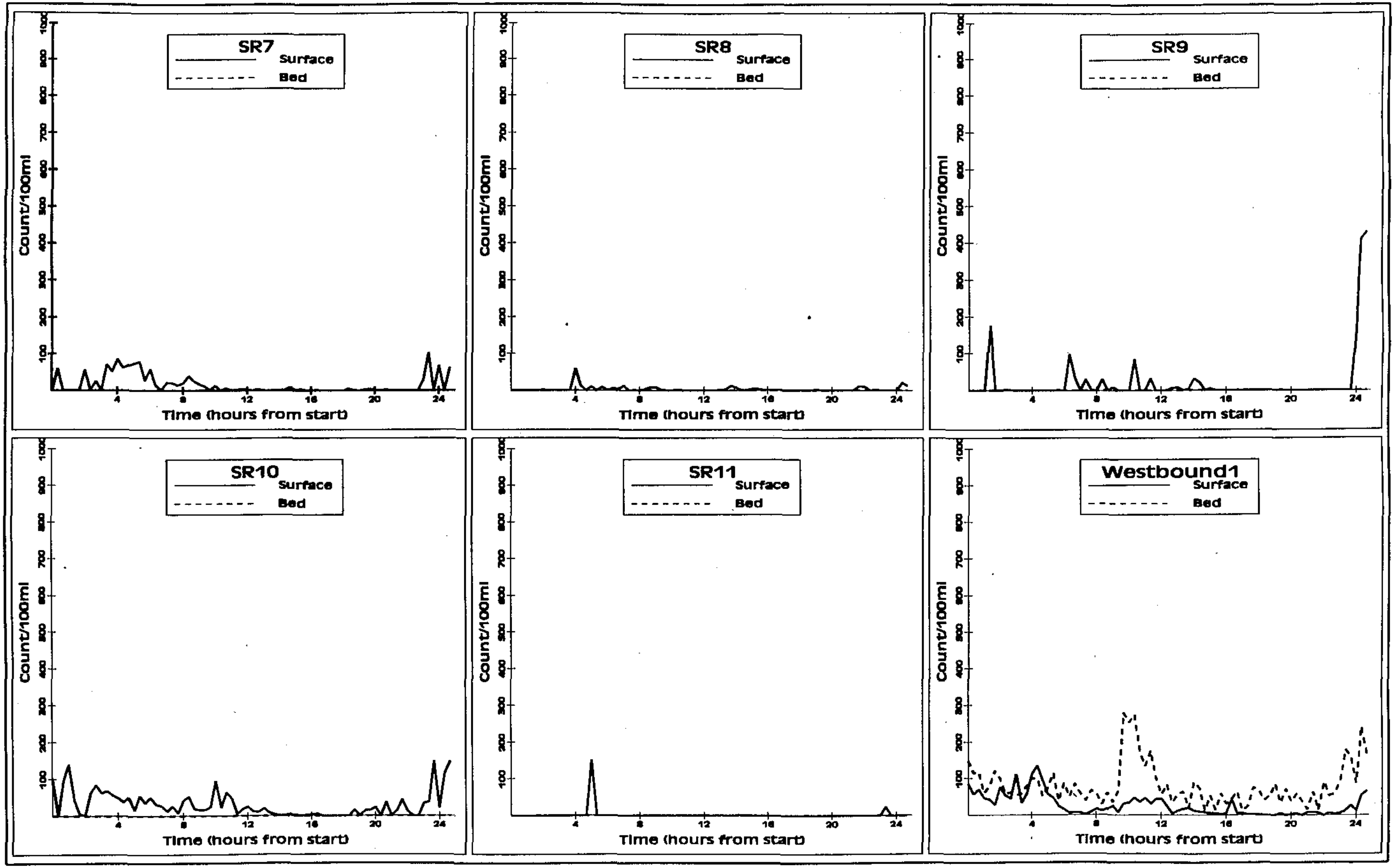


FIGURE 6 LONG OUTFALL, WET SEASON NEAP TIDE (Run No. 6)

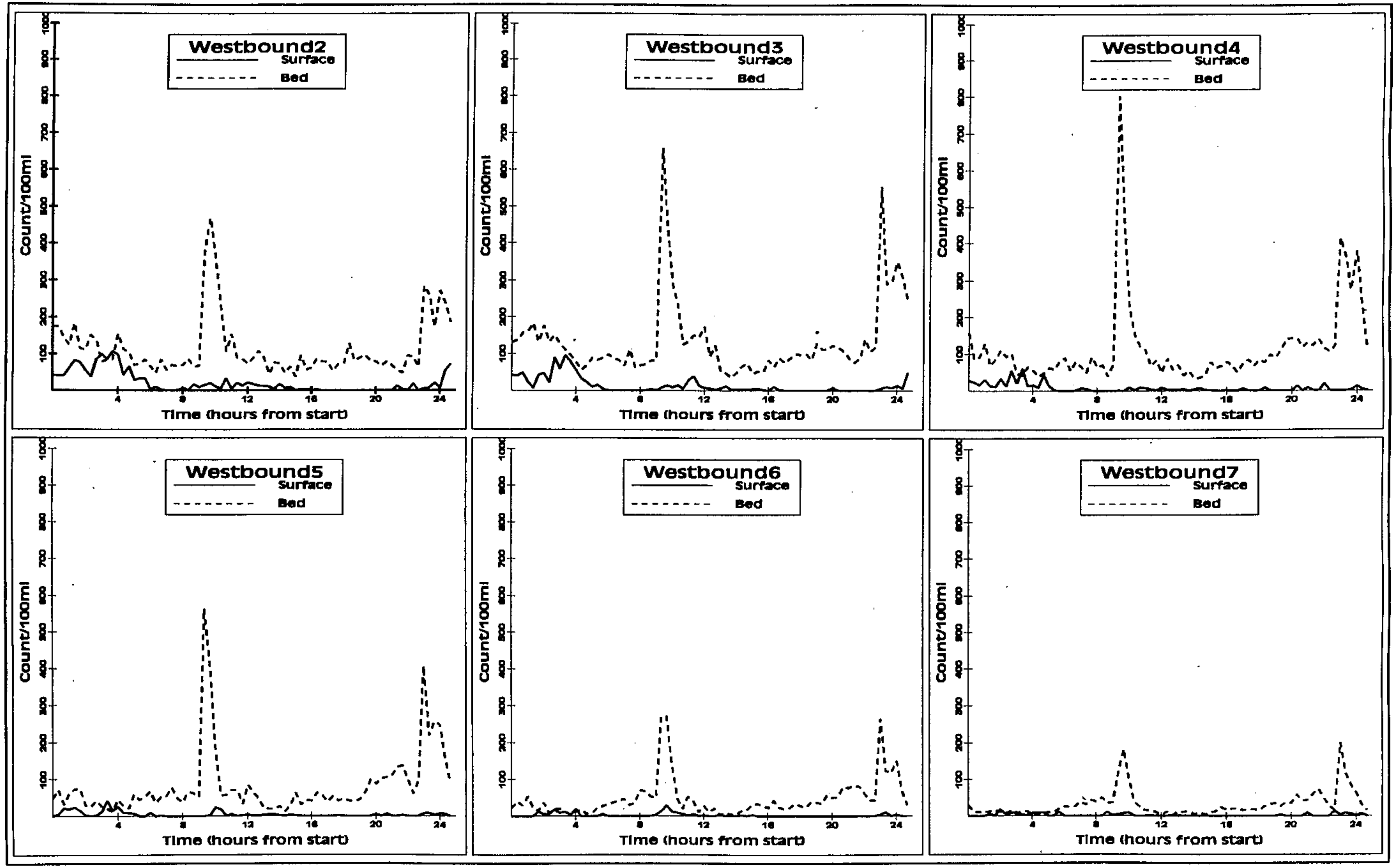


FIGURE 6 LONG OUTFALL, WET SEASON NEAP TIDE (Run No. 6)

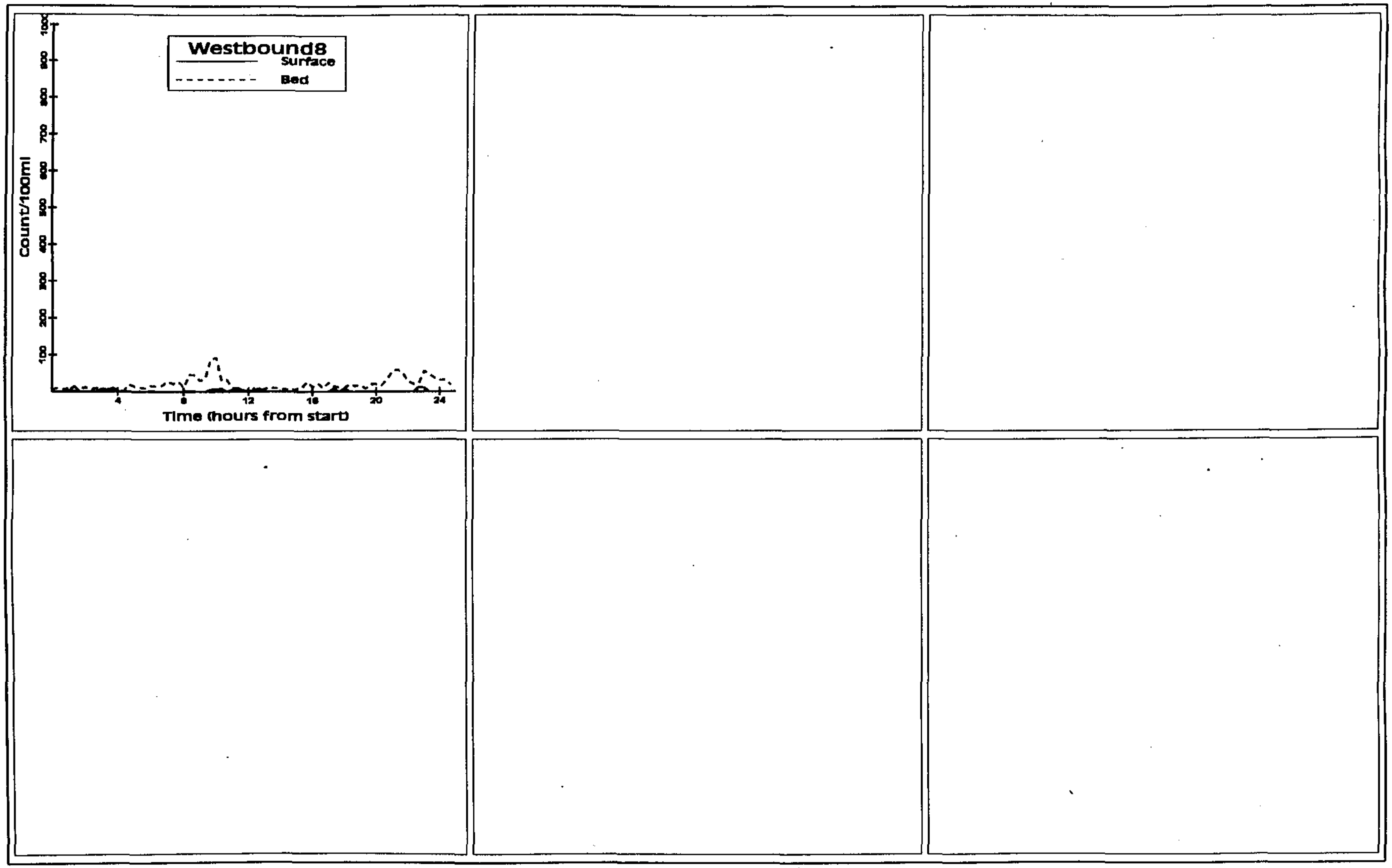


FIGURE 6 LONG OUTFALL, WET SEASON NEAP TIDE (Run No. 6)

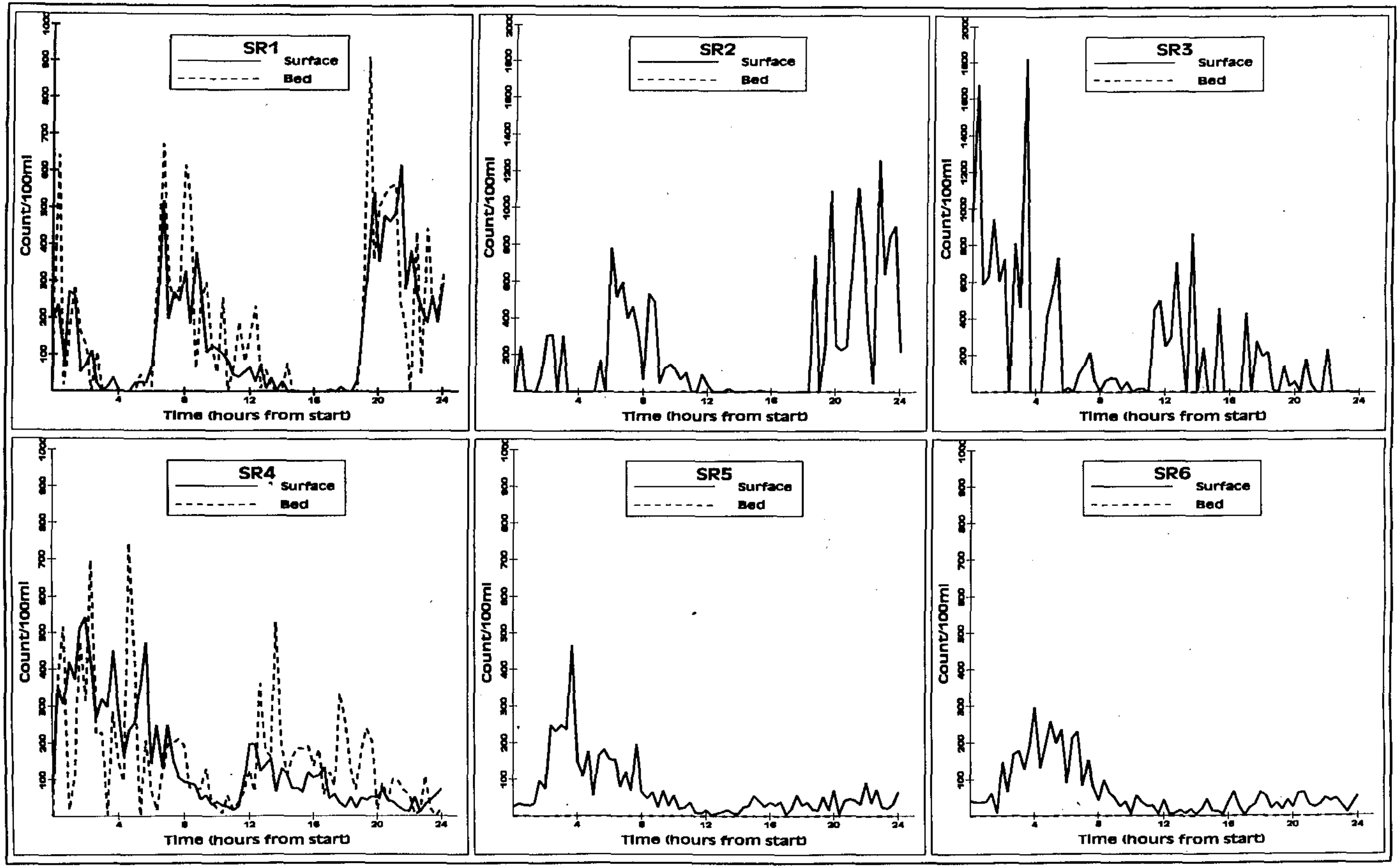


FIGURE 7 SHORT OUTFALL, DRY SEASON NEAP TIDE (Run No.7)

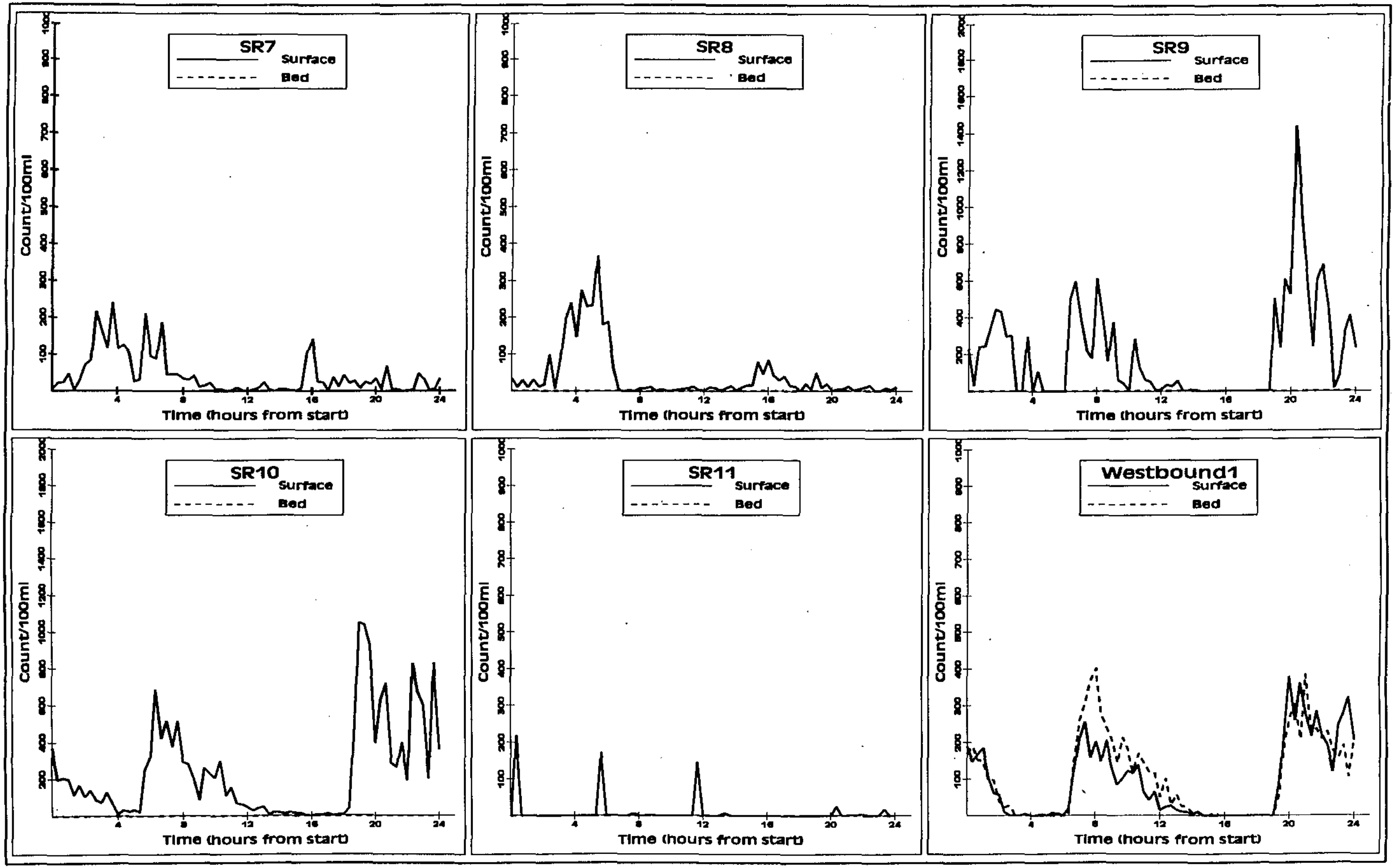


FIGURE 7 SHORT OUTFALL, DRY SEASON NEAP TIDE (Run No. 7)

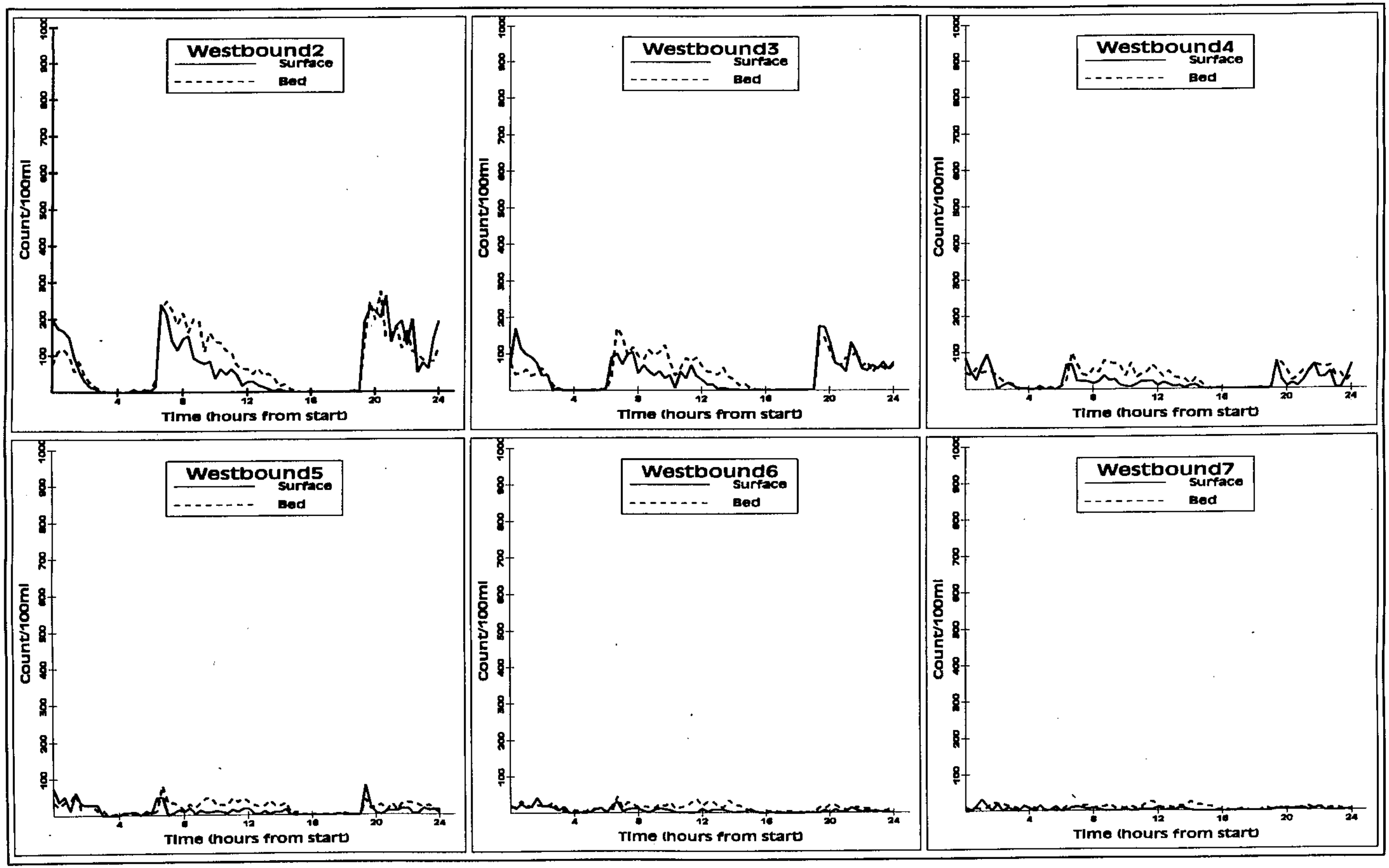


FIGURE 7 SHORT OUTFALL, DRY SEASON NEAP TIDE (Run No.7)

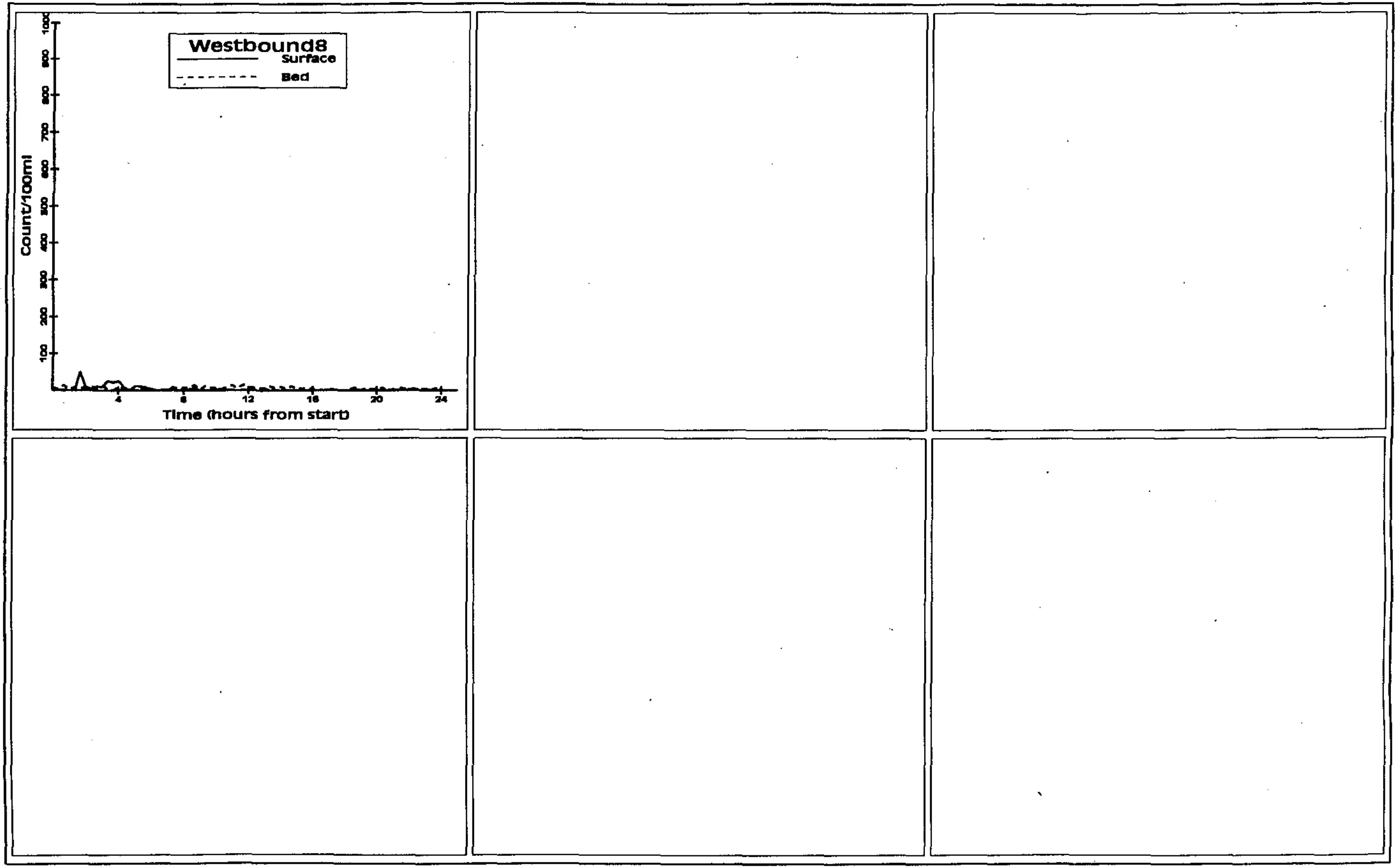


FIGURE 7 SHORT OUTFALL, DRY SEASON NEAP TIDE (Run No.7)

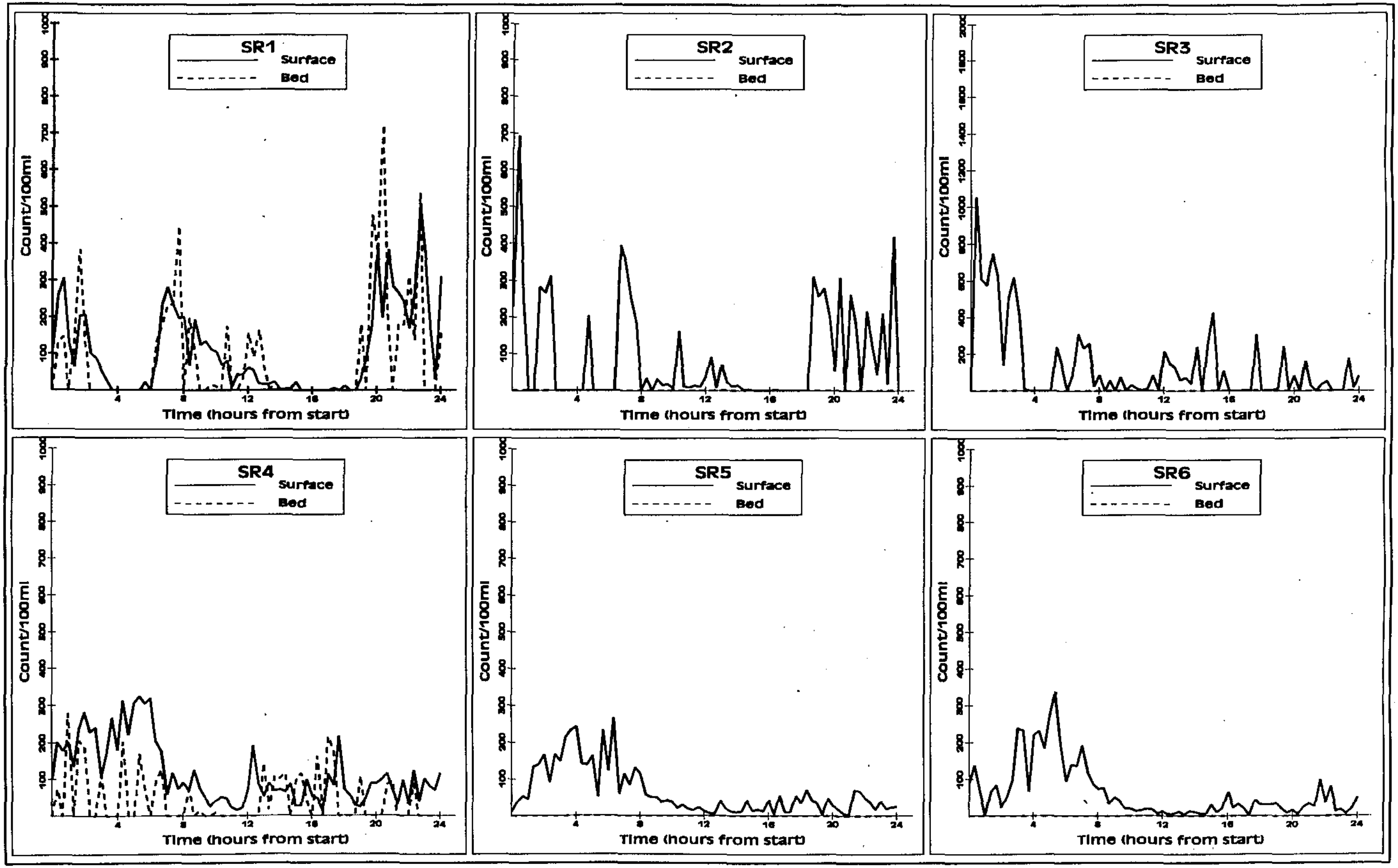


FIGURE 8 SHORT OUTFALL, INTERMEDIATE SEASON NEAP TIDE (Run No. 8)

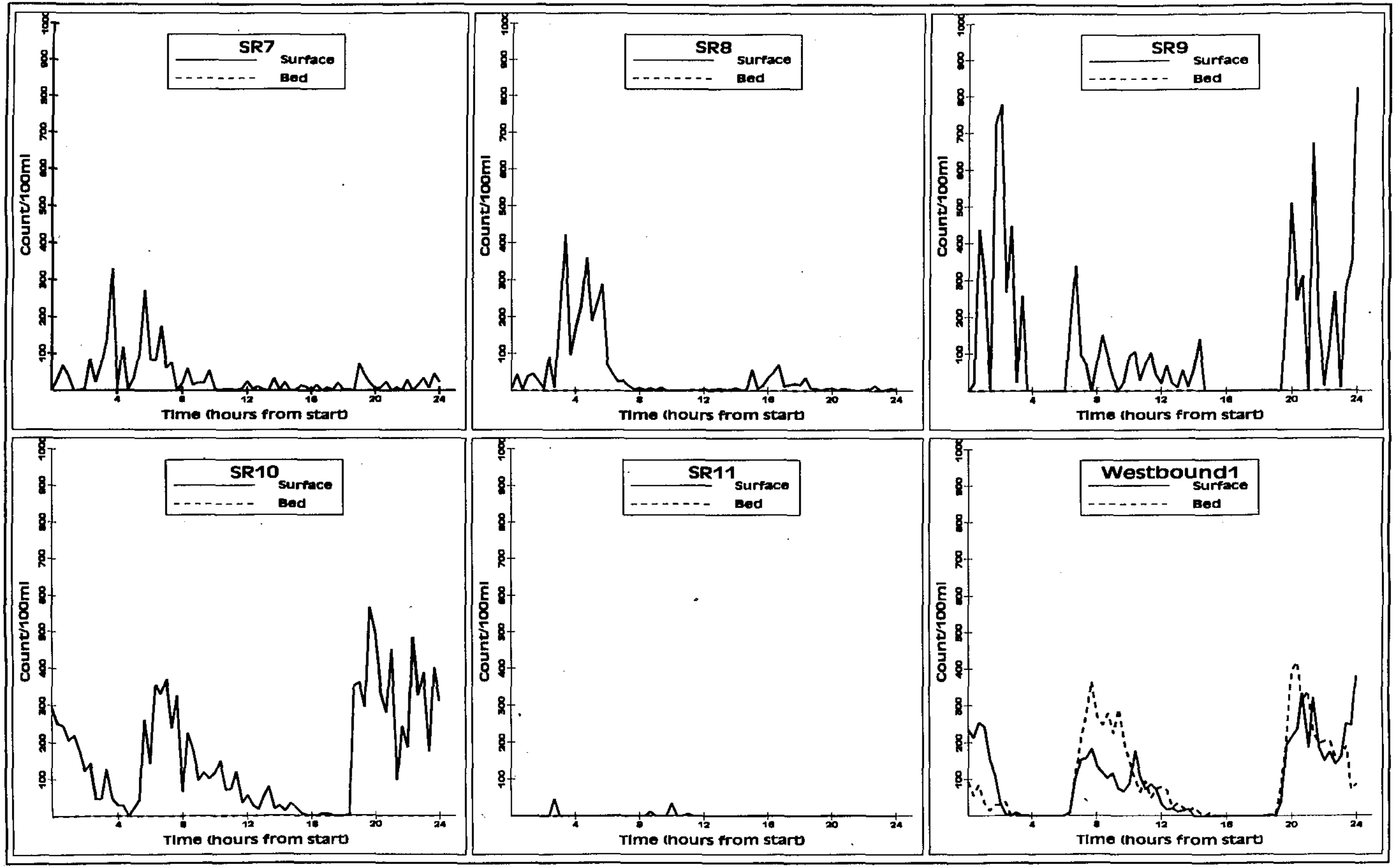


FIGURE 8 SHORT OUTFALL, INTERMEDIATE SEASON NEAP TIDE (Run No. 8)

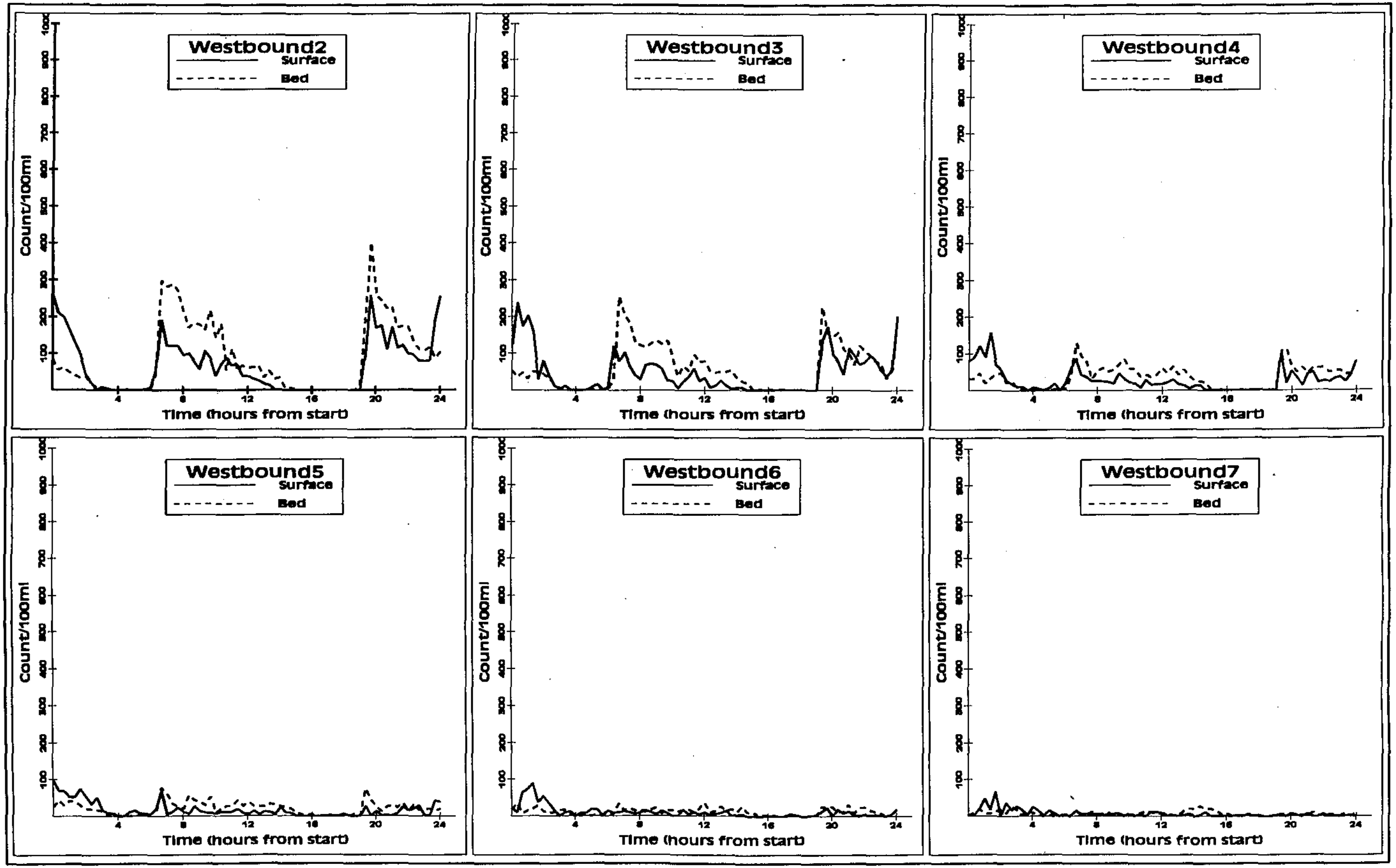


FIGURE 8 SHORT OUTFALL, INTERMEDIATE SEASON NEAP TIDE (Run No. 8)

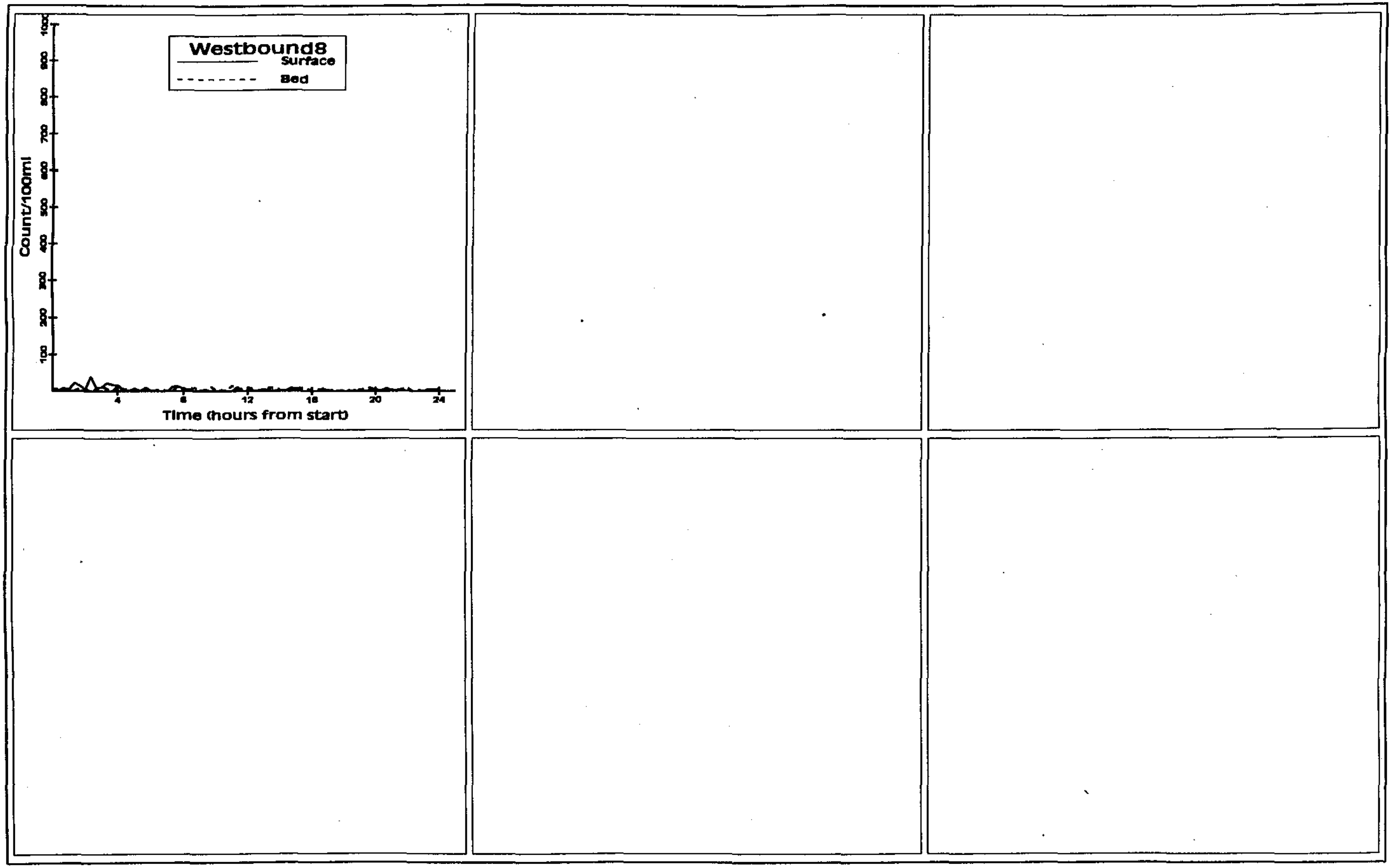


FIGURE 8 SHORT OUTFALL, INTERMEDIATE SEASON NEAP TIDE (Run No. 8)

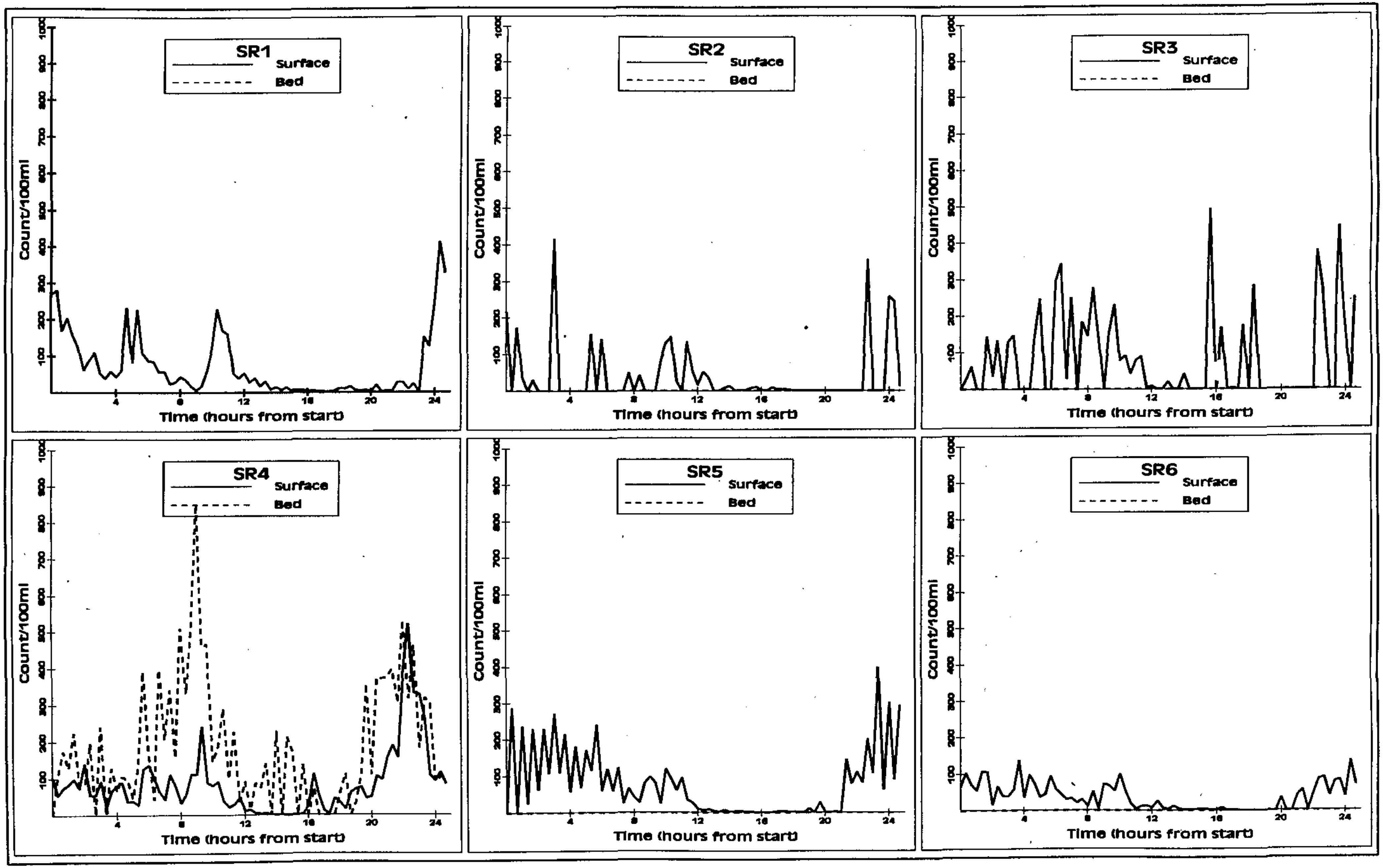


FIGURE 9 SHORT OUTFALL, WET SEASON NEAP TIDE (Run No. 9)

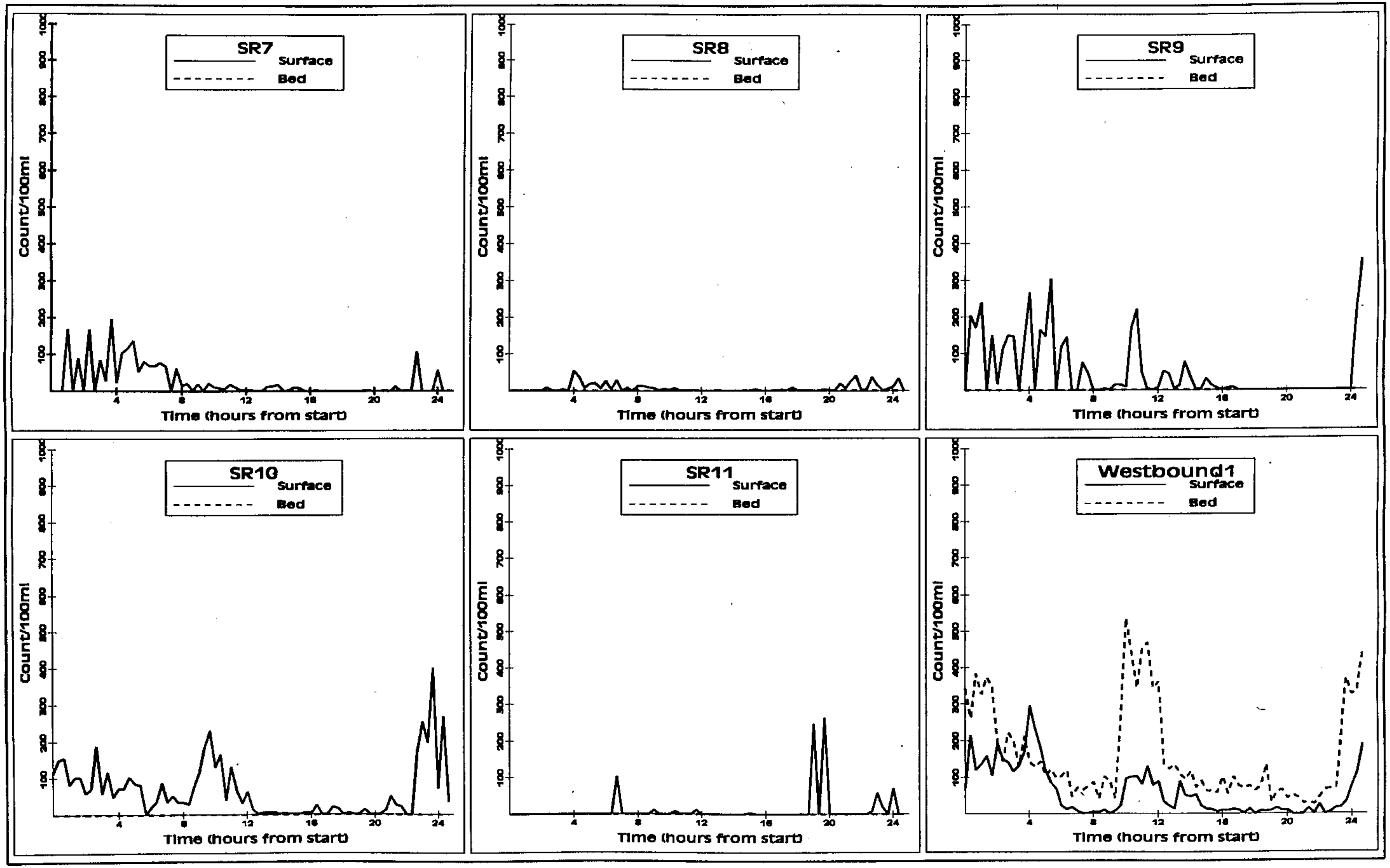


FIGURE 9 SHORT OUTFALL, WET SEASON NEAP TIDE (Run No. 9)

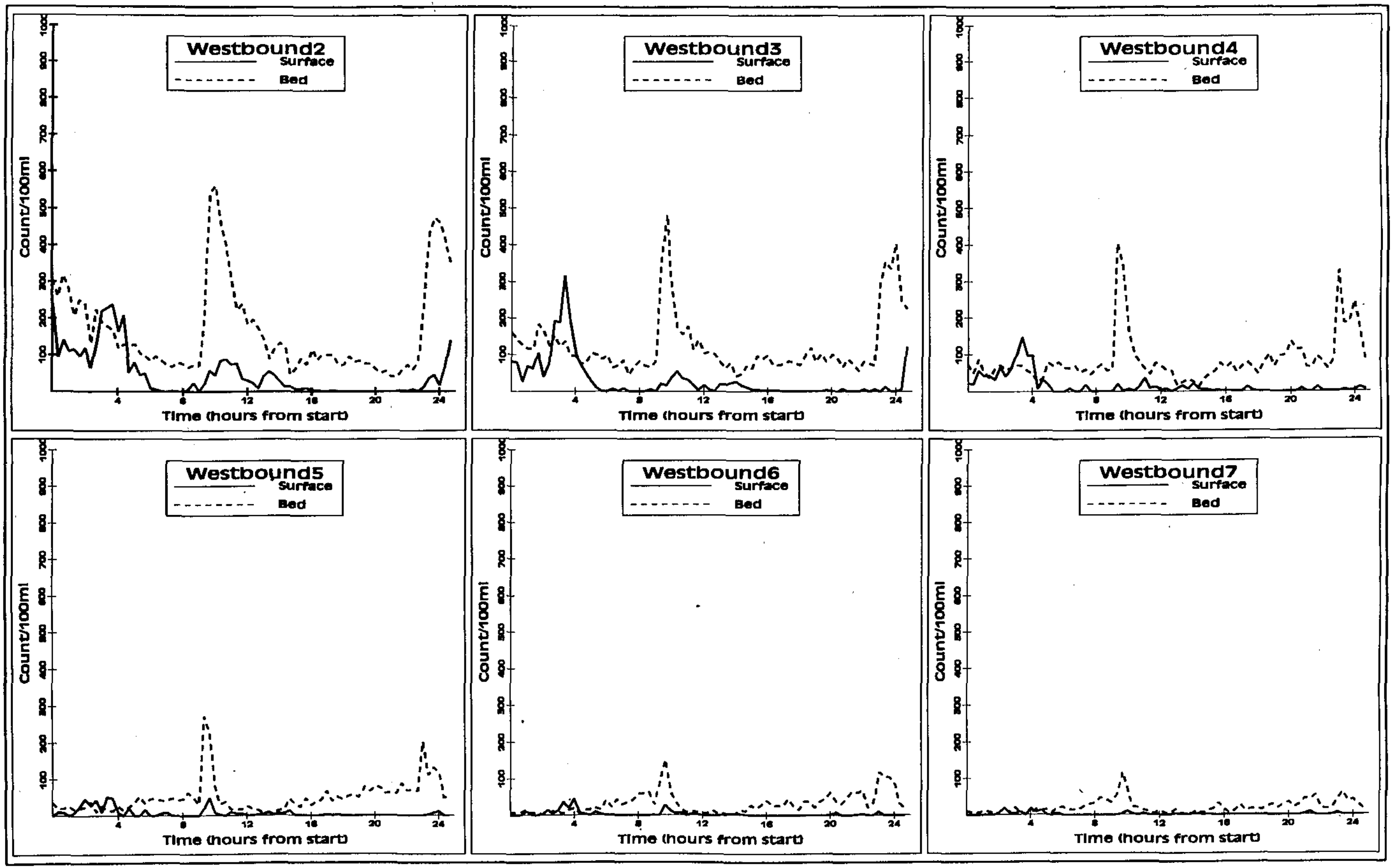


FIGURE 9 SHORT OUTFALL, WET SEASON NEAP TIDE (Run No. 9)

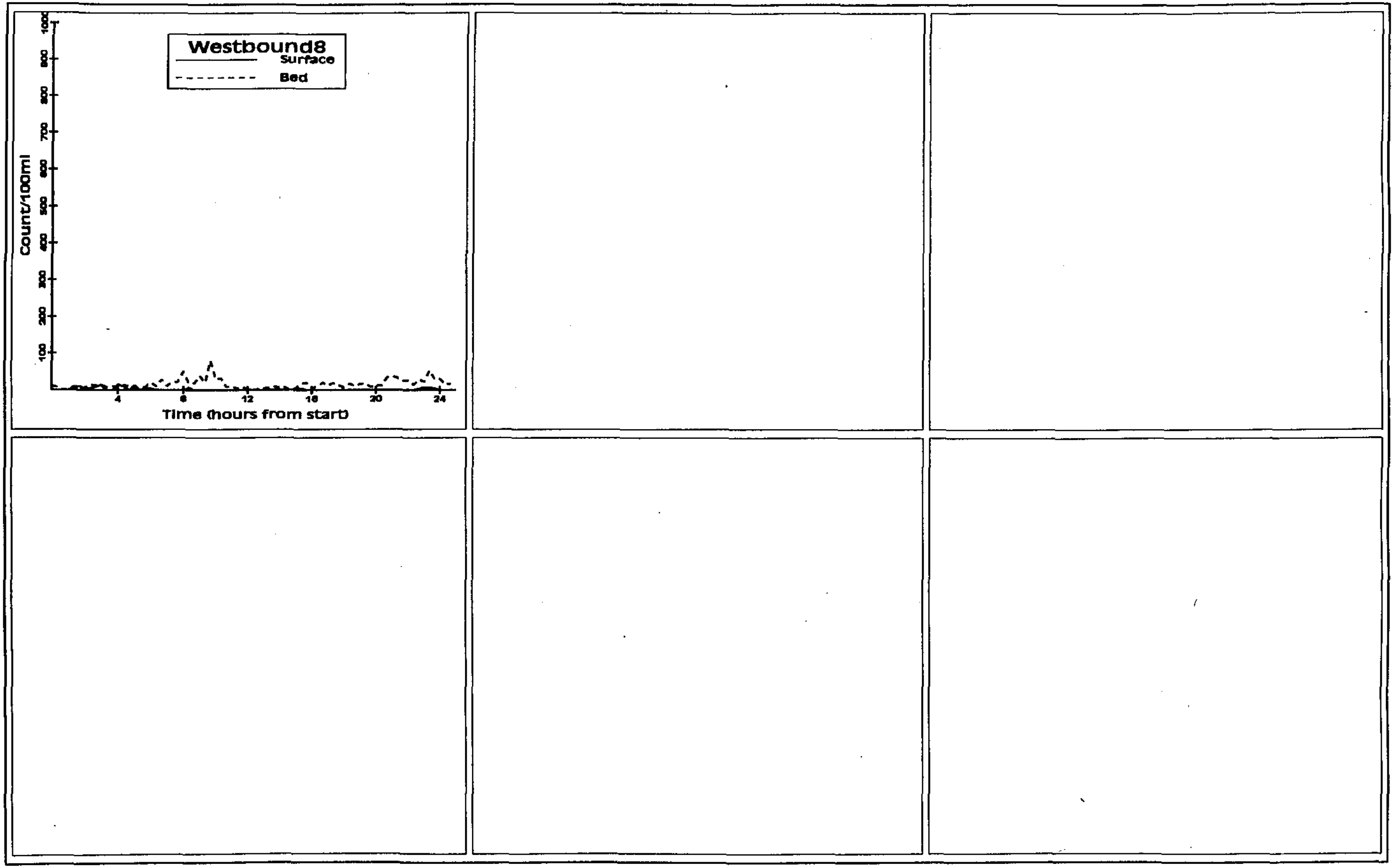


FIGURE 9 SHORT OUTFALL, WET SEASON NEAP TIDE (Run No. 9)

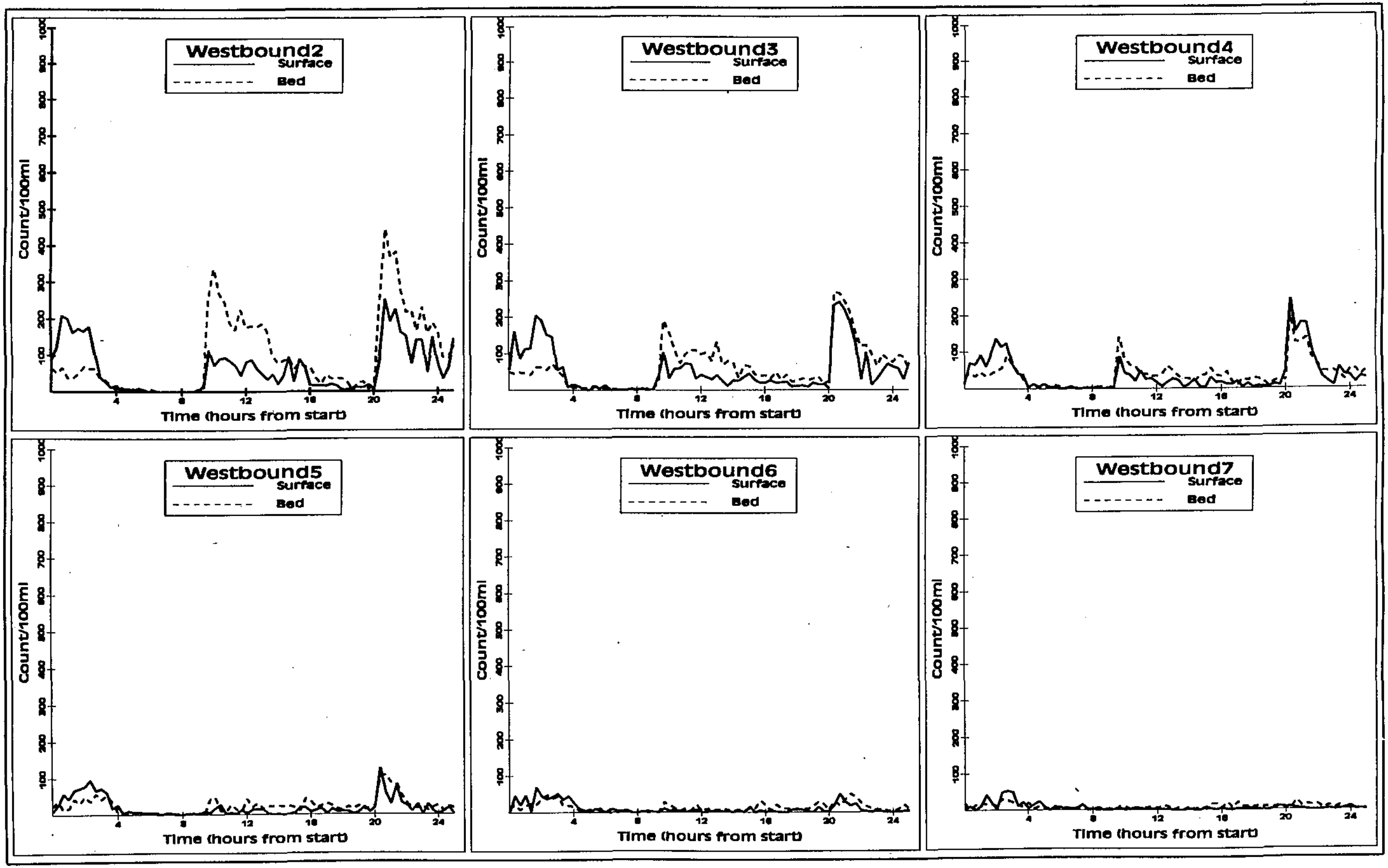


FIGURE 10 SHORT OUTFALL, INTERMEDIATE SEASON SPRING TIDE (Additional Simulation)

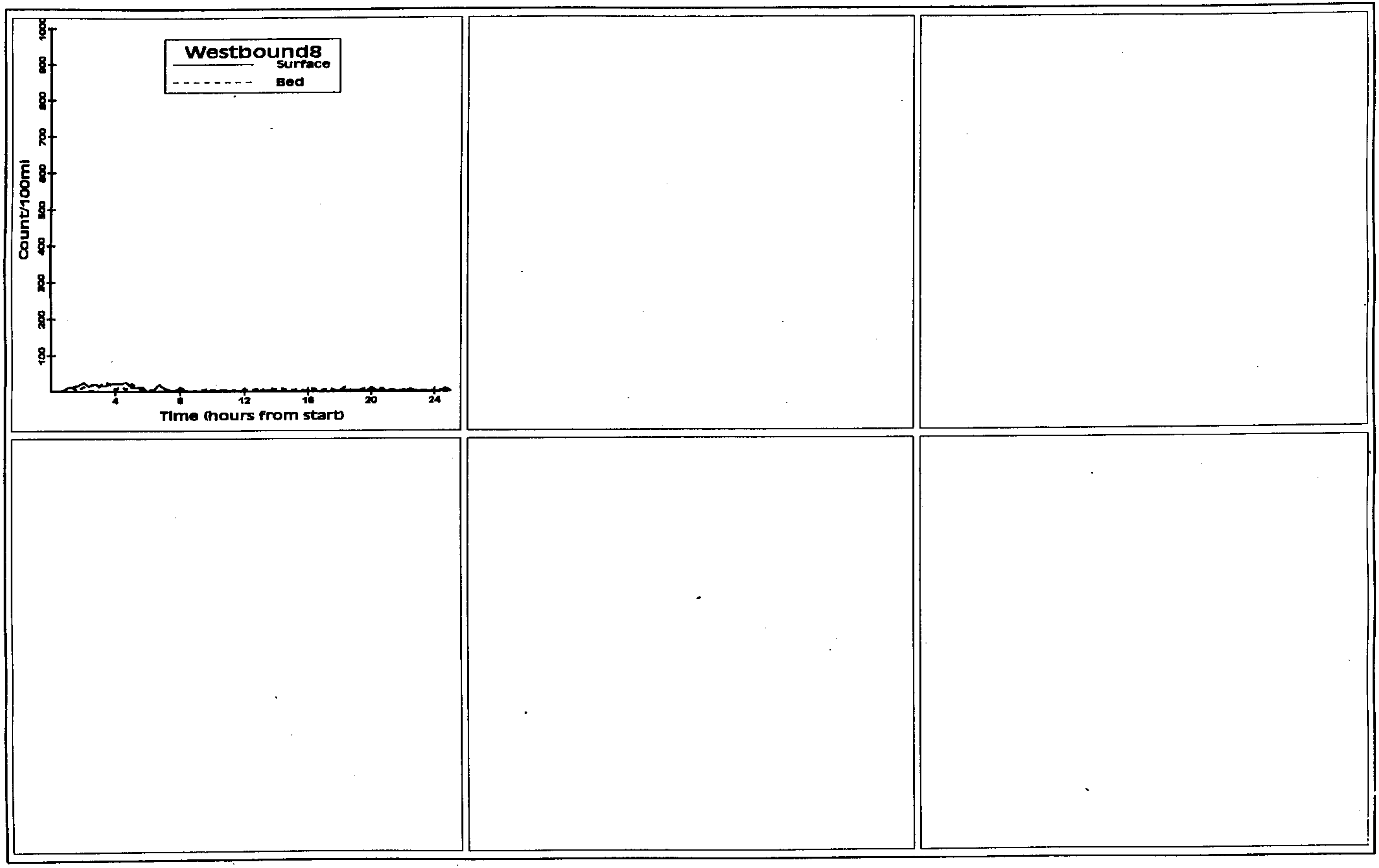


FIGURE 10 SHORT OUTFALL, INTERMEDIATE SEASON SPRING TIDE (Additional Simulation)

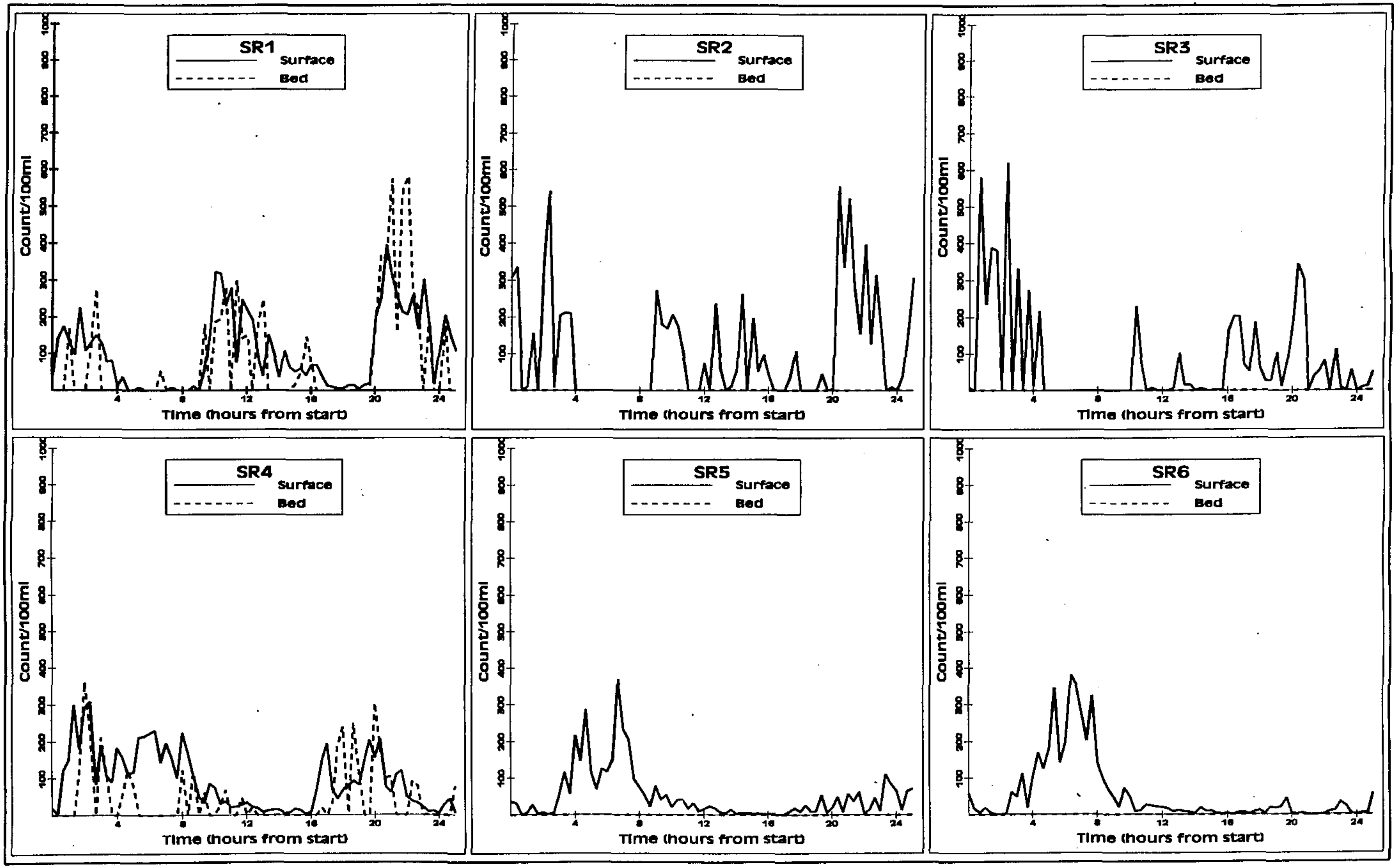


FIGURE 10 SHORT OUTFALL, INTERMEDIATE SEASON SPRING TIDE (Additional Simulation)

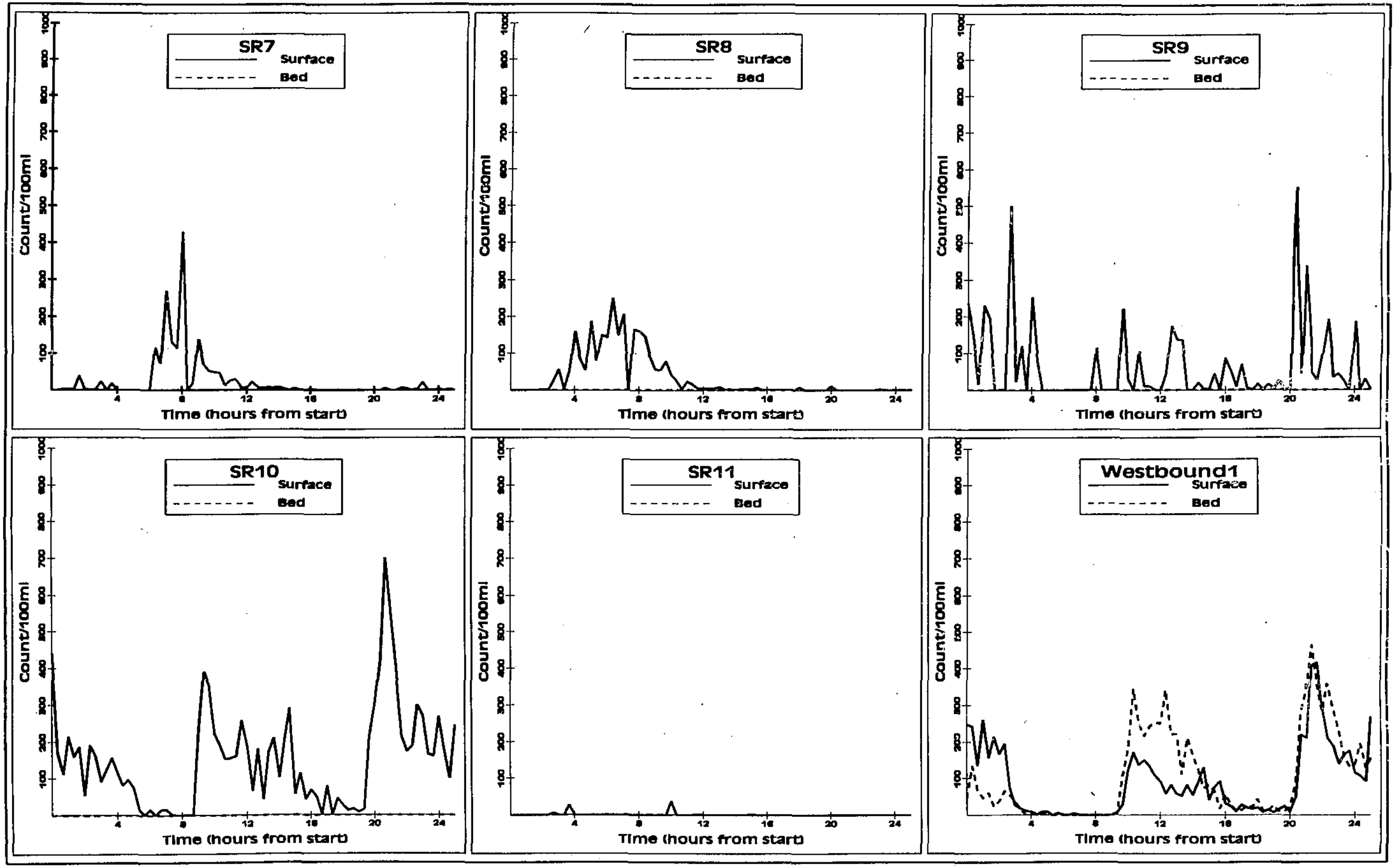
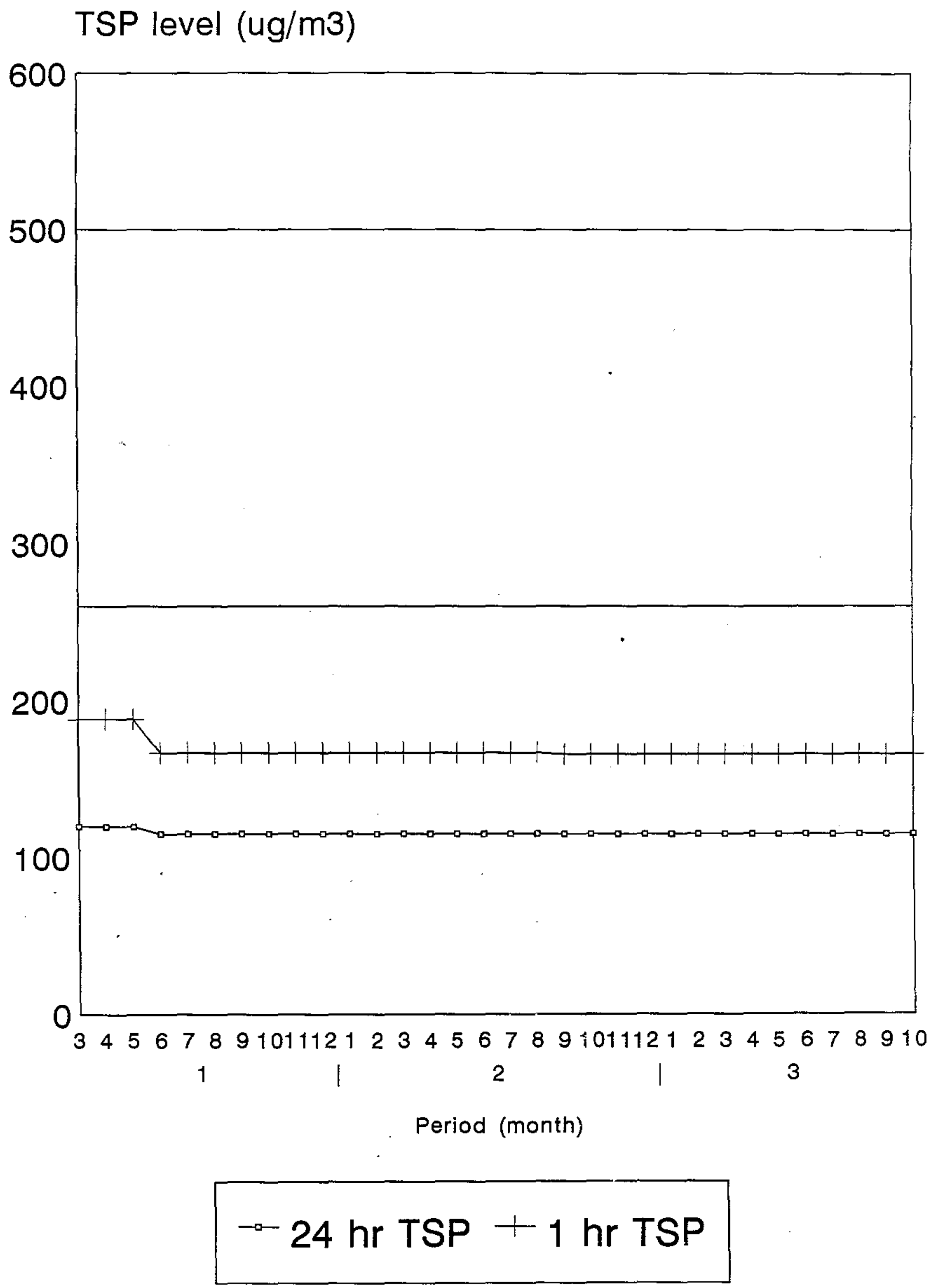


FIGURE 10 SHORT OUTFALL, INTERMEDIATE SEASON SPRING TIDE (Additional Simulation)

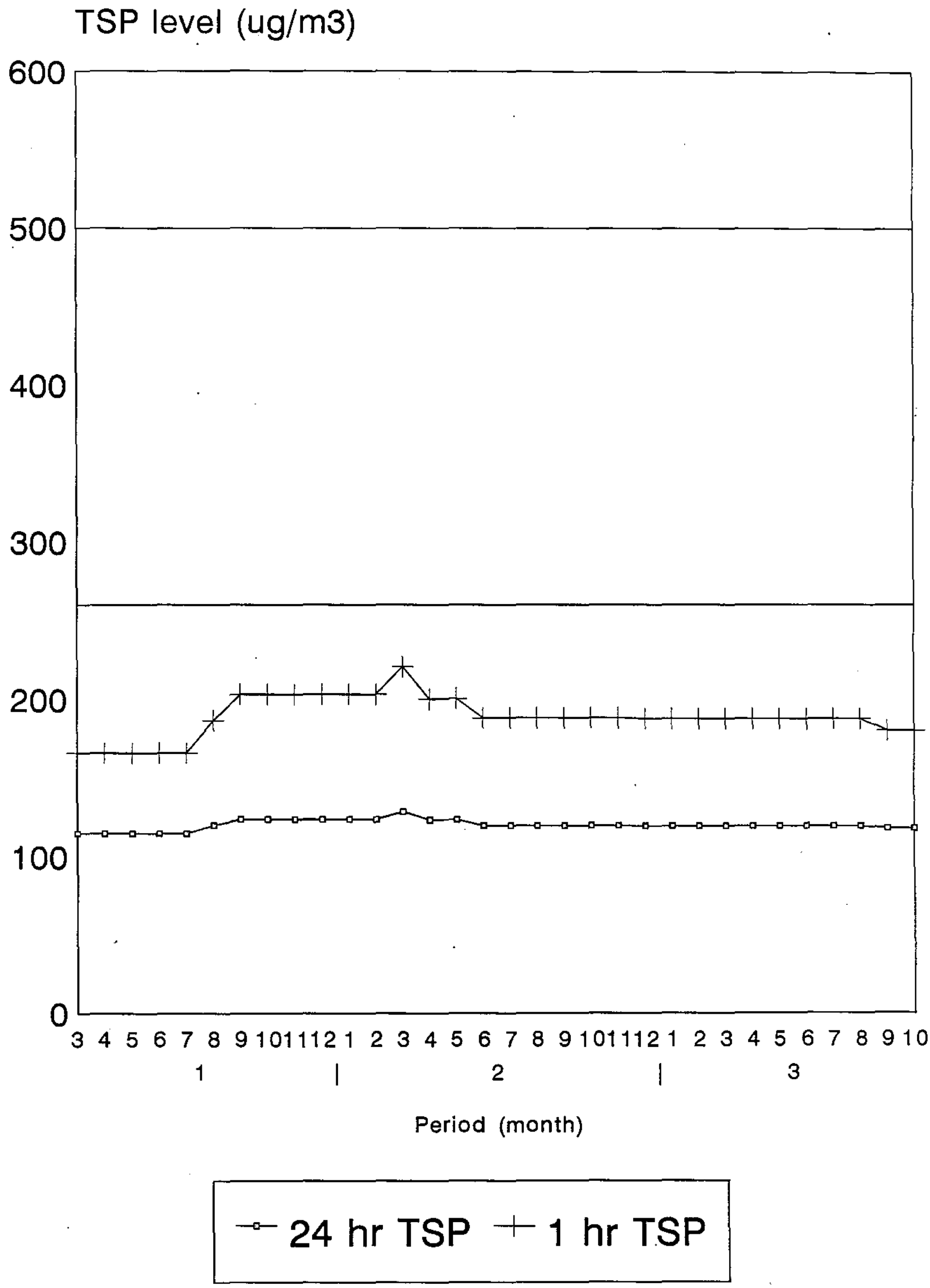
Appendix F

Air Quality Modelling Results
Construction Phase Dust Impacts

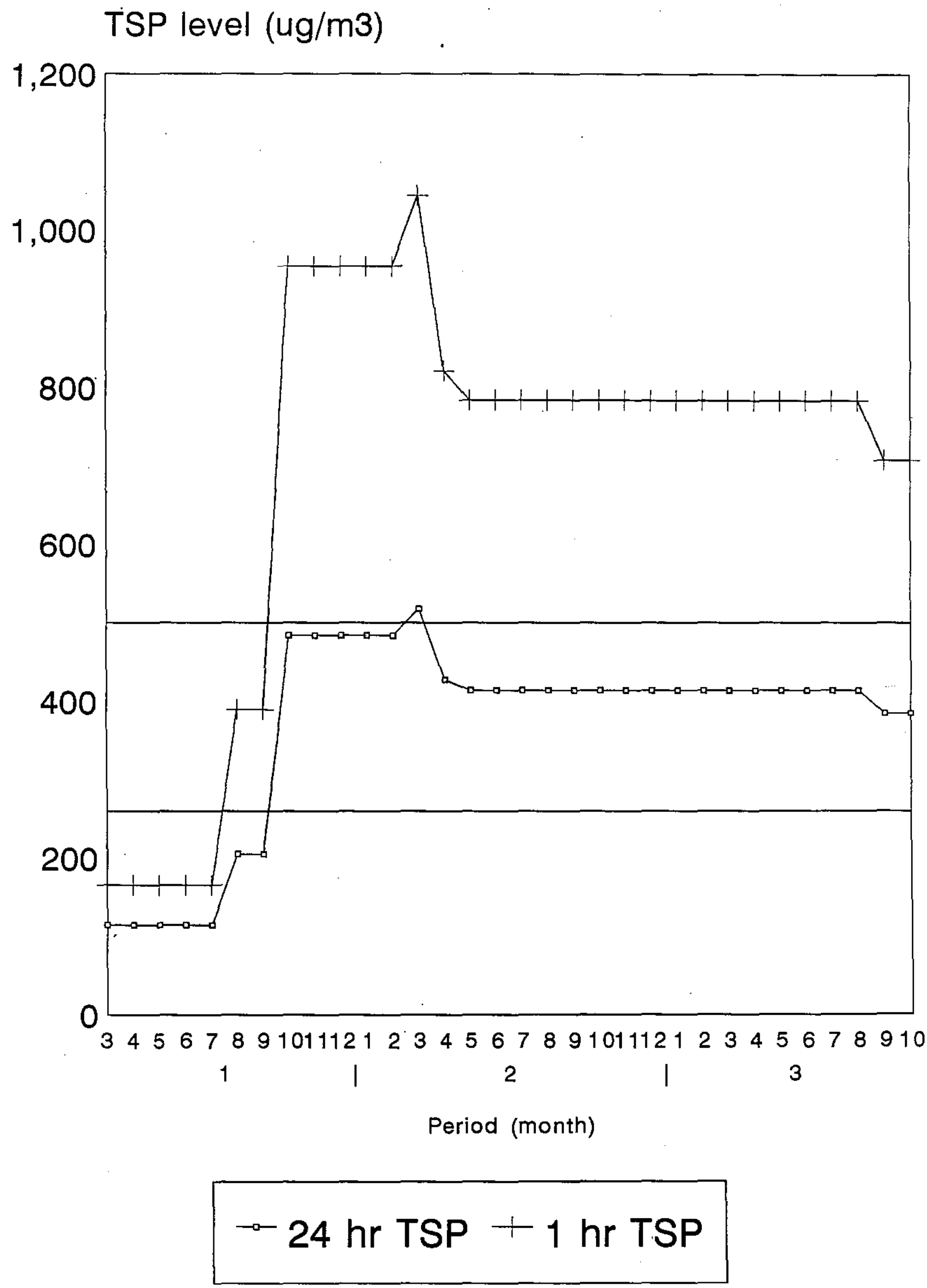
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR2 (Hong Kong Garden)
Without mitigation - using marine fill



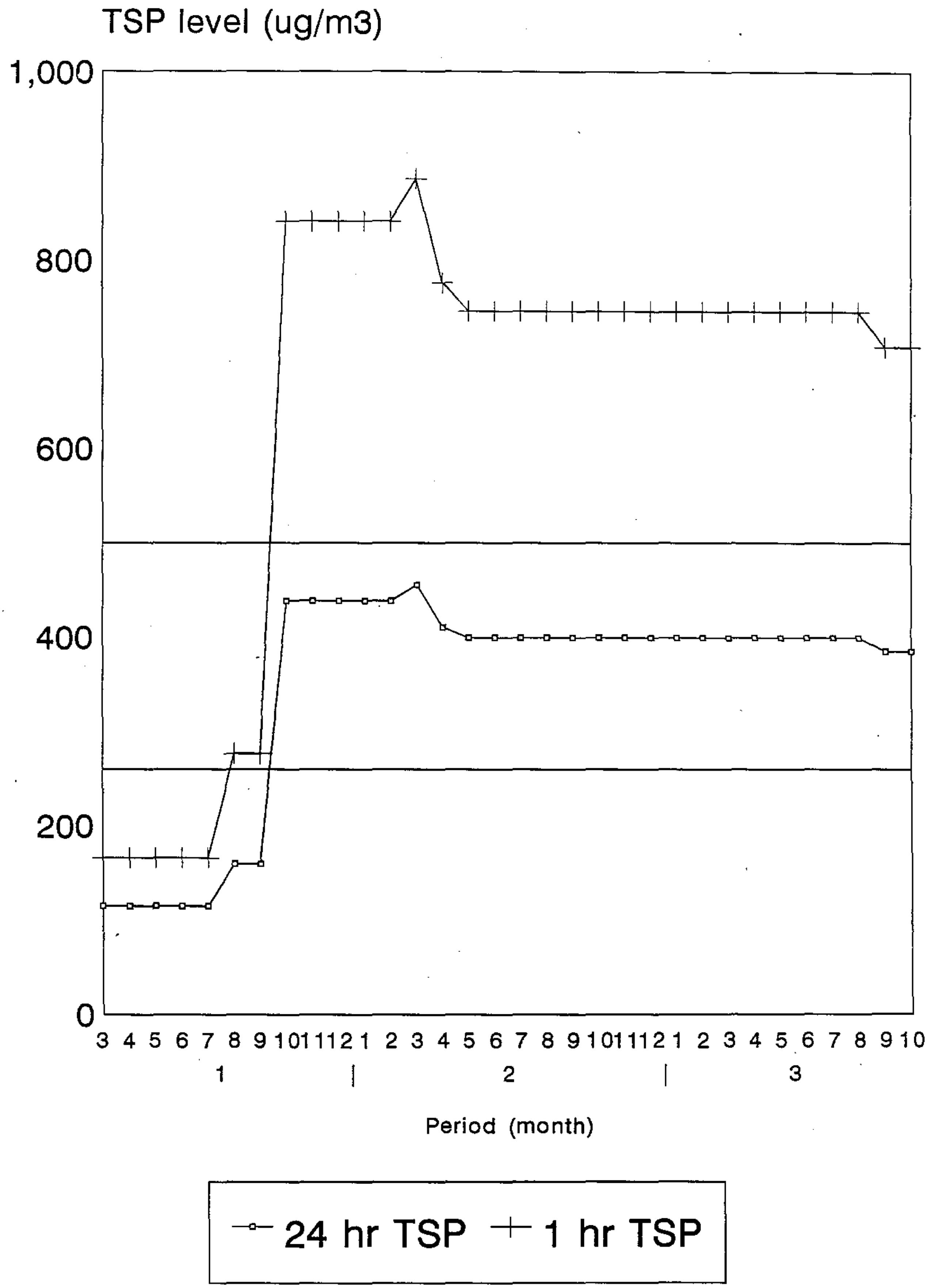
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR3 (Lido Garden)
Without mitigation - using marine fill



TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR4 (Garden Bakery)
Without mitigation - using marine fill

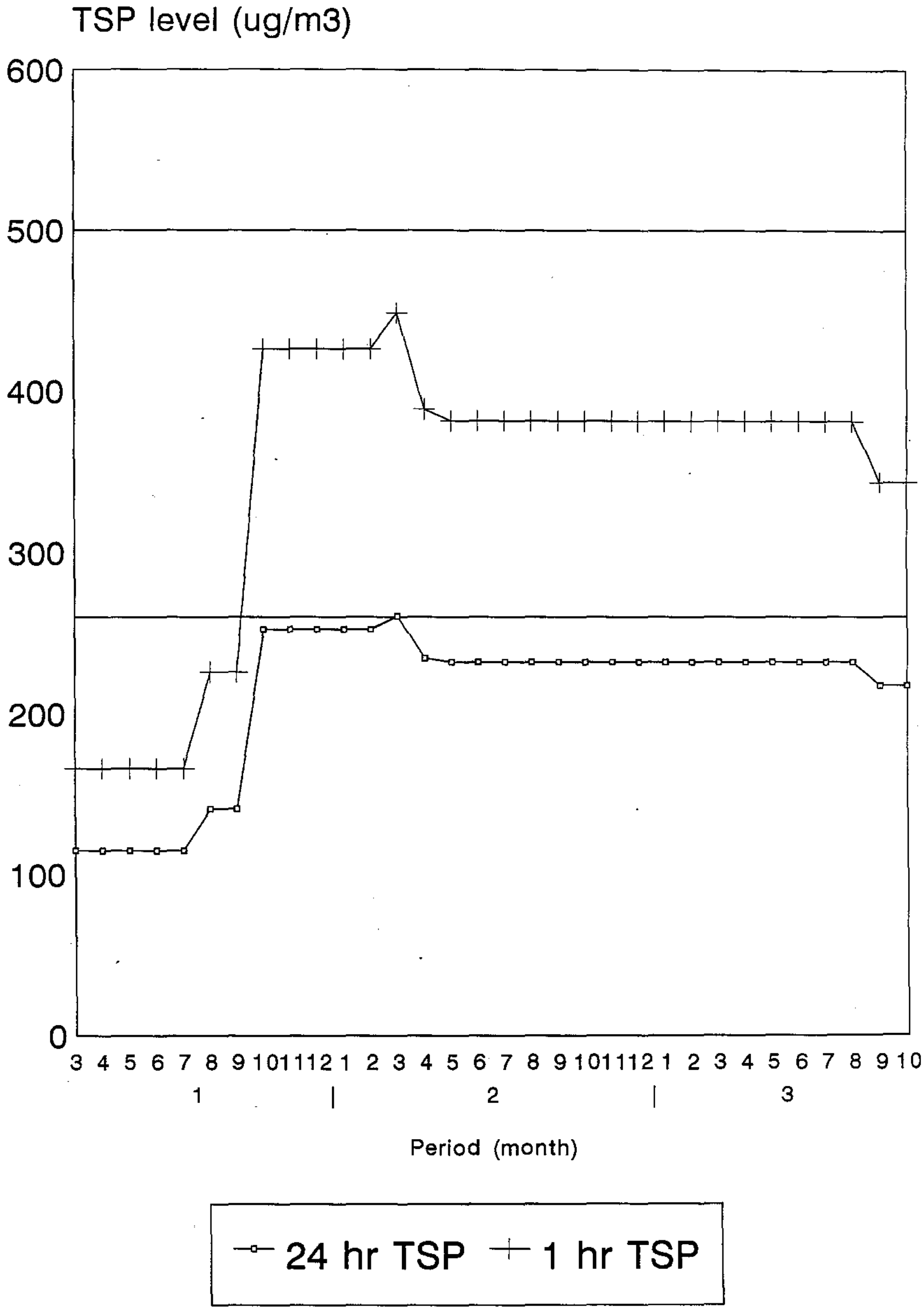


TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR4 (Garden Bakery)
With mitigation (by wetting) - using marine fill

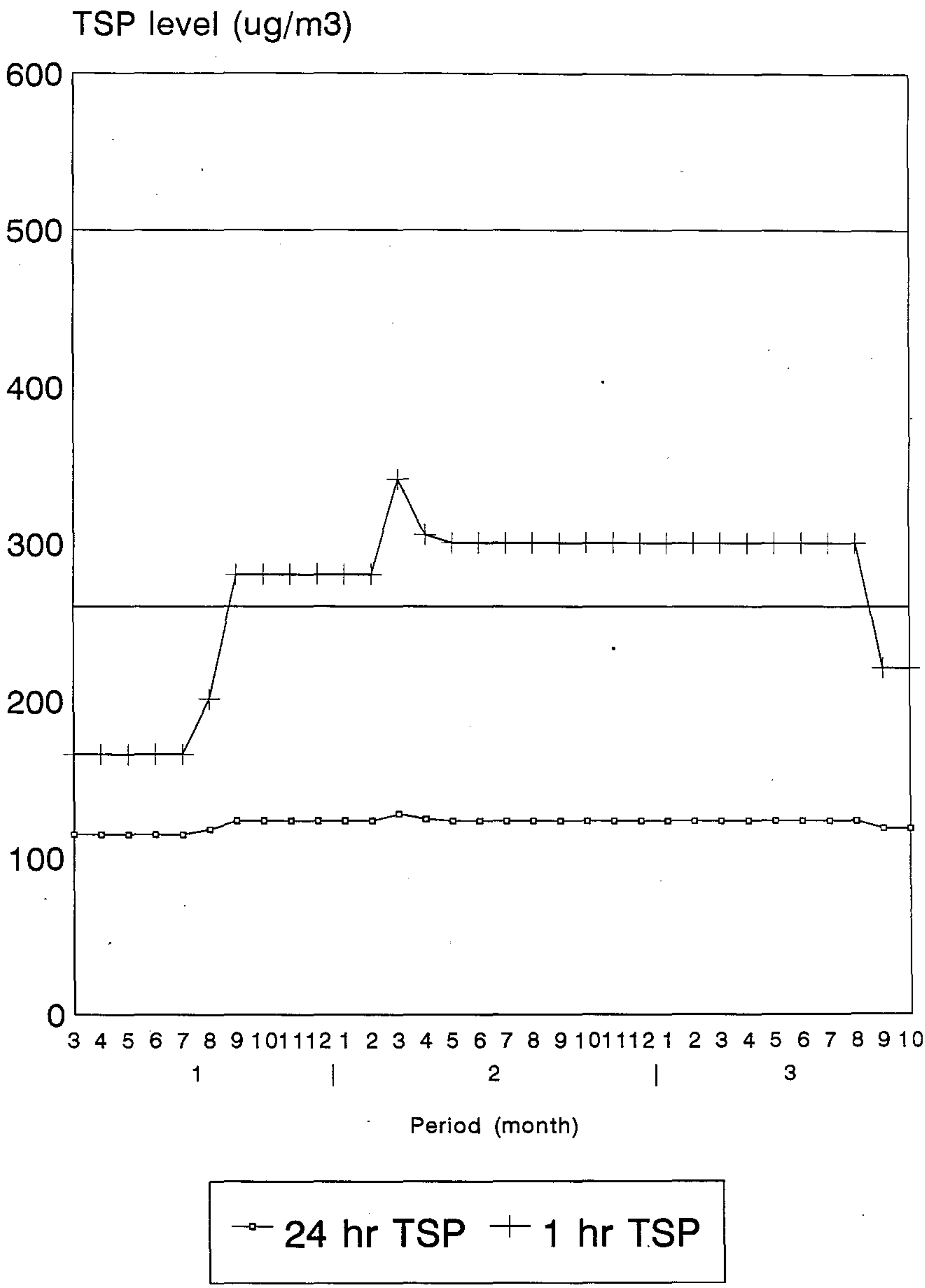


TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR4 (Garden Bakery)

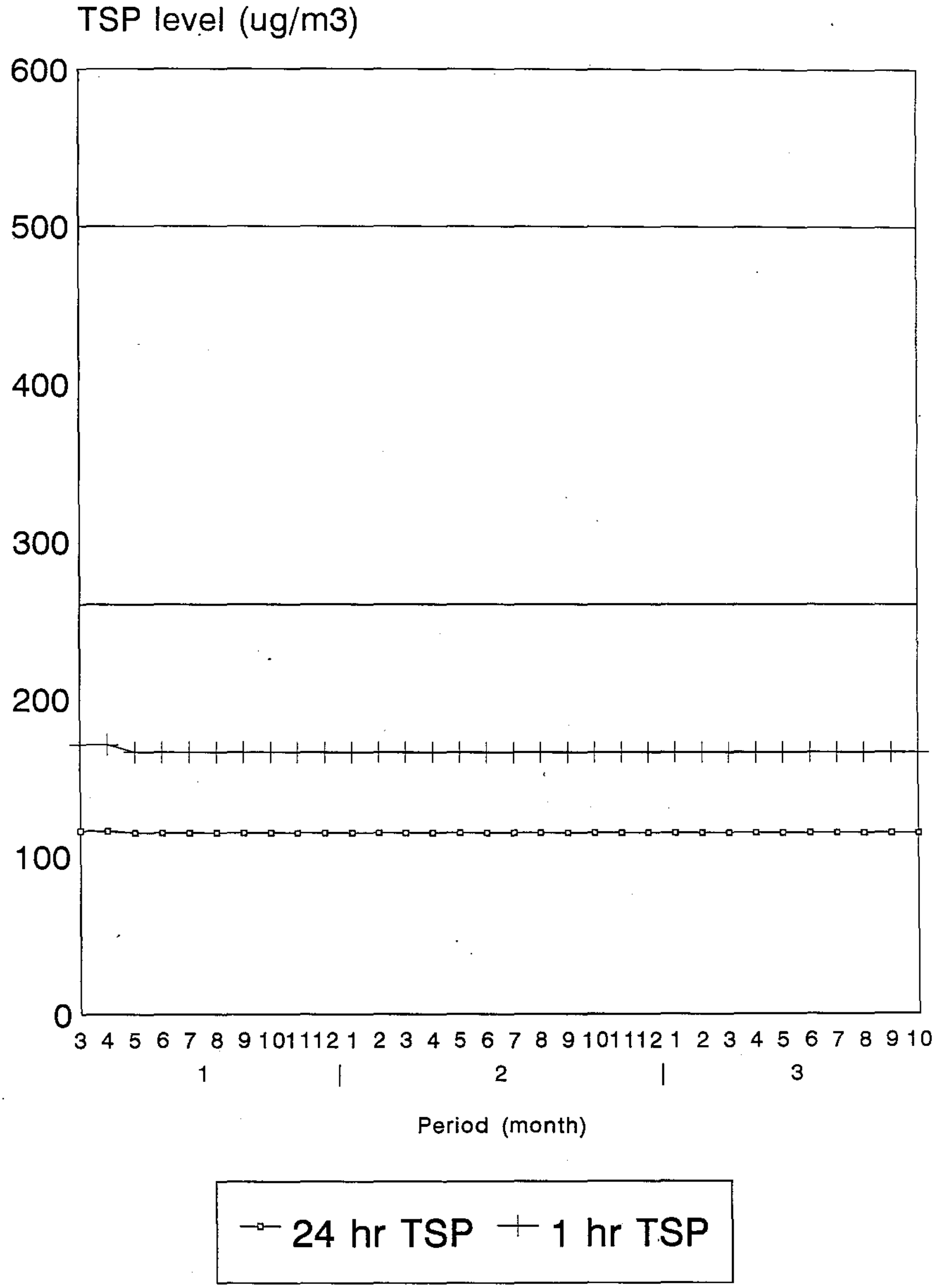
With mitigation (by wetting and covering with hydro-seeding) - using marine fill



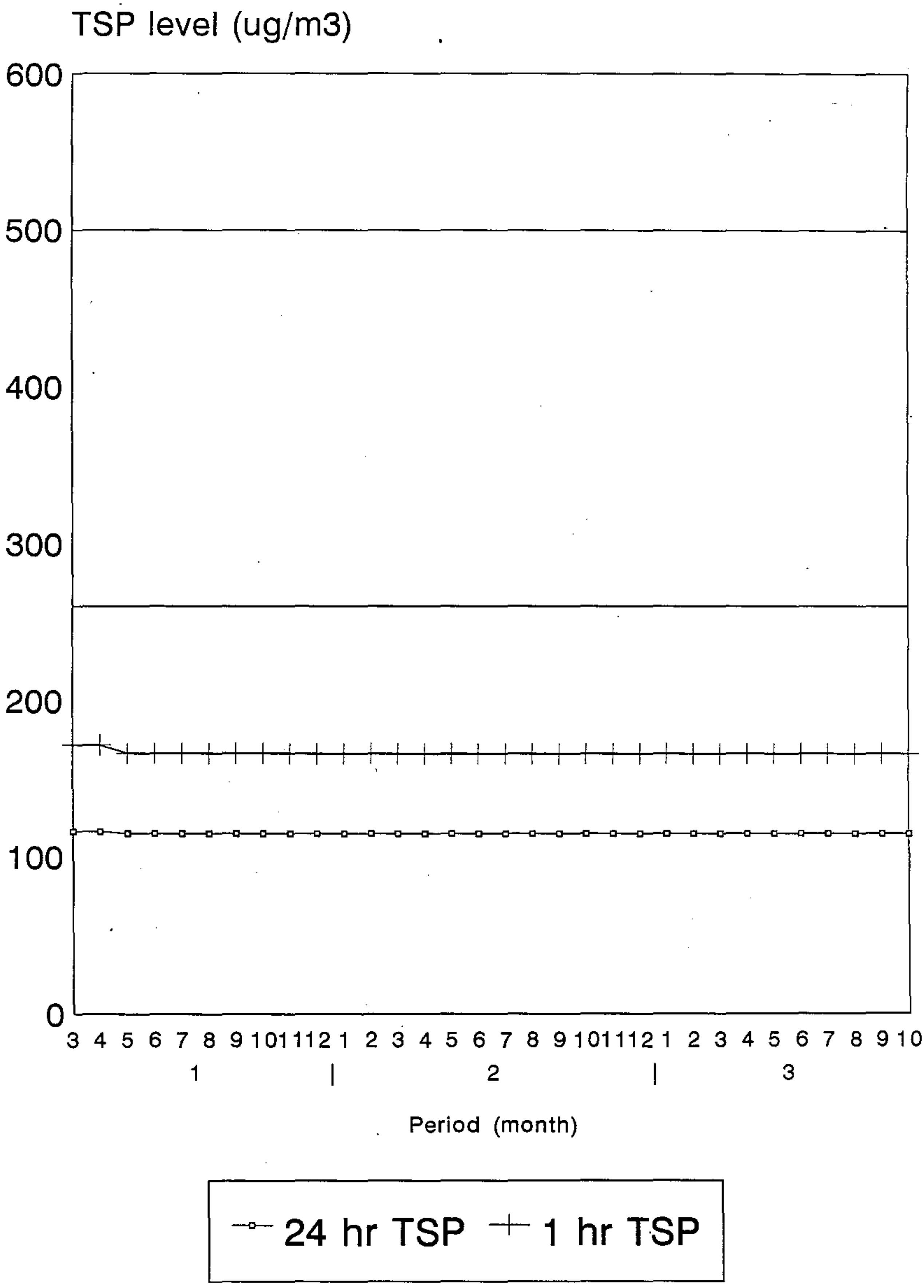
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR5 (Garden Villa)
Without mitigation - using marine fill



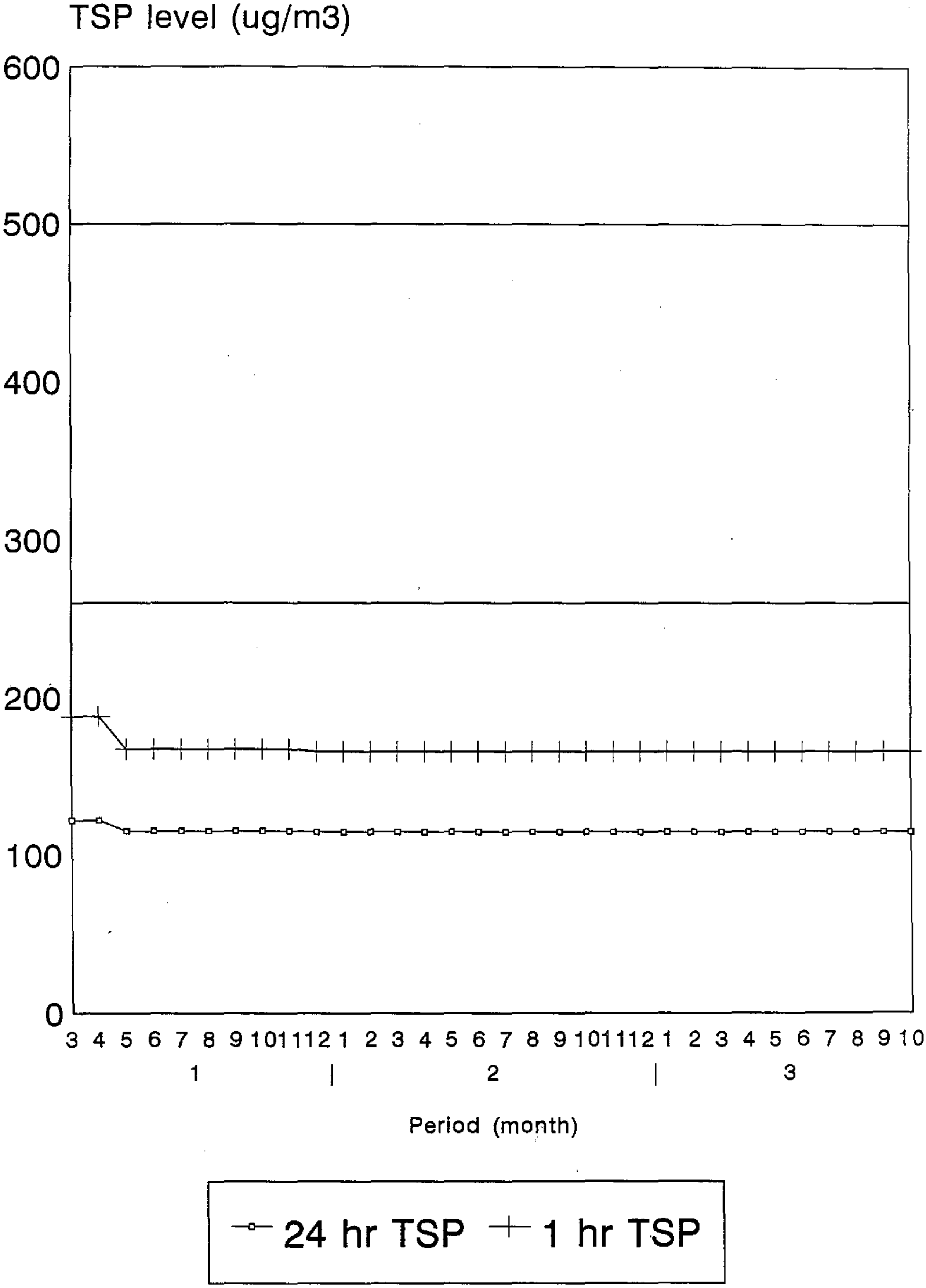
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR6 (Villar Mar)
Without mitigation - using marine fill



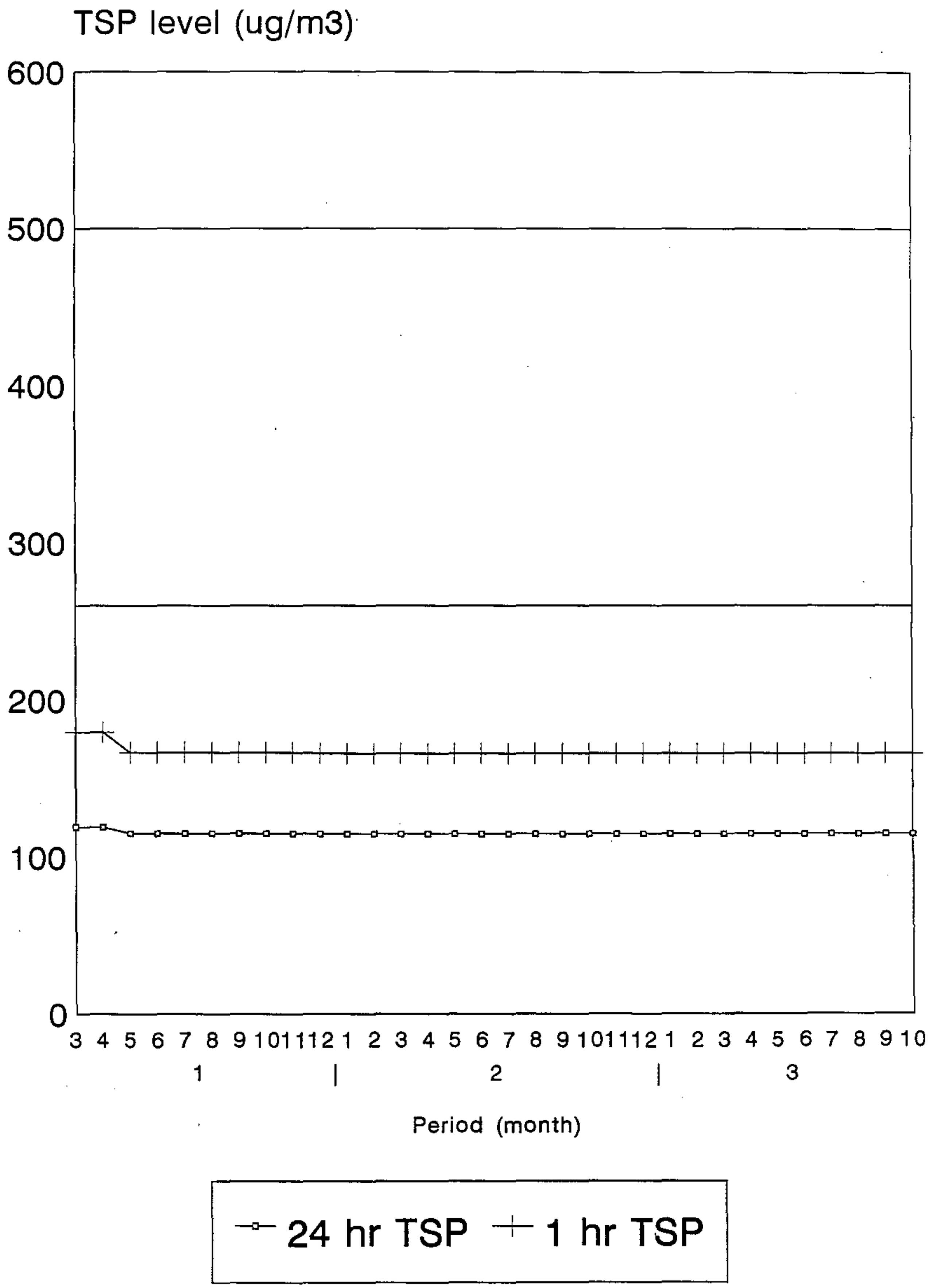
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR7 (Edinburgh Villa)
Without mitigation - using marine fill



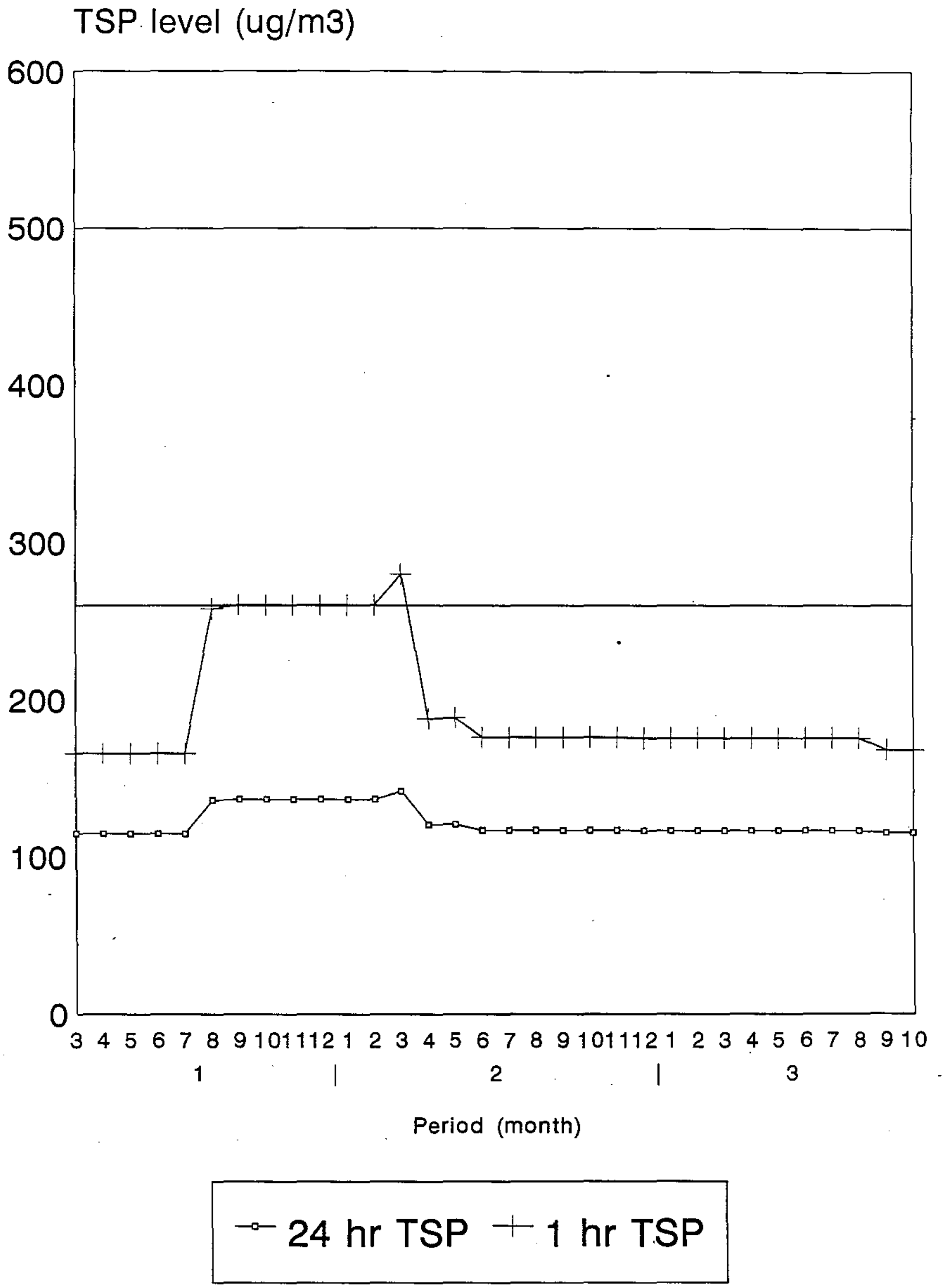
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR8 (Ting Kau Village)
Without mitigation - using marine fill



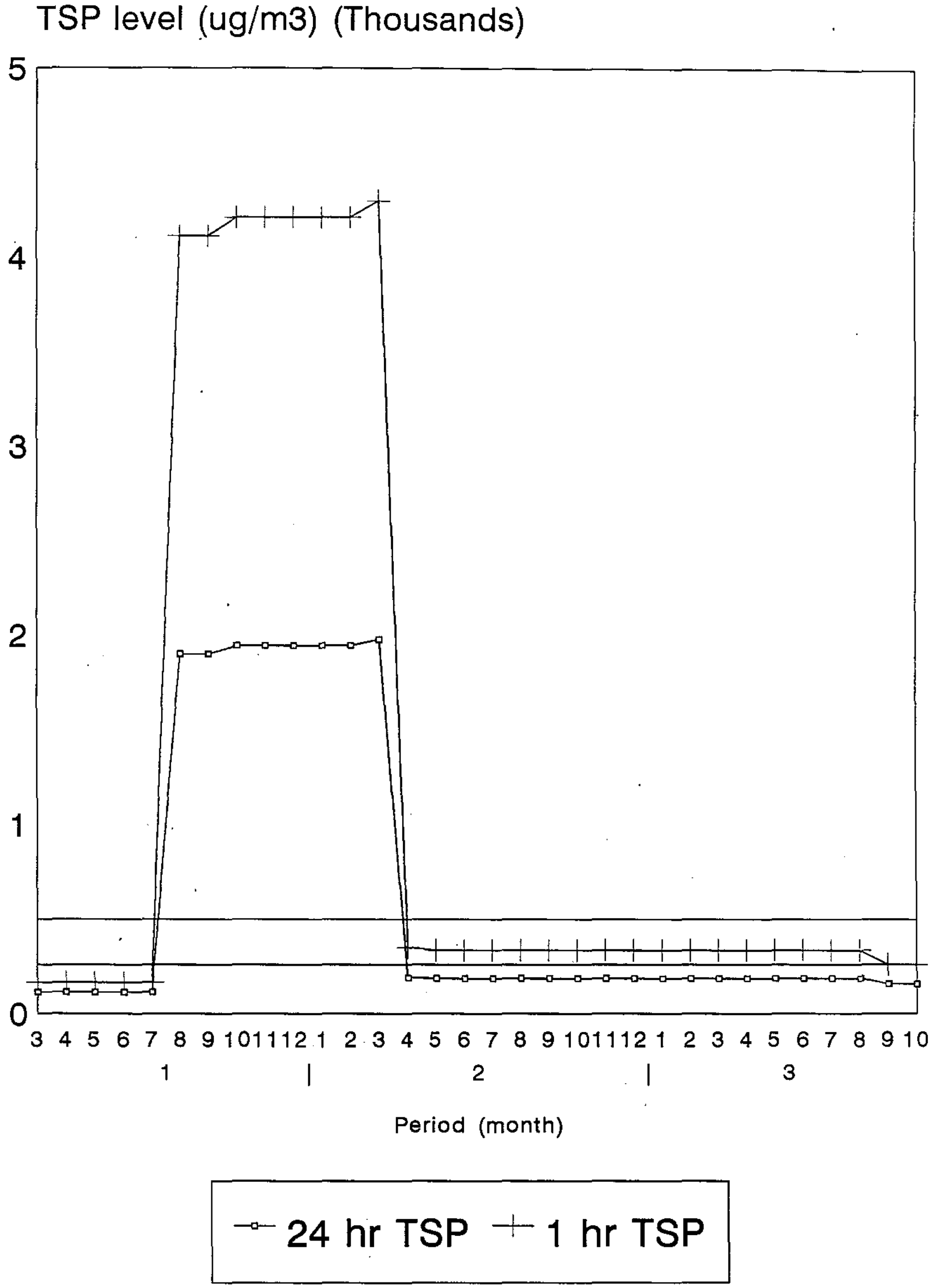
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR10 (Anton Villa)
Without mitigation - using marine fill



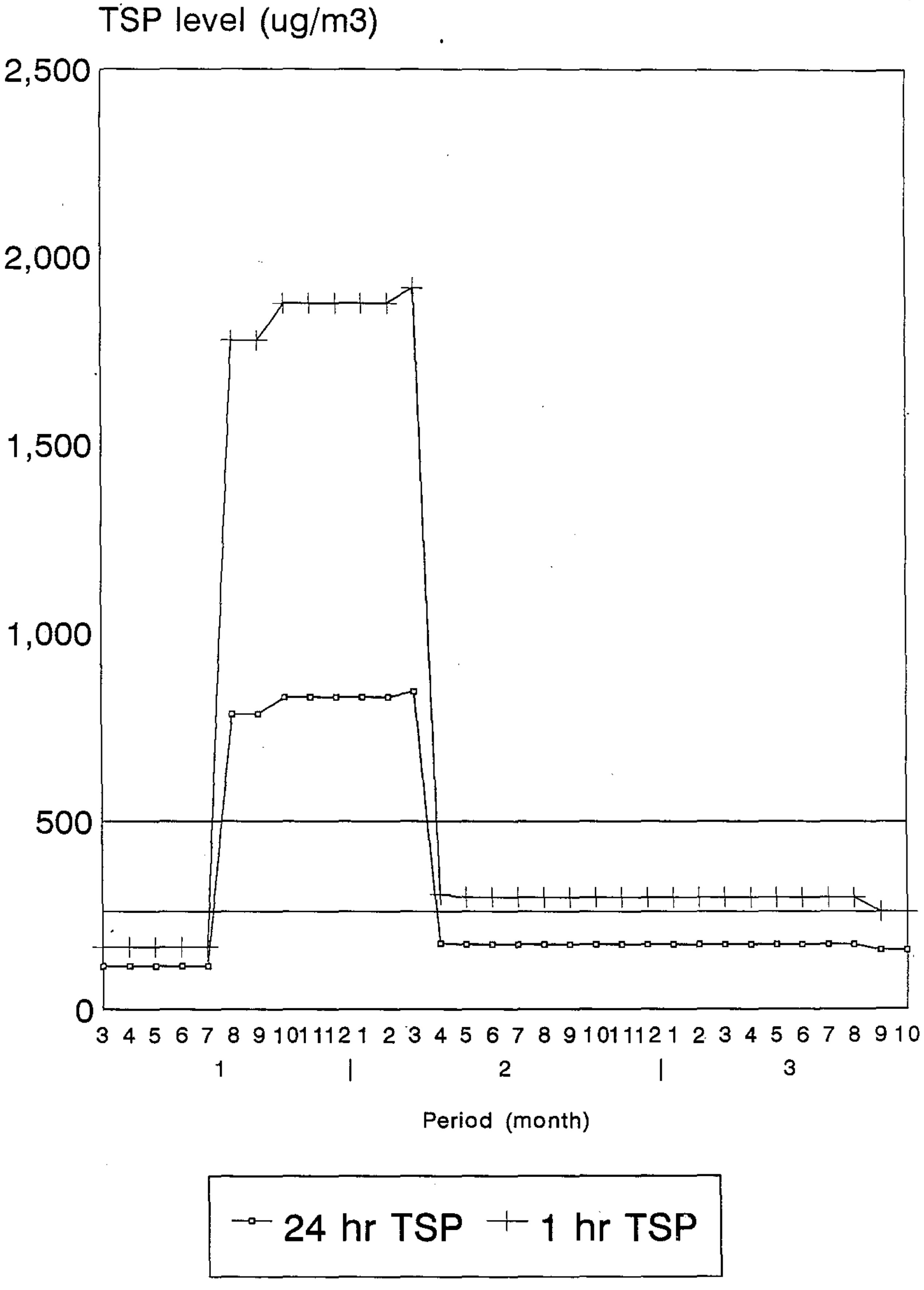
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR3 (Lido Garden)
Without mitigation - using general fill



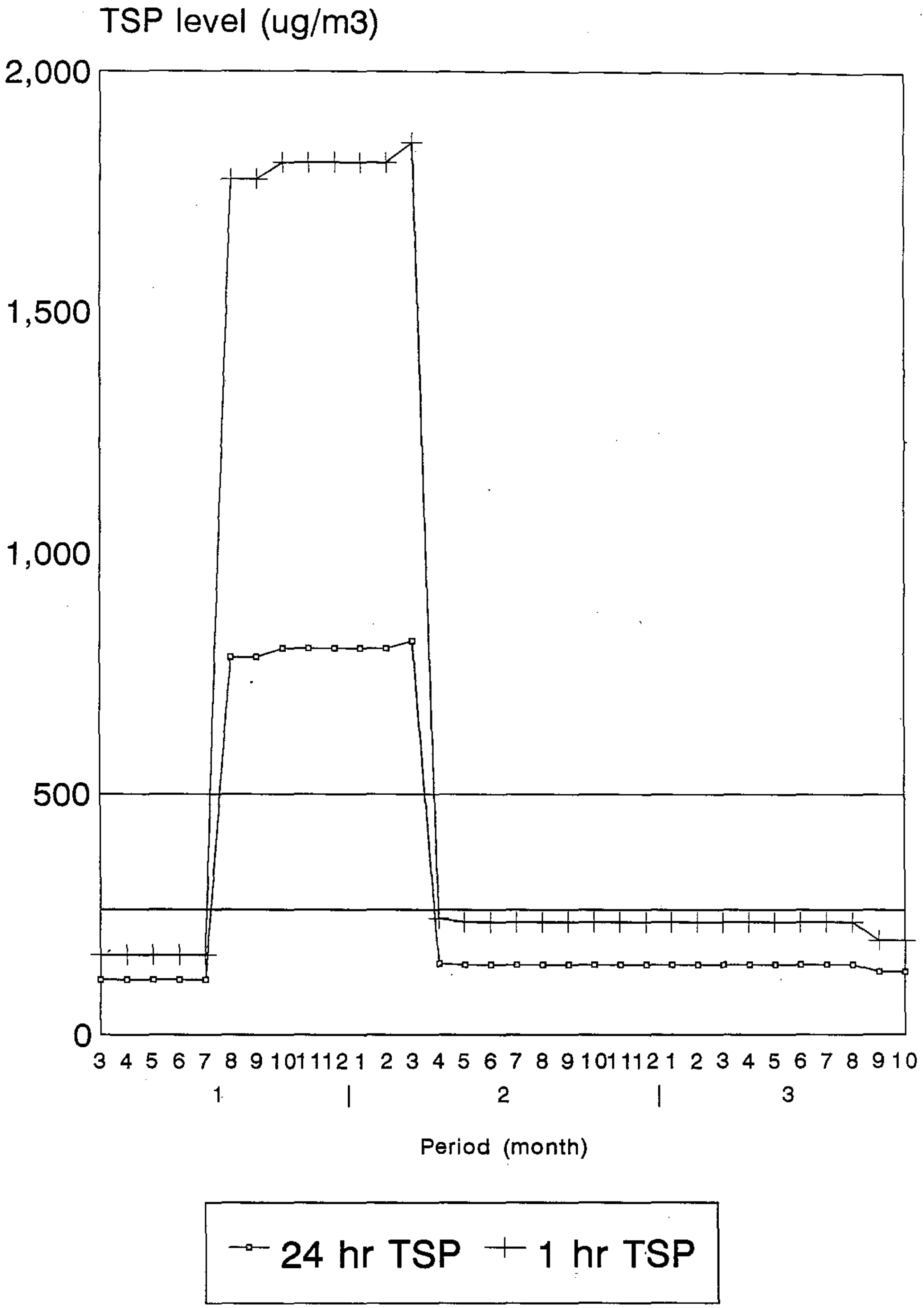
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR4 (Garden Bakery)
Without mitigation - using general fill



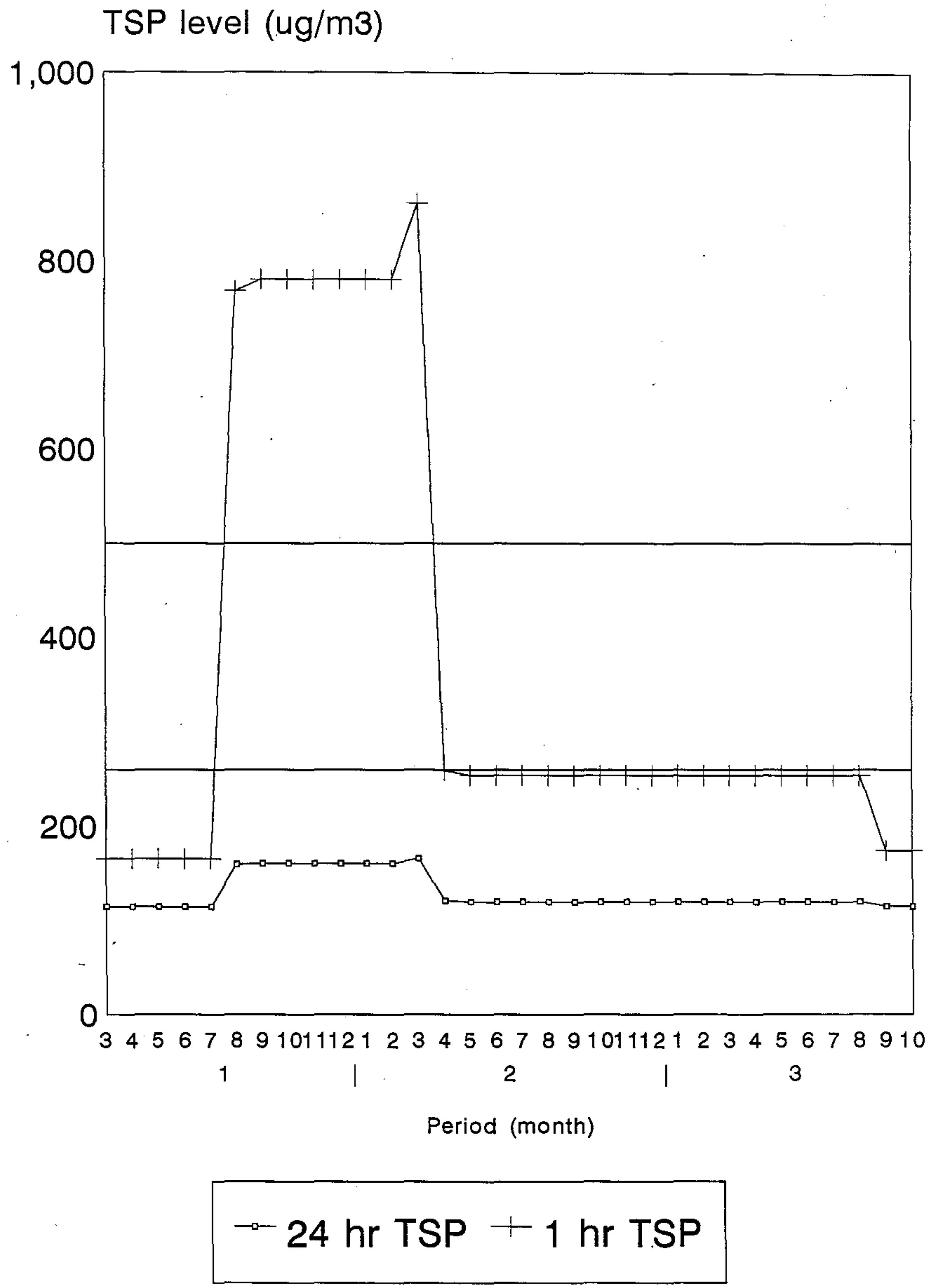
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR4 (Garden Bakery)
With mitigation (by wetting) - using general fill



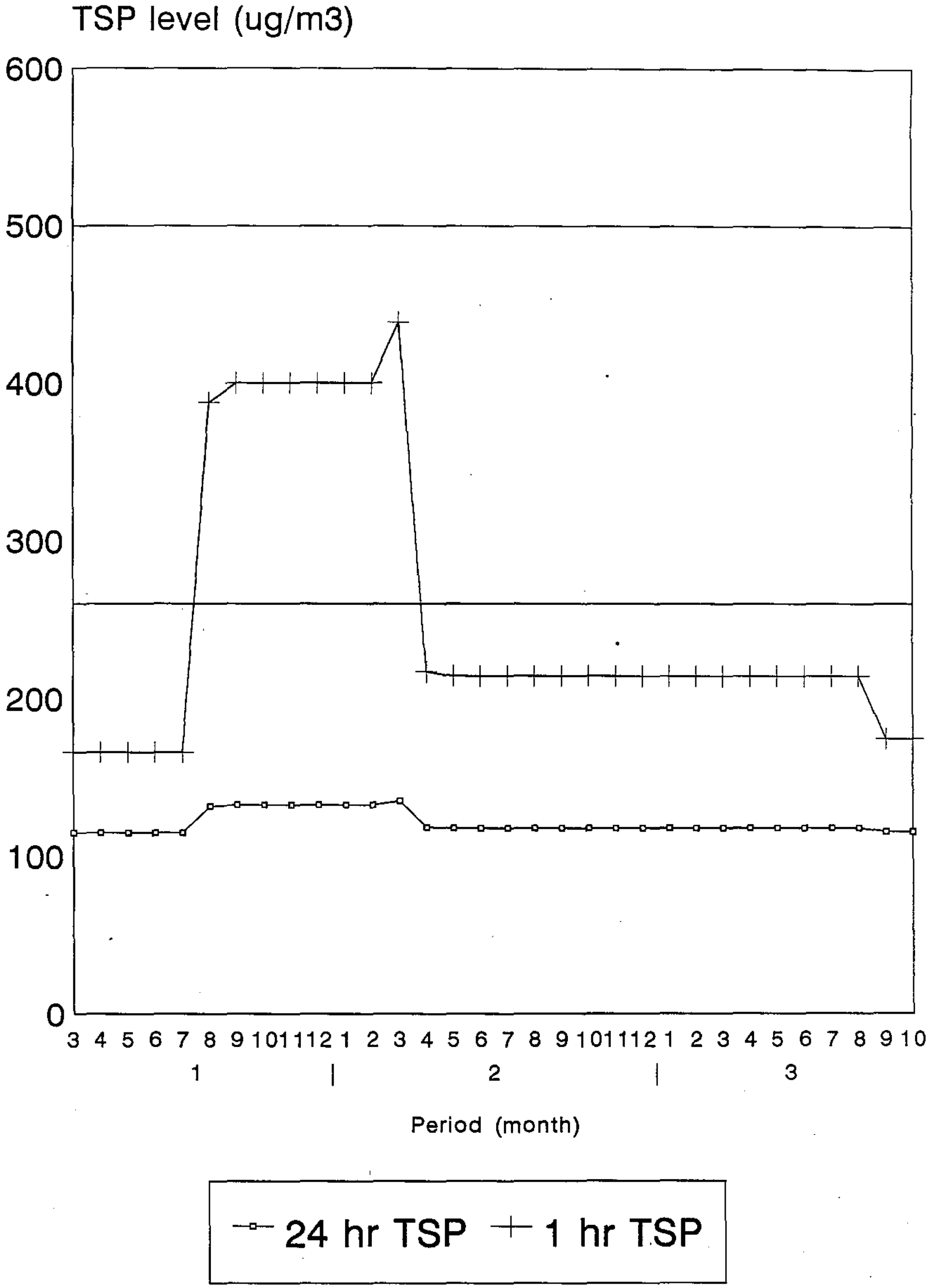
TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR4 (Garden Bakery)
With mitigation (by wetting and covering with hydro-seeding) - using general fil



TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR5 (Garden Villa)
Without mitigation - using general fill



TOTAL SUSPENDED PARTICULATE (TSP) LEVEL
SR5 (Garden Villa)
With mitigation (by wetting) - using general fill



FDM Emission Rate Calculation (Based on AP-42) Date: 1/4/95

JOB : SHAM TSENG Sewage Treatment Plant
(assumed using general fill)

1) Hauling

INPUT DATA		OUTPUT DATA			
k constant =	0.8	Loaded Weight (ton) =	21.5		
Silt Cont. (%) =	1.6	Unloaded Weight (ton) =	5.5		
Speed (km/h) =	10				
Truck Capacity (m3) =	8	Emission rate (loaded) =	0.1365		
Load Density (kg/M3) =	2000	Emission rate (unloaded) =	0.0526		
Truck Weight (kg) =	5500				
No. of Wheels =	6	Total (kg/VKT) =	0.1891		
No. of Dry Days =	113				
		No. of Truck per hr =	9		
		Emission rate (g/s/m) =		Suppression (%)	Operation hour
			4.7267E-04	50	11
		no mitigate, hourly	no mitigate, dairy	mitigated, hourly	mitigated, dairy
		4.7267E-04		2.3633E-04	1.083E-04

2) Erosion

INPUT DATA		OUTPUT DATA	
Silt Cont. (%) =	1.6	**Emission rate (g/s/m2) =**	5.031E-06
No. of Dry Days =	113		
Wind Speed (m/s) =	2		

3) Dozing (Wheelloader)

INPUT DATA		OUTPUT DATA		
Silt Cont. (%) =	1.6	**Emission rate (g/s) =**	2.0183	
Moisture Content (%) =	0.7	**Emission rate (g/s) =**	Suppression (%)	Operation hour
			50	11
			Hourly	Dairy
			1.0092	0.4625

4) Construction

INPUT DATA		OUTPUT DATA	Hourly	dairy
Emission rate (g/m2/month) =	296.5	Without mitigation		
		Emission rate (g/m2/s) =	1.144E-04	
Suppression (%) =	50	With mitigation (%) =		
Operation Hour (hr) =	11	**Emission rate (g/m2/s) =**	5.720E-05	2.621E-05

5) Unloading

INPUT DATA		OUTPUT DATA			
Batch Drop by barge (<30um)					
Silt Cont. (%) =	1.6	**Emission rate (kg/Mg) =**	3.036E-03		
Moisture Content (%) =	0.7				
k, constant =	0.73				
Mean Wind Speed (m/s) =	2				
Dumpling Capacity (m3) =	5				
Drop Height (m) =	3				
Duration of fill (days) =	109	**Emission rate (g/s) =**	1.227E+00		
Capacity (M3/day/no)=	2000				
no. of barge =	4				
Density (kg/m3) =	2000				
Batch Drop by truck (<30um)					
Silt Cont. (%) =	1.6	**Emission rate (kg/Mg) =**	2.024E-03		
Moisture Content (%) =	0.7				
k, constant =	0.73				
Mean Wind Speed (m/s) =	2				
Dumpling Capacity (m3) =	5				
Drop Height (m) =	2				
Duration of fill (days) =	109	**Emission rate (g/s) =**	8.095E-02		
Capacity (M3/day/no)=	8				
no. of truck =	99				
Density (kg/m3) =	2000				
		Total Emission rate (g/s) =		Suppression (%)	Operation hour
			1.308E+00	90	11
		no mitigate, hourly	no mitigate, dairy	mitigated, hourly	mitigated, dairy
		1.308E+00	5.9928E-01	1.3075E-01	5.993E-02

note : assumed data

FDM Emission Rate Calculati(Based on AP-42) **Date:** **1/4/95**

JOB : SHAM TSENG Sewage Treatment Plant **(assumed using general fill)**

i) Without Mitigation (Hourly)

Emission Rate of Each Source (g/s, g/m/s or g/m2/s)	(m2)	Construction	Hauling	Dozing	Unloading	TOTAL
Trench (Line)	/	5.72E-04	/	/	/	5.720E-04
Area I (Area)	13629	/	/	1.48E-04	9.59E-05	2.440E-04
Area II (Area)	28050	/	/	7.20E-05	4.66E-05	1.186E-04
Area III (Area)	9024	/	/	2.24E-04	1.45E-04	3.686E-04
Construction on the areas	/	1.144E-04	/	/	/	1.144E-04
Haul road on areas	/	/	4.727E-04	/	/	4.727E-04
Pumpling Station (Point)	/	1.144E-02	/	/	/	1.144E-02

ii) With Mitigation (Hourly)

Emission Rate of Each Source		Construction	Hauling	Dozing	Unloading	TOTAL
Trench (Line)	/	2.860E-04	/	/	/	2.860E-04
Area I (Area)	13629	/	/	7.404E-05	9.594E-06	8.364E-05
Area II (Area)	28050	/	/	3.598E-05	4.661E-06	4.064E-05
Area III (Area)	9024	/	/	1.118E-04	1.449E-05	1.263E-04
Construction on the areas	/	5.720E-05	/	/	/	5.720E-05
Haul road on areas	/	/	2.363E-04	/	/	2.363E-04
Pumpling Station (Point)	/	5.720E-03	/	/	/	5.720E-03

Assumption : 1. Width of trench = 5m
2. Area of Pumping Station : 10m x 10m

	% removal	Erosion (g/m2/s)
no mitigation	0	5.031E-06
mitigation by road carpets	50	2.515E-06
mitigation by hydro-seeding	75	1.258E-06

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 2/4/95

SR3 (Lido Garden) – **no mitigation**
– **assumed using general fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						166
	A						166
	M						166
	J						166
	J						166
	A	91.80					258
	S	91.80	2.56				260
	O	91.80	2.56				260
	N	91.80	2.56				260
	D	91.80	2.56				260
YEAR 2	J	91.80	2.56				260
	F	91.80	2.56				260
	M	91.80	2.20		12.39	7.55	280
	A		2.20		12.39	7.55	188
	M		2.20	0.51	12.39	7.55	189
	J		2.20	0.51		7.55	176
	J		2.20	0.51		7.55	176
	A		2.20	0.51		7.55	176
	S		2.20	0.51		7.55	176
	O		2.20	0.51		7.55	176
	N		2.20	0.51		7.55	176
	D		2.20			7.55	176
YEAR 3	J		2.20			7.55	176
	F		2.20			7.55	176
	M		2.20			7.55	176
	A		2.20			7.55	176
	M		2.20			7.55	176
	J		2.20			7.55	176
	J		2.20			7.55	176
	A		2.20			7.55	176
	S		2.20				168
	O		2.20				168

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						115
	A						115
	M						115
	J						115
	J						115
	A	21.29					136
	S	21.29	0.58				137
	O	21.29	0.58				137
	N	21.29	0.58				137
	D	21.29	0.58				137
YEAR 2	J	21.29	0.58				137
	F	21.29	0.58				137
	M	21.29	0.51		3.86	1.39	142
	A		0.51		3.86	1.39	121
	M		0.51	0.28	3.86	1.39	121
	J		0.51	0.28		1.39	117
	J		0.51	0.28		1.39	117
	A		0.51	0.28		1.39	117
	S		0.51	0.28		1.39	117
	O		0.51	0.28		1.39	117
	N		0.51	0.28		1.39	117
	D		0.51			1.39	117
YEAR 3	J		0.51			1.39	117
	F		0.51			1.39	117
	M		0.51			1.39	117
	A		0.51			1.39	117
	M		0.51			1.39	117
	J		0.51			1.39	117
	J		0.51			1.39	117
	A		0.51			1.39	117
	S		0.51				116
	O		0.51				116

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 2/4/95

SR4 Garden Bakery) — **no mitigation**
— **assumed using general fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						166
	A						166
Y	M						166
E	J						166
A	J						166
R	A	3948.81					4115
	S	3948.81					4115
1	O	3948.81	98.34				4213
	N	3948.81	98.34				4213
	D	3948.81	98.34				4213
	J	3948.81	98.34				4213
	F	3948.81	98.34				4213
	M	3948.81	94.20		14.96	75.61	4300
Y	A		94.20		14.96	75.61	351
E	M		94.20	0.45		75.61	336
A	J		94.20	0.45		75.61	336
R	J		94.20	0.45		75.61	336
	A		94.20	0.45		75.61	336
2	S		94.20	0.45		75.61	336
	O		94.20	0.45		75.61	336
	N		94.20	0.45		75.61	336
	D		94.20			75.61	336
	J		94.20			75.61	336
	F		94.20			75.61	336
Y	M		94.20			75.61	336
E	A		94.20			75.61	336
A	M		94.20			75.61	336
R	J		94.20			75.61	336
	J		94.20			75.61	336
3	A		94.20			75.61	336
	S		94.20				260
	O		94.20				260

Note : 1 hour TSP Background Level = 166 ug/m3

TSP Level exceeded EPD's recommended Level (500 ug/m3)

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						115
	A						115
Y	M						115
E	J						115
A	J						115
R	A	1785.94					1901
	S	1785.94					1901
1	O	1785.94	44.42				1945
	N	1785.94	44.42				1945
	D	1785.94	44.42				1945
	J	1785.94	44.42				1945
	F	1785.94	44.42				1945
	M	1785.94	42.93		4.99	28.90	1978
Y	A		42.93		4.99	28.90	192
E	M		42.93	0.17		28.90	187
A	J		42.93	0.17		28.90	187
R	J		42.93	0.17		28.90	187
	A		42.93	0.17		28.90	187
2	S		42.93	0.17		28.90	187
	O		42.93	0.17		28.90	187
	N		42.93	0.17		28.90	187
	D		42.93			28.90	187
	J		42.93			28.90	187
	F		42.93			28.90	187
Y	M		42.93			28.90	187
E	A		42.93			28.90	187
A	M		42.93			28.90	187
R	J		42.93			28.90	187
	J		42.93			28.90	187
3	A		42.93			28.90	187
	S		42.93				158
	O		42.93				158

Note : 24 hour TSP Background Level = 115 ug/m3

TSP Level exceeded AQO Level (260 ug/m3)

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 2/4/95

SR4 Gàrden Bakery) – **with mitigation (by wetting)**
– **assumed using general fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						166
	A						166
Y	M						166
E	J						166
A	J						166
R	A	1611.22					1777
	S	1611.22					1777
1	O	1611.22	98.34				1876
	N	1611.22	98.34				1876
	D	1611.22	98.34				1876
	J	1611.22	98.34				1876
	F	1611.22	98.34				1876
	M	1611.22	94.20		7.48	37.80	1917
Y	A		94.20		7.48	37.80	305
E	M		94.20	0.23		37.80	298
A	J		94.20	0.23		37.80	298
R	J		94.20	0.23		37.80	298
	A		94.20	0.23		37.80	298
2	S		94.20	0.23		37.80	298
	O		94.20	0.23		37.80	298
	N		94.20	0.23		37.80	298
	D		94.20			37.80	298
	J		94.20			37.80	298
	F		94.20			37.80	298
Y	M		94.20			37.80	298
E	A		94.20			37.80	298
A	M		94.20			37.80	298
R	J		94.20			37.80	298
	J		94.20			37.80	298
3	A		94.20			37.80	298
	S		94.20				260
	O		94.20				260

Note : 1 hour TSP Background Level = 166 ug/m3

TSP Level exceeded EPD's recommended Level (500 ug/m3)

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						115
	A						115
Y	M						115
E	J						115
A	J						115
R	A	669.31					784
	S	669.31					784
1	O	669.31	44.42				829
	N	669.31	44.42				829
	D	669.31	44.42				829
	J	669.31	44.42				829
	F	669.31	44.42				829
	M	669.31	42.93		2.50	14.45	844
Y	A		42.93		2.50	14.45	175
E	M		42.93	0.09		14.45	172
A	J		42.93	0.09		14.45	172
R	J		42.93	0.09		14.45	172
	A		42.93	0.09		14.45	172
2	S		42.93	0.09		14.45	172
	O		42.93	0.09		14.45	172
	N		42.93	0.09		14.45	172
	D		42.93			14.45	172
	J		42.93			14.45	172
	F		42.93			14.45	172
Y	M		42.93			14.45	172
E	A		42.93			14.45	172
A	M		42.93			14.45	172
R	J		42.93			14.45	172
	J		42.93			14.45	172
3	A		42.93			14.45	172
	S		42.93				158
	O		42.93				158

Note : 24 hour TSP Background Level = 115 ug/m3

TSP Level exceeded AQO Level (260 ug/m3)

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 2/4/95

SR4 Garden Bakery) – with mitigation (by wetting and cover the area [80m from the north site boundary] by hydro–seeding)
– assumed using general fill

1) 1 hour TSP Level

		1 Hour TSP (ug/m3)					
Period		Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						166
	A						166
Y	M						166
E	J						166
A	J						166
R	A	1611.22					1777
	S	1611.22					1777
1	O	1611.22	34.91				1812
	N	1611.22	34.91				1812
	D	1611.22	34.91				1812
	J	1611.22	34.91				1812
	F	1611.22	34.91				1812
	M	1611.22	30.77		7.48	37.80	1853
Y	A		30.77		7.48	37.80	242
E	M		30.77	0.23		37.80	235
A	J		30.77	0.23		37.80	235
R	J		30.77	0.23		37.80	235
	A		30.77	0.23		37.80	235
2	S		30.77	0.23		37.80	235
	O		30.77	0.23		37.80	235
	N		30.77	0.23		37.80	235
	D		30.77			37.80	235
	J		30.77			37.80	235
	F		30.77			37.80	235
Y	M		30.77			37.80	235
E	A		30.77			37.80	235
A	M		30.77			37.80	235
R	J		30.77			37.80	235
	J		30.77			37.80	235
3	A		30.77			37.80	235
	S		30.77				197
	O		30.77				197

Note : 1 hour TSP Background Level = 166 ug/m3

TSP Level exceeded EPD's recommended Level (500 ug/m3)

2) 24 hour TSP Level

		24 Hour TSP (ug/m3)					
Period		Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						115
	A						115
Y	M						115
E	J						115
A	J						115
R	A	669.31					784
	S	669.31					784
1	O	669.31	18.04				802
	N	669.31	18.04				802
	D	669.31	18.04				802
	J	669.31	18.04				802
	F	669.31	18.04				802
	M	669.31	16.55		2.50	14.45	818
Y	A		16.55		2.50	14.45	148
E	M		16.55	0.09		14.45	146
A	J		16.55	0.09		14.45	146
R	J		16.55	0.09		14.45	146
	A		16.55	0.09		14.45	146
2	S		16.55	0.09		14.45	146
	O		16.55	0.09		14.45	146
	N		16.55	0.09		14.45	146
	D		16.55			14.45	146
	J		16.55			14.45	146
	F		16.55			14.45	146
Y	M		16.55			14.45	146
E	A		16.55			14.45	146
A	M		16.55			14.45	146
R	J		16.55			14.45	146
	J		16.55			14.45	146
3	A		16.55			14.45	146
	S		16.55				132
	O		16.55				132

Note : 24 hour TSP Background Level = 115 ug/m3

TSP Level exceeded AQO Level (260 ug/m3)

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 2/4/95

SR5 (Garden Villa) – **no mitigation**
– **assumed using general fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						166
	A						166
Y	M						166
E	J						166
A	J						166
R	A	601.83					768
	S	601.83	12.41				780
1	O	601.83	12.41				780
	N	601.83	12.41				780
	D	601.83	12.41				780
	J	601.83	12.41				780
	F	601.83	12.41				780
	M	601.83	8.64		5.31	79.30	861
Y	A		8.64		5.31	79.30	259
E	M		8.64	0.21		79.30	254
A	J		8.64	0.21		79.30	254
R	J		8.64	0.21		79.30	254
	A		8.64	0.21		79.30	254
2	S		8.64	0.21		79.30	254
	O		8.64	0.21		79.30	254
	N		8.64	0.21		79.30	254
	D		8.64			79.30	254
	J		8.64			79.30	254
	F		8.64			79.30	254
Y	M		8.64			79.30	254
E	A		8.64			79.30	254
A	M		8.64			79.30	254
R	J		8.64			79.30	254
	J		8.64			79.30	254
3	A		8.64			79.30	254
	S		8.64				175
	O		8.64				175

Note : 1 hour TSP Background Level = 166 ug/m3

TSP level exceeded EPD's recommended level

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						115
	A						115
Y	M						115
E	J						115
A	J						115
R	A	45.22					160
	S	45.22	0.87				161
1	O	45.22	0.87				161
	N	45.22	0.87				161
	D	45.22	0.87				161
	J	45.22	0.87				161
	F	45.22	0.87				161
	M	45.22	0.65		1.08	4.63	167
Y	A		0.65		1.08	4.63	121
E	M		0.65	0.02		4.63	120
A	J		0.65	0.02		4.63	120
R	J		0.65	0.02		4.63	120
	A		0.65	0.02		4.63	120
2	S		0.65	0.02		4.63	120
	O		0.65	0.02		4.63	120
	N		0.65	0.02		4.63	120
	D		0.65			4.63	120
	J		0.65			4.63	120
	F		0.65			4.63	120
Y	M		0.65			4.63	120
E.	A		0.65			4.63	120
A	M		0.65			4.63	120
R	J		0.65			4.63	120
	J		0.65			4.63	120
3	A		0.65			4.63	120
	S		0.65				116
	O		0.65				116

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 2/4/95

SR5 (Garden Villa) – **with mitigation (by wetting)**
– **assumed using general fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						166
	A						166
	M						166
	J						166
	J						166
	A	221.85					388
	S	221.85	12.41				400
	O	221.85	12.41				400
	N	221.85	12.41				400
	D	221.85	12.41				400
YEAR 2	J	221.85	12.41				400
	F	221.85	12.41				400
	M	221.85	8.64		2.66	39.65	439
	A		8.64		2.66	39.65	217
	M		8.64	0.11		39.65	214
	J		8.64	0.11		39.65	214
	J		8.64	0.11		39.65	214
	A		8.64	0.11		39.65	214
	S		8.64	0.11		39.65	214
	O		8.64	0.11		39.65	214
	N		8.64	0.11		39.65	214
	D		8.64			39.65	214
YEAR 3	J		8.64			39.65	214
	F		8.64			39.65	214
	M		8.64			39.65	214
	A		8.64			39.65	214
	M		8.64			39.65	214
	J		8.64			39.65	214
	J		8.64			39.65	214
	A		8.64			39.65	214
	S		8.64				175
	O		8.64				175

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						115
	A						115
	M						115
	J						115
	J						115
	A	16.74					132
	S	16.74	0.87				133
	O	16.74	0.87				133
	N	16.74	0.87				133
	D	16.74	0.87				133
YEAR 2	J	16.74	0.87				133
	F	16.74	0.87				133
	M	16.74	0.65		0.54	2.31	135
	A		0.65		0.54	2.31	119
	M		0.65	0.01		2.31	118
	J		0.65	0.01		2.31	118
	J		0.65	0.01		2.31	118
	A		0.65	0.01		2.31	118
	S		0.65	0.01		2.31	118
	O		0.65	0.01		2.31	118
	N		0.65	0.01		2.31	118
	D		0.65			2.31	118
YEAR 3	J		0.65			2.31	118
	F		0.65			2.31	118
	M		0.65			2.31	118
	A		0.65			2.31	118
	M		0.65			2.31	118
	J		0.65			2.31	118
	J		0.65			2.31	118
	A		0.65			2.31	118
	S		0.65				116
	O		0.65				116

Note : 24 hour TSP Background Level = 115 ug/m3

FDM Emission Rate Calculation (Based on AP-42) Date: 27/03/95

JOB : SHAM TSENG Sewage Treatment Plant
(assumed using marine fill)

1) Hauling

INPUT DATA		OUTPUT DATA			
k constant =	0.8	Loaded Weight (ton) =	25.5		
Silt Cont. (%) =	11	Unloaded Weight (ton) =	5.5		
Speed (km/h) =	10				
Truck Capacity (m3) =	8	Emission rate (loaded) =	1.0575		
Load Density (kg/M3) =	2500	Emission rate (unloaded) =	0.3614		
Truck Weight (kg) =	5500				
No. of Wheels =	6	Total (kg/VKT) =	1.4189		
No. of Dry Days =	113				
		No. of Truck per hr =	9		
		Emission rate (g/s/m) =		Suppression (%)	Operation hour
			3.5472E-03	50	11
		no mitigate, hourly	no mitigate, dairy	mitigated, hourly	mitigated, dairy
		3.5472E-03		1.7736E-03	8.129E-04

2) Erosion

INPUT DATA		OUTPUT DATA	
Silt Cont. (%) =	11	**Emission rate (g/s/m2) =**	3.459E-05
No. of Dry Days =	113		
Wind Speed (m/s) =	2		

3) Dozing (Wheelloader)

INPUT DATA		OUTPUT DATA		
Silt Cont. (%) =	11	**Emission rate (g/s) =**	0.0794	
Moisture Content (%) =	50	**Emission rate (g/s) =**	Suppression (%)	Operation hour
			50	11
			Hourly	Dairy
			0.0397	0.0182

4) Construction

INPUT DATA		OUTPUT DATA	Hourly	dairy
Emission rate (g/m2/month) =	296.5	Without mitigation		
		Emission rate (g/m2/s) =	1.144E-04	
Suppression (%) =	50	With mitigation (%) =		
Operation Hour (hr) =	11	**Emission rate (g/m2/s) =**	5.720E-05	2.621E-05

5) Unloading

INPUT DATA		OUTPUT DATA			
Batch Drop by barge (<30um)					
Silt Cont. (%) =	11	**Emission rate (kg/Mg) =**	4.091E-06		
Moisture Content (%) =	50				
k, constant =	0.73				
Mean Wind Speed (m/s) =	2				
Dumpling Capacity (m3) =	5				
Drop Height (m) =	3				
Duration of fill (days) =	109	**Emission rate (g/s) =**	2.066E-03		
Capacity (M3/day/no)=	2000				
no. of barge =	4				
Density (kg/m3) =	2500				
Batch Drop by truck (<30um)					
Silt Cont. (%) =	11	**Emission rate (kg/Mg) =**	2.727E-06		
Moisture Content (%) =	50				
k, constant =	0.73				
Mean Wind Speed (m/s) =	2				
Dumpling Capacity (m3) =	5				
Drop Height (m) =	2				
Duration of fill (days) =	109	**Emission rate (g/s) =**	1.364E-04		
Capacity (M3/day/no)=	8				
no. of truck =	99				
Density (kg/m3) =	2500				
		Total Emission rate (g/s) =		Suppression (%)	Operation hour
			2.202E-03	90	11
		no mitigate, hourly	no mitigate, dairy	mitigated, hourly	mitigated, dairy
		2.202E-03	1.0094E-03	2.2024E-04	1.009E-04

note : assumed data

FDM Emission Rate Calculati(Based on AP-42) **Date:** **27/03/95**

JOB : SHAM TSENG Sewage Treatment Plant **(assumed using marine fill)**

i) Without Mitigation (Hourly)

Emission Rate of Each Source (g/s, g/m/s or g/m2/s)	(m2)	Construction	Hauling	Dozing	Unloading	TOTAL
Trench (Line)	/	5.72E-04	/	/	- /	5.720E-04
Area I (Area)	13629	/	/	5.82E-06	1.62E-07	5.986E-06
Area II (Area)	28050	/	/	2.83E-06	7.85E-08	2.908E-06
Area III (Area)	9024	/	/	8.80E-06	2.44E-07	9.040E-06
Construction on the areas	/	1.144E-04	/	/	/	1.144E-04
Haul road on areas	/	/	3.547E-03	/	/	3.547E-03
Pumpling Station (Point)	/	1.144E-02	/	/	/	1.144E-02

ii) With Mitigation (Hourly)

Emission Rate of Each Source		Construction	Hauling	Dozing	Unloading	TOTAL
Trench (Line)	/	2.860E-04	/	/	/	2.860E-04
Area I (Area)	13629	/	/	2.912E-06	1.616E-08	2.928E-06
Area II (Area)	28050	/	/	1.415E-06	7.852E-09	1.423E-06
Area III (Area)	9024	/	/	4.398E-06	2.441E-08	4.422E-06
Construction on the areas	/	5.720E-05	/	/	/	5.720E-05
Haul road on areas	/	/	1.774E-03	/	/	1.774E-03
Pumpling Station (Point)	/	5.720E-03	/	/	/	5.720E-03

Assumption : 1. Width of trench = 5m
2. Area of Pumping Station : 10m x 10m

	% removal	Erosion (g/m2/s)
no mitigation	0	3.459E-05
mitigation by road carpets	50	1.729E-05
mitigation by hydro-seeding	75	8.647E-06

SHAM TSENG SEWAGE TREATMENT WORKS Date : 27/3/95
Dust Impact Assessment by FDM

SR2 (Hong Kong Garden)

– no mitigation
– assumed using marine fill

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3)		
		Construction of Pumpling Station	Sewer Installation	TOTAL
YEAR 1	M		22.47	188
	A		22.47	188
	M		22.47	188
	J	0.97		167
	J	0.97		167
	A	0.97		167
	S	0.97		167
	O	0.97		167
	N	0.97		167
	D	0.97		167
YEAR 2	J	0.97		167
	F	0.97		167
	M	0.97		167
	A	0.97		167
	M	0.97		167
	J	0.97		167
	J	0.97		167
	A	0.97		167
	S			166
	O			166
	N			166
	D			166
YEAR 3	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3)		
		Construction of Pumpling Station	Sewer Installation	TOTAL
YEAR 1	M		4.85	120
	A		4.85	120
	M		4.85	120
	J	0.20		115
	J	0.20		115
	A	0.20		115
	S	0.20		115
	O	0.20		115
	N	0.20		115
	D	0.20		115
YEAR 2	J	0.20		115
	F	0.20		115
	M	0.20		115
	A	0.20		115
	M	0.20		115
	J	0.20		115
	J	0.20		115
	A	0.20		115
	S			115
	O			115
	N			115
	D			115
YEAR 3	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 27/3/95

SR3 (Lido Garden) – **no mitigation**
– **assumed using marine fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						166
	A						166
	M						166
	J						166
	J						166
	A	20.72					187
	S	20.72	16.42				203
	O	20.72	16.42				203
	N	20.72	16.42				203
	D	20.72	16.42				203
YEAR 2	J	20.72	16.42				203
	F	20.72	16.42				203
	M	20.72	14.14		12.39	7.55	221
	A		14.14		12.39	7.55	200
	M		14.14	0.51	12.39	7.55	201
	J		14.14	0.51		7.55	188
	J		14.14	0.51		7.55	188
	A		14.14	0.51		7.55	188
	S		14.14	0.51		7.55	188
	O		14.14	0.51		7.55	188
	N		14.14	0.51		7.55	188
	D		14.14			7.55	188
YEAR 3	J		14.14			7.55	188
	F		14.14			7.55	188
	M		14.14			7.55	188
	A		14.14			7.55	188
	M		14.14			7.55	188
	J		14.14			7.55	188
	J		14.14			7.55	188
	A		14.14			7.55	188
	S		14.14				180
	O		14.14				180

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						115
	A						115
	M						115
	J						115
	J						115
	A	5.28					120
	S	5.28	3.69				124
	O	5.28	3.69				124
	N	5.28	3.69				124
	D	5.28	3.69				124
YEAR 2	J	5.28	3.69				124
	F	5.28	3.69				124
	M	5.28	3.27		3.86	1.39	129
	A		3.27		3.86	1.39	124
	M		3.27	0.28	3.86	1.39	124
	J		3.27	0.28		1.39	120
	J		3.27	0.28		1.39	120
	A		3.27	0.28		1.39	120
	S		3.27	0.28		1.39	120
	O		3.27	0.28		1.39	120
	N		3.27	0.28		1.39	120
	D		3.27			1.39	120
YEAR 3	J		3.27			1.39	120
	F		3.27			1.39	120
	M		3.27			1.39	120
	A		3.27			1.39	120
	M		3.27			1.39	120
	J		3.27			1.39	120
	J		3.27			1.39	120
	A		3.27			1.39	120
	S		3.27				118
	O		3.27				118

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 27/3/95

SR4 Garden Bakery) — **no mitigation**
— **assumed using marine fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						166
	A						166
	M						166
	J						166
	J						166
	A	223.70					390
	S	223.70					390
	O	223.70	564.35				954
	N	223.70	564.35				954
	D	223.70	564.35				954
YEAR 2	J	223.70	564.35				954
	F	223.70	564.35				954
	M	223.70	564.35		14.96	75.61	1045
	A		564.35		14.96	75.61	821
	M		541.51	0.45		75.61	784
	J		541.51	0.45		75.61	784
	J		541.51	0.45		75.61	784
	A		541.51	0.45		75.61	784
	S		541.51	0.45		75.61	784
	O		541.51	0.45		75.61	784
	N		541.51	0.45		75.61	784
	D		541.51			75.61	783
YEAR 3	J		541.51			75.61	783
	F		541.51			75.61	783
	M		541.51			75.61	783
	A		541.51			75.61	783
	M		541.51			75.61	783
	J		541.51			75.61	783
	J		541.51			75.61	783
	A		541.51			75.61	783
	S		541.51				708
	O		541.51				708

Note : 1 hour TSP Background Level = 166 ug/m3

TSP Level exceeded EPD's recommended Level (500 ug/m3)

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						115
	A						115
	M						115
	J						115
	J						115
	A	90.40					205
	S	90.40					205
	O	90.40	278.65				484
	N	90.40	278.65				484
	D	90.40	278.65				484
YEAR 2	J	90.40	278.65				484
	F	90.40	278.65				484
	M	90.40	278.65		4.99	28.90	518
	A		278.65		4.99	28.90	428
	M		269.92	0.17		28.90	414
	J		269.92	0.17		28.90	414
	J		269.92	0.17		28.90	414
	A		269.92	0.17		28.90	414
	S		269.92	0.17		28.90	414
	O		269.92	0.17		28.90	414
	N		269.92	0.17		28.90	414
	D		269.92			28.90	414
YEAR 3	J		269.92			28.90	414
	F		269.92			28.90	414
	M		269.92			28.90	414
	A		269.92			28.90	414
	M		269.92			28.90	414
	J		269.92			28.90	414
	J		269.92			28.90	414
	A		269.92			28.90	414
	S		269.92				385
	O		269.92				385

Note : 24 hour TSP Background Level = 115 ug/m3

TSP Level exceeded AQO Level (260 ug/m3)

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 27/3/95

SR4 Garden Bakery) – **with mitigation (by wetting)**
– **assumed using marine fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						166
	A						166
	M						166
	J						166
	J						166
	A	110.80					277
	S	110.80					277
	O	110.80	564.35				841
	N	110.80	564.35				841
	D	110.80	564.35				841
YEAR 2	J	110.80	564.35				841
	F	110.80	564.35				841
	M	110.80	564.35		7.48	37.80	886
	A		564.35		7.48	37.80	776
	M		541.51	0.23		37.80	746
	J		541.51	0.23		37.80	746
	J		541.51	0.23		37.80	746
	A		541.51	0.23		37.80	746
	S		541.51	0.23		37.80	746
	O		541.51	0.23		37.80	746
	N		541.51	0.23		37.80	746
	D		541.51			37.80	745
YEAR 3	J		541.51			37.80	745
	F		541.51			37.80	745
	M		541.51			37.80	745
	A		541.51			37.80	745
	M		541.51			37.80	745
	J		541.51			37.80	745
	J		541.51			37.80	745
	A		541.51			37.80	745
	S		541.51				708
	O		541.51				708

Note : 1 hour TSP Background Level = 166 ug/m3

TSP Level exceeded EPD's recommended Level (500 ug/m3)

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						115
	A						115
	M						115
	J						115
	J						115
	A	44.73					160
	S	44.73					160
	O	44.73	278.65				438
	N	44.73	278.65				438
	D	44.73	278.65				438
YEAR 2	J	44.73	278.65				438
	F	44.73	278.65				438
	M	44.73	278.65		2.50	14.45	455
	A		278.65		2.50	14.45	411
	M		269.92	0.09		14.45	399
	J		269.92	0.09		14.45	399
	J		269.92	0.09		14.45	399
	A		269.92	0.09		14.45	399
	S		269.92	0.09		14.45	399
	O		269.92	0.09		14.45	399
	N		269.92	0.09		14.45	399
	D		269.92			14.45	399
YEAR 3	J		269.92			14.45	399
	F		269.92			14.45	399
	M		269.92			14.45	399
	A		269.92			14.45	399
	M		269.92			14.45	399
	J		269.92			14.45	399
	J		269.92			14.45	399
	A		269.92			14.45	399
	S		269.92				385
	O		269.92				385

Note : 24 hour TSP Background Level = 115 ug/m3

TSP Level exceeded AQO Level (260 ug/m3)

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 27/3/95

SR4 Garden Bakery) – **with mitigation (by wetting and cover the area [80m from the north site boundary] by hydro–seeding)**
– **assumed using marine fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3)					
		Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						166
	A						166
Y	M						166
E	J						166
A	J						166
R	A	59.89					226
	S	59.89					226
1	O	59.89	200.30				426
	N	59.89	200.30				426
	D	59.89	200.30				426
	J	59.89	200.30				426
	F	59.89	200.30				426
	M	59.89	177.46		7.48	37.80	449
Y	A		177.46		7.48	37.80	389
E	M		177.46	0.23		37.80	381
A	J		177.46	0.23		37.80	381
R	J		177.46	0.23		37.80	381
	A		177.46	0.23		37.80	381
2	S		177.46	0.23		37.80	381
	O		177.46	0.23		37.80	381
	N		177.46	0.23		37.80	381
	D		177.46			37.80	381
	J		177.46			37.80	381
	F		177.46			37.80	381
Y	M		177.46			37.80	381
E	A		177.46			37.80	381
A	M		177.46			37.80	381
R	J		177.46			37.80	381
	J		177.46			37.80	381
3	A		177.46			37.80	381
	S		177.46				343
	O		177.46				343

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3)					
		Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
	M						115
	A						115
Y	M						115
E	J						115
A	J						115
R	A	26.03					141
	S	26.03					141
1	O	26.03	111.23				252
	N	26.03	111.23				252
	D	26.03	111.23				252
	J	26.03	111.23				252
	F	26.03	111.23				252
	M	26.03	102.49		2.50	14.45	260
Y	A		102.49		2.50	14.45	234
E	M		102.49	0.09		14.45	232
A	J		102.49	0.09		14.45	232
R	J		102.49	0.09		14.45	232
	A		102.49	0.09		14.45	232
2	S		102.49	0.09		14.45	232
	O		102.49	0.09		14.45	232
	N		102.49	0.09		14.45	232
	D		102.49			14.45	232
	J		102.49			14.45	232
	F		102.49			14.45	232
Y	M		102.49			14.45	232
E	A		102.49			14.45	232
A	M		102.49			14.45	232
R	J		102.49			14.45	232
	J		102.49			14.45	232
3	A		102.49			14.45	232
	S		102.49				217
	O		102.49				217

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 27/3/95

SR5 (Garden Villa) – **no mitigation**
– **assumed using marine fill**

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						166
	A						166
	M						166
	J						166
	J						166
	A	35.34					201
	S	35.34	79.01				280
	O	35.34	79.01				280
	N	35.34	79.01				280
	D	35.34	79.01				280
YEAR 2	J	35.34	79.01				280
	F	35.34	79.01				280
	M	35.34	55.05		5.31	79.30	341
	A		55.05		5.31	79.30	306
	M		55.05	0.21		79.30	301
	J		55.05	0.21		79.30	301
	J		55.05	0.21		79.30	301
	A		55.05	0.21		79.30	301
	S		55.05	0.21		79.30	301
	O		55.05	0.21		79.30	301
	N		55.05	0.21		79.30	301
	D		55.05			79.30	300
YEAR 3	J		55.05			79.30	300
	F		55.05			79.30	300
	M		55.05			79.30	300
	A		55.05			79.30	300
	M		55.05			79.30	300
	J		55.05			79.30	300
	J		55.05			79.30	300
	A		55.05			79.30	300
	S		55.05				221
	O		55.05				221

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Reclamation + Hauling	Erosion	Construction of Pumpling Station	Sewer Installation	Construction of STW	TOTAL
YEAR 1	M						115
	A						115
	M						115
	J						115
	J						115
	A	3.26					118
	S	3.26	5.55				124
	O	3.26	5.55				124
	N	3.26	5.55				124
	D	3.26	5.55				124
YEAR 2	J	3.26	5.55				124
	F	3.26	5.55				124
	M	3.26	4.15		1.08	4.63	128
	A		4.15		1.08	4.63	125
	M		4.15	0.02		4.63	124
	J		4.15	0.02		4.63	124
	J		4.15	0.02		4.63	124
	A		4.15	0.02		4.63	124
	S		4.15	0.02		4.63	124
	O		4.15	0.02		4.63	124
	N		4.15	0.02		4.63	124
	D		4.15			4.63	124
YEAR 3	J		4.15			4.63	124
	F		4.15			4.63	124
	M		4.15			4.63	124
	A		4.15			4.63	124
	M		4.15			4.63	124
	J		4.15			4.63	124
	J		4.15			4.63	124
	A		4.15			4.63	124
	S		4.15				119
	O		4.15				119

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS Date : 27/3/95
Dust Impact Assessment by FDM

SR6 (Villar Mar)

– no mitigation
– assumed using marine fill

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Construction of Pumpling Station	Sewer Installation	TOTAL
YEAR 1	M		4.96	171
	A		4.96	171
	M	0.19		166
	J	0.19		166
	J	0.19		166
	A	0.19		166
	S	0.19		166
	O	0.19		166
	N	0.19		166
	D			166
YEAR 2	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166
	N			166
	D			166
YEAR 3	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Construction of Pumpling Station	Sewer Installation	TOTAL
YEAR 1	M		1.13	116
	A		1.13	116
	M	0.04		115
	J	0.04		115
	J	0.04		115
	A	0.04		115
	S	0.04		115
	O	0.04		115
	N	0.04		115
	D			115
YEAR 2	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115
	N			115
	D			115
YEAR 3	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 27/3/95

SR7 (Edinburgh Villa)

– no mitigation
– assumed using marine fill

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Construction of Pumpling Station	Sewer Installation	TOTAL
YEAR 1	M		5.62	172
	A		5.62	172
	M	0.27		166
	J	0.27		166
	J	0.27		166
	A	0.27		166
	S	0.27		166
	O	0.27		166
	N	0.27		166
	D			166
YEAR 2	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166
	N			166
	D			166
YEAR 3	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Construction of Pumpling Station	Sewer Installation	TOTAL
YEAR 1	M		1.24	116
	A		1.24	116
	M	0.05		115
	J	0.05		115
	J	0.05		115
	A	0.05		115
	S	0.05		115
	O	0.05		115
	N	0.05		115
	D			115
YEAR 2	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115
	N			115
	D			115
YEAR 3	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS Date : 27/3/95
Dust Impact Assessment by FDM

SR8 (Ting Kau Village)

– no mitigation
– assumed using marine fill

1) 1 hour TSP Level

Period		Construction of Pumpling Station (1 Hour TSP (ug/m3))	Sewer Installation (1 Hour TSP (ug/m3))	TOTAL (1 Hour TSP (ug/m3))
YEAR 1	M		22.13	188
	A		22.13	188
	M	1.53		168
	J	1.53		168
	J	1.53		168
	A	1.53		168
	S	1.53		168
	O	1.53		168
	N	1.53		168
	D			166
YEAR 2	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166
	N			166
	D			166
YEAR 3	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		Construction of Pumpling Station (24 Hour TSP (ug/m3))	Sewer Installation (24 Hour TSP (ug/m3))	TOTAL (24 Hour TSP (ug/m3))
YEAR 1	M		7.18	122
	A		7.18	122
	M	0.43		115
	J	0.43		115
	J	0.43		115
	A	0.43		115
	S	0.43		115
	O	0.43		115
	N	0.43		115
	D			115
YEAR 2	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115
	N			115
	D			115
YEAR 3	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115

Note : 24 hour TSP Background Level = 115 ug/m3

SHAM TSENG SEWAGE TREATMENT WORKS
Dust Impact Assessment by FDM

Date : 27/3/95

SR10 (Anton Villa)

– no mitigation
– assumed using marine fill

1) 1 hour TSP Level

Period		1 Hour TSP (ug/m3) Construction of Pumpling Station	Sewer Installation	TOTAL
YEAR 1	M		13.53	180
	A		13.53	180
	M	0.68		167
	J	0.68		167
	J	0.68		167
	A	0.68		167
	S	0.68		167
	O	0.68		167
	N	0.68		167
	D			166
YEAR 2	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166
	N			166
	D			166
YEAR 3	J			166
	F			166
	M			166
	A			166
	M			166
	J			166
	J			166
	A			166
	S			166
	O			166

Note : 1 hour TSP Background Level = 166 ug/m3

2) 24 hour TSP Level

Period		24 Hour TSP (ug/m3) Construction of Pumpling Station	Sewer Installation	TOTAL
YEAR 1	M		4.32	119
	A		4.32	119
	M	0.25		115
	J	0.25		115
	J	0.25		115
	A	0.25		115
	S	0.25		115
	O	0.25		115
	N	0.25		115
	D			115
YEAR 2	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115
	N			115
	D			115
YEAR 3	J			115
	F			115
	M			115
	A			115
	M			115
	J			115
	J			115
	A			115
	S			115
	O			115

Note : 24 hour TSP Background Level = 115 ug/m3

Appendix G

Evaluation of Potential H_2S Problem Odour Modelling Results

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
EVALUATION OF POTENTIAL H_2S PROBLEM IN SEWERAGE

Revision	*Date*	*Project Nr*	*File Nr*
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1 INTRODUCTION

The new sewerage system at Sham Tseng will contain about 7 km of new pipelines of which about 3 km will transfer sewage under pressure from seven pumping stations. The sewerage pipes especially those containing the pumped sewage have the potential to produce H_2S and give rise to the associated problems of odour nuisance and corrosion inside and outside the sewerage system.

The following investigates this potential problem and the strategies for a solution.

2 SEWERAGE DESCRIPTION

2.1 Diagram

Figure 1 shows a schematic layout of the new sewerage system based on the information given in report {1}. The pumping stations and manholes have been labelled to designate the different sections of pipe, each referring to the section immediately downstream. Pumping station (-E) is at the western end of the sewerage and station (+H) at the eastern end.

2.2 Pipe Diameters

As explained later, virtually all the sulphide produced in sewers arises from the reduction of sulphate by specific groups of bacteria growing in the anaerobic slimes attached to the sewer walls. To minimise the amount of slime and hence the SO_4^{--}-reducing potential,

{1} *Sham Tseng Sewerage & Sewage Treatment: Underground Cavern Options*, prepared for Hong Kong Government EPD by Pypun-Howard Humphreys Ltd, January 1993 pipes should be designed so that the shear stress at the wall is greater than a critical value {2}. Subjecting the pipe walls to this critical shear stress, say, once per day controls the build-up of the slime layer although the layer is generally not eliminated. The thickness and distribution of the residual layer depends on factors such as wall roughness and the number of bends in the pipe.

The critical stress is different for gravity pipes and pumped pipes (pumping mains) having values of 3.35 Pa and 3.85 Pa respectively; these values are greater than needed for self-cleansing of loose solids. The flow velocity required to obtain such values is approximately the same in the two types of pipes for the same pipe diameter when the gravity flow has a proportional depth of 0. This flow velocity varies with pipe diameter and the relationship is shown in Table 1.

Table 1: Critical flow velocities for controlling slime build-up

Diameter (mm)	200	400	600	800	1000	1200
Velocity (m/s)	1.0	1.12	1.2	1.25	1.31	1.35

For this investigation, the simplifying assumption is made that the design velocity is 1.5 m/s at peak flow for both types of pipes, assuming all the gravity pipes are full. Pipe diameters calculated on this basis are listed in Table 2, Page 1 and are shown to range from 200 to 800 mm depending on the particular pipe.

Calculations have been performed for all the pipes in the main flow. None has been performed for the branched pipes, although calculations will, of course, be needed at a later stage.

2.3 Other Sewerage Data

Table 2, Page 1 also lists the lengths of the various pipe sections and the peak flows in each calculated from values of the peaking factors taken from report {3}. The minimum gradients in the gravity pipe sections are also listed.

{2} *Hydrogen Sulphide Control Manual: Septicity, Corrosion and Odour Control in Sewerage Systems*, Technical Standing Committee on Hydrogen Sulphide Corrosion in Sewerage Works, Melbourne and Metropolitan Board of Works, 1989

{3} *Drainage Works Manual*, prepared in draft by the Drainage Services Department, Hong Kong Government

3 HYDROGEN SULPHIDE PRODUCTION

3.1 Mechanism

As previously explained, specific bacteria present in the anaerobic region of the slime attached to the sewer walls reduce SO_4^{--} to H_2S. When the sewage is anaerobic, SO_4^{--} reduction can also occur in the bulk of the sewage although the rate is comparatively low. Reduction in slimes can occur even through the sewage may contain low concentrations of dissolved oxygen because the inner region of the slime may be anaerobic while the outer region is aerobic. However, under such conditions, the H_2S produced in the inner region can be subsequently oxidised to sulphuric acid and other oxidation products by specific bacteria growing in the outer region . The soluble oxidation products then diffuse into the sewage to be carried away.

Problems associated with H_2S arise when the production rate exceeds the destruction rate allowing H_2S to diffuse into the sewage and then desorb into the atmosphere above the sewage. The H_2S can then cause odour nuisance and corrode exposed surfaces of metal fittings. Also, any H_2S re-absorbing on damp surfaces oxidises to sulphuric acid which is corrosive to cement and concrete as well as being highly corrosive to most metals.

3.2 Range of Calculations

The potential for H_2S production has been investigated for both the pumped and gravity pipes, although any production of H_2S is only likely to arise in the pumped pipes.

Calculations have been performed for three flow rates as follows:

- recurring peak diurnal flow occurring during dry-weather
- design ADWF
- an estimated minimum diurnal flow

The conditions in pumped pipes at peak flow is normally the least favourable for H_2S production, since the amount of dissolved oxygen entering the pipes is then at its maximum. Thus, the probability of obtaining anaerobic conditions conducive to the reduction of SO_4^{--} is minimised. The peak flow of most relevance is that which is produced regularly from day to day. Taking into account that the design ADWF will not arise for a decade or more and that at certain times of year rain is infrequent, the recurring peak flow is assumed to 50% of the ultimate design peak flow. Such a flow for most of the pipes is equal to two times the design ADWF.

The calculations for the future ADWF have been performed to represent average conditions.

The most favourable conditions for H_2S production in the pumped pipes usually occurs at night when retention times are comparatively high. Minimum flow in all the pipes is assumed to be 0.15ADWF.

A sewage temperature of 25° C has been assumed. Any H_2S problem will be exacerbated at higher temperatures.

3.1 Production in Gravity Pipes

3.1.1 Z Factor

An indication of whether H_2S is likely to be a problem in gravity pipes can be deduced from the value of a Z factor which has been developed by the US EPA {4} and is defined by

$$Z = 0.3\ BOD\ G^{-0.5}\ Q^{-0.33}\ R\ 1.07^{(T-20)}$$

where BOD is the BOD_5 (mg/l) of the sewage
G is the pipe gradient (m/m)
Q is sewage flow rate (l/s)
R is the ratio of the wetted perimeter to the surface width
and T is sewage temperature (°C).

Sewers having Z values less than 5 000 will not generally give rise to a H_2S problems and the sewage will be well aerated. Problems of odour nuisance and corrosion generally arise when the value exceeds 10 000.

3.1.2 Results

Z values have been calculated for the three flow rates and each gravity pipe section in the main flow. The calculations are based on the lowest gradient in each section so that the worst-case values of Z have been determined. Results in Table 2, Page 2 show that all the values are generally around 200 or less. Thus, it can be safely assumed that none of the gravity pipes will give rise to H_2S production and that the degree of oxygen saturation in the sewage at the end of the sections will be high.

3.2 Production in Pumped Pipes

3.2.1 Anaerobic Length

In pumped pipes, the concentration of oxygen dissolved in the sewage declines with the distance from the inlet Most of the oxygen is consumed by heterotrophic microorganisms suspended in the sewage as well as resident in the slime and the sediment at the pipe bottom. When all the oxygen has been consumed, the sewage turns anaerobic. Pumped pipes can therefore be divided into an initial aerobic length followed, in problem pipes, by an anaerobic length.

{4} Pomeroy, Johnson and Bailey, 1974, *Sulphide Control in Sanitary sewerage Systems*, published by US EPA

As in gravity pipes, H_2S production can occur in aerobic lengths when the slime has anaerobic regions. However, production rate in the anaerobic length of the pipe is several fold higher and none of the H_2S is subsequently oxidised within the length. A simplifying assumption made here is that H_2S production occurs only in the anaerobic length and that the production rate is uniform along the length.

3.2.2 Reaction Rates

Rates for the various biochemical reactions occurring in the aerobic and anaerobic parts have been taken from Pomeroy {5} and are listed in Table 3. These rates pertain to favourable reaction conditions, such as reasonably constant oxygen potential and nutrient supply and a continuous flow of sewage. However, these conditions will not be found in the pumped pipes in the Sham Tseng sewerage for several reasons as follows.

- Sewage will be pumped intermittently reducing the supply of nutrients to the wall slime.
- Flow velocity during pumping will be comparatively high (1.5 m/s) reducing the thickness and coverage of the slime.
- The aerobic and anaerobic lengths in any particular pipe may vary diurnally as the amount of dissolved oxygen entering the pipe and other factors vary. Thus, reaction rates in pipe lengths subjected to alternating aerobic and anaerobic conditions will be reduced owing to a reduction in the concentration of SO_4^{--}-reducing bacteria in the slimes.

Table 3: Assumptions for calculating H_2S production in pumped pipes

Parameter	**Value**
Normal respiration rate in sewage at 15°C (g $O_2/m^3.h$)	6.0
Normal respiration rate in slime at 15°C (g $O_2/m^2.h$)	0.7
Normal sulphide production rate in slime at 20°C (g $S^{=}/m^2.h$)	0.001 sewage BOD (mg/l)

An allowance has been made for these factors by multiplying the reaction rates in Table 3 by activity coefficients. For simplicity, the coefficient values vary only with flow rate; they do not model the effect of any alternating oxygen potential on reaction rate. Table 4 lists a value of unity for the coefficient of respiration in the bulk sewage, indicating that such respiration is not influenced by the flow conditions in the pipe as would be expected. However, the coefficients for the slime reactions are assumed to decrease from a value of 0.5 at peak flow to 0.1 at minimum flow. These values are based on judgement and could contain large positive or negative errors.

{5} Pomeroy R D, 1992, The Problem of Hydrogen Sulphide in Sewers, 2nd Edition, Clay pipe Association, Chesham, Bucks, England

Table 4: Activity coefficients for modifying reaction rates			
Flow	Activity coefficient		
	Bulk respiration	Slime respiration	SO_4^{--} reduction
Peak	`1.0	0.5	0.5
Average	1.0	0.25	0.25
Minimum	1.0	0.1	0.1

3.2.3 Dissolved Oxygen at Inlet

Assumptions also have to be made regarding the concentration of dissolved oxygen in the sewage at the pumping stations. For simplicity, it is assumed that the DO value is the same at each station but inversely related to flow rate. Since previous calculations have shown that the sewage is likely to be well aerated in the gravity sections, the assumed DO values are 5 mg/l, 6 mg/l and 7 mg/l for peak, average and minimum flows respectively.

In principle, the DO values at the pumping stations can be calculated from the aeration and respiration rates; these calculations are involved but should be undertaken at a later stage in the design.

3.2.4 Sulphide at Inlet

The sulphide concentration in the sewage at the inlet of each pumped pipe is assumed to be zero. Thus, the calculations predict the additional sulphide which may be produced in any particular pipe.

3.2.5 Results

Table 2, Page 2 shows the results of the calculations for the four main pumped pipes at (-E), (+H), (+E) and (+B). Table 5 summarises the main results.

None of the predicted H_2S concentrations in the sewage is particularly high. Never-the-less, the concentrations are sufficiently high to cause odour and corrosion problems.

Two pipes, namely (-E) and (+H) at the two ends of the sewerage, are predicted to have anaerobic lengths at all (dry-weather) flows indicating that they are likely to be a potential source of sulphide most of the time. Although some of the sulphide will be sequestered by compounds of metals such as Fe, Cu, Zn and Pb present in the sewage, the residual concentration of soluble H_2S will probably be sufficiently high to cause problems.

Table 2: H2S ASSESSMENT

PARAMETER			MANHOLE/PUMPING STATION IDENTIFICATION																
			-F	-E	-D	-C	-B	-A	+H	+G	+F	+E	+D	+C	+B	+A	X	Y	Z
FLOW RATES AND PIPELINE SIZES																			
Additional population			20250	3240	0	5670	5670	3500	1620	0	2430	0	0	1620	0	0			
Total population			20250	23490	23490	29160	34830	38330	1620	1620	4050	4050	4050	5670	5670	5670	44000		
Per capital flow	l/c.day		341	341		341	341	184	341	0	341			341					
Additional flow	m3/day	Residential	6905	1105		1933	1933	644	552.4	0	828.6			552.4				0	0
		Commercial workers						450											
		Industrial workers																0	0
		Overnight visitors						40											
		Day visitors						10											
		Beach goers								150									
		Industrial effluent																0	0
		Total	6905	1105	0	1933	1933	1144	552.4	150	828.6	0	0	552.4	0	0	0	0	0
Total ADWF	m3/day		6905	8010	8010	9944	11877	13021	552.4	702.4	1531	1531	1531	2083	2083	2083	15105	15105	15105
Peaking factor			4	4	4	4	4	4	6	6	6	6	6	5	5	5	4	4	4
Peak flow rate	l/s		319.7	370.8	370.8	460.4	549.9	602.8	38.36	48.78	106.3	106.3	106.3	120.6	120.6	120.6	699.3	699.3	699.3
Pipeline type			G	P	G	G	G	G	P	G	G	P	G	G	P	G	G	G	G
Minimum pipe gradient					0.048	0.0034	0.0034	0.0034		0.012	0.012		0.014	0.028		0.016			
Max flow velocity	m/s		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Pipe diameter	mm		520.9	561	561	625.1	683.2	715.3	180.5	203.5	300.4	300.4	300.4	319.9	319.9	319.9	770.4	770.4	770.4
Chainage from manhole at X	m			2400	1320	1170	980	480	2850	1950	1550	1390	1050	830	350	100	0		
Length of stretch	m			1080	150	190	500	480	900	400	160	340	220	480	250	100			

GENERAL DATA FOR H2S PRODUCTION

Normal respiration in sewage at 15C	g O2/m3.h	6
Normal respiration at walls at 15C	g O2/m2.h	0.7
Normal sulphide production at 20C and BOD of 200 mg/l	g S/m2.h	0.2
Solubility of sulphide at 20C in sewage	mg/l.bar	3700
Temperature coefficient for solubility	%/degreeC	2.5
Sewage temperature	C	25
Normal respiration in sewage at sewage temp	g O2/m3.h	11.80
Normal respiration at walls at sewage temp	g O2/m2.h	0.94
Normal sulphide production at sewage temp and BOD of 200 mg/l	g S/m2.h	0.28
Solubility of H2S at sewage temp	mg/l.bar	3237.50
Partition cefficient for H2S in sewage		0.5

Table 2: H2S ASSESSMENT

PARAMETER		MANHOLE/PUMPING STATION IDENTIFICATION																
		-F	-E	-D	-C	-B	-A	+H	+G	+F	+E	+D	+C	+B	+A	X	Y	Z

H2S CALCULATIONS FOR PEAK DIURNAL DWF

Flow rate	x ADWF		2	2	2	2	2	3	3	3	3	3	2.5	2.5	2.5			
BOD of sewage	mg/l		150	150	150	150	150	150	150	150	150	150	150	150	150			
Sulphate reduction activity coefficient (0.1 to 1.5)			0.5					0.5			0.5			0.5				
Respiration activity coefficient at walls (0.1 to 1.5)			0.5					0.5			0.5			0.5				
Respiration activity coefficient in sewage (0.5 to 2.0)			1					1			1			1				
DO at pumping station	g/m3		5					5			5			5				
Av. flow rate	m3/h		667.5	667.5	828.6	989.8	1085	69.05	87.8	191.4	191.4	191.4	217	217	217			
Av. flow velocity	m/s		0.75					0.75			0.75			0.75				
Retention time	mins		24					20			7.556			5.556				
Total respiration over x-section	g O2/m.h		3.747					0.835			1.724			1.894				
Length of aerobic section	m		890.7					413.4			554.9			572.9				
Length of anaerobic section	m		189.3					486.6			0			0				
Sulphide production	g/h		35.1					29.02			0			0				
Sulphide concentration in sewage	mg/l		0.053					0.42			0			0				
Equilibrium conc. in atmosphere	ppm (v/v)		8.12					64.9			0			0				
Wetted perimeter/surface width				3	3	3	3		3	3		3	3		3			
US EPA Z-factor (no sulphide when <5000)				66.22	231.7	218.5	211.9		258.7	200		185.2	125.6		166.2			

H2S CALCULATIONS FOR ADWF

Flow rate	x ADWF		1	1	1	1	1	1	1	1	1	1	1	1	1			
BOD of sewage	mg/l		130	130	130	130	130	130	130	130	130	130	130	130	130			
Sulphate reduction activity coefficient (0.1 to 1.5)			0.25					0.25			0.25			0.25				
Respiration activity coefficient at walls (0.1 to 1.5)			0.25					0.25			0.25			0.25				
Respiration activity coefficient in sewage (0.5 to 2.0)			1					1			1			1				
DO at pumping station	g/m3		6					6			6			6				
Av. flow rate	m3/h		333.8	333.8	414.3	494.9	542.5	23.02	29.27	63.79	63.79	63.79	86.81	86.81	86.81			
Av. flow velocity	m/s		0.375					0.25			0.25			0.3				
Retention time	mins		48					60			22.67			13.89				
Total respiration over x-section	g O2/m.h		3.333					0.835			1.724			1.894				
Length of aerobic section	m		600.9					165.4			222			275				
Length of anaerobic section	m		479.1					734.6			118			0				
Sulphide production	g/h		59.22					18.98			5.078			0				
Sulphide concentration in sewage	mg/l		0.177					0.825			0.08			0				
Equilibrium conc. in atmosphere	ppm (v/v)		27.4					127.4			12.29			0				
Wetted perimeter/surface width				1.6	1.6	1.6	1.6		1.6	1.6		1.6	1.6		1.6			
US EPA Z-factor (no sulphide when <5000)				38.47	134.6	126.9	123.1		171.8	132.8		123	78.56		103.9			

H2S CALCULATIONS FOR MINIMUM FLOW

Flow rate	x ADWF		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15			
BOD of sewage	mg/l		75	75	75	75	75	75	75	75	75	75	75	75	75			
Sulphate reduction activity coefficient (0.1 to 1.5)			0.1					0.1			0.1			0.1				
Respiration activity coefficient at walls (0.1 to 1.5)			0.1					0.1			0.1			0.1				
Respiration activity coefficient in sewage (0.5 to 2.0)			1					1			1			1				
DO at pumping station	g/m3		7					7			7			7				
Av. flow rate	m3/h		50.06	50.06	62.15	74.23	81.38	3.453	4.39	9.569	9.569	9.569	13.02	13.02	13.02			
Av. flow velocity	m/s		0.056					0.037			0.037			0.045				
Retention time	mins		320					400			151.1			92.59				
Total respiration over x-section	g O2/m.h		3.084					0.835			1.724			1.894				
Length of aerobic section	m		113.6					28.94			38.84			48.12				
Length of anaerobic section	m		966.4					871.1			301.2			201.9				
Sulphide production	g/h		47.78					5.194			2.99			2.134				
Sulphide concentration in sewage	mg/l		0.954					1.505			0.312			0.164				
Equilibrium conc. in atmosphere	ppm (v/v)		147.4					232.4			48.25			25.31				
Wetted perimeter/surface width				1.1	1.1	1.1	1.1		1.1	1.1		1.1	1.1		1.1			
US EPA Z-factor (no sulphide when <5000)				28.54	99.85	94.16	91.35		127.4	98.55		91.24	58.28		77.09			

At average flow, three of the pipes are predicted to produce H_2S. The exception is the comparatively short length of pipe at (+B).

At minimum flow, all four pipes are predicted to have anaerobic sections. The sulphide concentration from pipe (+H) is predicted to be 1.5 mg/l. The volumetric H_2S concentration in the atmosphere in equilibrium with this aqueous concentration is 232 ppm (as S) which is about 500 000 times higher than the standard detection limit for people. Such atmospheric concentrations would, of course, not be obtained in practice since the desorption of H_2S from the sewage occurs at a comparatively low rate.

In terms of the H_2S production potential of each pipe, the following conclusions are drawn.

- Pipe (+H) is likely to be a source of H_2S throughout the day, the concentration of sulphide in the sewage varying up to a maximum of about 1.5 mg/l at night. Sulphide production rate is predicted to peak at a value of about 30 g/h at high sewage flow.
- Pipe (-E) could also be a continuous source of H_2S. Although the sulphide concentrations in the sewage would be lower than in pipe (+H), the sulphide production rate could be appreciably higher having a maximum value of 60 g/h at average sewage flow.
- Pipe (+E) would be anaerobic only at flows less than average. The long periods of aerobicity would therefore suppress the presence of SO_4^{--}-reducing bacteria in the slime. Any significant production of H_2S would probably only arise at night at a rate of less than 5 g/h.
- Pipe (+B) would be aerobic for most of the time and unlikely to be a source of significant quantities of H_2S, although the occasional production at night may arise.

Table 5: Summary of main results for H_2S production in pumped pipes			
Pipe	**Flow**	**Sulphide**	
		Production (g/h)	**Concentration (mg/l)**
-E	Peak	35	0.05
	Average	59	0.18
	Minimum	48	0.95
+H	Peak	29	0.42
	Average	19	0.83
	Minimum	5.2	1.5
+E	Peak	0	0
	Average	5.1	12.3
	Minimum	3.0	0.3
+B	Peak	0	0
	Average	0	0
	Minimum	2.1	0.16

Table 6: Substances for controlling H_2S		
Basis of technique		**Substances**
Preventive	Maintain aerobicity	Air, Pure oxygen
	Maintain anoxicity	Nitrate salt
	Disinfection	Chlorine, Hypochlorite, Hydrogen peroxide
Remedial	Sequestration	Ferrous salt, Ferric salt, Mixture of these
	Chemical/biochemical oxidation	Pure oxygen
	Chemical oxidation	Chlorine, Hypochlorite, Hydrogen peroxide

4 CONTROL STRATEGY

H_2S could be produced in sufficient quantities, particularly at the two ends of the sewerage system, to cause odour and corrosion problems. The following investigates the various techniques and strategies for controlling such problems.

4.1 Options

Techniques can be classed as either preventive or remedial. Two preventive techniques have already been mentioned, these are to design the pipes for a velocity of at least 1.5 m/s and to use pipes with comparative smooth walls. However, such techniques only reduce the size of the problem rather than eliminate it.

Table 6 lists other techniques, all of which rely on dosing a substance into the sewage. In the preventive techniques, the substance is dosed into the pipe immediately downstream of the pumping station, and, in the remedial techniques, is dosed at the end of the pipe into say a tank or chamber. These success of these techniques various depending on the specific conditions in the sewerage.

Another remedial option is to allow the H_2S to escape from the sewage and then collect and treat the gases, and use materials resistant to corrosion by H_2S and sulphuric acid for the pipes and fittings. In many cases, a combination of techniques is needed.

4.2 Suitable Option

An evaluation of the numerous options is beyond the scope of this report. Instead, one option which has some attractions and could be implemented for a comparatively small addition capital investment is described.

In this option, a solution of an iron salt would be dosed at pumping stations (-E) and (+H), that is at both ends of the sewage system. Thus, only two dosing points would be involved. A disadvantage of iron is that it reacts or combines with other substances such as phosphates so that high doses up to say 20 mg/l are necessary. Mixtures of ferric and ferrous salts give the best performance per unit dose and ferrous salts the worst. However, the efficacy of iron salts is improved when the sewage contains oxygen since the iron has a dual role; serving as a catalyst in the oxidation of the H_2S to sulphur as well sequestering the sulphide. The gravity pipes in the Sham Tseng sewerage will serve as efficient aerators in this respect.

In spite of iron dosing, precautions will have to be taken as follows.

- All the pumping stations will, of course, have to be force ventilated. In particular, the ventilation system at stations at (+B) and (+E) will have to be designed so that the station and the adjoining gravity pipes receive an air-change rate of at least 12 per hour and the air vented in open space well away from buildings.
- One of the manholes at either (-B), (-C) or (-D) will probably have to be forced ventilated and the air similarly vented.
- To eliminated the possibility of odours at manhole (X) which is in an extremely sensitive area, the gravity pipe downstream of (X) should be vented to the treatment works where the air can then pass through the works odour removal system.
- The material of construction of the pipes especially the gravity pipes should be polypropylene. Similarly, the all the manholes and covers downstream of the pumped pipes should be protected from H_2S and sulphuric acid corrosion.

5 CONCLUSIONS

Calculations have shown that the two pumped pipes at either end of the sewerage have the potential to produce H_2S in sufficient quantities to cause odour and corrosion problems. The two intermediate pumped pipes are only likely to produce H_2S at times of low flow and in much reduced quantities.

An option for dealing with the potential problems associated with the H_2S would be to dose a solution of an iron salt, preferably a proprietary mixture of ferric and ferrous salts or a ferric salt, at the two pumping stations at either end of the sewerage system. Pumping stations and some manholes would need to be ventilated and the air release in open space well away from buldings. Also, the gravity pipes near the treatment works would be vented into the works and treated in the works odour removal system.

6 RECOMMENDATIONS

The H_2S production potential of the sewerage should be fully evaluated and the numerous options for controlling the production assessed in terms of reliability and cost. The most attractive strategy may contain several stages allowing control measures to be implemented if experience at site demonstrates the need. For the study, the dosing a solution of an iron salt and ventilating the pumping stations and some of the manholes should be assumed to be the preferred option.

Ting Kau and Sham Tseng Sewerage Scheme
Environmental Impact Assessment
Agreement No. CE 35/94

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BY: ANTHONY LEUNG

Odour Assessment

Sewerage: Ground Levels, Invert Levels, Chainages, Pipe Diameters and Flows

Section			Upstream Levels (m)		Downstream Levels (m)		Chainage from PS7 (m)		Length	Diameter	Type	ADWF
			Ground	Invert	Ground	Invert	Upstream	Downstream	(m)	(m)		(cu.m/d)
COLUMN			A	B	C	D	E	F	G	H	I	J
PS1 (-E)	to	(-D)	4.80	2.80	21.10	19.80	5390	4285	1105	0.400	PUMPED	8010.0
(-D)	to	(-C)	21.10	19.80	20.00	18.70	4285	4245	40	0.375	GRAVITY	8010.0
(-C)	to	(-B)	20.00	18.70	6.40	4.70	4245	3950	295	0.375	GRAVITY	9944.0
(-B)	to	(-A)	6.40	4.40	4.60	2.80	3950	3440	510	0.675	GRAVITY	11877.0
(-A)	to	(X)	4.60	2.80	6.70	1.00	3440	2960	480	0.675	GRAVITY	13021.0
PS7(+H)	to	(+G)	4.20	2.50	26.80	25.50	0	880	880	0.150	PUMPED	552.4
(+G)	to	(+F)	26.80	25.50	17.00	15.30	880	1370	490	0.225	GRAVITY	702.4
(+F)	to	PS4(+E)	17.00	15.22	16.00	13.50	1370	1505	135	0.300	GRAVITY	1531.0
PS4(+E)	to	(+D)	16.00	14.50	30.50	29.00	1505	1845	340	0.250	PUMPED	1531.0
(+D)	to	(+C)	30.50	29.00	26.50	25.00	1845	2125	280	0.300	GRAVITY	1531.0
(+C)	to	PS3(+B)	26.50	25.00	6.00	4.40	2125	2570	445	0.300	GRAVITY	2083.0
PS3(+B)	to	(+A)	6.00	4.40	9.50	7.80	2570	2845	275	0.250	PUMPED	2083.0
(+A)	to	(X)	9.50	7.80	6.70	5.15	2845	2960	115	0.300	GRAVITY	2083.0
(-F)	to	PS1 (-E)	4.80	2.80	4.80	2.80					GRAVITY	6905.0
PS2(-G)	to	(-A)	4.70	2.70	4.60	2.80		3440			PUMPED	1144.0
PS5(+I)	to	(+F)	3.40	1.40	17.00	15.30		1370			PUMPED	828.6
PS6(+J)	to	(+G)	4.60	2.60	26.80	25.50		880			PUMPED	150.0

References:
Column A to I: Sham Tseng Sewerage & Sewage Treatment Underground Cavern Options, Volume 2 of 2, Figure 7
Column J: Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Appendix C, Table 2

DATE:24-Jul-95

Odour Assessment **ISCST Modelling**

Air Sensitive Receivers

Positions of Air Sensitive Receivers (ASRs)

ASR	Code	Easting (m)	Northing (m)
DD 387 / LOT 17 – 18	SR1	822420	824685
Hong Kong Garden	SR2	822530	824725
Lido Garden	SR3	824080	825230
DD 390 LOT 94	SR4	824645	825165
Golden Villa	SR5	825005	824990
Villa Mar	SR6	825650	825430
Edinburgh Villa	SR7	825800	825480
Ting Kau Village	SR8	826300	825610
DD 399 LOT 367 – 368	SR9	826815	825465
Anton Villa	SR10	826290	825675

Coordinates Measured from Survey Map

Sources of Hydrogen Sulphide

Pumping Stations

Location	Code	Easting (m)	Northing (m)	Emission Height (m)	Estimated Sewage Surface Area (sq.m)	H2S Flux (ug/sq.m-s)	Emission Rate (ug/s)	Air Flow Rate (cu.m/s)	Concentration (ppm)
Column	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
Approach Beach	PS7	826928	825378	3	7.84	20.00	156.80	0.10	1.13
Ting Kau Beach	PS6	826231	825556	3	7.84	20.00	156.80	0.10	1.13
Lido Beach	PS5	825896	825449	3	7.84	20.00	156.80	0.10	1.13
Casam Beach	PS4	825680	825400	3	12.25	20.00	245.00	0.10	1.76
Sham Tseng East	PS3	824847	825021	3	9.00	20.00	180.00	0.10	1.30
Sham Tseng West	PS2	824158	825387	3	7.84	20.00	156.80	0.10	1.13
Tsing Lung Tau Tseung	PS1	822451	824682	3	23.04	20.00	460.80	0.10	3.32
Sham Tseng STW (Inlet)	STW	824860	824978	3	120.00	20.00	2400.00	0.20	8.64

Note:

Column (A)	Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Appendix C, Figure 1
Column (B)&(C)	Sham Tseng Sewerage & Sewage Treatment Underground Cavern Options, Volume 1 of 2, Appendix 1
Column (D)	Assumed
Column (E)	Estimated from flow rates and duty head of the pumping stations
Column (F)	The flux were assumed to be the same as those estimated for the wet well of Cheung Sha Wan Pumping Station
Column (G)	(G) = (E) x (F)
Column (H)	Assumed
Column (I)	(G)/(H) x 0.72 /1000

Chambers (CHMBR) Downstreams of Pumped Mains

Location	Code	Easting (m)	Northing (m)	Emission Height (m)	Estimated Sewage Surface Area (sq.m)	H2S Flux (ug/sq.m-s)	Emission Rate (ug/s)	Air Flow Rate (cu.m/s)	Concentration (ppm)
Column	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
Ting Kau CHMBR	+G	826125	825660	0	6.25	20.00	125.00	0.04	2.25
Hoi Mei Beach CHMBR	+D	825420	825180	0	6.25	20.00	125.00	0.04	2.25
Garden Bakery CHMBR	+A	824665	825195	0	6.25	20.00	125.00	0.04	2.25
Tsing Lung Wan CHMBR	-D	823465	825920	0	6.25	20.00	125.00	0.04	2.25

Note:

Column (A)	Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Appendix C, Figure 1
Column (B)&(C)	Sham Tseng Sewerage & Sewage Treatment Underground Cavern Options, Volume 2 of 2, Figure 1
Column (D)	Assumed the manhole covers are at ground level
Column (E)	The surface areas were assumed to be the same as those of similar chambers (e.g. Yau Tong Rising Main in Kwun Tong PTW)
Column (F)	The flux were assumed to be the same as those estimated for the wet well of Cheung Sha Wan Pumping Station
Column (G)	(G) = (E) x (F)
Column (H)	Assumed
Column (I)	(G)/(H) x 0.72 /1000

Odour Assessment **ISCST Modelling**

Preliminary Treatment Facilities and Sludge Treatment Facilities in Sham Tseng STW

Location		Easting (m)	Northing (m)	Base Area (sq.m)	Height (m)	Volume (cu.m)	[H2S] of Air Extracted (ppm)	Air Flow Rate (cu.m/s)	Emission Rate (ug/s)	Emission Height (m)
Column	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Preliminary Treatment Facilities		824850	824990	294.00	7.00	2058.00	3.00	3.43	14303.10	9.00
Sludge Treatment Facilities		824755	824985	875.00	10.00	8750.00	5.00	14.58	101354.17	12.00

Note:

Column (B)&(C)	Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Figure 8.7
Column (D)	Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Figure 8.7
Column (E)	Assumed
Column (F)	(F) = (D) X (E)
Column (G)	Assumed the concentration is 0.1ppm (100ppb) after odour treatment
Column (H)	(H) = (F) X "No. of Air Changes per hour" /3600; No. of Air changes per hour = 6
Column (I)	(I) = (G) X (H) X 1390
Column (J)	(J) = (E) + 3, stack height: 3m above roof

Sedimentation Tanks in Sham Tseng STW

Location		South East Corner Easting (m)	Northing (m)	Sewage Area (sq.m)	H2S Flux (ug/sq.m-s)	Emission Height (m)
Column	(A)	(B)	(C)	(D)	(E)	(F)
Sedimentation Tanks		824804	824975	378.00	0.0004	3.50

Note:

Column (B)&(C)	Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Figure 8.7
Column (D)	from Calculation Sheets: Odour Assessment, No.1-2, 23 March 1995
Column (E)	from Calculation Sheets: Odour Assessment, No.1-2, 23 March 1995
Column (F)	Assumed to be the same as the height of the sedimentation tanks

Summary of Sources of Hydrogen Sulphide for ISCST Input

No Mitigations (except for PTW and STF in STSTW)

Location	Code	Easting (m)	Northing (m)	Source Type	Emission Height (m)	Emission Rate	Emission Rate Unit	Air Flow Rate (cu.m/min)	Stack Diameter (m)	Velocity (m/s)	Area Length (m)
Approach Beach	PS7	826928	825378	Stack	3.00	156.80	(ug/s)	6.00	0.30	1.415	N/A
Ting Kau Beach	PS6	826231	825556	Stack	3.00	156.80	(ug/s)	6.00	0.30	1.415	N/A
Lido Beach	PS5	825896	825449	Stack	3.00	156.80	(ug/s)	6.00	0.30	1.415	N/A
Casam Beach	PS4	825680	825400	Stack	3.00	245.00	(ug/s)	6.00	0.30	1.415	N/A
Sham Tseng East	PS3	824847	825021	Stack	3.00	180.00	(ug/s)	6.00	0.30	1.415	N/A
Sham Tseng West	PS2	824158	825387	Stack	3.00	156.80	(ug/s)	6.00	0.30	1.415	N/A
Tsing Lung Tau Tseung	PS1	822451	824682	Stack	3.00	460.80	(ug/s)	6.00	0.30	1.415	N/A
Sham Tseng STW (Inlet)	STW	824860	824978	Stack	3.00	2400.00	(ug/s)	12.00	0.30	2.829	N/A
Ting Kau CHMBR	+G	826125	825660	Stack	0.00	125.00	(ug/s)	2.40	0.30	0.566	N/A
Hoi Mei Beach CHMBR	+D	825420	825180	Stack	0.00	125.00	(ug/s)	2.40	0.30	0.566	N/A
Garden Bakery CHMBR	+A	824665	825195	Stack	0.00	125.00	(ug/s)	2.40	0.30	0.566	N/A
Tsing Lung Wan CHMBR	-D	823465	825920	Stack	0.00	125.00	(ug/s)	2.40	0.30	0.566	N/A
Preliminary Treatment Facilitie	PTW	824850	824990	Stack	9.00	14303.10	(ug/s)	205.80	1.00	4.367	N/A
Sludge Treatment Facilities	STF	824755	824985	Stack	12.00	101354.17	(ug/s)	875.00	2.00	4.642	N/A
Sedimentation Tanks	SedTanks	824804	824975	Area	3.50	0.0004	(ug/sq.m-s)	N/A	N/A	N/A	19.44

Ting Kau and Sham Tseng Sewerage Scheme
Environmental Impact Assessment
Agreement No. CE 35/94

FILE: C:\TK-ODOUR\ODRM-ISC.WK1
BY: ANTHONY LEUNG

Odour Assessment **ISCST Modelling**
With Further Mitigation Measures: Option 1 – Dedorisation of Air
Air Sensitive Receivers
Positions of Air Sensitive Receivers (ASRs)

ASR	Code	Easting (m)	Northing (m)
DD 387 / LOT 17 – 18	SR1	822420	824685
Hong Kong Garden	SR2	822530	824725
Lido Garden	SR3	824080	825230
DD 390 LOT 94	SR4	824645	825165
Golden Villa	SR5	825005	824990
Villa Mar	SR6	825650	825430
Edinburgh Villa	SR7	825800	825480
Ting Kau Village	SR8	826300	825610
DD 399 LOT 367 – 368	SR9	826815	825465
Anton Villa	SR10	826290	825675

Coordinates Measured from Survey Map

Sources of Hydrogen Sulphide
Pumping Stations

Location	Code	Easting (m)	Northing (m)	Emission Height (m)	Estimated Sewage Surface Area (sq.m)	H2S Flux (ug/sq.m-s)	Emission Rate (ug/s)	Air Flow Rate (cu.m/s)	Concentration (ppm)	Concentration Deodorised (ppm)	Emission Rate Dodorised (ug/s)
Column	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
Approach Beach	PS7	826928	825378	3	7.84	20.00	156.80	0.10	1.13	0.005	0.70
Ting Kau Beach	PS6	826231	825556	3	7.84	20.00	156.80	0.10	1.13	0.005	0.70
Lido Beach	PS5	825896	825449	3	7.84	20.00	156.80	0.10	1.13	0.005	0.70
Casam Beach	PS4	825680	825400	3	12.25	20.00	245.00	0.10	1.76	0.005	0.70
Sham Tseng East	PS3	824847	825021	3	9.00	20.00	180.00	0.10	1.30	0.005	0.70
Sham Tseng West	PS2	824158	825387	3	7.84	20.00	156.80	0.10	1.13	0.005	0.70
Tsing Lung Tau Tseung	PS1	822451	824682	3	23.04	20.00	460.80	0.10	3.32	0.005	0.70
Sham Tseng STW (Inlet)	STW	824860	824978	3	120.00	20.00	2400.00	0.20	8.64	0.005	1.39

Note:
Column (A) Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Appendix C, Figure 1
Column (B)&(C) Sham Tseng Sewerage & Sewage Treatment Underground Cavern Options, Volume 1 of 2, Appendix 1
Column (D) Assumed
Column (E) Estimated from flow rates and duty head of the pumping stations
Column (F) The flux were assumed to be the same as those estimated for the wet well of Cheung Sha Wan Pumping Station
Column (G) (G) = (E) x (F)
Column (H) Assumed
Column (I) (G)/(H) x 0.72 /1000
Column (J) Recommended Level of Treatment
Column (K) (K) = (J) X (H) X1390

Chambers (CHMBR) Downstreams of Pumped Mains

Location	Code	Easting (m)	Northing (m)	Emission Height (m)	Estimated Sewage Surface Area (sq.m)	H2S Flux (ug/sq.m-s)	Emission Rate (ug/s)	Air Flow Rate (cu.m/s)	Concentration (ppm)	Concentration Deodorised (ppm)	Emission Rate Dodorised (ug/s)
Column	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
Ting Kau CHMBR	+G	826125	825660	0	6.25	20.00	125.00	0.04	2.25	0.005	0.28
Hoi Mei Beach CHMBR	+D	825420	825180	0	6.25	20.00	125.00	0.04	2.25	0.005	0.28
Garden Bakery CHMBR	+A	824665	825195	0	6.25	20.00	125.00	0.04	2.25	0.005	0.28
Tsing Lung Wan CHMBR	–D	823465	825920	0	6.25	20.00	125.00	0.04	2.25	0.005	0.28

Note:
Column (A) Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Appendix C, Figure 1
Column (B)&(C) Sham Tseng Sewerage & Sewage Treatment Underground Cavern Options, Volume 2 of 2, Figure 1
Column (D) Assumed the manhole covers are at ground level
Column (E) The surface areas were assumed to be the same as those of similar chambers (e.g. Yau Tong Rising Main in Kwun Tong PTW)
Column (F) The flux were assumed to be the same as those estimated for the wet well of Cheung Sha Wan Pumping Station
Column (G) (G) = (E) x (F)
Column (H) Assumed
Column (I) (G)/(H) x 0.72 /1000
Column (J) Recommended Level of Treatment
Column (K) (K) = (J) X (H) X1390

Ting Kau and Sham Tseng Sewerage Scheme
Environmental Impact Assessment
Agreement No. CE 35/94

FILE: C:\TK-ODOUR\ODRM-ISC.WK1
BY: ANTHONY LEUNG

Odour Assessment **ISCST Modelling**
With Further Mitigation Measures: Option 1 – Dedorisation of Air
Preliminary Treatment Facilities and Sludge Treatment Facitities in Sham Tseng STW

Location	Easting (m)	Northing (m)	Base Area (sq.m)	Height (m)	Volume (cu.m)	[H2S] of Air Extracted (ppm)	Air Flow Rate (cu.m/s)	Emission Rate (ug/s)	Emission Height (m)	Concentration Deodorised (ppm)	Emission Rate Deodorised (ug/s)
Column (A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
Preliminary Treatment Facilities	824850	824990	294.00	7.00	2058.00	3.00	3.43	14303.10	9.00	0.005	23.84
Sludge Treatment Facilities	824755	824985	875.00	10.00	8750.00	5.00	14.58	101354.17	12.00	0.005	101.35

Note:
Column (B)&(C) Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Figure 8.7
Column (D) Ting Kau and Sham Tseng Sewerage Scheme EIA, Agreement No. CE 35/94, WP 3, Figure 8.7
Column (E) Assumed
Column (F) (F) = (D) X (E)
Column (G) Assumed the concentration is 0.1ppm (100ppb) after odour treatment
Column (H) (H) = (F) X "No. of Air Changes per hour" /3600; No. of Air changes per hour = 6
Column (I) (I) = (G) X (H) X 1390
Column (J) (J) = (E) + 3, stack height: 3m above roof

Sedimentation Tanks in Sham Tseng STW
There should not be any hydrogen sulphide emission at the sedimentation tanks because odour is removed at the preliminary treatment facilities.

Summary of Sources of Hydrogen Sulphide for ISCST Input
No Mitigations (except for PTW and STF in STSTW)

Location	Code	Easting (m)	Northing (m)	Source Type	Emission Height (m)	Emission Rate	Emission Rate Unit	Air Flow Rate (cu.m/min)	Stack Diameter (m)	Velocity (m/s)	Area Length (m)
Approach Beach	PS7	826928	825378	Stack	3.00	0.70	(ug/s)	6.00	0.30	1.415	N/A
Ting Kau Beach	PS6	826231	825556	Stack	3.00	0.70	(ug/s)	6.00	0.30	1.415	N/A
Lido Beach	PS5	825896	825449	Stack	3.00	0.70	(ug/s)	6.00	0.30	1.415	N/A
Casam Beach	PS4	825680	825400	Stack	3.00	0.70	(ug/s)	6.00	0.30	1.415	N/A
Sham Tseng East	PS3	824847	825021	Stack	3.00	0.70	(ug/s)	6.00	0.30	1.415	N/A
Sham Tseng West	PS2	824158	825387	Stack	3.00	0.70	(ug/s)	6.00	0.30	1.415	N/A
Tsing Lung Tau Tseung	PS1	822451	824682	Stack	3.00	0.70	(ug/s)	6.00	0.30	1.415	N/A
Sham Tseng STW (Inlet)	STW	824860	824978	Stack	3.00	1.39	(ug/s)	12.00	0.30	2.829	N/A
Ting Kau CHMBR	+G	826125	825660	Stack	0.00	0.28	(ug/s)	2.40	0.30	0.566	N/A
Hoi Mei Beach CHMBR	+D	825420	825180	Stack	0.00	0.28	(ug/s)	2.40	0.30	0.566	N/A
Garden Bakery CHMBR	+A	824665	825195	Stack	0.00	0.28	(ug/s)	2.40	0.30	0.566	N/A
Tsing Lung Wan CHMBR	–D	823465	825920	Stack	0.00	0.28	(ug/s)	2.40	0.30	0.566	N/A
Preliminary Treatment Facilitie	PTW	824850	824990	Stack	9.00	23.84	(ug/s)	205.80	1.00	4.367	N/A
Sludge Treatment Facilities	STF	824755	824985	Stack	12.00	101.35	(ug/s)	875.00	2.00	4.642	N/A

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1                    ISCST2 - (DATED 93109)

                     IBM-PC VERSION (2.11 ) ISCST2
                     (C) COPYRIGHT 1992, TRINITY CONSULTANTS, INC.
                     SERIAL NUMBER 10386 SOLD TO MOTT MACDONALD

Run Began on  7/24/1995 at 15:33:54

*** TRINITY RECEPTOR FILE NAME: C:\TK-ODOUR\TK-DIS.REC
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CO TITLEONE Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment
CO TITLETWO Ground Level, No Mitigation Measures
CO MODELOPT CONC RURAL NOCALM MSGPRO
CO AVERTIME 1
CO POLLUTID H2S
CO TERRHGTS FLAT
CO ELEVUNIT METERS
CO FLAGPOLE 0.000000
CO RUNORNOT RUN
CO FINISHED
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SO SRCPARAM ABPS 156.8000        3.00      298.00     1.4150      0.300
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SO SRCPARAM LBPS 156.8000        3.00      298.00     1.4150      0.300
SO LOCATION CBPS POINT  825680.00  825400.00        0.00
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SO LOCATION STEPS POINT  824847.00  825021.00        0.00
SO SRCPARAM STEPS 180.0000        3.00      298.00     1.4150      0.300
SO LOCATION STWPS POINT  824158.00  825387.00        0.00
SO SRCPARAM STWPS 156.8000        3.00      298.00     1.4150      0.300
SO LOCATION TLTTPS POINT  822451.00  824682.00        0.00
SO SRCPARAM TLTTPS 460.7998        3.00      298.00     1.4150      0.300
SO LOCATION STSTWPS POINT  824860.00  824978.00        0.00
SO SRCPARAM STSTWPS 2400.000        3.00      298.00     2.8290      0.300
SO LOCATION TKCBR POINT  826125.00  825660.00        0.00
SO SRCPARAM TKCBR 125.0000        0.00      298.00     0.5660      0.300
SO LOCATION HMBCBR POINT  825420.00  825180.00        0.00
SO SRCPARAM HMBCBR 125.0000        0.00      298.00     0.5660      0.300
SO LOCATION GBCBR POINT  824665.00  825195.00        0.00
SO SRCPARAM GBCBR 125.0000        0.00      298.00     0.5660      0.300
SO LOCATION TLWCBR POINT  823465.00  825920.00        0.00
SO SRCPARAM TLWCBR 125.0000        0.00      298.00     0.5660      0.300
SO LOCATION STSTWPTW POINT  824850.00  824990.00        0.00
SO SRCPARAM STSTWPTW 14303.08        9.00      298.00     4.3670      1.000
SO LOCATION STSTWSTF POINT  824755.00  824985.00        0.00
SO SRCPARAM STSTWSTF 101354.2       12.00      298.00     4.6420      2.000
SO LOCATION STSTWST AREA  824804.00  824975.00        0.00
SO SRCPARAM STSTWST 0.000400        3.50      19.44
SO EMISUNIT 76.600000 GRAMS/SEC USER-UNITS
SO SRCGROUP ALL
SO FINISHED
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RE DISCCART 822530.00 824725.00 0.000
RE DISCCART 824080.00 825230.00 0.000
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RE DISCCART 826290.00 825675.00 0.000
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ME UAIRDATA 99999 1994 UAIRNAME
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ME FINISHED
OU STARTING
OU RECTABLE 1 FIRST
OU FINISHED

**********************************
*** SETUP Finishes Successfully ***
**********************************

 *** ISCST2 - VERSION 93109 ***    *** Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment        ***      07/24/95
                                   *** Ground Level, No Mitigation Measures                             ***      15:33:56
                                                                                                                 PAGE   1
 *** MODELING OPTIONS USED:  CONC   RURAL  FLAT   FLGPOL                          NOCALM MSGPRO

                                    ***     MODEL SETUP OPTIONS SUMMARY      ***
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

**Model Is Setup For Calculation of Average CONCentration Values.

**Model Uses RURAL Dispersion.

**Model Uses User-Specified Options:
          1. Final Plume Rise.
          2. Stack-tip Downwash.
          3. Buoyancy-induced Dispersion.
          4. Not Use Calms Processing Routine.
          5. Missing Data Processing Routine.
          6. Default Wind Profile Exponents.
          7. Default Vertical Potential Temperature Gradients.

**Model Assumes Receptors on FLAT Terrain.

**Model Accepts FLAGPOLE Receptor Heights.

**Model Calculates  1 Short Term Average(s) of:   1-HR

**This Run Includes:   15 Source(s);       1 Source Group(s); and       10 Receptor(s)

**The Model Assumes A Pollutant Type of:  H2S

**Model Set To Continue RUNning After the Setup Testing.

**Output Options Selected:
        Model Outputs Tables of Highest Short Term Values by Receptor (RECTABLE Keyword)

**NOTE:  The Following Flags May Appear Following CONC Values:  c for Calm Hours
                                                                m for Missing Hours
                                                                b for Both Calm and Missing Hours

**Misc. Inputs:  Anem. Hgt. (m) =     10.00 ;    Decay Coef. =    .0000     ;   Rot. Angle =       .0
                 Emission Units = GRAMS/SEC                                 ;  Emission Rate Unit Factor =    76.600
                 Output Units   = USER-UNITS

**Input Runstream File: C:\TK-ODOUR\TK-NO-MI.DAT                 ;  **Output Print File: C:\TK-ODOUR\TK-NO-MI.LST
 *** ISCST2 - VERSION 93109 ***    *** Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment        ***      07/24/95
                                   *** Ground Level, No Mitigation Measures                             ***      15:33:56
                                                                                                                 PAGE   2
 *** MODELING OPTIONS USED:  CONC   RURAL  FLAT   FLGPOL                          NOCALM MSGPRO


                                               *** POINT SOURCE DATA ***

              NUMBER EMISSION RATE                          BASE     STACK    STACK    STACK     STACK    BUILDING EMISSION RATE
   SOURCE      PART. (USER UNITS)     X         Y          ELEV.    HEIGHT   TEMP.   EXIT VEL. DIAMETER   EXISTS   SCALAR VARY
     ID        CATS.                (METERS)  (METERS)   (METERS)  (METERS) (DEG.K)   (M/SEC)  (METERS)              BY
```

ABPS	0	.15680E+03	826928.0	825378.0	.0	3.00	298.00	1.41	.30	NO
TKBPS	0	.15680E+03	826231.0	825556.0	.0	3.00	298.00	1.41	.30	NO
LBPS	0	.15680E+03	825896.0	825449.0	.0	3.00	298.00	1.41	.30	NO
CBPS	0	.24500E+03	825680.0	825400.0	.0	3.00	298.00	1.41	.30	NO
STEPS	0	.18000E+03	824847.0	825021.0	.0	3.00	298.00	1.41	.30	NO
STWPS	0	.15680E+03	824158.0	825387.0	.0	3.00	298.00	1.41	.30	NO
TLTTPS	0	.46080E+03	822451.0	824682.0	.0	3.00	298.00	1.41	.30	NO
STSTWPS	0	.24000E+04	824860.0	824978.0	.0	3.00	298.00	2.83	.30	NO
TKCBR	0	.12500E+03	826125.0	825660.0	.0	.00	298.00	.57	.30	NO
HMBCBR	0	.12500E+03	825420.0	825180.0	.0	.00	298.00	.57	.30	NO
GBCBR	0	.12500E+03	824665.0	825195.0	.0	.00	298.00	.57	.30	NO
TLWCBR	0	.12500E+03	823465.0	825920.0	.0	.00	298.00	.57	.30	NO
STSTWPTW	0	.14303E+05	824850.0	824990.0	.0	9.00	298.00	4.37	1.00	NO
STSTWSTF	0	.10135E+06	824755.0	824985.0	.0	12.00	298.00	4.64	2.00	NO

*** AREA SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (USER UNITS /METER**2)	COORD (SW CORNER) X (METERS)	Y (METERS)	BASE ELEV. (METERS)	RELEASE HEIGHT (METERS)	WIDTH OF AREA (METERS)	EMISSION RATE SCALAR VARY BY
STSTWST	0	.40000E-03	824804.0	824975.0	.0	3.50	19.44	

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID	SOURCE IDs
ALL	ABPS , TKBPS , LBPS , CBPS , STEPS , STWPS , TLTTPS , STSTWPS , TKCBR , HMBCBR , GBCBR , TLWCBR , STSTWPTW, STSTWSTF, STSTWST ,

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

```
( 822420.0,  824685.0,      .0,      .0);      ( 822530.0,  824725.0,      .0,      .0);
( 824080.0,  825230.0,      .0,      .0);      ( 824645.0,  825165.0,      .0,      .0);
( 825005.0,  824990.0,      .0,      .0);      ( 825650.0,  825430.0,      .0,      .0);
( 825800.0,  825480.0,      .0,      .0);      ( 826300.0,  825610.0,      .0,      .0);
( 826815.0,  825465.0,      .0,      .0);      ( 826290.0,  825675.0,      .0,      .0);
```


*** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***
(1=YES; 0=NO)

```
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1
```

METEOROLOGICAL DATA PROCESSED BETWEEN START DATE: 94 1 1 1
AND END DATE: 94 12 31 24

NOTE: METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO DEPEND ON WHAT IS INCLUDED IN THE DATA FILE.

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
B	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
C	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
D	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
E	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00
F	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** THE FIRST 24 HOURS OF METEOROLOGICAL DATA ***

FILE: C:\TK-ODOUR\TUN94.MET   FORMAT: (4I2,2F9.4,F6.1,I2,2F7.1)
SURFACE STATION NO.: 99999   UPPER AIR STATION NO.: 99999
NAME: SURFNAME   NAME: UAIRNAME
YEAR: 1994   YEAR: 1994

YEAR	MONTH	DAY	HOUR	FLOW VECTOR	SPEED (M/S)	TEMP (K)	STAB CLASS	MIXING HEIGHT (M) RURAL	URBAN
94	1	1	1	210.0	2.40	288.2	5	787.8	787.8
94	1	1	2	170.0	1.50	287.7	6	787.8	787.8
94	1	1	3	180.0	1.80	287.6	6	787.8	787.8
94	1	1	4	190.0	1.80	287.2	6	787.8	787.8
94	1	1	5	190.0	2.30	286.5	5	787.8	787.8

```
94   1   1    6   200.0  2.40  286.3   5   787.8   787.8
94   1   1    7   180.0  1.80  286.1   6   772.9   772.9
94   1   1    8   170.0  1.70  286.0   6   772.9   772.9
94   1   1    9   190.0  1.60  286.9   4   772.9   772.9
94   1   1   10   200.0  1.50  288.2   2   772.9   772.9
94   1   1   11   999.9  1.00  289.3   2   772.9   772.9
94   1   1   12    40.0  1.00  291.0   2   772.9   772.9
94   1   1   13   999.9  1.00  292.6   2   772.9   772.9
94   1   1   14    20.0  1.30  292.4   2   772.9   772.9
94   1   1   15   360.0  1.80  291.5   2   772.9   772.9
94   1   1   16   350.0  1.60  291.3   2   772.9   772.9
94   1   1   17   999.9  1.00  291.0   4   772.9   772.9
94   1   1   18   250.0  1.00  290.2   6   772.9   772 9
94   1   1   19   330.0  1.00  289.6   6   787.8   787 8
94   1   1   20   350.0  1.20  289.3   6   787.8   787.8
94   1   1   21   350.0  2.10  289.2   6   787.8   787.8
94   1   1   22   350.0  1.70  289.0   6   787.8   787.8
94   1   1   23   160.0  1.00  288.5   6   787.8   787.8
94   1   1   24   110.0  1.00  287.8   6   787.8   787.8

*** NOTES:  STABILITY CLASS 1=A, 2=B, 3=C, 4=D, 5=E AND 6=F.
            FLOW VECTOR IS DIRECTION TOWARD WHICH WIND IS BLOWING.
```



```
*** THE   1ST HIGHEST  1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL      ***
    INCLUDING SOURCE(S):      ABPS     , TKBPS    , LBPS     , CBPS     , STBPS    , STWPS    , TLTTPS   ,
STSTWPS  , TKCBR    , HMBCBR   , GBCBR    , TLWCBR   , STSTWPTW, STSTWSTF, STSTWST ,

                 *** DISCRETE CARTESIAN RECEPTOR POINTS ***

                 ** CONC OF H2S       IN USER-UNITS                      **
```

X-COORD (M)	Y-COORD (M)	CONC	(YYMMDDHH)	X-COORD (M)	Y-COORD (M)	CONC	(YYMMDDHH)
822420.00	824685.00	300.54410	(94111918)	822530.00	824725.00	207.09960	(94010709)
824080.00	825230.00	1091.17400	(94102618)	824645.00	825165.00	842.70670	(94021023)
825005.00	824990.00	1090.30200	(94031015)	825650.00	825430.00	650.80040	(94080804)
825800.00	825480.00	390.55980	(94010709)	826300.00	825610.00	641.67850	(94100101)
826815.00	825465.00	225.32600	(94082905)	826290.00	825675.00	208.71200	(94021623)


```
                 *** THE SUMMARY OF HIGHEST  1-HR RESULTS ***

                 ** CONC OF H2S       IN USER-UNITS                      **

                                             DATE                                                    NETWORK
GROUP ID                    AVERAGE CONC   (YYMMDDHH)          RECEPTOR  (XR, YR, ZELEV, ZFLAG)   OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

ALL     HIGH  1ST HIGH VALUE IS    1091.17400  ON 94102618: AT (  824080.00,   825230.00,      .00,       .00)  DC

*** RECEPTOR TYPES:  GC = GRIDCART
                     GP = GRIDPOLR
                     DC = DISCCART
                     DP = DISCPOLR
                     BD = BOUNDARY
```



```
*** Message Summary For ISC2 Model Execution ***

 --------- Summary of Total Messages --------

A Total of          0 Fatal Error Message(s)
A Total of       1528 Warning Message(s)
A Total of       1242 Informational Message(s)

A Total of       1242 Missing Hours Identified

   ******** FATAL ERROR MESSAGES ********
              ***   NONE   ***
   ************************************
   *** ISCST2 Finishes Successfully ***
   ************************************
```

```
1                   ISCST2 - (DATED 93109)

                    IBM-PC VERSION (2.11 ) ISCST2
                    (C) COPYRIGHT 1992, TRINITY CONSULTANTS, INC.
                    SERIAL NUMBER 10386 SOLD TO MOTT MACDONALD

Run Began on  7/24/1995 at 15:31:12

*** TRINITY RECEPTOR FILE NAME: C:\TK-ODOUR\TK-DIS.REC
CO STARTING
CO TITLEONE Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment
CO TITLETWO Ground Level, Mitigations to 0.005 ppm
CO MODELOPT CONC RURAL NOCALM MSGPRO
CO AVERTIME 1
CO POLLUTID H2S
CO TERRHGTS FLAT
CO ELEVUNIT METERS
CO FLAGPOLE 0.000000
CO RUNORNOT RUN
CO FINISHED
SO STARTING
SO LOCATION ABPS POINT  826928.00  825378.00        0.00
SO SRCPARAM ABPS 0.700000       3.00      298.00     1.4150      0.300
SO LOCATION TKBPS POINT  826231.00  825556.00        0.00
SO SRCPARAM TKBPS 0.700000       3.00      298.00     1.4150      0.300
SO LOCATION LBPS POINT  825896.00  825449.00        0.00
SO SRCPARAM LBPS 0.700000       3.00      298.00     1.4150      0.300
SO LOCATION CBPS POINT  825680.00  825400.00        0.00
SO SRCPARAM CBPS 0.700000       3.00      298.00     1.4150      0.300
SO LOCATION STEPS POINT  824847.00  825021.00        0.00
SO SRCPARAM STEPS 0.700000       3.00      298.00     1.4150      0.300
SO LOCATION STWPS POINT  824158.00  825387.00        0.00
SO SRCPARAM STWPS 0.700000       3.00      298.00     1.4150      0.300
SO LOCATION TLTTPS POINT  822451.00  824682.00        0.00
SO SRCPARAM TLTTPS 0.700000       3.00      298.00     1.4150      0.300
SO LOCATION STSTWPS POINT  824860.00  824978.00        0.00
SO SRCPARAM STSTWPS 1.390000       3.00      298.00     2.8290      0.300
SO LOCATION TKCBR POINT  826125.00  825660.00        0.00
SO SRCPARAM TKCBR 0.280000       0.00      298.00     0.5660      0.300
SO LOCATION HMBCBR POINT  825420.00  825180.00        0.00
SO SRCPARAM HMBCBR 0.280000       0.00      298.00     0.5660      0.300
SO LOCATION GBCBR POINT  824665.00  825195.00        0.00
SO SRCPARAM GBCBR 0.280000       0.00      298.00     0.5660      0.300
SO LOCATION TLWCBR POINT  823465.00  825920.00        0.00
SO SRCPARAM TLWCBR 0.280000       0.00      298.00     0.5660      0.300
SO LOCATION STSTWPTW POINT  824850.00  824990.00        0.00
SO SRCPARAM STSTWPTW 23.84000       9.00      298.00     4.3670      1.000
SO LOCATION STSTWSTF POINT  824755.00  824985.00        0.00
SO SRCPARAM STSTWSTF 101.3498      12.00      298.00     4.6420      2.000
SO EMISUNIT 76.600000 GRAMS/SEC USER-UNITS
SO SRCGROUP ALL
SO FINISHED
RE STARTING
RE DISCCART 822420.00 824685.00 0.000
RE DISCCART 822530.00 824725.00 0.000
RE DISCCART 824080.00 825230.00 0.000
RE DISCCART 824645.00 825165.00 0.000
RE DISCCART 825005.00 824990.00 0.000
RE DISCCART 825650.00 825430.00 0.000
RE DISCCART 825800.00 825480.00 0.000
RE DISCCART 826300.00 825610.00 0.000
RE DISCCART 826815.00 825465.00 0.000
RE DISCCART 826290.00 825675.00 0.000
RE FINISHED
ME STARTING
ME INPUTFIL C:\TK-ODOUR\TUN94.MET
ME ANEMHGHT   10.000 METERS
ME SURFDATA 99999 1994 SURFNAME
ME UAIRDATA 99999 1994 UAIRNAME
ME STARTEND 1994 1 1 1 1994 12 31 24
ME FINISHED
OU STARTING
OU RECTABLE 1 FIRST
OU FINISHED

************************************
*** SETUP Finishes Successfully ***
************************************

 *** ISCST2 - VERSION 93109 ***     *** Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment          ***        07/24/95
                                    *** Ground Level, Mitigations to 0.005 ppm                              ***        15:31:13
                                                                                                                       PAGE   1
 *** MODELING OPTIONS USED:  CONC   RURAL  FLAT   FLGPOL                           NOCALM MSGPRO

                                      ***     MODEL SETUP OPTIONS SUMMARY       ***
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

**Model Is Setup For Calculation of Average CONCentration Values.

**Model Uses RURAL Dispersion.

**Model Uses User-Specified Options:
          1. Final Plume Rise.
          2. Stack-tip Downwash.
          3. Buoyancy-induced Dispersion.
          4. Not Use Calms Processing Routine.
          5. Missing Data Processing Routine.
          6. Default Wind Profile Exponents.
          7. Default Vertical Potential Temperature Gradients.

**Model Assumes Receptors on FLAT Terrain.

**Model Accepts FLAGPOLE Receptor Heights.

**Model Calculates  1 Short Term Average(s) of:   1-HR

**This Run Includes:   14 Source(s);       1 Source Group(s); and      10 Receptor(s)

**The Model Assumes A Pollutant Type of:  H2S

**Model Set To Continue RUNning After the Setup Testing.

**Output Options Selected:
        Model Outputs Tables of Highest Short Term Values by Receptor (RECTABLE Keyword)

**NOTE:  The Following Flags May Appear Following CONC Values:  c for Calm Hours
                                                               m for Missing Hours
                                                               b for Both Calm and Missing Hours

**Misc. Inputs:  Anem. Hgt. (m) =    10.00 ;    Decay Coef. =    .0000      ;    Rot. Angle =      .0
                 Emission Units = GRAMS/SEC                                 ;  Emission Rate Unit Factor =    76.600
                 Output Units   = USER-UNITS

**Input Runstream File: C:\TK-ODOUR\TK-MI.DAT                  ;  **Output Print File: C:\TK-ODOUR\TK-MI.LST
 *** ISCST2 - VERSION 93109 ***     *** Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment          ***        07/24/95
                                    *** Ground Level, Mitigations to 0.005 ppm                              ***        15:31:13
                                                                                                                       PAGE   2
 *** MODELING OPTIONS USED:  CONC   RURAL  FLAT   FLGPOL                           NOCALM MSGPRO


                                                 *** POINT SOURCE DATA ***

               NUMBER EMISSION RATE                        BASE     STACK   STACK    STACK     STACK    BUILDING EMISSION RATE
   SOURCE       PART. (USER UNITS)     X         Y         ELEV.    HEIGHT  TEMP.   EXIT VEL. DIAMETER   EXISTS   SCALAR VARY
     ID         CATS.               (METERS)  (METERS)  (METERS)  (METERS) (DEG.K)  (M/SEC)   (METERS)               BY
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

ABPS	0	.70000E+00	826928.0	825378.0	.0	3.00	298.00	1.41	.30	NO
TKBPS	0	.70000E+00	826231.0	825556.0	.0	3.00	298.00	1.41	.30	NO
LBPS	0	.70000E+00	825896.0	825449.0	.0	3.00	298.00	1.41	.30	NO
CBPS	0	.70000E+00	825680.0	825400.0	.0	3.00	298.00	1.41	.30	NO
STEPS	0	.70000E+00	824847.0	825021.0	.0	3.00	298.00	1.41	.30	NO
STWPS	0	.70000E+00	824158.0	825387.0	.0	3.00	298.00	1.41	.30	NO
TLTTPS	0	.70000E+00	822451.0	824682.0	.0	3.00	298.00	1.41	.30	NO
STSTWPS	0	.13900E+01	824860.0	824978.0	.0	3.00	298.00	2.83	.30	NO
TKCBR	0	.28000E+00	826125.0	825660.0	.0	.00	298.00	.57	.30	NO
HMBCBR	0	.28000E+00	825420.0	825180.0	.0	.00	298.00	.57	.30	NO
GBCBR	0	.28000E+00	824665.0	825195.0	.0	.00	298.00	.57	.30	NO
TLWCBR	0	.28000E+00	823465.0	825920.0	.0	.00	298.00	.57	.30	NO
STSTWPTW	0	.23840E+02	824850.0	824990.0	.0	9.00	298.00	4.37	1.00	NO
STSTWSTF	0	.10135E+03	824755.0	824985.0	.0	12.00	298.00	4.64	2.00	NO

*** MODELING OPTIONS USED: CONC RURAL FLAT FLGPOL NOCALM MSGPRO

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID SOURCE IDs

ALL ABPS , TKBPS , LBPS , CBPS , STEPS , STWPS , TLTTPS , STSTWPS , TKCBR , HMBCBR , GBCBR , TLWCBR ,
STSTWPTW, STSTWSTF,

*** MODELING OPTIONS USED: CONC RURAL FLAT FLGPOL NOCALM MSGPRO

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

```
( 822420.0, 824685.0,   .0,   .0);    ( 822530.0, 824725.0,   .0,   .0);
( 824080.0, 825230.0,   .0,   .0);    ( 824645.0, 825165.0,   .0,   .0);
( 825005.0, 824990.0,   .0,   .0);    ( 825650.0, 825430.0,   .0,   .0);
( 825800.0, 825480.0,   .0,   .0);    ( 826300.0, 825610.0,   .0,   .0);
( 826815.0, 825465.0,   .0,   .0);    ( 826290.0, 825675.0,   .0,   .0);
```


*** MODELING OPTIONS USED: CONC RURAL FLAT FLGPOL NOCALM MSGPRO

*** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***
(1=YES; 0=NO)

```
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1
```

METEOROLOGICAL DATA PROCESSED BETWEEN START DATE: 94 1 1 1
AND END DATE: 94 12 31 24

NOTE: METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO DEPEND ON WHAT IS INCLUDED IN THE DATA FILE.

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** WIND PROFILE EXPONENTS ***

STABILITY	WIND SPEED CATEGORY					
CATEGORY	1	2	3	4	5	6
A	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
B	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
C	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
D	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
E	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00
F	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY	WIND SPEED CATEGORY					
CATEGORY	1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** MODELING OPTIONS USED: CONC RURAL FLAT FLGPOL NOCALM MSGPRO

*** THE FIRST 24 HOURS OF METEOROLOGICAL DATA ***

FILE: C:\TK-ODOUR\TUN94.MET FORMAT: (4I2,2F9.4,F6.1,I2,2F7.1)
SURFACE STATION NO.: 99999 UPPER AIR STATION NO.: 99999
NAME: SURFNAME NAME: UAIRNAME
YEAR: 1994 YEAR: 1994

YEAR	MONTH	DAY	HOUR	FLOW VECTOR	SPEED (M/S)	TEMP (K)	STAB CLASS	MIXING HEIGHT (M) RURAL	URBAN
94	1	1	1	210.0	2.40	288.2	5	787.8	787.8
94	1	1	2	170.0	1.50	287.7	6	787.8	787.8
94	1	1	3	180.0	1.80	287.6	6	787.8	787.8
94	1	1	4	190.0	1.80	287.2	6	787.8	787.8
94	1	1	5	190.0	2.30	286.5	5	787.8	787.8
94	1	1	6	200.0	2.40	286.3	5	787.8	787.8
94	1	1	7	180.0	1.80	286.1	6	772.9	772.9
94	1	1	8	170.0	1.70	286.0	6	772.9	772.9
94	1	1	9	190.0	1.60	286.9	4	772.9	772.9
94	1	1	10	200.0	1.50	288.2	2	772.9	772.9
94	1	1	11	999.9	1.00	289.3	2	772.9	772.9
94	1	1	12	40.0	1.00	291.0	2	772.9	772.9
94	1	1	13	999.9	1.00	292.6	2	772.9	772.9
94	1	1	14	20.0	1.30	292.4	2	772.9	772.9
94	1	1	15	360.0	1.80	291.5	2	772.9	772.9
94	1	1	16	350.0	1.60	291.3	2	772.9	772.9
94	1	1	17	999.9	1.00	291.0	4	772.9	772.9
94	1	1	18	250.0	1.00	290.2	6	772.9	772.9
94	1	1	19	330.0	1.00	289.6	6	787.8	787.8
94	1	1	20	350.0	1.20	289.3	6	787.8	787.8
94	1	1	21	350.0	2.10	289.2	6	787.8	787.8
94	1	1	22	350.0	1.70	289.0	6	787.8	787.8

```
94    1    1   23      160.0   1.00  288.5      6        787.8    787.8
94    1    1   24      110.0   1.00  287.8      6        787.8    787.8
```

```
*** NOTES:  STABILITY CLASS 1=A, 2=B, 3=C, 4=D, 5=E AND 6=F.
            FLOW VECTOR IS DIRECTION TOWARD WHICH WIND IS BLOWING.
*** ISCST2 - VERSION 93109 ***    *** Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment          ***       07/24/95
                                  *** Ground Level, Mitigations to 0.005 ppm                               ***       15:31:13
                                                                                                                     PAGE   7
*** MODELING OPTIONS USED:  CONC   RURAL  FLAT   FLGPOL                              NOCALM MSGPRO

                        *** THE   1ST HIGHEST  1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  ALL       ***
                            INCLUDING SOURCE(S):      ABPS     , TKBPS    , LBPS     , CBPS     , STEPS    , STWPS    , TLTTPS   ,
     STSTWPS , TKCBR    , HMBCBR   , GBCBR    , TLWCBR   , STSTWPTW, STSTWSTF,

                                     *** DISCRETE CARTESIAN RECEPTOR POINTS ***

                              ** CONC OF H2S      IN USER-UNITS                                    **

   X-COORD (M)  Y-COORD (M)          CONC     (YYMMDDHH)                X-COORD (M)  Y-COORD (M)          CONC     (YYMMDDHH)
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
     822420.00    824685.00          .34627  (94051809)                   822530.00    824725.00          .31460  (94010709)
     824080.00    825230.00         1.16235  (94102618)                   824645.00    825165.00         1.27096  (94050404)
     825005.00    824990.00         1.25111  (94031015)                   825650.00    825430.00          .81471  (94080804)
     825800.00    825480.00          .53311  (94010709)                   826300.00    825610.00          .78644  (94100101)
     826815.00    825465.00          .24981  (94082905)                   826290.00    825675.00          .23227  (94021623)
*** ISCST2 - VERSION 93109 ***    *** Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment          ***       07/24/95
                                  *** Ground Level, Mitigations to 0.005 ppm                               ***       15:31:13
                                                                                                                     PAGE   8
*** MODELING OPTIONS USED:  CONC   RURAL  FLAT   FLGPOL                              NOCALM MSGPRO

                                          *** THE SUMMARY OF HIGHEST  1-HR RESULTS ***

                              ** CONC OF H2S      IN USER-UNITS                                    **

                                                            DATE                                                        NETWORK
GROUP ID                              AVERAGE CONC       (YYMMDDHH)              RECEPTOR  (XR, YR, ZELEV, ZFLAG)     OF TYPE  GRID-ID
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

ALL      HIGH  1ST HIGH VALUE IS       1.27096  ON 94050404: AT (  824645.00,   825165.00,        .00,        .00)  DC

*** RECEPTOR TYPES:  GC = GRIDCART
                     GP = GRIDPOLR
                     DC = DISCCART
                     DP = DISCPOLR
                     BD = BOUNDARY
*** ISCST2 - VERSION 93109 ***    *** Ting Kau and Sham Tseng Sewerage Scheme, Odour Assessment          ***       07/24/95
                                  *** Ground Level, Mitigations to 0.005 ppm                               ***       15:31:13
                                                                                                                     PAGE   9
*** MODELING OPTIONS USED:  CONC   RURAL  FLAT   FLGPOL                              NOCALM MSGPRO

*** Message Summary For ISC2 Model Execution ***

 --------- Summary of Total Messages --------

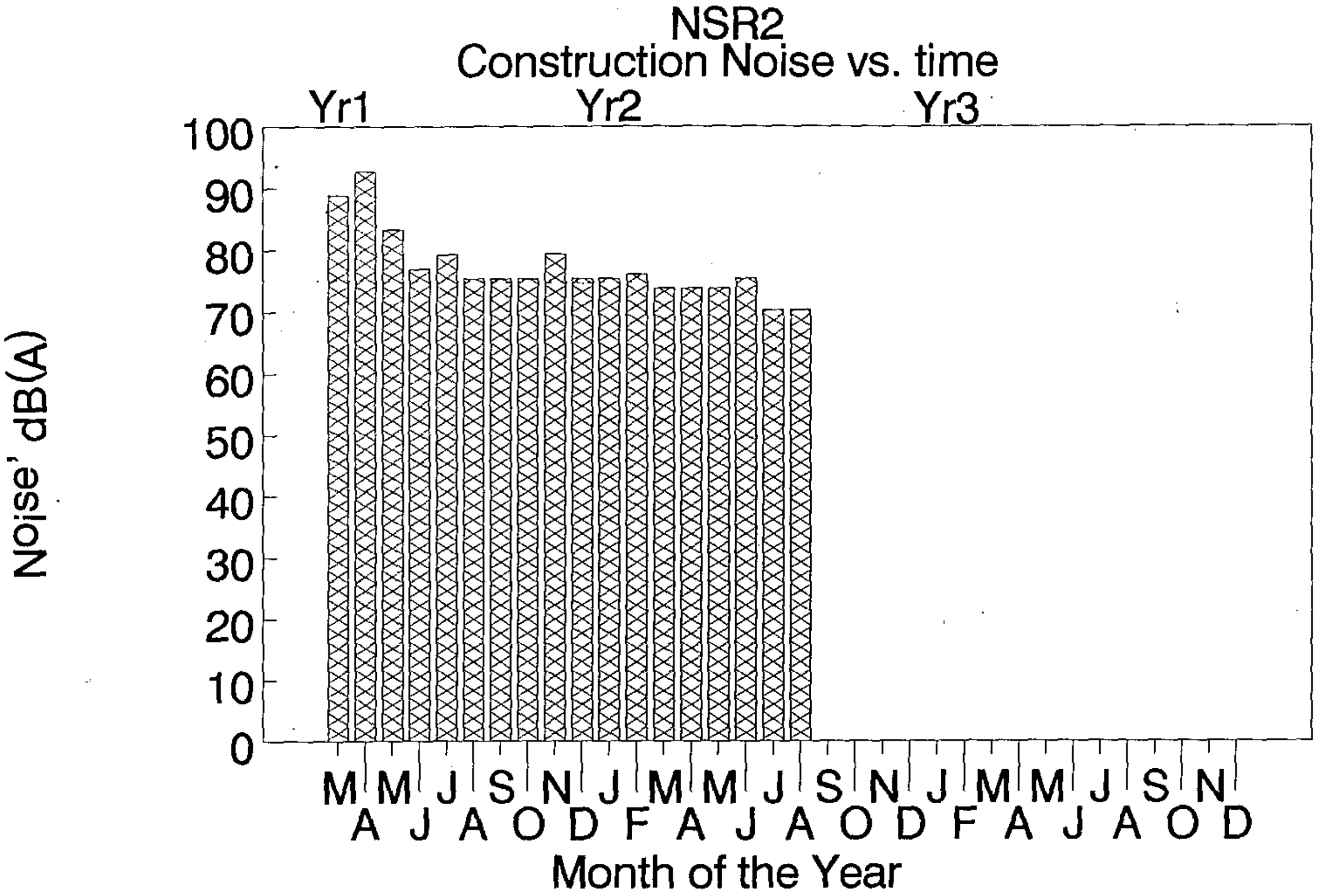
A Total of          0 Fatal Error Message(s)
A Total of       1528 Warning Message(s)
A Total of       1242 Informational Message(s)

A Total of       1242 Missing Hours Identified

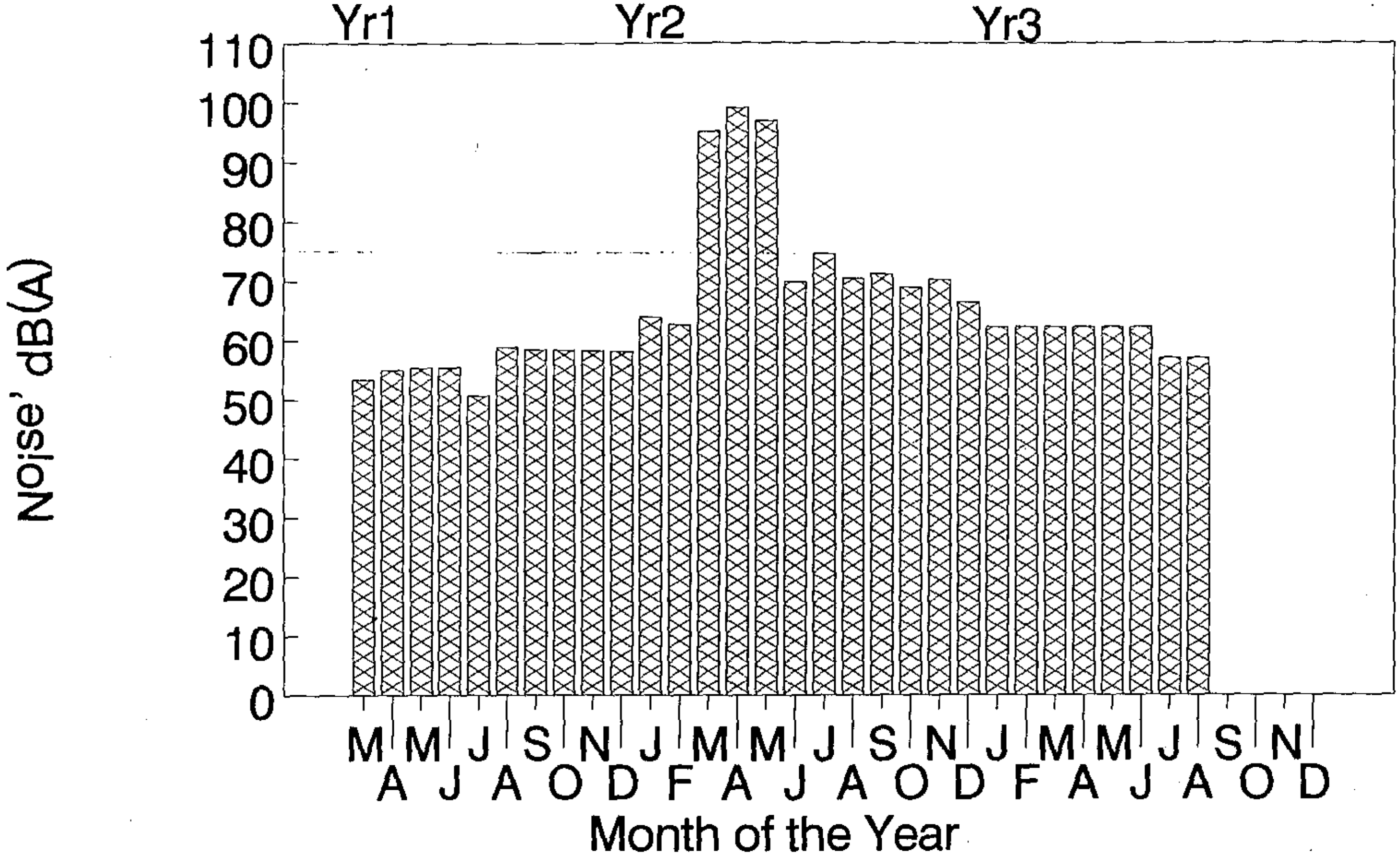
   ******** FATAL ERROR MESSAGES ********
              ***  NONE  ***
   ************************************
   *** ISCST2 Finishes Successfully ***
   ************************************
```

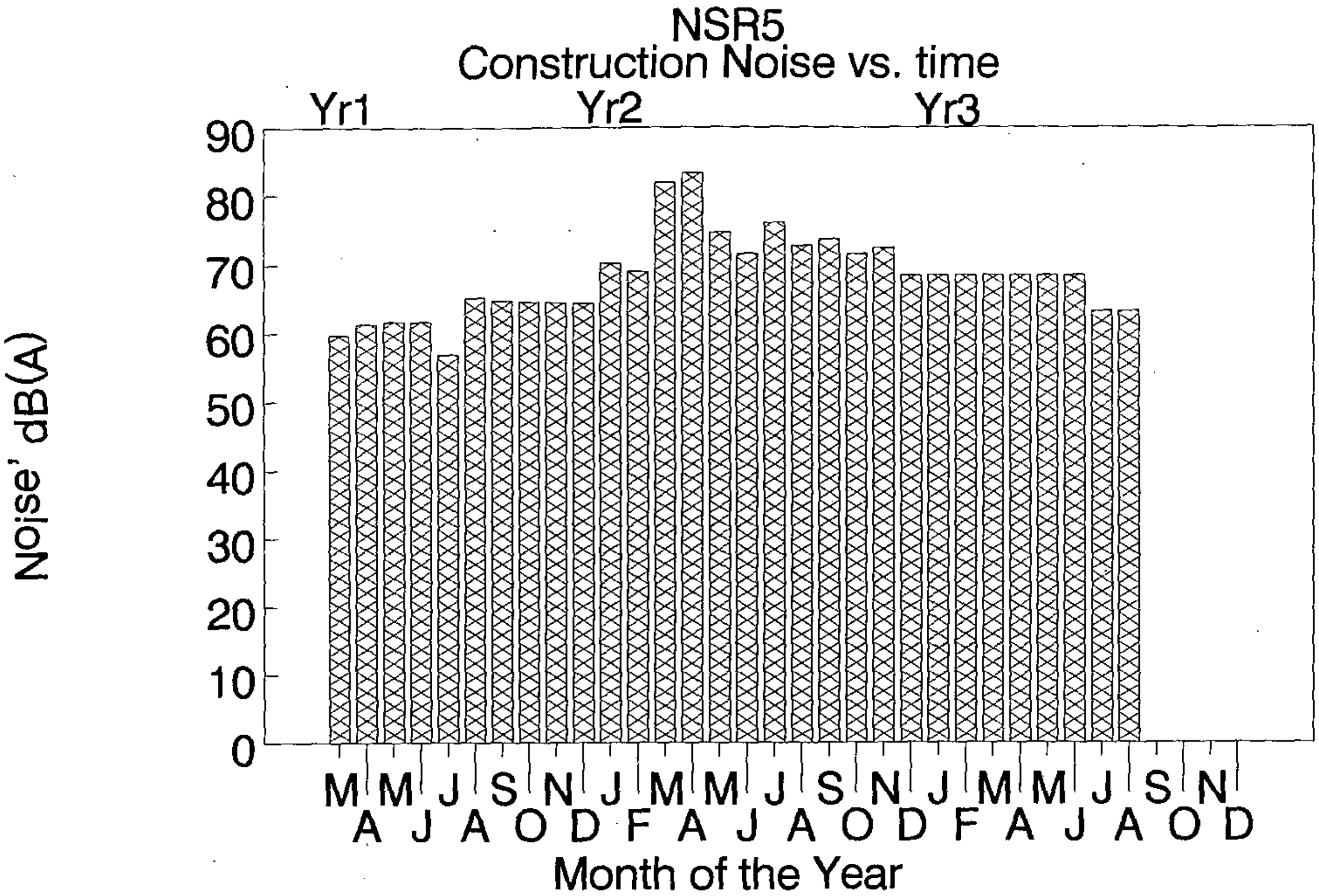
Appendix H

Construction Phase Noise Modelling Results


NSR2
Construction Noise vs. time
Yr1
Yr2
Yr3
Noise' dB(A)
100
90
80
70
60
50
40
30
20
10
0
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Month of the Year

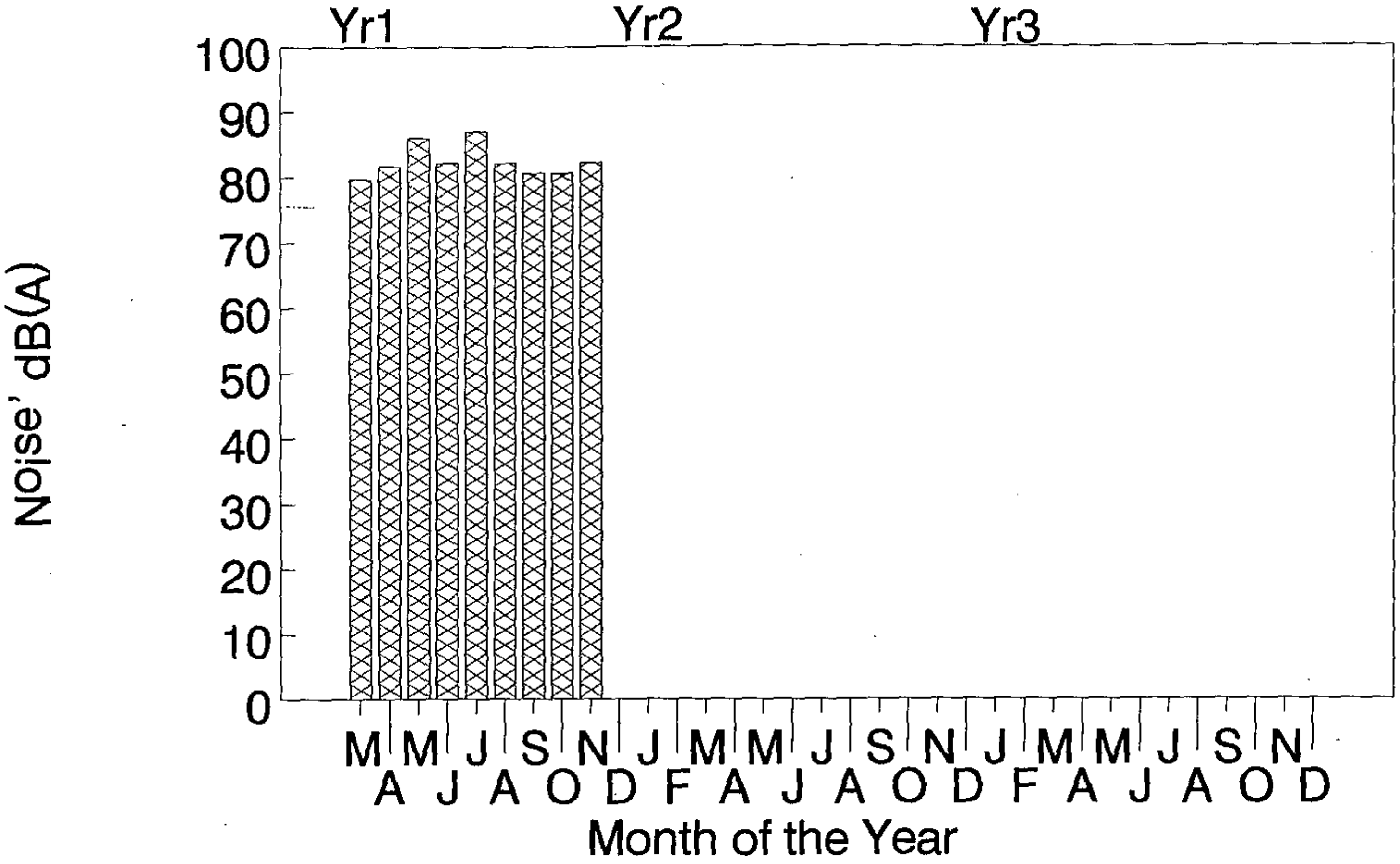
NSR3
Construction Noise vs. time

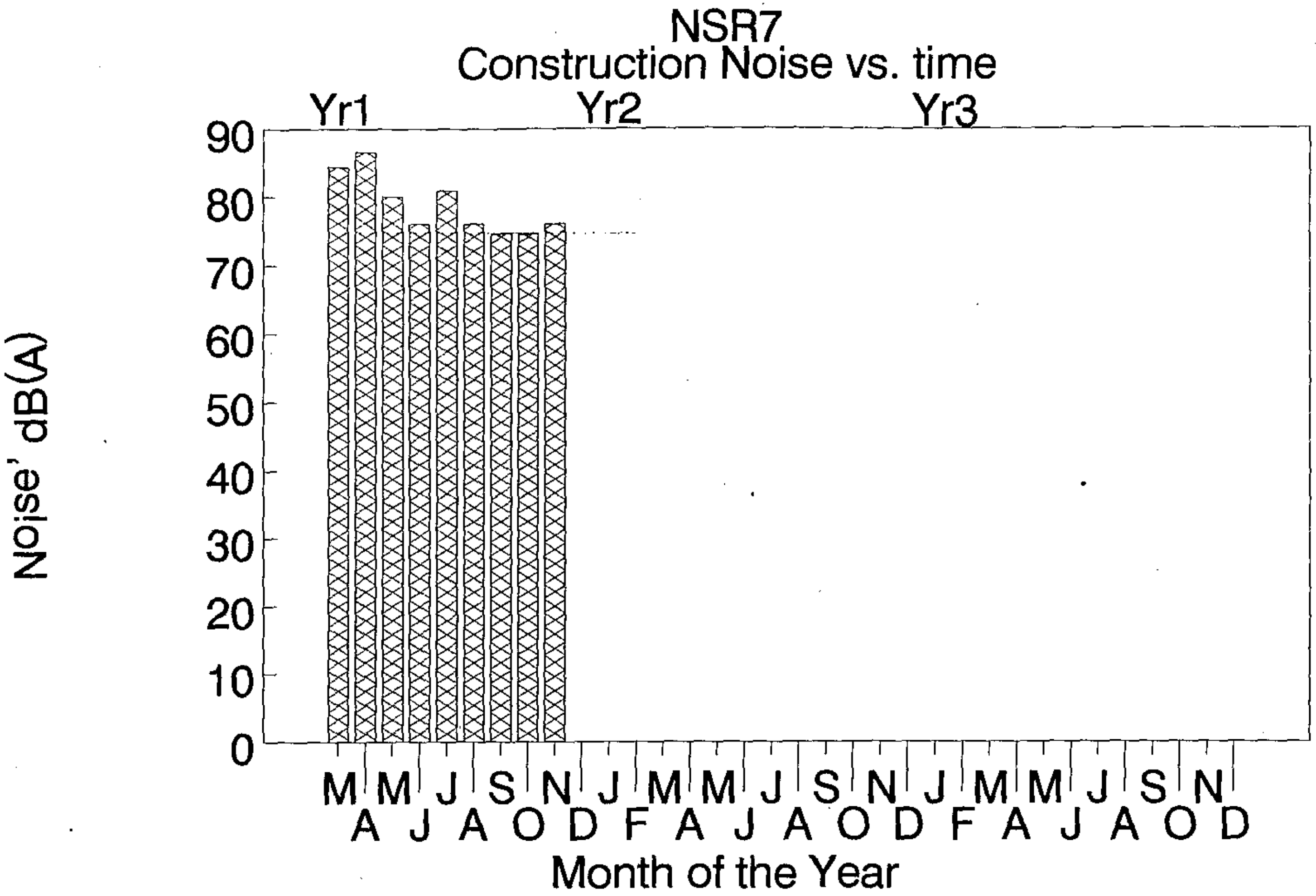




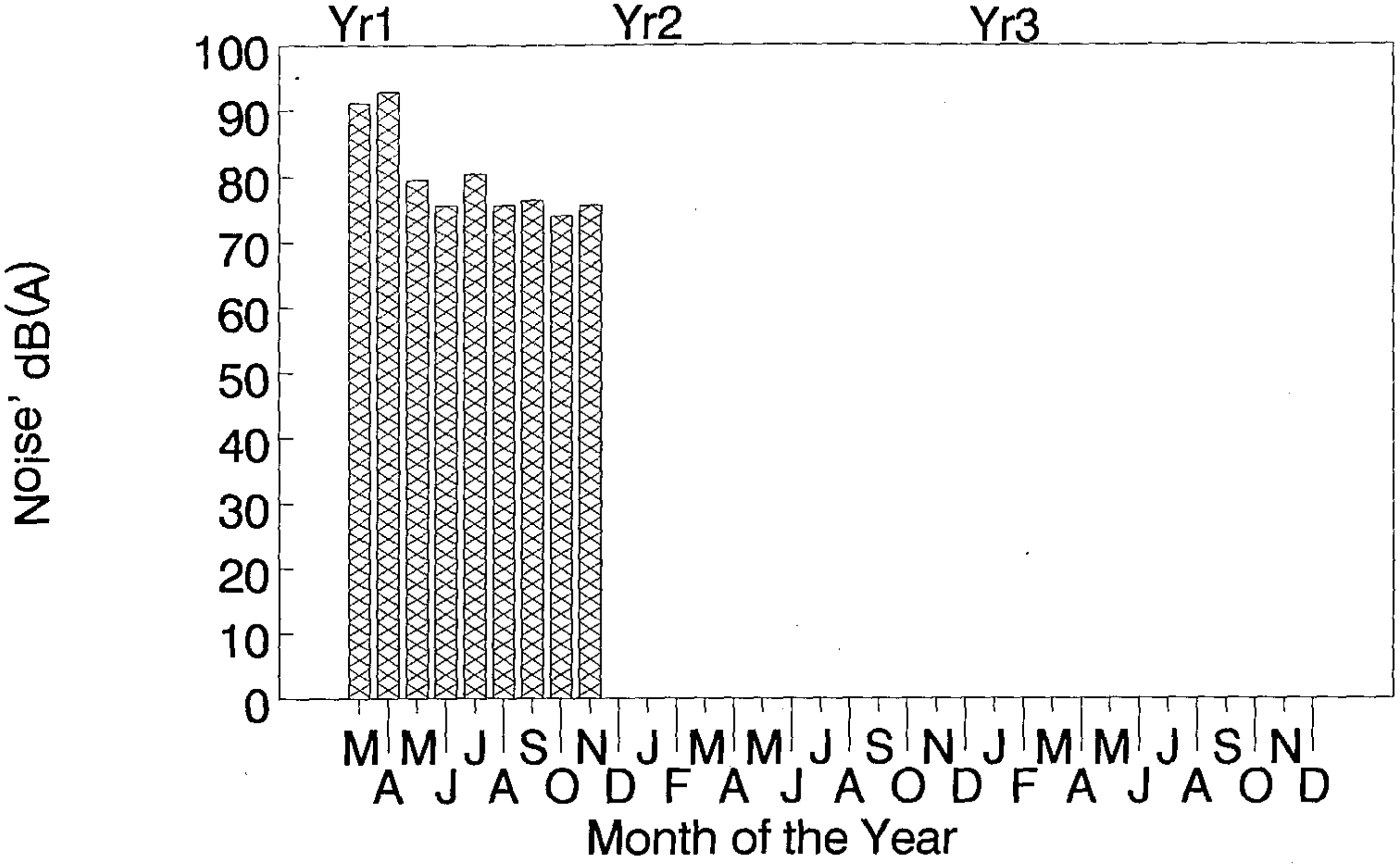
NSR5
Construction Noise vs. time
Yr1
Yr2
Yr3
90
80
70
60
50
40
30
20
10
0
Noise' dB(A)
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Month of the Year

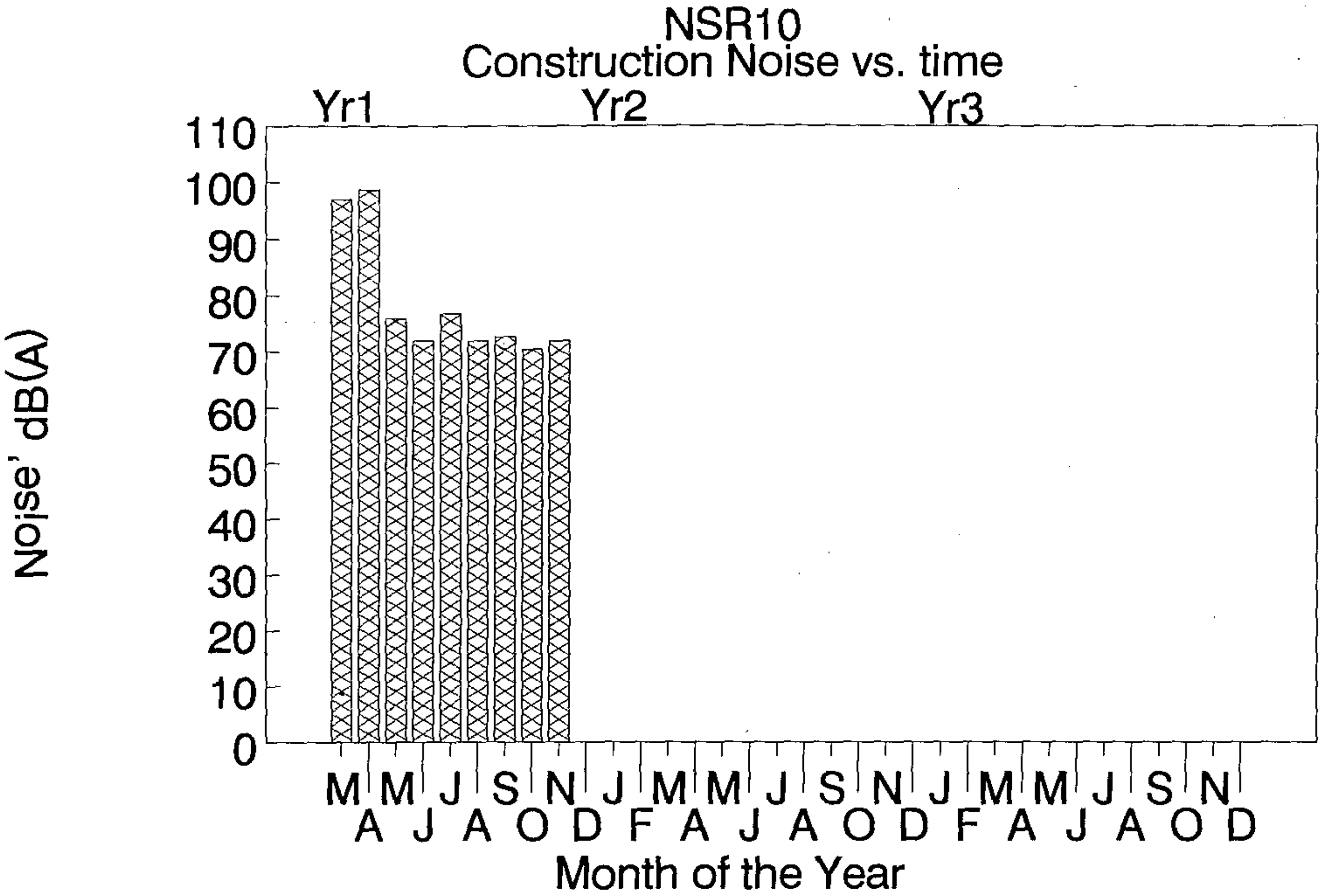
NSR6
Construction Noise vs. time




NSR7
Construction Noise vs. time
Yr1
Yr2
Yr3
Noise' dB(A)
90
80
70
60
50
40
30
20
10
0
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Month of the Year

Construction Noise vs. time





NSR10
Construction Noise vs. time
Yr1
Yr2
Yr3
110
100
90
80
70
60
50
40
30
20
10
0
Noise' dB(A)
M M J S N J M M J S N J M M J S N
A J A O D F A J A O D F A J A O D
Month of the Year

Cumulative Piling Noise SPL (dBA) at NSR

Year 1

NSR#	Easting	Northing	Elevation	M	A	M	J	J	A	S	O	N	D
2	22530	24725	5	85	85	85							
3	24080	25230	5										
5	25005	24990	5										
6	25650	25430	5	92	92								
7	25800	25480	5	86	86								
8	26300	25610	5	85	85								
10	26290	25675	5	81	81								

Year 2

NSR#	J	F	M	A	M	J	J	A	S	O	N	D
2												
3			79	79	67	67	67					
5			81	81	73	73	73					
6												
7												
8												
10												

Year 3

NSR#	J	F	M	A	M	J	J	A	S	O	N	D
2												
3												
5												
6												
7												
8												
10												

Cumulative Construction Noise SPL (dBA) at NSR

year1

NSR#	Easting	Northing	Elevation	M	A	M	J	J	A	S	O	N	D
2	22530	24725	5	89	93	83	77	79	75	75	75	79	75
3	24080	25230	5	53	55	55	55	51	59	58	58	58	58
5	25005	24990	5	60	61	62	62	57	65	65	65	64	64
6	25650	25430	5	80	82	86	82	87	82	81	81	82	
7	25800	25480	5	84	87	80	76	81	76	75	75	76	
8	26300	25610	5	91	93	80	76	80	76	76	74	76	
10	26290	25675	5	97	99	76	72	77	72	73	70	72	

year2

NSR#	J	F	M	A	M	J	J	A	S	O	N	D
2	75	76	74	74	74	75	70	70				
3	64	63	95	99	97	70	75	70	71	69	70	66
5	70	69	82	83	75	72	76	73	74	72	72	68
6												
7												
8												
10												

year3

NSR#	J	F	M	A	M	J	J	A	S	O	N	D
2												
3	62	62	62	62	62	62	57	57				
5	68	68	68	68	68	68	63	63				
6												
7												
8												
10												

PME Noise

					Year 1										Year 2												Year 3											
[illegible]y	E[illegible]nt	[illegible]	[illegible]	TSwl	[illegible]	a	[illegible]	[illegible]	j	[illegible]	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Excavation	excavator	2	112	121.				====	====																													
	trucks	2	117																																			
Substructure constructn	crane	1	112	116.					====	====	====	====	====																									
	concret lorry	1	109																																			
	concret vibr	1	113																																			
Backfill & extract pile	roller	1	108	121.									====																									
	hand compact	1	105																																			
	truck	2	117																																			
	excavator	1	112																																			
	crane	1	112																																			
	vibr pile extrt	1	90																																			
Superstruct constructn	crane	1	112	116.										====	====	====																						
	concret lorry	1	109																																			
	concret vibr	1	113																																			
E&M Installations	crane	1	112	112												====	====	====	====	====																		
Pipe laying, etc.	excavator	1	112	116.					====	====	====	====	====	====	====	====	====	====	====	====																		
	bulldozer	1	115																																			
External building works	concret lorry	1	109	114.																====	====	====																
	vibrators	1	113																																			
Total SWL vs. t								121.	123.	119.	119.	119.	123.	119.	119.	120.	118.	118.	118.	119.	114.	114.																

PS#2
PME Noise

					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Excavation	excavator	2	112	121.															====																			
	trucks	2	117																																			
Substructure constructn	crane	1	112	116.															====	====	====																	
	concret lorry	1	109																																			
	concret vibr	1	113																																			
Backfill & extract pile	roller	1	108	121.																	====																	
	hand compact	1	105																																			
	truck	2	117																																			
	excavator	1	112																																			
	crane	1	112																																			
	vibr pile extrt	1	90																																			
Superstruct constructn	crane	1	112	116.																	====	====	====															
	concret lorry	1	109																																			
	concret vibr	1	113																																			
E&M Installations	crane	1	112	112																			====	====	====													
Pipe laying, etc.	excavator	1	112	116.															====	====	====	====	====	====	====													
	bulldozer	1	115																																			
External building works	concret lorry	1	109	114.																					====	====												
	vibrators	1	113																																			
Total SWL vs. t																			123.	119.	124.	119.	120.	118.	119.	114.												

PS#3
PME Noise

					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Excavation	excavator	2	112	121.															====																			
	trucks	2	117																																			
Substructure constructn	crane	1	112	116.															====	====	====																	
	concret lorry	1	109																																			
	concret vibr	1	113																																			
Backfill & extract pile	roller	1	108	121.																	====																	
	hand compact	1	105																																			
	truck	2	117																																			
	excavator	1	112																																			
	crane	1	112																																			
	vibr pile extrt	1	90																																			
Superstruct constructn	crane	1	112	116.																	====	====	====															
	concret lorry	1	109																																			
	concret vibr	1	113																																			
E&M Installations	crane	1	112	112																			====	====	====													
Pipe laying, etc.	excavator	1	112	116.															====	====	====	====	====	====	====													
	bulldozer	1	115																																			
External building works	concret lorry	1	109	114.																					====													
	vibrators	1	113																																			
Total SWL vs. t																			123.	119.	124.	119.	120.	118.	119.													

PME Noise

					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Excavation	excavator	2	112	121.			====																															
	trucks	2	117																																			
Substructure constructn	crane	1	112	116.			====	====	====																													
	concret lorry	1	109																																			
	concret vibr	1	113																																			
Backfill & extract pile	roller	1	108	121.					====																													
	hand compact	1	105																																			
	truck	2	117																																			
	excavator	1	112																																			
	crane	1	112																																			
	vibr pile extrt	1	90																																			
Superstruct constructn	crane	1	112	116.					====	====																												
	concret lorry	1	109																																			
	concret vibr	1	113																																			
E&M Installations	crane	1	112	112							====	====	====																									
Pipe laying, etc.	excavator	1	112	116.			====	====	====	====	====	====	====																									
	bulldozer	1	115																																			
External building works	concret lorry	1	109	114.									====																									
	vibrators	1	113																																			
Total SWL vs. t							123	119.	124	119.	118	118	119.																									

PS#5
PME Noise

					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Excavation	excavator	2	112	121.		====	====																															
	trucks	2	117																																			
Substructure constructn	crane	1	112	116.			====	====	====																													
	concret lorry	1	109																																			
	concret vibr	1	113																																			
Backfill & extract pile	roller	1	108	121.					====																													
	hand compact	1	105																																			
	truck	2	117																																			
	excavator	1	112																																			
	crane	1	112																																			
	vibr pile extrt	1	90																																			
Superstruct constructn	crane	1	112	116.					====	====																												
	concret lorry	1	109																																			
	concret vibr	1	113																																			
E&M Installations	crane	1	112	112							====	====	====																									
Pipe laying, etc.	excavator	1	112	116.			====	====	====	====	====	====	====																									
	bulldozer	1	115																																			
External building works	concret lorry	1	109	114.									====																									
	vibrators	1	113																																			
Total SWL vs. t						121.	123	119.	124	119.	118	118	119.																									

PS#6
PME Noise

					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Excavation	excavator	2	112	121.		====	====																															
	trucks	2	117																																			
Substructure constructn	crane	1	112	116.			====	====	====																													
	concret lorry	1	109																																			
	concret vibr	1	113																																			
Backfill & extract pile	roller	1	108	121.					====																													
	hand compact	1	105																																			
	truck	2	117																																			
	excavator	1	112																																			
	crane	1	112																																			
	vibr pile extrt	1	90																																			
Superstruct constructn	crane	1	112	116.					====	====	====																											
	concret lorry	1	109																																			
	concret vibr	1	113																																			
E&M Installations	crane	1	112	112							====	====	====																									
Pipe laying, etc.	excavator	1	112	116.			====	====	====	====	====	====	====																									
	bulldozer	1	115																																			
External building works	concret lorry	1	109	114.									====																									
	vibrators	1	113																																			
Total SWL vs. t						121.	123	119.	124	119.	120	118	119.																									

PME Noise					Year 1										Year 2												Year 3											
Activity	Equipment	[illegible]	[illegible]	TSwl	[illegible]	a	[illegible]	j	[illegible]	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Surface Breaking	pneumat drill	3	116	120.	====	====																																
Pipe laying	truck	2	117	121.		====																																
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.		====	====																															
	concret lorry	1	109																																			
	vibrator	1	113																																			
Total SWL vs. t					120.	124.	115.																															

Sewer Installation #3

PME Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Surface Breaking	pneumat drill	3	116	120.													====	====																				
Pipe laying	truck	2	117	121.														====	====																			
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.														====	====																			
	concret lorry	1	109																																			
	vibrator	1	113																																			
Total SWL vs. t																	120.	124.	122																			

Sewer Installation #4

PME Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Surface Breaking	pneumat drill	3	116	120.													====																					
Pipe laying	truck	2	117	121.														====																				
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.														====																				
	concret lorry	1	109																																			
	vibrator	1	113																																			
Total SWL vs. t																	120.	122																				

Sewer Installation #5

PME Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Surface Breaking	pneumat drill	3	116	120.													====																					
Pipe laying	truck	2	117	121.														====																				
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.														====																				
	concret lorry	1	109																																			
	vibrator	1	113																																			
Total SWL vs. t																	120.	122																				

Sewer Installation #6

PME Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Surface Breaking	pneumat drill	3	116	120.	====																																	
Pipe laying	truck	2	117	121.		====																																
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.		====																																
	concret lorry	1	109																																			
	vibrator	1	113																																			
Total SWL vs. t					120.	122																																

PME Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Surface Breaking	pneumat drill	3	116	120.	====																																	
Pipe laying	truck	2	117	121.		====																																
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.		====																																
	concret lorry	1	109																																			
	vibrator	1	113																																			
Total SWL vs. t					120.	122																																

Sewer Installation #8 PME Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Surface Breaking	pneumat drill	3	116	120.	====																																	
Pipe laying	truck	2	117	121.		====																																
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.		====																																
	concret lorry	1	109																																			
	vibrator	1	113																																			
Total SWL vs. t					120.	122																																

Sewer Installation #10 PME Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Surface Breaking	pneumat drill	3	116	120.	====																																	
Pipe laying	truck	2	117	121.		====																																
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.		====																																
	concret lorry	1	109																																			
	vibrator	1	113																																			
Surface Breaking	pneumat drill	3	116	120.	====																																	
Pipe laying	truck	2	117	121.		====																																
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.		====																																
	concret lorry	1	109																																			
	vibrator	1	113																																			
Surface Breaking	pneumat drill	3	116	120.	====																																	
Pipe laying	truck	2	117	121.		====																																
	excavator	2	112																																			
	roller	1	108																																			
	hand compacto	1	105																																			
Reinstatement	roller	1	108	115.		====																																
	concret lorry	1	109																																			
	vibrator	1	113																																			
Total SWL vs. t					125.	127.																																

IPME Noise

					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Place Rock Fill	derrick Barge	2	104	112	===	===	===	===																														
	tug	1	110																																			
	launch	1	104																																			
Set Concrete Sea wall Blo	derrick barge	2	104	111.		===	===	===	===	===																												
	tug	1	110																																			
Reclamation/Site Formatio	trailing suction	1	109	119.						===	===	===	===	===	===																							
	derrick lighter	5	104																																			
	hopper barge/p	8	104																																			
	Tug boat	4	110																																			
General Earthworks	compactors	2	105	124.											===	===	===																					
	backhoe	2	112																																			
	loaders	2	112																																			
	dozers	2	115																																			
	dump trucks	3	117																																			
Total SWL vs. t					112	115	115	115	111.	119.	119.	119.	119.	119.	125.	124.	124.																					

Submarine Outfall
PME Noise

					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Excavation	grab dredger	1	112	112	===	===	===	===																														
Bedding and Trimming	derrick Barge	2	104	107.			===	===																														
Pipe Fabrication	tower crane	1	95	95	===	===	===	===	===	===																												
Pipe Installation	linear winch ba	1	104	104					===	===	===																											
Backfill	derrick Barge	1	104	104						===	===	===																										
	Tug Boat	1	110	110																																		
Armour Placement	derrick Barge	1	104	104								===	===	===																								
	Tug Boat	1	110	110																																		
Diffuser Cap Installation	derrick Barge	1	104	104						===	===																											
	Tug Boat	1	110	110																																		
Back Fill & Rock Aprons	derrick barge	1	104	104							===	===	===																									
Landward End Chamber	excavator	1	112	112						===	===	===	===	===	===																							
	truck	1	117	117																																		
Total SWL vs. t					112	112	113.	113	104.	113	114.	113.	113.	112	112																							

Sewage Treatment Works
PME Noise

					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Excavation	excavator	2	112	121.															===	===																		
	trucks	2	117																																			
Substructure constructn	crane	1	112	116.																	===	===																
	concret lorry	1	109																																			
	concret vibr	1	113																																			
Backfill & extraction of she	roller	1	108	121.																			===															
	hand compact	1	105																																			
	truck	2	117																																			
	excavator	1	112																																			
	crane	1	112																																			
	vibr pile extrt	1	90																																			
Civil Works	crane	2	112	122																	===	===	===	===	===	===	===	===	===	===	===	===						
	vibration poker	3	113																																			
	bar bending m	2	90																																			
	electric saws	2	108																																			
	concrete wago	1	109																																			
	excavator	1	112																																			
	dump truck	1	117																																			
Finishing Work & Pipe Lay	excavator	1	112	118.																	===	===	===	===	===	===	===	===	===	===	===	===	===	===				
	bulldozer	1	115																																			
	concrete lorries	1	109																																			
	vibrators	1	113																																			
Total SWL vs. t																			121.	121.	124.	124.	125.	124.	124	124.	124.	124.	124.	124.	124.	124.	118.	118.				

Piling Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Sheet Pile	crane	1	112	129.	====	====	====																															
	hammer	1	129																																			
Total SWL vs. t					129.	129.	129.																															

PS#2																																						
Piling Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Sheet Pile	crane	1	112	129.													====	====																				
	hammer	1	129																																			
Total SWL vs. t																	129.	129.																				

PS#3																																						
Piling Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Sheet Pile	crane	1	112	129.													====	====																				
	hammer	1	129																																			
Total SWL vs. t																	129.	129.																				

PS#4																																						
Piling Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Sheet Pile	crane	1	112	129.	====	====																																
	hammer	1	129																																			
Total SWL vs. t					129.	129.																																

PS#5																																						
Piling Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Sheet Pile	crane	1	112	129.	====	====																																
	hammer	1	129																																			
Total SWL vs. t					129.	129.																																

PS#6																																						
Piling Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Sheet Pile	crane	1	112	129.	====	====																																
	hammer	1	129																																			
Total SWL vs. t					129.	129.																																

Sewage Treatment Works																																						
Piling Noise					Year 1										Year 2												Year 3											
Activity	Equipment	Qty	Swl	TSwl	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Piling	crane	1	112	129.													====	====	====	====	====																	
	hammer	1	129																																			
Total SWL vs. t																	129.	129.	129.	129.	129.																	

Ting Kau and Sham Tseng Sewerage Scheme
Environmental Impact Assessment
Agreement No. CE 35/94

FILE: C:\TK-NOI\SUMMARY.WK1
BY: ANTHONY LEUNG
CHECKED BY: W.P. KO

Operational Noise Assessment
Summary

Positions of NSR's

	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8	SR9	SR10
E (m)	822420	822530	824080	824645	825005	825650	825800	826300	826815	826290
N (m)	824685	824725	825230	825165	824990	825430	825480	825610	825465	825675

SPL of Equipments at NSR's

	@1m away		Location		SPL at NSR (dB(A))									
Equipment	SPL (dB(A))	Number	E (m)	N (m)	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8	SR9	SR10
Preliminary Treatment Facilities														
extraction fan	84.0	2	824850	824990	22.23	22.64	31.88	41.40	46.20	30.80	29.43	26.05	23.90	25.96
indoor equipment					8.00	8.41	17.65	27.17	31.97	16.57	15.20	11.82	9.67	11.73
Sedimentation Tanks														
sludge pump	74.5	1	824804	824975	9.90	10.32	19.81	29.63	31.42	17.86	16.55	13.29	11.19	13.20
scum pump	81.5	1	824804	824975	16.90	17.32	26.81	36.63	38.42	24.86	23.55	20.29	18.19	20.20
Sludge Treatment Facilities														
extraction fan	84.0	2	824775	824965	22.50	22.93	32.66	43.08	42.77	30.17	28.89	25.67	23.58	25.58
indoor equipment (1m from wall)	65.0				19.37	19.78	29.01	38.53	43.34	27.94	26.57	23.19	21.03	23.09
Pumping Stations														
PS1	50.5	1	822451	824682	23.63	14.42	−11.21	−13.53	−14.71	−16.84	−17.24	−18.46	−19.44	−18.47
PS2	50.5	1	824158	825387	−11.96	−11.40	8.62	−1.07	−5.92	−9.98	−10.83	−13.17	−15.00	−13.16
PS3	50.5	1	824847	825021	−14.29	−13.87	−4.51	5.60	9.36	−5.60	−6.99	−10.41	−12.60	−10.50
PS4	50.5	1	825680	825400	−16.97	−16.67	−10.64	−7.02	−4.45	20.94	10.32	−2.82	−7.62	−3.01
PS5	50.5	1	825896	825449	−17.53	−17.24	−11.75	−8.67	−6.52	5.65	13.42	0.73	−5.77	0.35
PS6	50.5	1	826231	825556	−18.35	−18.08	−13.26	−10.77	−9.11	−1.99	0.67	14.64	−1.94	11.03
PS7	50.5	1	826928	825378	−19.69	−19.46	−15.61	−13.71	−12.36	−8.64	−7.59	−3.02	10.41	−3.45
STW Inlet	61.4	1	824860	824978	−3.42	−3.01	6.11	15.29	21.13	5.20	3.83	0.45	−1.70	0.35
STW Outlet	61.4	1	824860	824978	−3.42	−3.01	6.11	15.29	21.13	5.20	3.83	0.45	−1.70	0.35

Total SPL (dB(A))	NSR1	NSR2	NSR3	NSR4	NSR5	NSR6	NSR7	NSR8	NSR9	NSR10
	28.62	27.59	36.84	46.76	49.66	35.33	33.89	30.63	28.45	30.48

Preliminary Treatment Facilities

	E (m)	N (m)
Notional Source Location	824850	824990
SR1	822420	824685
SR2	822530	824725
SR3	824080	825230
SR4	824645	825165
SR5	825005	824990
SR6	825650	825430
SR7	825800	825480
SR8	826300	825610
SR9	826815	825465
SR10	826290	825675

Equipment	SPL(1m) (dB(F))							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
coarse screen	57	60	62	65	65	64	59	51
fine screen	57	60	62	65	65	64	59	51
grit conveyer	57	60	62	65	65	64	59	51
grit conveyer	57	60	62	65	65	64	59	51
grit conveyer	57	60	62	65	65	64	59	51
grit conveyer	57	60	62	65	65	64	59	51
washer compactor	69	72	74	77	77	76	71	63
grit trap mixer	49	52	54	57	57	56	51	43
air blower	58	67	78	78	76	72	69	66
Total SPL (dB(F))	70.67	74.32	79.91	81.23	80.39	78.52	74.05	68.29
Correct. factor (from flat response to A weighting)	-26.20	-16.10	-8.60	-3.20	0.00	1.20	1.00	-1.10
Total SPL (dB(A))	44.47	58.22	71.31	78.03	80.39	79.72	75.05	67.19

Average Absorption Coefficients

	Concrete 200mm	Louvre	Roller Gate 1.2mm G.I.	FRP	Skylight 6mm glass	Door 1.2mm G.I	Average	Room Constant
Area (sq.m)	977.00	25.00	60.00	0.00	0.00	0.00		
Frequency (Hz)								
63 Hz	0.01	0.01	0.01	0.05	0.08	0.01	0.010	10.73
125 Hz	0.01	0.01	0.01	0.05	0.15	0.01	0.010	10.73
250 Hz	0.01	0.01	0.01	0.10	0.06	0.01	0.010	10.73
500 Hz	0.02	0.01	0.01	0.15	0.04	0.01	0.019	20.79
1000 Hz	0.02	0.01	0.01	0.25	0.03	0.01	0.019	20.79
2000 Hz	0.02	0.01	0.01	0.30	0.02	0.01	0.019	20.79
4000 Hz	0.03	.0.01	0.01	0.30	0.02	0.01	0.028	31.04
8000 Hz	0.03	0.01	0.01	0.25	0.02	0.01	0.028	31.04

Average TL

	Concrete 200mm	Louvre	Roller Gate 1.2mm G.I.	Skylight 6mm glass	Door 1.2mm G.I	Average (dB)
Area (sq.m)	691	25.00	60	0.00	0.00	
Frequency (Hz)						
63 Hz	36	7	8	17	8	17.23
125 Hz	42	8	13	11	13	20.44
250 Hz	41	11	20	24	20	24.68
500 Hz	50	12	24	28	24	26.29
1000 Hz	57	15	29	32	29	29.52
2000 Hz	60	16	33	27	33	30.71
4000 Hz	65	12	39	35	39	26.90
8000 Hz	70	11	44	39	44	25.91

SPL at NSR

Frequency (Hz)	Total SWL dB(A)	Area (sq.m)	Rev.SPL (dB(A))	SPL - SR1 (dB(A))	SPL-SR2 (dB(A))	SPL - SR3 (dB(A))	SPL - SR4 (dB(A))	SPL - SR5 (dB(A))	SPL - SR6 (dB(A))	SPL - SR7 (dB(A))	SPL - SR8 (dB(A))	SPL - SR9 (dB(A))	SPL - SR10 (dB(A))
63	52.47	776.00	48.18	-18.93	-18.52	-9.28	0.24	5.04	-10.36	-11.73	-15.11	-17.27	-15.21
125	66.22	776.00	61.93	-8.39	-7.97	1.26	10.78	15.58	0.18	-1.19	-4.57	-6.72	-4.66
250	79.31	776.00	75.03	0.46	0.88	10.11	19.63	24.44	9.03	7.67	4.29	2.13	4.19
500	86.03	776.00	78.87	2.70	3.11	12.35	21.87	26.67	11.27	9.90	6.52	4.36	6.43
1000	88.39	776.00	81.23	1.84	2.25	11.48	21.00	25.81	10.41	9.04	5.66	3.50	5.56
2000	87.72	776.00	80.56	-0.03	0.38	9.62	19.14	23.94	8.54	7.17	3.79	1.64	3.70
4000	83.05	776.00	74.15	-2.63	-2.21	7.02	16.54	21.35	5.94	4.58	1.20	-0.96	1.10
8000	75.19	776.00	68.30	-9.50	-9.09	0.15	9.67	14.47	-0.93	-2.30	-5.68	-7.83	-5.77
			Total SPL	8.00	8.41	17.65	27.17	31.97	16.57	15.20	11.82	9.67	11.73

Operational Noise Assessment

1 Noise Sensitive Receivers

Positions of Noise Sensitive Receivers (ASRs)

ASR	Code	Easting (m)	Northing (m)
DD 387 / LOT 17 – 18	SR1	822420	824685
Hong Kong Garden	SR2	822530	824725
Lido Garden	SR3	824080	825230
DD 390 LOT 94	SR4	824645	825165
Golden Villa	SR5	825005	824990
Villa Mar	SR6	825650	825430
Edinburgh Villa	SR7	825800	825480
Ting Kau Village	SR8	826300	825610
DD 399 LOT 367 – 368	SR9	826815	825465
Anton Villa	SR10	826290	825675

Coordinates Measured from Survey Map

2 Location of Sources

Source	Notional Source Centre	
	Easting (m)	Northing (m)
Approach Beach Pumping Station	826928	825378
Ting Kau Beach Pumping Station	826231	825556
Lido Beach Pumping Station	825896	825449
Casam Beach Pumping Station	825680	825400
Sham Tseng East Pumping Station	824847	825021
Sham Tseng West Pumping Station	824158	825387
Tsing Lung Tau Tseung Pumping Station	822451	824682
Sham Tseng STW (Inlet) Pumping Station	824860	824978
Sham Tseng STW (Outfall) Pumping Station	824860	824978
Preliminary Treatment Facilities	824850	824990
Sedimentation Tanks	824804	824975
Sludge Treatment Facilities	824755	824985

3 Equipment Details at Every Source

3.1 Approach Beach Pumping Station
Ting Kau Beach Pumping Station
Lido Beach Pumping Station
Casam Beach Pumping Station
Sham Tseng East Pumping Station
Sham Tseng West Pumping Station
Tsing Lung Tau Tseung Pumping Station

Assume there will be one pump in each of the above pumping stations
Assume all pumps are submerged

Characteristic Impedance of Water:	1480000 ray/s
Characteristic Impedance of Air:	415 ray/s
Transmission Loss:	-29.50 dB

Pump Location	Flow Rate ADWF (cu.m/s)	Flow x 3 (cu.m/s)	Duty Head (m)	Minimum Power Required (kW)	Speed Assumed (rpm)	SWL (dB(A))	SWL above Water (dB(A))	SPL(1m) above Water (dB(A))
Approach Beach	0.006	0.019	23.00	4.32	1000.00	88	58.50	50.50
Ting Kau Beach	0.002	0.005	22.90	1.17	1000.00	88	58.50	50.50
Lido Beach	0.010	0.029	13.90	3.92	1000.00	88	58.50	50.50
Casam Beach	0.018	0.053	14.50	7.55	1000.00	88	58.50	50.50
Sham Tseng East	0.024	0.072	3.40	2.41	1000.00	88	58.50	50.50
Sham Tseng West	0.013	0.040	0.10	0.04	1000.00	88	58.50	50.50
Tsing Lung Tau Tseung	0.093	0.278	17.00	46.34	1000.00	88	58.50	50.50

Assume the SWL of each pump is 88dB(A) from TM (Construction Noise)

Sludge Treatment Facilities

	E (m)	N (m)
Notional Source Location	824850	824990
SR1	822420	824665
SR2	822530	824725
SR3	824080	825230
SR4	824645	825165
SR5	825005	824990
SR6	825650	825430
SR7	825800	825480
SR8	826300	825610
SR9	826815	825465
SR10	826290	825675

Length:	36 m
Width:	24 m
Height:	10 m
Enclosure Surface Area:	2064

SPL at NSR

Area (sq.m)	SPL 1 m from wall (dB(A))	SPL – SR1 (dB(A))	SPL–SR2 (dB(A))	SPL – SR3 (dB(A))	SPL – SR4 (dB(A))	SPL – SR5 (dB(A))	SPL – SR6 (dB(A))	SPL – SR7 (dB(A))	SPL – SR8 (dB(A))	SPL – SR9 (dB(A))	SPL – SR1 (dB(A)
2064.00	65.00	19.37	19.78	29.01	38.53	43.34	27.94	26.57	23.19	21.03	23.09

Ting Kau and Sham Tseng Sewerage Scheme
Environmental Impact Assessment
Agreement No. CE 35/94

FILE: C:\TK–NOI\EQPTLIST.WK1
BY: ANTHONY LEUNG
CHECKED BY: W. P. KO

Operational Noise Assessment
3.2 Sham Tseng Sewage Treatment Works Inlet and Outfall Pumping Stations

Assume one pump will be in operation in inlet or outfall pumping station

ADWF:	15104 cu.m/hr		
	0.17 cu.m/s		
Peak Factor:	3		
Design Flow Rate:	0.52 cu.m/s		
Duty head assumed:	10 m		
RPM:	1000		
Power:	51.40 KW	=	69.88 hp
SPL of Pump =	88.53 dB(F)		
SPL of Motor =	90.44 dB(F)		

Pump
SPL (1m): 88.53 dB(F)

Frequency	SPL Subtracted	SPL Predicted	A Weightings	SPL Predicted
(Hz)	(dB)	(dB)	(dB)	(dB(A))
31	13	75.53	−39.40	36.13
63	12	76.53	−26.20	50.33
125	11	77.53	−16.10	61.43
250	9	79.53	−8.60	70.93
500	9	79.53	−3.20	76.33
1000	6	82.53	0.00	82.53
2000	9	79.53	1.20	80.73
4000	13	75.53	1.00	76.53
8000	19	69.53	−1.10	68.43
			Total	86.09 dB(A)

Motor
SPL (1m): 90.44 dB(F)

Frequency	SPL Subtracted	SPL Predicted	A Weightings	SPL Predicted
(Hz)	(dB)	(dB)	(dB)	(dB(A))
31	14	76.44	−39.40	37.04
63	14	76.44	−26.20	50.24
125	11	79.44	−16.10	63.34
250	9	81.44	−8.60	72.84
500	6	84.44	−3.20	81.24
1000	6	84.44	0.00	84.44
2000	7	83.44	1.20	84.64
4000	12	78.44	1.00	79.44
8000	20	70.44	−1.10	69.34
			Total	89.14 dB(A)

Total SPL of each inlet and outfall pump:	90.89 dB(A)
Transmission Loss Through Water to Air:	−29.50 dB(A)
Total Sound Pressure Level above water:	61.39 dB(A)

Pump Location	SPL (1m)
	(dB(A))
Sham Tseng STW (Inlet)	61.39
Sham Tseng STW (Outfall)	61.39

Operational Noise Assessment

3.3 Preliminary Treatment Facilities

Indoor Equipment	Number	Sound Pressure Level (1m), dB(F)							
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Coase Screen	1	57	60	62	65	65	64	59	51
Fine Screen	1	57	60	62	65	65	64	59	51
Grit/Screenings Conveyer	4	57	60	62	65	65	64	59	51
Washer Compactor	1	69	72	74	77	77	76	71	63
Grit Trap Mixer	1	49	52	54	57	57	56	51	43
Air Blower	1	58	67	78	78	76	72	69	66

Enclosure Details	
Length	22
Width	13
Height	7
Louvre Area	25
Roller Gate Area	60

Outdoor Equipment	Number	SWL (dB(A))	SILENCER I.L.	NET SWL (dB(A))	SPL (1m) (dB(A))
Extraction Fans	2	108	16	92	84

SWL of Extraction Fans was taken from TM (construction)

3.4 Sedimentation Tanks

Outdoor Equipment:	No.	SPL (1m), dB(A)	Sound Pressure Level (1m), dB(A)							
			63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Sludge Pump	1	74.51	39	50	59	65	71	69	65	57
Scum Pump	1	81.51	46	57	66	72	78	76	72	64

3.5 Sludge Treatment Facilities

Enclosure Details	
Length	36
Width	24
Height	10

Assume the SPL 1 metre from wall is 65 dB(A)

Outdoor Equipment	Number	SWL (dB(A))	SILENCER I.L.	NET SWL (dB(A))	SPL (1m) (dB(A))
Extraction Fans	2	108	16	92	84

SWL of Extraction Fans was taken from TM (construction)

Appendix I

Operation Phase Noise Modelling Results

Ting Kau and Sham Tseng Sewerage Scheme
Environmental Impact Assessment
Agreement No. CE 35/94

FILE: C:\TK-NOI\SUMMARY.WK1
BY: ANTHONY LEUNG
CHECKED BY: W.P. KO

Operational Noise Assessment
Summary

Positions of NSR's

	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8	SR9	SR10
E (m)	822420	822530	824080	824645	825005	825650	825800	826300	826815	826290
N (m)	824685	824725	825230	825165	824990	825430	825480	825610	825465	825675

SPL of Equipments at NSR's

	@1m away		Location		SPL at NSR (dB(A))									
Equipment	SPL (dB(A))	Number	E (m)	N (m)	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8	SR9	SR10
Preliminary Treatment Facilities														
extraction fan	84.0	2	824850	824990	22.23	22.64	31.88	41.40	46.20	30.80	29.43	26.05	23.90	25.96
indoor equipment					8.00	8.41	17.65	27.17	31.97	16.57	15.20	11.82	9.67	11.73
Sedimentation Tanks														
sludge pump	74.5	1	824804	824975	9.90	10.32	19.81	29.63	31.42	17.86	16.55	13.29	11.19	13.20
scum pump	81.5	1	824804	824975	16.90	17.32	26.81	36.63	38.42	24.86	23.55	20.29	18.19	20.20
Sludge Treatment Facilities														
extraction fan	84.0	2	824775	824985	22.50	22.93	32.66	43.08	42.77	30.17	28.89	25.67	23.58	25.58
indoor equipment (1m from wall)	65.0				19.37	19.78	29.01	38.53	43.34	27.94	26.57	23.19	21.03	23.09
Pumping Stations														
PS1	50.5	1	822451	824682	23.63	14.42	-11.21	-13.53	-14.71	-16.84	-17.24	-18.46	-19.44	-18.47
PS2	50.5	1	824158	825387	-11.96	-11.40	8.62	-1.07	-5.92	-9.98	-10.83	-13.17	-15.00	-13.16
PS3	50.5	1	824847	825021	-14.29	-13.87	-4.51	5.60	9.36	-5.60	-6.99	-10.41	-12.60	-10.50
PS4	50.5	1	825680	825400	-16.97	-16.67	-10.64	-7.02	-4.45	20.94	10.32	-2.82	-7.62	-3.01
PS5	50.5	1	825896	825449	-17.53	-17.24	-11.75	-8.67	-6.52	5.65	13.42	0.73	-5.77	0.35
PS6	50.5	1	826231	825556	-18.35	-18.08	-13.26	-10.77	-9.11	-1.99	0.67	14.64	-1.94	11.03
PS7	50.5	1	826928	825378	-19.69	-19.46	-15.61	-13.71	-12.36	-8.64	-7.59	-3.02	10.41	-3.45
STW Inlet	61.4	1	824860	824978	-3.42	-3.01	6.11	15.29	21.13	5.20	3.83	0.45	-1.70	0.35
STW Outlet	61.4	1	824860	824978	-3.42	-3.01	6.11	15.29	21.13	5.20	3.83	0.45	-1.70	0.35

Total SPL (dB(A))	NSR1	NSR2	NSR3	NSR4	NSR5	NSR6	NSR7	NSR8	NSR9	NSR10
	28.62	27.59	36.84	46.76	49.66	35.33	33.89	30.63	28.45	30.48

Preliminary Treatment Facilities

	E (m)	N (m)
Notional Source Location	824850	824990
SR1	822420	824665
SR2	822530	824725
SR3	824080	825230
SR4	824645	825165
SR5	825005	824990
SR6	825650	825430
SR7	825800	825480
SR8	826300	825610
SR9	826815	825465
SR10	826290	825675

Equipment	SPL(1m) (dB(F))							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
coarse screen	57	60	62	65	65	64	59	51
fine screen	57	60	62	65	65	64	59	51
grit conveyer	57	60	62	65	65	64	59	51
grit conveyer	57	60	62	65	65	64	59	51
grit conveyer	57	60	62	65	65	64	59	51
grit conveyer	57	60	62	65	65	64	59	51
washer compactor	69	72	74	77	77	76	71	63
grit trap mixer	49	52	54	57	57	56	51	43
air blower	58	67	78	78	76	72	69	66
Total SPL (dB(F))	70.67	74.32	79.91	81.23	80.39	78.52	74.05	68.29
Correct. factor (from flat response to A weighting)	−26.20	−16.10	−8.60	−3.20	0.00	1.20	1.00	−1.10
Total SPL (dB(A))	44.47	58.22	71.31	78.03	80.39	79.72	75.05	67.19

Average Absorption Coefficients

	Concrete 200mm	Louvre	Roller Gate 1.2mm G.I.	FRP	Skylight 6mm glass	Door 1.2mm G.I	Average	Room Constant
Area (sq.m)	977.00	25.00	60.00	0.00	0.00	0.00		
Frequency (Hz)								
63 Hz	0.01	0.01	0.01	0.05	0.08	0.01	0.010	10.73
125 Hz	0.01	0.01	0.01	0.05	0.15	0.01	0.010	10.73
250 Hz	0.01	0.01	0.01	0.10	0.06	0.01	0.010	10.73
500 Hz	0.02	0.01	0.01	0.15	0.04	0.01	0.019	20.79
1000 Hz	0.02	0.01	0.01	0.25	0.03	0.01	0.019	20.79
2000 Hz	0.02	0.01	0.01	0.30	0.02	0.01	0.019	20.79
4000 Hz	0.03	0.01	0.01	0.30	0.02	0.01	0.028	31.04
8000 Hz	0.03	0.01	0.01	0.25	0.02	0.01	0.028	31.04

Average TL

	Concrete 200mm	Louvre	Roller Gate 1.2mm G.I.	Skylight 6mm glass	Door 1.2mm G.I	Average (dB)
Area (sq.m)	691	25.00	60	0.00	0.00	
Frequency (Hz)						
63 Hz	36	7	8	17	8	17.23
125 Hz	42	8	13	11	13	20.44
250 Hz	41	11	20	24	20	24.66
500 Hz	50	12	24	28	24	26.29
1000 Hz	57	15	29	32	29	29.52
2000 Hz	60	18	33	27	33	30.71
4000 Hz	65	12	39	35	39	26.90
8000 Hz	70	11	44	39	44	25.91

SPL at NSR

Frequency (Hz)	Total SWL dB(A)	Area (sq.m)	Rev.SPL (dB(A))	SPL − SR1 (dB(A))	SPL−SR2 (dB(A))	SPL − SR3 (dB(A))	SPL − SR4 (dB(A))	SPL − SR5 (dB(A))	SPL − SR6 (dB(A))	SPL − SR7 (dB(A))	SPL − SR8 (dB(A))	SPL − SR9 (dB(A))	SPL − SR10 (dB(A))
63	52.47	776.00	46.18	−18.93	−18.52	−9.28	0.24	5.04	−10.36	−11.73	−15.11	−17.27	−15.21
125	66.22	776.00	61.93	−8.39	−7.97	1.26	10.78	15.58	0.18	−1.19	−4.57	−6.72	−4.6[illegible]
250	79.31	776.00	75.03	0.46	0.88	10.11	19.63	24.44	9.03	7.67	4.29	2.13	4.1[illegible]
500	86.03	776.00	78.87	2.70	3.11	12.35	21.87	26.67	11.27	9.90	6.52	4.36	6.4[illegible]
1000	88.39	776.00	81.23	1.84	2.25	11.48	21.00	25.81	10.41	9.04	5.66	3.50	5.5[illegible]
2000	87.72	776.00	80.56	−0.03	0.38	9.62	19.14	23.94	8.54	7.17	3.79	1.64	3.70
4000	83.05	776.00	74.15	−2.63	−2.21	7.02	16.54	21.35	5.94	4.58	1.20	−0.96	1.10
8000	75.19	776.00	68.30	−9.50	−9.09	0.15	9.67	14.47	−0.93	−2.30	−5.68	−7.83	−5.77
			Total SPL	8.00	8.41	17.65	27.17	31.97	16.57	15.20	11.82	9.67	11.7[illegible]

Sludge Treatment Facilities

	E (m)	N (m)
Notional Source Location	824850	824990
SR1	822420	824685
SR2	822530	824725
SR3	824080	825230
SR4	824645	825165
SR5	825005	824990
SR6	825650	825430
SR7	825800	825480
SR8	826300	825610
SR9	826815	825465
SR10	826290	825675

Length:	36 m
Width:	24 m
Height:	10 m
Enclosure Surface Area:	2064

SPL at NSR

Area (sq.m)	SPL 1 m from wall (dB(A))	SPL – SR1 (dB(A))	SPL–SR2 (dB(A))	SPL – SR3 (dB(A))	SPL – SR4 (dB(A))	SPL – SR5 (dB(A))	SPL – SR6 (dB(A))	SPL – SR7 (dB(A))	SPL – SR8 (dB(A))	SPL – SR9 (dB(A))	SPL – SR10 (dB(A))
2064.00	65.00	19.37	19.78	29.01	38.53	43.34	27.94	26.57	23.19	21.03	23.09

Operational Noise Assessment

1 Noise Sensitive Receivers

Positions of Noise Sensitive Receivers (ASRs)

ASR	Code	Easting (m)	Northing (m)
DD 387 / LOT 17 – 18	SR1	822420	824685
Hong Kong Garden	SR2	822530	824725
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Golden Villa	SR5	825005	824990
Villa Mar	SR6	825650	825430
Edinburgh Villa	SR7	825800	825480
Ting Kau Village	SR8	826300	825610
DD 399 LOT 367 – 368	SR9	826815	825465
Anton Villa	SR10	826290	825675

Coordinates Measured from Survey Map

2 Location of Sources

Source	Notional Source Centre	
	Easting (m)	Northing (m)
Approach Beach Pumping Station	826928	825378
Ting Kau Beach Pumping Station	826231	825556
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Sham Tseng STW (Inlet) Pumping Station	824860	824978
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Preliminary Treatment Facilities	824850	824990
Sedimentation Tanks	824804	824975
Sludge Treatment Facilities	824755	824985

3 Equipment Details at Every Source

3.1 Approach Beach Pumping Station
Ting Kau Beach Pumping Station
Lido Beach Pumping Station
Casam Beach Pumping Station
Sham Tseng East Pumping Station
Sham Tseng West Pumping Station
Tsing Lung Tau Tseung Pumping Station

Assume there will be one pump in each of the above pumping stations
Assume all pumps are submerged

Characteristic Impedance of Water: 1480000 ray/s
Characteristic Impedance of Air: 415 ray/s
Transmission Loss: –29.50 dB

Pump Location	Flow Rate ADWF (cu.m/s)	Flow x 3 (cu.m/s)	Duty Head (m)	Minimum Power Required (kW)	Speed Assumed (rpm)	SWL (dB(A))	SWL above Water (dB(A))	SPL(1m) above Water (dB(A))
Approach Beach	0.006	0.019	23.00	4.32	1000.00	88	58.50	50.50
Ting Kau Beach	0.002	0.005	22.90	1.17	1000.00	88	58.50	50.50
Lido Beach	0.010	0.029	13.90	3.92	1000.00	88	58.50	50.50
Casam Beach	0.018	0.053	14.50	7.55	1000.00	88	58.50	50.50
Sham Tseng East	0.024	0.072	3.40	2.41	1000.00	88	58.50	50.50
Sham Tseng West	0.013	0.040	0.10	0.04	1000.00	88	58.50	50.50
Tsing Lung Tau Tseung	0.093	0.278	17.00	46.34	1000.00	88	58.50	50.50

Assume the SWL of each pump is 88dB(A) from TM (Construction Noise)

Operational Noise Assessment

3.2 Sham Tseng Sewage Treatment Works Inlet and Outfall Pumping Stations

Assume one pump will be in operation in inlet or outfall pumping station

ADWF:	15104 cu.m/hr		
	0.17 cu.m/s		
Peak Factor:	3		
Design Flow Rate:	0.52 cu.m/s		
Duty head assumed:	10 m		
RPM:	1000		
Power:	51.40 KW	=	69.88 hp
SPL of Pump =	88.53 dB(F)		
SPL of Motor =	90.44 dB(F)		

Pump

SPL (1m): 88.53 dB(F)

Frequency	SPL Subtracted	SPL Predicted	A Weightings	SPL Predicted
(Hz)	(dB)	(dB)	(dB)	(dB(A))
31	13	75.53	-39.40	36.13
63	12	76.53	-26.20	50.33
125	11	77.53	-16.10	61.43
250	9	79.53	-8.60	70.93
500	9	79.53	-3.20	76.33
1000	6	82.53	0.00	82.53
2000	9	79.53	1.20	80.73
4000	13	75.53	1.00	76.53
8000	19	69.53	-1.10	68.43
			Total	86.09 dB(A)

Motor

SPL (1m): 90.44 dB(F)

Frequency	SPL Subtracted	SPL Predicted	A Weightings	SPL Predicted
(Hz)	(dB)	(dB)	(dB)	(dB(A))
31	14	76.44	-39.40	37.04
63	14	76.44	-26.20	50.24
125	11	79.44	-16.10	63.34
250	9	81.44	-8.60	72.84
500	6	84.44	-3.20	81.24
1000	6	84.44	0.00	84.44
2000	7	83.44	1.20	84.64
4000	12	78.44	1.00	79.44
8000	20	70.44	-1.10	69.34
			Total	89.14 dB(A)

Total SPL of each inlet and outfall pump:	90.89 dB(A)
Transmission Loss Through Water to Air:	-29.50 dB(A)
Total Sound Pressure Level above water:	61.39 dB(A)

Pump Location	SPL (1m)
	(dB(A))
Sham Tseng STW (Inlet)	61.39
Sham Tseng STW (Outfall)	61.39

Operational Noise Assessment

3.3 Preliminary Treatment Facilities

Indoor Equipment	Number	Sound Pressure Level (1m), dB(F)							
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Coase Screen	1	57	60	62	65	65	64	59	51
Fine Screen	1	57	60	62	65	65	64	59	51
Grit/Screenings Conveyer	4	57	60	62	65	65	64	59	51
Washer Compactor	1	69	72	74	77	77	76	71	63
Grit Trap Mixer	1	49	52	54	57	57	56	51	43
Air Blower	1	58	67	78	78	76	72	69	66

Enclosure Details	
Length	22
Width	13
Height	7
Louvre Area	25
Roller Gate Area	60

Outdoor Equipment	Number	SWL (dB(A))	SILENCER I.L.	NET SWL (dB(A))	SPL (1m) (dB(A))
Extraction Fans	2	108	16	92	84

SWL of Extraction Fans was taken from TM (construction)

3.4 Sedimentation Tanks

Outdoor Equipment:	No.	SPL (1m), dB(A)	Sound Pressure Level (1m), dB(A)							
			63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Sludge Pump	1	74.51	39	50	59	65	71	69	65	57
Scum Pump	1	81.51	46	57	66	72	78	76	72	64

3.5 Sludge Treatment Facilities

Enclosure Details	
Length	36
Width	24
Height	10

Assume the SPL 1 metre from wall is 65 dB(A)

Outdoor Equipment	Number	SWL (dB(A))	SILENCER I.L.	NET SWL (dB(A))	SPL (1m) (dB(A))
Extraction Fans	2	108	16	92	84

SWL of Extraction Fans was taken from TM (construction)

Appendix J

Blank

Appendix K

Avoidance of Nuisance Particular Specification

APPENDIX K

PARTICULAR SPECIFICATION FOR ENVIRONMENTAL PROTECTION AVODIANCE OF NUISANCE

1. AVOIDANCE OF NUISANCE

(1) The Contractor shall comply with the Public Cleansing and Prevention of Nuisances By-Law 1972.

(2) The Site shall be maintained in a clean and tidy condition. Materials, including materials required for Temporary Works, shall be stored in an orderly manner. Rubbish and debris shall be removed from the Site at a frequency agreed by of the Engineer.

(3) Earth, rock or debris, including any deposits arising from the movement of Constructional Plant or vehicles, shall not be deposited on public or private rights of way. The Contractor shall provide wheel washing and vehicle cleaning facilities at the exits from sites from which material is hauled. The facilities shall be a type approved by the Engineer and shall comply with the requirements of the Commissioner of Police. Cement and concrete trucks shall be effectively cleaned before leaving the Site. The Contractor shall provide a hard-surfaced road between the facilities and public roads.

(4) Existing stream courses and drains within and adjacent to the Site shall be kept safe and free from any debris and any excavated material arising from the Works. Chemicals and concrete agitator washings shall not be deposited in stream courses and drains.

(5) Water and liquid waste products arising on Site shall be collected and removed from the Site by a suitable and properly designed temporary drainage system and shall be disposed of at a location and in a manner that will not cause pollution or a public health nuisance.

(6) The Contractor shall construct, maintain, remove and reinstate temporary drainage works and shall take other precautions necessary to avoid damage by flooding and by silt washed down from the Works. Adequate precautions shall be provided to ensure that spoil or debris is not allowed to be pushed, washed down, fall or be deposited on land or on the seabed adjacent to the Site.

(7) Spoil and debris from the Works which is deposited on adjacent land or seabed, and silt washed down to any area, shall be immediately removed and the affected land or seabed areas restored to their natural state.

(8) The Contractor shall make provision for the disposal from the Works of all solid waste products such that pollution and nuisance are not caused; the manner and location of disposal shall be as agreed by the Engineer.

(9) An adequate firebreak shall be maintained between the Site and adjoining areas.

(10) Wastes and other materials shall not be burned on the Site.

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(11) The use of access roads shall be kept to a minimum at night and spoil removed from tunnelling operations shall be stored on the Site and removed from the Site during daytime.

(12) The Contractor shall comply with and observe all Ordinances, bye-laws, regulations and rules for the time being in force in Hong Kong governing the control of any form of pollution, including air, noise, water and waste pollution, and for the protection of the environment, and shall implement all pollution control measures to the satisfaction of the Engineer and the Director of Environmental Protection.

(13) Waste collected from grease traps shall be collected and disposed of by a licensed contractor.

(14) The Contractor shall provide a refuse storage area with sewerage and drainage connections at each site.

NOISE CONTROL

2. GENERAL REQUIREMENTS FOR NOISE CONTROL

(1) The Contractor shall consider noise as an environmental constraint in the planning and execution of the Works.

(2) The Contractor shall comply with the Noise Control Ordinance (Cap 400) and with any Regulations made under the Ordinance, including restrictions placed on noise from construction work and the requirements to seek Construction Noise Permits. Before commencing work which requires Construction Noise Permits, the Contractor shall obtain such permits and shall provide a copy of the application and permit to the Engineer for his information, together with two copies of relevant Technical Memoranda and literature as published by the Environmental Protection Department.

(3) Rock breakers shall not be used within 125 m of noise sensitive receivers (NSR) unless permitted by the Engineer in writing.

(4) Blasting, if permitted, shall be carried out between 1200 and 1400 hours unless otherwise permitted by the Engineer.

(5) Noise mitigation measures agreed by the Engineer shall be provided when diesel cranes are operated within 40 m of any noise sensitive receivers.

(6) Methods of working shall be devised and arranged to minimize noise impacts; experienced personnel with suitable training shall be employed to ensure that these methods are implemented.

(7) Constructional Plant to be used on the Site shall be effectively sound-reduced by means of silencers, mufflers, acoustic linings or shields, acoustic sheds or screens or other means to avoid disturbance to any nearby noise sensitive receivers. Hand-held percussive breakers and air compressors shall comply with the Noise Control (Hand-held Percussive Breakers) Regulations and Noise Control (Air Compressors) Regulations respectively under the Noise Control Ordinance (NCO).

3. PARTICULARS TO BE SUBMITTED

(1) Particulars of all Constructional Plant which is likely to cause excessive noise shall be submitted to the Engineer. The particulars shall be submitted before the Constructional Plant is used on the Site. Unless otherwise permitted by the Engineer, trials of the Constructional Plant shall be carried out to demonstrate that the Constructional Plant can be operated in a manner which will minimise noise during the Works; the trials shall be carried out in the presence of the Engineer. The Constructional Plant shall not be used on the Site until agreed by the Engineer.

(2) Particulars of all operations which are likely to cause excessive noise, together with measures to be implemented to control noise, shall be submitted to the Engineer for approval. The particulars shall be submitted before commencing any work and shall be revised and resubmitted when instructed by the Engineer.

4. PERMITTED NOISE LEVELS

(1) Construction noise shall not exceed the terms and conditions set out in the Construction Noise Permit obtained for the Works. Construction noise shall not exceed the maximum permissible levels set out under the NCO, including its subsidiary regulations and Technical Memorandum.

(2) In addition to the requirements imposed by the NCO, the noise level of any construction work other than percussive piling, during the period from 0700 to 1900 hours on any day not being a General Holiday (including Sunday), measured at 1 m from the most affected external facade of the nearby noise sensitive receivers during any 30 minutes, shall not exceed an equivalent sound level (L_{eq}) of 75 dB(A), reduced to 70 dB(A) for schools and 65 dB(A) during school examination periods.

5. NOISE MONITORING

(1) Monitoring equipment and methodology shall comply with the Technical Memorandum on Noise from Construction Work other than Percussive Piling, issued under section 9 of the Noise Control Ordinance.

(2) The Engineer will, prior to commencement of the relevant construction work, carry out baseline monitoring to determine baseline noise levels at the noise sensitive receivers. The baseline monitoring will be carried out for a period of at least two weeks, with measurements taken every day at locations and to a schedule determined by the Engineer. The baseline noise levels $L_{eq(5\ min)}$ and $L_{eq(30\ min)}$ will be calculated from these measurements.

(3) Impact noise monitoring will be carried out at all noise sensitive receivers whenever construction work is being carried out. The measurements and monitoring stations will be determined by the Engineer to measure the maximum noise impact during the period. Measurements will not be taken if the Contractor is not working during any of these periods. Monitoring will be undertaken according to the following schedule:

(a) at least one $L_{eq(5\ min)}$ measurement between 1900 and 2300 hours on weekdays;

(b) at least one $L_{eq(5\ min)}$ measurement between 2300 and 0700 hours on weekdays;

(c) at least one $L_{eq(5\ min)}$ measurement on General Holidays and Sundays between 0700 and 1900 hours;

(d) at least one $L_{eq(30\ min)}$ measurement between 0700 and 1900 hours on normal weekdays, one to three times each week; and

(e) at any NSR as determined by the Engineer from time to time and when any powered mechanical equipment is operating from 0700 to 1900 hours on General Holidays (including Sundays) and from 1900 to 0700 hours on all days.

(4) Trigger, action and target levels will be based on complaints and the maximum allowable noise levels set out in PS Clause 4. If any of the trigger, action or target levels is exceeded, immediate action shall be taken by the Contractor in accordance with an action plan to be submitted to, and as agreed by, the Engineer.

6. COMPLIANCE AUDIT REPORTING

A monthly summary report of all noise monitoring data will be prepared by the Engineer, including at least the following:

(a) copy of all data;

(b) highlighting of any failures to comply with the criteria set out in the NCO or in the Contract;

(c) implementation of the action plan when the trigger, action or target levels are exceeded;

(d) identification of reasons for non-compliance;

(e) identification of additional mitigation measures taken by the Contractor as a result of (b) above;

(f) copies of all Construction Noise Permits; and

(g) copy of all noise complaints received.

A copy of the summary report will be made available for inspection by the Director of Environmental Protection at his request.

7. ACTION ON DETECTION OF EXCESSIVE NOISE LEVEL

(1) If monitoring of the noise level shows, in the opinion of the Engineer, an excessive noise level, the Contractor shall take all necessary measures to ensure that the actions of the Contractor are not contributing to the excess. The measures shall include, but shall not be limited to, the following:

(a) checking all Constructional Plant;

(b) maintenance or replacement of any Constructional Plant contributing to the excess;

(c) installation of Constructional Plant soundproofing, provision of alternative Constructional Plant or erection of sound barriers; and

(d) review and modification of all working methods and scheduling of activities.

(2) The Contractor shall inform the Engineer of all measures taken, and shall submit to the Engineer written reports and proposals for action, whenever monitoring shows that an excessive noise level is arising.

(3) If proposed remedial measures include the use of additional or alternative Constructional Plant, such Constructional Plant shall not be used on the Works until agreed by the Engineer. If proposed remedial measures include maintenance or modification of previously agreed Constructional Plant, such Constructional Plant shall not be used on the Works until the proposed maintenance or modification has been completed and the adequacy of the maintenance or modification has been demonstrated and agreed by the Engineer as being satisfactory.

(4) If approved remedial measures are not being implemented and serious impacts persist, the Contractor shall cease related parts of the Works until the measures are implemented.

AIR QUALITY CONTROL

8. GENERAL REQUIREMENTS FOR AIR QUALITY CONTROL

(1) Effective dust suppression measures as are necessary shall be installed to ensure that, at the boundary of the Site and at any sensitive receivers, the concentration of total suspended particulates (TSP) shall not exceed that defined in the Hong Kong Air Quality Objectives or 0.5 mg/m^3, at a standard temperature of 25°C and pressure of 1.0 bar, averaged for one hour.

(2) Furnaces, boilers and other similar Constructional Plant which uses fuel that may produce air pollutants shall not be used without the prior written consent of the Director of Environmental Protection pursuant to the Air Pollution Control Ordinance.

(3) Debris and other materials shall not be burned on the Site.

(4) Methods of working shall be devised and arranged to minimize dust emission.

9. DUST SUPPRESSION MEASURES

(1) Dust suppression measures shall be implemented which shall include, but shall not be limited to, the measures stated in PS Clause 9 (2) to (13).

(2) Stockpiles of sand and aggregate greater than 20 m^3 for use in concrete manufacture shall be enclosed on three sides, with walls extending above the stockpile and 2 m beyond the front of the stockpile. The locations of the stockpiles shall be as agreed by the Engineer.

(3) Effective water sprays shall be used during the delivery and handling of raw sand, aggregate and other similar materials and when dust is likely to be created and shall be used to dampen all stored materials during dry and windy weather.

(4) Areas within the Site where there is a regular movement of vehicles shall have a hard surface as agreed by the Engineer and shall be kept clear of loose surface material.

(5) Conveyor belts shall be fitted with windboards and conveyor transfer points and hopper discharge areas shall be enclosed to minimize dust emission. Conveyors carrying materials which have the potential to create dust shall be totally enclosed through all stages of the process and shall be fitted with belt cleaners.

(6) Cement and other fine grained materials delivered in bulk shall be stored in closed silos fitted with a high level alarm indicator. The high level alarm indicators shall be interlocked with the filling line such that, in the event of the hopper approaching an over-full condition, an audible alarm will operate and the pneumatic line to the filling tanker will close.

(7) Air vents on cement silos shall be fitted with suitable fabric filters provided with either shaking or pulse-air cleaning mechanisms. The fabric filter area shall be determined using an air-cloth ratio (filtering velocity) of 0.01 - 0.03 m/s.

(8) Weigh hoppers shall be vented to a suitable filter.

(9) Filter bags in cement silo dust collectors shall be thoroughly shaken after cement is blown into the silos to ensure adequate dust collection for subsequent loading.

(10) Adequate dust suppression plant, including water bowsers with spray bars, shall be provided.

(11) Unless otherwise permitted by the Engineer, motorised vehicles on the Site shall be restricted to a maximum speed of 8 km per hour and haulage and delivery vehicles shall be restricted to designated roads inside the Site. Suitable hard road surfaces agreed by the Engineer shall be provided for lengths of road exceeding 100 m or if vehicle movements exceed 100 movements/day.

(12) Vehicles with an open load carrying area used for moving potentially dust producing materials shall have properly fitting side and tail boards. Materials having the potential to create dust shall not be loaded to a level higher than the side and tail boards and shall be covered by a clean tarpaulin in good condition.

The tarpaulin shall be properly secured and shall extend at least 300 mm over the edges of the side and tail boards.

(13) The location of dust producing plant or facilities, either fixed or temporary, shall be as agreed by the Engineer.

10. PARTICULARS TO BE SUBMITTED

(1) Particulars of all Constructional Plant which is likely to cause dust problems shall be submitted to the Engineer. The particulars shall be submitted before the Constructional Plant is used on the Site. Unless otherwise permitted by the Engineer, trials of the Constructional Plant shall be carried out to demonstrate that the Constructional Plant can be operated in a manner which will minimize dust during the Works; the trials shall be carried out in the presence of the Engineer. The Constructional Plant shall not be used on the Site until agreed by the Engineer.

(2) Particulars of all operations which are likely to cause dust emissions, together with measures to be implemented to monitor and control dust emissions shall be submitted to the Engineer for approval. The particulars shall be submitted before commencing any work and shall be revised and resubmitted when instructed by the Engineer.

11. LICENCE FOR BATCHING PLANTS

(1) Concrete batching plant shall not be installed without obtaining a license from the Director of Environmental Protection in accordance with the Air Pollution Control Ordinance. Concrete batching plants shall comply with the particular requirements stated in PS Clause 11(2) to (6).

(2) The Contractor shall at all times prevent dust nuisance as a result of operation of the plant. An air pollution control system shall be installed and shall be operated whenever the plant is in operation.

(3) Where dusty materials are being discharged to vehicles from a conveying system at a fixed transfer point, a three-sided roofed enclosure with a flexible curtain across the entry shall be provided. Exhaust fans shall be provided for this enclosure and shall be vented to a suitable fabric filter system.

(4) The concrete batching plant and ancillary areas shall be frequently cleaned and watered to minimize any dust emissions.

(5) Dry mix batching shall be carried out in a totally enclosed area with an exhaust to suitable fabric filters.

(6) In addition to the requirements stated in PS Clause 11(2) to (5), the Contractor shall employ the Best Practical Means (BPM) to reduce the air pollution impact from any batching plant as stated in PS Clauses 12 to 21.

12. GENERAL REQUIREMENTS FOR BATCHING PLANTS

The minimum requirements for meeting the Best Practicable Means for Cement Works (Concrete Batching Plant) are stated in PS Clauses 12 to 21. In granting a licence under the Ordinance, the Authority, i.e., the Director of Environmental Protection, will also consider all other relevant aspects and may impose more stringent and additional control requirements by taking into account individual process characteristics, local topography and air quality and any other factors.

13. EXHAUST FROM PARTICULATE ARRESTMENT PLANT

Unless otherwise permitted by the Engineer, where it is not necessary to achieve dispersion of the residual pollutants, the final discharge point from particulate matter arrestment plant at batching plants shall be at low level to minimise the effect on the local community in case of abnormal emissions and to facilitate maintenance and inspection.

14. EMISSION LIMITS

All emissions to air, other than steam or water vapour, from batching plants shall be colourless and free from persistent mist or smoke. The maximum concentration of particulates in emissions shall be 50 mg/m^3 expressed at the reference conditions of 0°C and 101.325 kilopascals, without correction for water vapour content. Dilution air shall not be introduced to achieve the emission concentration limits.

15. FUGITIVE EMISSION CONTROL: BOUNDARY AMBIENT STANDARDS

The Boundary Ambient Standards for fugitive emission control for batching plants shall comply with the following:

The maximum concentration of air pollutants at the boundary of the Site shall be:

- total suspended particulates:	260 μg/m^3 (24-hour average)
- respirable suspended particulates:	160 μg/m^3 (24-hour average)
- odour:	2 odour units

(where: An odour unit is the measuring unit of odour level and is analogous to pollution concentration. The odour level is defined as the ratio of the volume which the sample would occupy when diluted with air to the odour threshold, to the volume of the sample, i.e. one odour unit is the concentration of odorant which just induces an odour sensation.)

16. FUGITIVE EMISSION CONTROL:ENGINEERING DESIGN AND TECHNICAL REQUIREMENTS

(1) The engineering design and technical requirements for fugitive emission control for batching plants shall be as agreed by the Authority. The loading, unloading, handling and storage of fuel, raw materials, products, wastes or by-products shall be carried out in a manner agreed by the Authority so as to prevent the release of visible dust emissions and other noxious or offensive emissions.

(2) The control measures stated in PS Clauses 17 and 18 shall be implemented.

17. FUGITIVE EMISSION CONTROL:CEMENT AND SIMILAR DUSTY MATERIALS

(1) Fugitive emission control for cement and similar dusty materials for batching plants shall comply with the requirements stated in PS Clause 17(2) to (6).

(2) The loading, unloading, handling, transfer and storage of cement, pulverised fuel ash and other similar dusty materials shall be carried out in a totally enclosed system agreed by the Authority. Dust-laden air or waste gas generated by the process operations shall be properly extracted and vented to a fabric filtering system to meet the emission limits stated in PS Clauses 14 and 15.

(3) Cement, pulverised fuel ash and other similar dusty materials shall be stored in storage silos fitted with audible high level alarms warning of over-filling. The high-level alarm indicators shall be interlocked with the material filling line such that in the event of the silo approaching an overfilling condition, an audible alarm will operate and after 1 minute or less the material filling line will be closed.

(4) Vents of silos shall be fitted with a fabric filtering system to meet the emission limits stated in PS Clauses 14 and 15.

(5) Vents of cement and pulverised fuel ash weighing scales shall be fitted with a fabric filtering system to meet the emission limits stated in PS Clauses 14 and 15.

(6) Seating of pressure relief valves of silos shall be checked, and the valves reseated if necessary, before each delivery.

18. FUGITIVE EMISSION CONTROL: OTHER RAW MATERIALS

(1) Fugitive emission control for raw materials other than cement and similar dusty materials for batching plants shall comply with the requirements stated in PS Clause 18(2) to (17).

(2) The loading, unloading, handling, transfer and storage of raw materials which may generate airborne dust emissions, such as crushed rock, sand and aggregate, shall be carried out in a manner which will prevent or minimise dust emissions.

(3) The raw materials shall be adequately wetted before and during the loading, unloading and handling operations. Manual or automatic water spraying systems shall be provided at unloading areas, stockpiles and material discharge points.

(4) Receiving hoppers for unloading the raw materials shall be enclosed on three sides up to 3 m above the unloading point. The hoppers shall not be used as the material storage devices.

(5) Belt conveyors for handling the raw materials shall be enclosed on top and on two sides with a metal board at the bottom to eliminate dust emissions due to wind-whipping effects. Other types of enclosure which achieve the same performance may be provided.

(6) Conveyor transfer points shall be totally enclosed. Openings for the passage of conveyors shall be fitted with adequate flexible seals.

(7) Scrapers shall be provided at the turning points of conveyors to remove dust adhering to the belt surface.

(8) Conveyors discharging to stockpiles of the raw materials shall be arranged to minimise free fall as far as practicable. Free falling transfer points from conveyors to stockpiles shall be enclosed with chutes and shall be sprayed with water.

(9) Aggregates with a nominal size less than or equal to 5 mm shall be stored in a totally enclosed structure and shall not be handled in an open area. Where there is a sufficient buffer area surrounding the concrete batching plant, ground stockpiling may be used. The stockpile shall be enclosed at least on top and on three sides and shall have a flexible curtain to cover the entrance side.

(10) Unless otherwise permitted by the Engineer, aggregates with a nominal size greater than 5 mm shall be stored in a totally enclosed structure. If open stockpiling is used, the stockpile shall be enclosed on three sides with the enclosure wall sufficiently higher than the top of the stockpile to prevent wind whipping.

(11) The opening between the storage bin and weighing scale of the raw materials shall be fully enclosed.

(12) Concrete trucks shall be loaded in such a way as to minimise airborne dust emissions. The following particular control measures shall be implemented.

(a) Unless otherwise permitted by the Engineer, the materials shall be pre-mixed in a totally enclosed concrete mixer before loading the materials into the concrete truck. Dust-laden air generated by the pre-mixing process, and by the loading process, shall be totally vented to a fabric filtering system to meet the emission limits stated in PS Clauses 14 and 26A.15.

(b) If truck mixing, batching or other types of batching method is used, effective dust control measures agreed by the Authority shall be adopted. The dust control measures shall have been demonstrated to the Authority to prove that they are capable of collecting and venting all dust-laden air generated by the material loading and mixing to dust arrestment plant to meet the emission limits stated in PS Clauses 14 and 15.

(13) Loading bays shall be totally enclosed during the loading process.

(14) All practicable measures shall be taken to prevent or minimize dust emissions caused by vehicle movement.

(15) Roads within the premises shall be paved and adequately wetted.

(16) Vehicle cleaning facilities shall be provided and used by all concrete trucks after loading, and by other vehicles leaving the premises, to wash off any dust or mud deposited on the wheels and vehicle body.

(17) A high standard of housekeeping shall be maintained. Spillages and deposits of materials on the ground, support structures and roofs shall be cleaned up promptly by a cleaning method agreed by the Authority. Materials shall not be dumped at open areas.

19. MONITORING REQUIREMENTS

(1) Monitoring parameters and sampling frequencies for fugitive emission control for batching plants will be determined by the Authority.

(2) The total monthly raw input, product output and material stock (by manual recording), and other essential operating parameters which may significantly affect the emission of air pollutants will be monitored continuously.

(3) At the boundary of the Site or other locations agreed by the Authority, the total suspended particulates and respirable suspended particulates shall be monitored by taking at least one 24-hour sample per six calendar days.

20. COMMISSIONING TRIALS

Commissioning trials for batching plants shall be conducted to demonstrate the performance and capability of the air pollution control measures. The commissioning trials shall be witnessed by the Authority when appropriate and a report of the commissioning trial shall be submitted to the Authority within one month after completion of the trial.

21. OPERATION AND MAINTENANCE

(1) Batching plants shall be operated and maintained properly, including provision of required appliances, proper operation and maintenance of equipment, supervision when in use and the training and supervision of properly qualified staff. Specific operation and maintenance requirements specified by the Authority for individual equipment shall be carried out.

(2) Malfunctioning and breakdown of the process or air pollution control equipment which would cause the emission limits to be exceeded or breaches of other air pollution control requirements shall be reported to the Engineer and the Authority within three working days of the event.

22. AIR QUALITY MONITORING

(1) The Engineer will carry out dust (TSP) impact monitoring throughout the construction period. The exact location and direction of the monitoring equipment will be determined by the Engineer.

(2) Monitoring stations shall be provided by the Contractor and shall be free of local obstructions and sheltering. Suitable access, security fencing and hardstanding shall be provided by the Contractor at each fixed monitoring station.

(3) The dust (TSP) levels will be measured by the "High Volume Method for total suspended particulates" as described by the United States Environmental Protection Agency in 40 CFR Part 50.

(4) The Engineer will carry out baseline monitoring before the commencement of the Works to determine ambient dust (TSP) levels at each monitoring station. The baseline monitoring will be carried out for a period of at least two weeks, with measurements taken every day at each monitoring station, to establish the representative one hour and 24 hour TSP background levels. Readings will be taken for two weeks for the 24 hour TSP and three times daily for two weeks for the one hour TSP. Baseline monitoring will be repeated every six months when no activities are taking place on the Site. Baseline data will be prepared in a report on completion as the basis for calculation of the trigger, action and target levels to be used in subsequent impact monitoring.

(5) Impact monitoring during the Works will be undertaken at one or more of the monitoring stations as determined by the Engineer. Impact monitoring will be designed by the Engineer to ensure that the one hour and 24 hour compliance standards of 500 $\mu g/m^3$ and 260 $\mu g/m^3$ respectively are not exceeded.

(6) If the impact monitoring records dust levels which are indicative of a deteriorating situation which are in excess of the trigger, action or target levels, immediate action shall be taken by the Contractor in accordance with an action plan to be submitted to, and as agreed by, the Engineer.

23. COMPLIANCE AUDIT REPORTING

A monthly summary report of all air quality monitoring data will be prepared by the Engineer, including at least the following:

(a) copy of all the data;

(b) highlighting of any failures to comply with the required standards;

(c) implementation of the action plan when trigger, action or target levels are exceeded;

(d) identification of reasons for non-compliance;

(e) identification of remedial action taken by the Contractor as a result of (b) above; and

(f) copy of all air quality complaints received.

A copy of the summary data will be made available for inspection by the Director of Environmental Protection at his request.

24. ACTION ON DETECTION OF DETERIORATING AIR QUALITY

(1) If monitoring of the air quality shows, in the opinion of the Engineer, a deteriorating air quality, the Contractor shall take all necessary measures to ensure that the actions of the Contractor are not contributing to the deterioration. The measures shall include, but shall not be limited to, the following:

(a) checking of all Constructional Plant;

(b) maintenance or replacement of any Constructional Plant contributing to the deterioration; and

(c) review and modification of all working methods and scheduling of activities.

(2) The Contractor shall inform the Engineer of all measures taken, and shall submit to the Engineer written reports and proposals for action, whenever monitoring shows an adverse impact upon air quality.

(3) If proposed remedial measures include the use of additional or alternative Constructional Plant, such Constructional Plant shall not be used on the Works until agreed by the Engineer. If proposed remedial measures include maintenance or modification of previously agreed Constructional Plant, such Constructional Plant shall not be used on the Works until the proposed maintenance or modification has been completed and the adequacy of the maintenance or modification has been demonstrated and agreed by the Engineer as being satisfactory.

(4) If approved remedial measures are not being implemented and serious impacts persist, the Contractor shall cease related parts of the Works until the measures are implemented.

REMOVAL OF WASTE MATERIAL

25. REMOVAL OF WASTE MATERIAL

(1) The Contractor shall comply with the Waste Disposal Ordinance, the Public Health and Municipal Services Ordinance and the Water Pollution Control Ordinance.

(2) Sewage, wastewater and effluent containing sand, cement, silt or other suspended or dissolved material arising from the Works shall not be allowed to flow from the Site onto any adjoining land. Waste matter and refuse from the Works shall not be allowed to be deposited anywhere within the Site or onto adjoining land.

(3) Open streams and drains intercepted by the Works shall be trained, diverted or

conducted and shall be reinstated to their original courses on completion of the Works.

(4) Existing drainage systems shall be properly maintained at all times, including removal of solids in sand traps, manholes and stream beds.

(5) Inert construction waste material suitable for reclamation or land formation shall be segregated and disposed of at such public dumping areas as may be specified from time to time by the Director of Civil Engineering Services.

(6) Non-inert construction waste material deemed unsuitable for reclamation or land formation and all general refuse other than chemical wastes shall be disposed of at a public landfill.

(7) Waste oil, grease, lubricants and batteries arising from the construction phase are classified as chemical wastes. Their storage, transportation and disposal are subject to control under the Chemical Waste (General) Regulation. Waste oil, grease and lubricants should be delivered to the Chemical Waste Treatment Centre in Tsing Yi for treatment and waste batteries to landfill for co-disposal.

DISCHARGE INTO SEWERS AND DRAINS

26. DISCHARGE INTO SEWERS AND DRAINS

(1) The Contractor shall comply with the Buildings Ordinance, the Water Pollution Control Ordinance and the Technical Memorandum "Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters".

(2) Effluent, foul or contaminated water and cooling or hot water shall not be discharged directly or indirectly into public sewers, storm-water drains, channels, stream-courses or the sea without the prior approval of the relevant authority. The Contractor shall provide, operate and maintain suitable works for the treatment and disposal of such effluent, foul or contaminated water or cooling or hot water unless otherwise approved by the relevant authority. The design of such treatment works shall be submitted to the Engineer for approval not less than one month before the commencement of the relevant work.

(3) Foul water effluent from offices, site canteens and toilet facilities shall be directed to a foul sewer or to a sewage treatment facility either directly or indirectly by means of a pumping facility of a type approved by the Engineer.

WATER POLLUTION CONTROL

27. GENERAL REQUIREMENTS FOR WATER POLLUTION CONTROL

(1) The Contractor shall carry out the Works in such a manner as to minimize adverse impacts on the water quality during execution of the Works. Methods of working shall be arranged to minimize the effects on the water quality within the Site, adjacent to the Site, on transport routes and at loading, dredging and dumping areas.

(2) Methods of working shall be designed to minimize adverse impacts upon water quality in Hong Kong waters in terms of the WQO; experienced personnel with

suitable training shall be employed to ensure that these methods are implemented.

(3) Particulars of proposed methods of working which are likely to cause adverse impacts upon water quality shall be submitted to the Engineer. The particulars shall be submitted before such work starts.

(4) Seawater intakes which may be affected by dredging or by placing fill shall be surrounded with suitable silt curtain systems to prevent excess silt contaminating the water drawn into the intakes. The silt curtain systems shall be designed to ensure that the intake water shall contain less than 140 mg/l suspended solids.

(5) The Contractor shall comply with the provisions of the Summary Offenses Ordinance, particularly with respect to marine littering.

(6) The transport of sediment to a fresh water environment shall be minimized by the installation of appropriate sediment traps within the drainage system.

(7) The marine environment and all existing stream courses and drains within and adjacent to the Site shall be kept safe and free from debris and excavated material arising from the Works. Chemicals and concrete agitator washings shall not be deposited in watercourses.

(8) Site compounds shall be designed to take account of contaminated surface water, including provision of drainage channels and sediment lagoons where necessary to allow interception and controlled release of settled and treated water and provision of bunding for hazardous materials including fuels. Emergency procedures in the event of any spills of hazardous materials shall be established as agreed with the Engineer.

(9) Discharges from concrete batching shall be settled and necessary pH adjustments shall be made to the supernatant liquor. If settlement alone is insuffucient to settle colloidal materials, further treatment with settling agents shall be given prior to discharge.

28. GLOSSARY OF TERMS

(1) Terms used in PS Section 26A shall have the meanings stated in PS Clause 28(2) to (6).

(2) Dredged material is all dredged material.

(3) Marine mud is dredged material which is to be removed from reclamation or borrow areas and which will not be reused in the Works.

(4) Contaminated marine mud is designated dredged material which, in the opinion of the Director of Environmental Protection, is contaminated by pollutants such as to require particular handling and disposal procedures and as defined in the Environmental Protection Department Technical Circular (TC) No. 1.1.92.

(5) Fill material is dredged or land based material which is to be used in reclamation, including foundations to seawalls, drainage layers and similar works.

(6) Unsuitable material is material, other than marine mud, which is to be taken from the Site, including borrow areas, and which is unsuitable for use as fill material. The unsuitable material is to be disposed of at designated spoil dumping grounds. The unsuitable material may include builder's debris, spoil and hard material dumped by others, and seabed debris.

29. WATER QUALITY REQUIREMENTS

Methods of working shall be designed and implemented to minimize adverse impacts resulting from the Works on the water quality. Methods of working shall:

(a) minimize disturbance to the seabed while dredging;

(b) minimize leakage of dredged material during lifting;

(c) minimize loss of material during transport of fill or dredged material;

(d) prevent discharge of fill or dredged material except at approved locations;

(e) prevent the unacceptable reduction, due to the Works, of the dissolved oxygen content of the water affected by the Works; and

(f) prevent excess suspended solids from being present in intake waters.

30. WATER QUALITY MONITORING

(1) The Engineer will carry out water quality monitoring throughout the period of construction of the Works.

(2) Water quality monitoring will be carried out in accordance with the following.

(a) The 'Baseline' conditions for water quality will be established before commencement of marine works. The Engineer will establish the 'Baseline' conditions by insitu measurement of dissolved oxygen concentration (mg/L) (DO), dissolved oxygen saturation (%) (DOS) and temperature (°C). Water samples will be taken for immediate insitu measurement of turbidity (NTU) and laboratory analysis of suspended solids (mg/L).

(b) Baseline monitoring will be undertaken at monitoring stations on four days per week for a period of four consecutive weeks within a period of six weeks before commencement of the marine works. Monitoring will be undertaken at each station on the mid-flood and mid-ebb tides at three depths, namely, one metre below the water surface (upper), mid-water depth (middle) and one metre above the sea bed (lower).

(c) The baseline results control station monitoring results and WQO shall form the basis for calculating trigger, action and target (TAT) levels to be used in the impact monitoring.

(d) During the Works, 'Impact' monitoring will be undertaken on three working days per week at each monitoring station. The interval between each sampling series (mid-ebb and mid-flood) will not be less than 36 hours where two sets of the turbidity, DO, DOS and temperature levels will be measured and water samples for suspended solids will be taken at each depth. If the difference in value between the first and second reading of each set is more than 25% of the value of the first reading, the readings will be discarded and further readings will be taken.

(3) If the monitoring data of turbidity or suspended solids or dissolved oxygen shows a deteriorating trend or if TAT levels for any of these three parameters are exceeded, the Contractor shall take action in accordance with an action plan to be submitted to, and as agreed by, the Engineer.

31. COMPLIANCE AUDIT REPORTING

(1) A monthly summary report of all water quality monitoring data will be prepared by the Engineer, including at least the following:

(a) copy of all the data;

(b) highlighting whenever the trigger, action and target limits or WQO's are exceeded;

(c) implementation of the action plan when the trigger, action and target levels are exceeded;

(d) identification of reasons for non-compliance;

(e) identification of mitigation measures taken by the Contractor as a result of (b) above; and

(f) copy of all water quality complaints received.

A copy of the summary data will be made available for inspection by the Director of Environmental Protection at his request.

(2) The Contractor shall provide a summary of any specific activities recently undertaken which may affect the water quality parameters and any remedial measures deemed necessary as a result of non-compliance whenever target limits are exceeded.

(3) If, in the opinion of the Engineer, the Contractor has not taken appropriate and effective measures to reduce the water quality impacts, the Engineer may instruct the Contractor to take such measures as the Engineer considers necessary to improve the water quality.

32. ACTION ON DETECTION OF DETERIORATING WATER QUALITY

(1) If monitoring of the water quality shows, in the opinion of the Engineer, a deteriorating water quality, the Contractor shall take all necessary measures to ensure that the actions of the Contractor are not contributing to the deteriora-

tion. The measures shall include, but shall not be limited to, the following:

(a) checking of all Constructional Plant;

(b) maintenance or replacement of any Constructional Plant contributing to the deterioration;

(c) checking and maintenance of all silt screens; and

(d) review and modification of all working methods and scheduling of activities.

(2) The Contractor shall inform the Engineer of all measures taken, and shall submit to the Engineer written reports and proposals for action, whenever monitoring shows non-compliance with the WQO.

(3) If proposed remedial measures include the use of additional or alternative Constructional Plant, such Constructional Plant shall not be used on the Works until agreed by the Engineer. If proposed remedial measures include maintenance or modification of previously agreed Constructional Plant, such Constructional Plant shall not be used on the Works until the proposed maintenance or modification has been completed and the adequacy of the maintenance or modification has been demonstrated and agreed by the Engineer as being satisfactory.

(4) If approved remedial measures are not being implemented and serious deterioration persists, the Contractor shall cease related parts of the Works until the measures are implemented.

33. GENERAL PROCEDURES DURING DREDGING, TRANSPORTING AND DUMPING

(1) Constructional Plant shall be designed and maintained to minimize the risk of silt and other contaminants being released into the water column or deposited in locations other than designated locations.

(2) Pollution avoidance measures shall include, but shall not be limited, to the following:

(a) mechanical grabs shall be designed and maintained to avoid spillage and shall seal tightly while being lifted;

(b) cutterheads of suction dredgers shall be suitable for the material being excavated and shall be designed to minimize overbreak and sedimentation around the cutter;

(c) if trailing suction hopper dredgers for dredging of uncontaminated marine mud are used, overflow from the dredger and the operation of lean mixture overboard systems shall not be used, unless permitted by the Engineer;

(d) vessels shall be sized such that adequate clearance is maintained between vessels and the sea bed at all states of the tide to ensure that undue turbidity is not generated by turbulence from vessel movement or propeller wash;

(e) pipe leakages shall be repaired promptly and plant shall not be operated with leaking pipes;

(f) the Works shall not cause visible foam, oil, grease, scum, litter or other objectionable matter to be present on the water within the Site or dumping grounds;

(g) barges and hopper dredgers shall be fitted with tight fitting seals to their bottom openings to prevent leakage of material;

(h) excess material shall be cleaned from the decks and exposed fittings of barges and hopper dredgers before the vessel is moved;

(i) loading of barges and hoppers shall be controlled to prevent splashing of dredged material to the surrounding water and barges or hoppers shall not be filled to a level which will cause overflow of material or polluted water during loading or transportation; and

(j) adequate freeboard shall be maintained on barges to ensure that decks are not washed by wave action.

(3) Marine mud, contaminated marine mud and unsuitable material shall be disposed of at the approved locations. Vessels shall be accurately positioned before discharge. Particulars of the method of accurately controlling position at disposal sites shall be submitted to the Engineer for agreement. The particulars shall be submitted before dredging starts.

(4) Disposal in designated marine dumping grounds shall be in accordance with the conditions of a licence issued by the Director of Environmental Protection under the Dumping at Sea Act (Overseas Territories) Order 1975. Floatable and contaminated materials, as defined by the Director of Environmental Protection, shall not be permitted at marine dumping grounds and other methods of disposal shall be used.

(5) The Engineer may monitor vessels transporting material to ensure that dumping outside the approved location or loss of material does not take place.

34. DESIGNATED CONTAMINATED MARINE MUD

The locations and depths of the designated contaminated marine mud will be as instructed by the Engineer on the Site. Designated contaminated marine mud shall be dredged, transported and placed in approved special dumping grounds in accordance with the provisions of PS Section 26A and in such a manner as to minimize the loss of material to the water column.

35. SPECIAL PROCEDURES DURING DREDGING, TRANSPORTING AND DISPOSAL

(1) Uncontaminated mud shall only be dumped in dumping grounds as approved by the Director of Environmental Protection and in accordance with the Dumping at Sea 1974 (Overseas Territory) Order 1975. Contaminated mud shall not be dumped in gazetted dumping grounds. Contaminated mud which cannot be left in situ shall be disposed of by specific methods as directed by the Director Environmental Protection. The Contractor shall be responsible for obtaining all necessary licences for these operations.

(2) When dredging, transporting or disposing of designated contaminated marine mud, additional special procedures for the avoidance of pollution shall be implemented including, but not limited to, the following:

(a) dredging of designated contaminated marine mud shall only be undertaken by a suitable grab dredger using a closed watertight grab;

(b) transport of designated contaminated marine mud shall be by split barge of not less than 750 m^3 capacity; the barge shall be well maintained and shall be capable of rapid opening and discharge at the disposal site;

(c) the material shall be placed in the pit by bottom dumping at a location within the pit to be specified from time to time by the Secretary of Fill Management Committee;

(d) discharge shall be undertaken rapidly and the hoppers shall then immediately be closed; any material adhering to the sides of the hopper shall not be washed out of the hopper and the hopper shall remain closed until the barge next returns to the disposal site;

(e) the dumping vessel shall be positioned to an accuracy of 10 m;

(f) the Engineer will inspect and record the disposal operation; the details of the inspection and record keeping will be agreed beforehand by the Director of Environmental Protection; and

(g) the dumping vessel shall be stationary throughout the dumping operation.

SPECIAL REQUIREMENTS FOR MARINE DISPOSAL OF DREDGED MATERIAL

36. GENERAL REQUIREMENTS

(1) Surplus dredged material shall be disposed of according to the requirements of the Fill Management Committee (FMC) and the Environmental Protection Department (EPD). Contaminated material will have different disposal requirements to uncontaminated material.

(2) The Contractor will be required to obtain a licence from EPD for the disposal of all dredged material.

37. DISPOSAL OF UNCONTAMINATED MATERIAL: FMC GENERAL CONDITIONS

(1) A spoil ground will be allocated to the Ting Kau and Sham Tseng Sewerage Scheme project for the disposal of uncontaminated mud arising from dredging works for the project.

(2) The exact location for dumping spoil will be indicated on the dumping licence to be issued to the Contractor by EPD. The dumping location will be changed from time to time.

(3) Mud dumped within the South Cheung Chau or East of Ninepins marine disposal sites shall be uncontaminated. Prior confirmation of the uncontaminated nature of the mud shall be obtained in writing from the Director of Environmental Protection. The same shall apply to any mud which the FMC has agreed may be disposed of in exhausted marine borrow pits.

(4) The dumping of mud shall be strictly within the designated marine disposal sites. The Contractor shall properly locate the boundaries of the dumping site to ensure that the mud is dumped at the correct location. The dumping of mud shall be carried out in accordance with the requirements of the Director of Environmental Protection and shall be controlled through a separate licence, to be issued by the Director of Environmental Protection, who may at any time during the Contract, with reasonable notice, change the areas available for dumping within the designated marine disposal sites.

(5) The Contractor shall provide, through the Engineer, to the Director of Environmental Protection and the Secretary FMC, a programme for the relevant work showing the number of barge loads and the estimated quantity of dumped material at the dumping site on a monthly basis and within one week after the completion of dumping.

(6) The Contractor shall carry out bathymetric surveys of the mud disposal sites as stated in the accompanying Special Conditions of Allocation, and shall submit these, through the Engineer, to the Secretary FMC and the Director of Marine.

(7) Water quality monitoring will be carried out during the dumping of mud in marine borrow areas. Water quality monitoring shall be as stated in PS Clause 39.

38. DISPOSAL OF CONTAMINATED MATERIAL: FMC GENERAL CONDITIONS

(1) The Contractor will be permitted to use the contaminated mud disposal pit on a non-exclusive basis only, and shall delay dumping operations temporarily if other users are positioned to dump at the same time.

(2) Mud shall be placed in the pit, at a location within the pit to be specified from time to time by the Engineer, on advice from the Secretary FMC.

(3) Barges and dredgers shall be stationary throughout the dumping operation and throughout the flushing of the hopper.

(4) The dumping vessel shall be positioned to an accuracy of 10 m.

(5) The Engineer will supervise and record the disposal operation. Details of the supervision and record keeping shall be as agreed beforehand by the Director of Environmental Protection.

(6) A comprehensive water quality monitoring programme shall be submitted to the Director of Environmental Protection for his approval before the commencement of any dumping activity. Depending on the disposal method and site conditions, extra monitoring requirements may be imposed by the Director of Environmental Protection.

39. WATER QUALITY MONITORING OF DISPOSAL SITES

(1) The Engineer will carry out water quality monitoring at disposal sites.

(2) Water quality monitoring will be carried out in accordance with the following.

(a) The 'Baseline' conditions for water quality will be established before commencement of the dumping or dredging operation. The Engineer will establish the 'Baseline' conditions by insitu measurement of turbidity, dissolved oxygen concentration (mg/L)(DO) and dissolved oxygen saturation (%) (DOS).

(b) Baseline monitoring will be undertaken at monitoring stations on four days per week for a period of one week before commencement of the operation. Monitoring will be undertaken at each station on the mid-flood and mid-ebb tides at three depths, namely, one metre below the water surface (upper), mid-water depth (middle), and one metre above the sea bed (lower).

(c) During the dumping operation, monitoring will be undertaken on three working days per week at each monitoring station. The interval between each sampling series (mid-ebb and mid-flood) will not be less than 36 hours where two sets of turbidity, DO and DOS will be measured. If the difference in value between the first and second reading of each set is more than 25% of the value of the first reading, the readings will be discarded and further readings taken.

(3) If the monitoring data of turbidity or dissolved oxygen shows a deteriorating

trend such that, in the opinion of the Engineer, closer monitoring is required, monitoring will be undertaken daily at each Designated Monitoring Station until the recorded values of these parameters indicate to the satisfaction of the Director of Environmental Protection an improving and acceptable level of water quality.

(4) The initial target limits will be determined by the Engineer for each monitoring station.

(5) Trigger, action and target (TAT) levels for dissolved oxygen, turbidity and suspended solids for the Marine Disposal Areas will be determined by the Engineer. An action plan illustrating what to do if TAT levels are exceeded shall be prepared by the Contractor and submitted to the Engineer for approval.

40. COMPLIANCE AUDIT REPORTING

(1) The Engineer will submit the results of all monitoring to the Director of Environmental Protection and DAF at the end of each month.

(2) The Contractor shall provide a summary of any specific activities recently undertaken which may affect the water quality parameters and any remedial measures deemed necessary as a result of non-compliance.

(3) If, in the opinion of the Engineer, the Contractor has not taken appropriate and effective measures to reduce the water quality impacts, the Engineer may instruct the Contractor to take such measures as the Engineer considers necessary to improve the water quality.

41. SPECIAL PROCEDURES FOR THE PROTECTION OF CHINESE WHITE DOLPHINS

"Dredging or blasting works may have an impact on the dolphins and the measures which are recommended for the protection of Chinese White Dolphins include:

(a) the Contractors will be required to undertake dolphin spotting when operating in these waters;
(b) the Contractors will be required to use predefined and regular routes, especially when disposing of spoil, as these will become known to dolphins and porpoises using these waters;
(c) the Contractors should be required to provide a buffer/safety zone of at least 500m for the dolphin during stressful construction activities (eg percussive piling) should they take place;
(d) the Contractor will be required to minimise the impacts of his works on water quality particularly with respect to dissolved oxygen and turbidity; and
(e) the Contractor should be required to control and manage all effluent from vessels and worksites as described in the Practice Note on "Construction Site Drainage."

Appendix L

Interim Report on Sewage Treatment Options

Ting Kau and Sham Tseng Sewerage Scheme

Environmental Impact Assessment

Interim Report on Sewage Treatment Options

SUMMARY

S.1 A sewerage and sewage treatment scheme is planned for Sham Tseng; the treatment works will be constructed on a coastal site to be reclaimed from the sea. The main objective of this study is to perform a process evaluation of the treatment options for the works and identify two or so preferred options which can then be given a full environmental assessment. Aspects considered in the process assessment include the size of the works footprint, performance and reliability of the treatment and the capital and operating costs.

S.2 The major conclusions drawn in the study are listed as follows:

- Hydrogen sulphide and similar odorous gases could be produced in the sewerage pumping mains.
- The marine outfall is likely to be comparatively short, say up to 200m.
- A review of the Water Quality Standards has indicated that the main parameters controlling the type of treatment at the prospective works will be the removal of *E coli* and nitrogen and the pH value of the effluent.
- The favoured forms of treatment for the prospective works are lime treatment (Option 1), activated sludge (Option 2) and submerged aerated filtration (Option 3).
- The conventional operational pH value of 11 has been specified for the lime treatment.
- All three treatment options can safely reduce the *E coli* content of the sewage by the necessary amount and remove inorganic nitrogen. However, the lime treatment effluent will almost certainly cause, at certain times of the tide *and* year, the pH value of the sea water to increase above the WQO limit of 8.5 within and possibly outside the primary mixing zone.
- Production rate of sludge solids from lime treatment would be extremely high owing to the presence of sea water in the sewage at Sham Tseng. The production rate of the calcium and magnesium salts precipitated by the lime would be some 10 times higher than the production rate of the organic solids removed from the sewage.
- The capital and operating costs of the three options are as follows.

Cost	Option 1	Option 2	Option 3
Capital (MHK$)	99	113	110
Operating (MHK$/year)	12.3	4.71	5.48

Net Present Costs indicate that lime treatment is between 33% and 50% more expensive than Options 2 and 3.

- It may be possible to reduce the operational pH value of lime treatment from 11 to 9.5 and retain compliance with the *E coli* standard, but removal of ammoniacal nitrogen from the sewage would not then be viable. However, the NPC of the treatment would still be higher than that for Options 2 and 3. Also, the treatment would have no performance or operational advantages over the other treatment options.

S.3 Given the conclusions, it is recommended that treatment should be based on either activated sludge or submerged aerated filtration.

TING KAU AND SHAM TSENG SEWERAGE SCHEME

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

AGREEMENT NUMBER CE 35/94

PROJECT NUMBER T399

INTERIM REPORT ON SEWAGE TREATMENT OPTIONS

CONTENTS

TABLES

TABLE (Cont'd)

APPENDICES

1. INTRODUCTION

1.1 Plans are advanced to provide a new sewerage and sewage treatment scheme for Sham Tseng. The site for the treatment works will be a coastal reclaimed area near the main commercial centre of the town. The environmentally-sensitive nature of this area will require the works to be enclosed in a building and all gaseous emissions to be controlled to prevent odour nuisance. A full assessment of the environmental impact of the works during the construction phase and thereafter when the works is operational will be performed.

1.2 The type of treatment to be used at the new works will be largely determined by the requirement to comply with the Water Quality Objectives and Standards specified for the mixture of treated effluent and sea water outside the mixing zones. Part of the environmental assessment is to assess the impact of the treated effluent on the coastal water using mathematical models of dispersion.

1.3 The part of the overall study described in this report is a process assessment of the treatment options suitable for the new works. The main objective is to identify two preferred options for further study, particularly with respect to their environmental impact. Aspects considered in the process assessment include the size of the works footprint, performance and reliability of the treatment and the capital and operating costs.

1.4 To focus the process assessment on appropriate types of treatment, this study reviews the Water Quality Objectives in the context of the existing quality of the coastal water around Sham Tseng. The review provides guidance on the type of treatment which will be most valuable in terms of alleviating sea water pollution in the area and on the quality of the treated effluent necessary to obtain compliance with the WQOs.

1.5 This study also includes a synthesis of the characteristic flows and loads for Sham Tseng sewage. Based on the latest per-capita production rates issued by the Drainage Services Department, the synthesis takes account of future population increases.

1.6 New sewerage will also be provided as part of the overall scheme. This sewerage will collect the sewage from the various villages in Sham Tseng and transfer it to the new works. Pumping will be involved in the transfer and this may give rise to hydrogen sulphide production which, in turn, may cause corrosion and odour nuisance. An assessment of this problem is made and presented in Appendix C.

2. SYNTHESIS OF FLOWS & LOADS

2.1 Major parameters for designing the sewerage and pumping stations for the Sham Tseng Scheme include the maximum flow rate of the sewage, the ADWF and the minimum night flow rate. These parameters also serve in the design of the treatment works, together with the loads of BOD, SS, NH_4-N and pathogens. The following derives values for these design parameters.

2.2 Values for DWF and the various loads have been synthesised from the per-capita production rates and the sizes of the various demographic groups living, working or using the facilities in the drainage area. Similarly, account is taken of the pollution arising from the industrial and commercial activities in the area.

2.3 Synthesises have been performed for the present and for the planning horizon which is assumed to be 20 years ahead, that is 2011.

2.4 Maximum and minimum flow rates have been determined by applying factors to the ADWF.

Population Sizes

2.5 The demographic groups in the area have been classified as either, residents, office, service workers, industrial workers and visitors. Care has been taken to avoid any double counting.

Residential Population

2.6 Information from the Planning Department (PlanD) has been obtained on the sizes of the current and future residential populations. Currently at 28 500, the population is expected to increase over the next 20 years or so to around 44 000. This will then be the ceiling value for the area.

2.7 Housing is largely R3/R4 type in all the villages apart from Kau Tsuen where it is largely R1 type. An assumption is that all the population growth will be accommodated in R3/R4 type housing and that the growth in each village, apart from Kau Tsuen, will be proportional to the current population size. No growth will occur in R1 type housing.

Workers

2.8 The second largest demographic group in the area comprises workers in offices and in services such as shops, restaurants and hotels. The size of this group is assumed to be 2 250, increasing to 3 500 by the planning horizon.

2.9 Another significant group contributing to the pollution load comprises the industrial workers at the three major factories, namely the Garden Bakery, the San Miguel brewery and the Union Carbide Depot. The current size of the workforce at these factories is assumed to be 300. However, the factories are on a prime site, and PlanD has plans is to move these factories within the next 10 years or so to vacate the site for housing development. The new factories will be outside the drainage area of the prospective treatment works.

Visitors

2.10 This category largely comprises beach goers. As indicated in report [1], the beaches in the area have the capacity for 76 000 people. However, on the basis that the beaches rarely, if ever, fill to capacity it has been assumed that a maximum of 25 000 currently visit the beaches on occasional days. When the works is operational, the concomitant improvement in water quality will probably increase interest in bathing. In the future, therefore, the number of beach goers is expected to increase, and 50 000 has been assumed. Such high numbers will, in all probability, arise only during public holidays and Sundays when offices are closed so that some of the pollution load from workers and beach goers may not arise simultaneously. However, for safety, this study assumes the loads are additive.

Students

2.11 The area contains no institutions of higher education so that the student population visiting the area daily is effectively zero. School children attending local schools are taken into account by an allowance in the per capita production rates for residents.

Commercial & Industrial Loads

2.12 Pollution generated by commercial activities such as restaurants and hotels is assumed to be proportional to the number of employees. The number of employees in these activities is assumed to be 250 currently, increasing to 500 by the planning horizon.

2.13 As previously explained, there are three major factories in the area. However, only two, namely the Garden Bakery and the San Miguel Brewery discharge trade effluent to the sewerage system. According to the information given in report {1}, the combined flow from the two factories on a weekday is 4 150 m^3/day and on a weekend, 1 200 m^3/day, the brewery effluent accounting for about 88% of the total.

2.14 Report {2} indicates that the current consent standard for the brewery waste specifies BOD and SS values of 300 mg/l. Assuming these are 95 percentiles, the average values can be assumed to be around 100 mg/l, giving average loads for BOD and SS of about 415 kg/day from both factories.

2.15 The industrial effluents are also likely to contain some NH_3N. In the absence of any detailed information, the load is assumed to be 1% of the BOD, giving a value of 4 kg/day.

2.16 The industrial loadings are a significant fraction of the total from the drainage area. Even though the factories are due to be resited elsewhere, it may be expedient to confirm that the estimated pollution loads are reasonably accurate since the performance of the prospective treatment works could be affected by the loads in the short term.

[1] *Sham Tseng Sewerage & Sewage Treatment: Underground Cavern Options*, prepared for HK Government EPD by Pypun - Howard Humphreys Ltd, January 1993

Per Capita Production Rates

2.17 Table 2.1 lists the annual average per capita production rates for the various population groups. All the values are the latest issued by the DSD in the draft manual [2].

2.18 The per capita flows rates for residents includes an allowance for infiltration of ground water.

Total Flows & Loads

2.19 Table 2.1 also lists the data involved in synthesising the ADWF and the various loads. ADWF is predicted to have a current value of 14.5 Ml/d, increasing to 16.0 Ml/d at the planning horizon.

2.20 The synthesis of ADWF is based on the production of pollution loads occurring on working days. No calculations have been performed for non-working days since the general assumption is that the flows and loads on such days are no greater than those on the working days. For a largely commuting population like that at Sham Tseng, this assumption may not be necessarily valid.

2.21 The strength of the sewage is comparatively low owing to the predominance in the area of R3/R4 housing for which per capita sewage flow rates are comparatively high.

Peaking Factors

2.22 The maximum or peak flows are calculated from the ADWF using peaking factors. These relate to either the instantaneous peak which is required for the design of the pumping stations and sewerage or to the hourly-average peak which is more relevant to the design of the treatment works.

2.23 By comparison with flow, the daily-average loads of the various pollution parameters can be assumed to be reasonably constant from day-to-day, although they may increased on occasional days owing to the influx of beach goers and other visitors.

Treatment Peaking Factors

Flow

2.24 Report {1} explains that the DWF varies seasonally, reaching a peak in summer owing to the increased per capita consumption of water. The summer peaking factor (SPF), equal to the maximum DWF occurring in summer divided by the ADWF, is typically 1.17 irrespective of the nature of the drainage area.

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2 *Draft Drainage Works Manual*, HK Government, Drainage Services Department

Table 2.1: Summary of current and future loads

Pollution sources		Housing	Current										
			Daily per capita production					Population	Average daily loads				
Type	Identification	Type	DWF (l)	BOD (g)	SS (g)	NH4-N (g)	E Coli (TNr)	(Nr)	Flow (m3)	BOD (kg)	SS (kg)	NH-N (kg)	E coli (GNr)
Residential	Ting Kau	R3/R4	370	42	40	5	43	1000	370	42	40	5	43
	Casam	R3/R4	370	42	40	5	43	1500	555	63	60	8	65
	Sheung Sin Wan	R3/R4	370	42	40	5	43	1000	370	42	40	5	43
	Kau Tsuen	R1	240	42	40	5	43	3500	840	147	140	18	151
	Pai Min Kok A	R3/R4	370	42	40	5	43	3500	1295	147	140	18	151
	Pai Min Kok B	R3/R4	370	42	40	5	43	3500	1295	147	140	18	151
	Yuen Tun B	R3/R4	370	42	40	5	43	2000	740	84	80	10	86
	Yuen Tun A	R3/R4	370	42	40	5	43	12500	4625	525	500	63	538
	TOTAL							**28500**					
Employees	Office, shops & service		60	34	34	4	35	2250	135	77	77	9	79
	Commercial activity		290	53	25	1	0	250	73	13	6	0	0
	Industrial		60	34	25	3	28	300	18	10	8	1	8
Visitors	Beach goers		2.4	1.2	1.2	0.9	1.9	25000	60	30	30	23	48
Industry	Garden Bakery								500	50	50	0.5	0
	San Miguel Brewery								3650	365	365	3.7	0
	Union Carbide								0	0	0	0	0
TOTAL									**14526**	**1742**	**1675**	**179**	**1360**
CONCENTRATION										**120** (mg/l)	**115** (mg/l)	**12.3** (mg/l)	**9.4** (MNr/100ml)

Pollution sources		Housing	Future										
			Daily per capita production					Population	Average daily loads				
Type	Identification	Type	DWF (l)	BOD (g)	SS (g)	NH4-N (g)	E Coli (TNr)	Nr	Flow (m3)	BOD (kg)	SS (kg)	NH4-N (g)	E Coli (GNr)
Residential	Ting Kau	R3/R4	370	42	40	5	43	1544	571	65	62	8	66
	Casam	R3/R4	370	42	40	5	43	2316	857	97	93	12	100
	Sheung Sin Wan	R3/R4	370	42	40	5	43	1544	571	65	62	8	66
	Kau Tsuen	R1	240	42	40	5	43	5404	1297	227	216	27	232
	Pai Min Kok A	R3/R4	370	42	40	5	43	5404	1999	227	216	27	232
	Pai Min Kok B	R3/R4	370	42	40	5	43	5404	1999	227	216	27	232
	Yuen Tun B	R3/R4	370	42	40	5	43	3088	1142	130	124	15	133
	Yuen Tun A	R3/R4	370	42	40	5	43	19298	7140	811	772	96	830
	TOTAL							**44000**					
Employees	Office, shops & service		60	34	34	4	35	3500	210	119	119	14	123
	Commercial activities		290	53	25	1	0	500	145	27	13	0	0
	Industrial		60	34	25	3	28	0	0	0	0	0	0
Visitors	Beach goers		2.4	1.2	1.2	0.9	1.9	50000	120	60	60	45	95
Industry	Garden Bakery								0	0	0	0	0
	San Miguel Brewery								0	0	0	0	0
	Union Carbide								0	0	0	0	0
TOTAL									**16053**	**2054**	**1952**	**279**	**2110**
CONCENTRATION										**128** (mg/l)	**122** (mg/l)	**17.4** (mg/l)	**13.1** (MNr/100ml)

2.25 Within any diurnal period, the flow varies from hour to hour, usually peaking during late morning and late evening. A diurnal peaking factor (DPF), equal to the maximum hourly-average flow rate divided by the daily-average DWF, characterises the maximum flow. According to report [3], drainage areas of a similar size to Sham Tseng are characterised by a DPF usually in the range 1.53 to 1.94 depending on factors such the domestic and working patterns of the local population. Since the Sham Tseng population has a large commuting component, the DPF is likely to have a value at the high end of the scale.

2.26 Further flow variation occurs owing to the infiltration of surface storm water. Depending on factors such as housing density and the number of illicit sewer connections carrying storm water, the infiltration peaking factor (IPF), equal to the maximum hourly-average flow rate of infiltrated water divided by the ADWF, is typically less than 0.4 but, in some areas, has been found to be greater than 2.

2.27 It follows that an overall peaking factor (OPF) equal to the maximum hourly-average flow rate occurring at any particular time divided by the ADWF, is given by:

$$OPF = SPF.DPF + IPF.$$

2.28 Substituting 1.17, 1.94 and 0.4 for SPF, DPF and IPF respectively gives a value of 2.7 for the OPF. This value is slightly lower than the standard value of 3.0 specified by the SDD for treatment works of the size to be provided at Sham Tseng.

2.29 In this study, full treatment is provided for flows up to 3xADWF and preliminary treatment for flows between 3xADWF and 4xADWF. There is no provision for flows greater than 4xADWF.

Loads

2.30 Maximum hourly-average load is assumed to twice the average.

Sewerage Peaking Factors

2.31 Peaking factors for designing sewerage and pumping stations are given in the DSD manual {2} and listed in Table 2.2 The overall factors are relevant to this study.

Table 2.2 : Values of Sewerage Peaking Factors

Population size	Peaking factor	
	Overall	Without stormwater
<1 000	8	6
1 000 to 5 000	6	5
5 000 to 10 000	5	4
10 000 to 50 000	4	3

[3] Sewage Strategy Study, prepared for Hong Kong Government EPD by Watson Hawksley Consulting Engineers, November 1989

Minimum Flows

2.32 Minimum flow is a pertinent design parameter since it determines the maximum retention time in sewers and treatment processes. Such retention times influence, for example, the production of odorous gases.

2.33 Six sample patterns showing the diurnal variation in sewage flow are given in paper [4]. These show that the minimum night flow occurring typically between 03:00 and 05:00 varies between virtually zero up to 0.57DWF with an average of 0.31DWF. In the largely residential area of Sham Tseng the minimum night flow is likely to be comparatively low and a value of 0.15ADWF will be assumed.

Sewage Temperature

2.34 Sewage temperature is a major design parameter since it controls the rate of the biochemical reactions occurring in process units and sewers. The temperature is assumed to vary between 20°C in winter and 28°C in summer.

[4] Leung CT and Tai TH, *Operation and Maintenance Experience of Wastewater Treatment Plants in Hong Kong*, presented at the Joint Seminar for World Environment Day, HK University, May 1987

3. WATER QUALITY STANDARDS

3.1 Treatment of the sewage at the works will be supplemented by further treatment and dispersion of the residual pollution in the sea. The water quality standards or objectives controlling the overall degree of treatment relate to the mixture of the effluent and the sea water at the periphery of the mixing zone and are reproduced in Table 3.1

3.2 The following reviews these standards, comparing them with the current actual water quality to determine the implications for treatment at the prospective works. Actual water quality expressed in terms of measured values of the relevant pollution parameters has been taken from the latest publication of *Marine Water Quality in Hong Kong, 1992.*

Table 3.1 : Water Quality Objectives

Pollution parameter		Value
E coli	Geometric mean[1] at any position inside water-sport and fish culture areas	<610 per 100 ml
	Geometric mean[1] at bathing beaches	<180 per 100 ml
Inorganic N	Averaged value[1] at any position on periphery of mixing zone	<0.4 mg N/l
Un-ionized ammonia	Maximum value at any position on periphery of mixing zone	<0.021 mg N/l
pH value	Instantaneous value at any position on periphery of mixing zone	6.5 to 8.5
Dissolved oxygen	Minimum depth-average value at any position in fish culture area	>5 mg/l
	Minimum depth-average value at any position on periphery of mixing zone	>4 mg/l
	Minimum value within 2 m of sea bed	>2 mg/l
Note[1]: Refers to long-term or annual values		

<u>Review of WQOs</u>

Biological Standard

3.3 Standards for *E coli* which serve as an indicator for other more potentially harmful pathogens are specified primarily to protect bathers and consumers of marine food from infection. Two standards defined in terms of geometric mean concentrations are specified, one for the bathing beaches and the other for the water-contact sports and fish culture areas. At Sham Tseng, the bathing beach standard will be controlling since the concentration specified in this standard is lower and, unless the marine outfall pipe is extremely long, dispersion of the treated effluent in the sea water will be lower at the beaches than at the contact sport and fish culture areas.

3.4 Table 3.2 compares *E coli* concentrations measured in samples of sea water taken from three beaches, namely Gemini, Anglers' Reach and Lido, and from two water-quality sampling sites, namely NM1 and WM4. Gemini and Anglers' Reach are the two nearest beaches and NM1 and WM4 the two nearest sampling sites to the prospective works. Anglers' Reach is the most polluted of the beaches in the area, probably because a polluted nullah discharges to the sea nearby. Lido Beach is the least polluted. The data for the beaches, provided by the EPD, pertain to the period 04 Jan 94 to 14 Sep 94.

3.5 The comparison shows that none of the beaches currently complies with the *E coli* standard presumably owing, at least partly, to the pollution from Sham Tseng sewage which currently discharges untreated into the sea.

3.6 Geometric mean concentrations of *E coli* at the water quality sampling locations, NM1 and WM4, are 49 Nr/100 ml and 122 Nr /100 ml respectively. The higher count found at WM4 can probably be directly attributed to the discharge of sewage from Sham Tseng and Ma Wan. The count found at NM1 typifies the minimum values found in the coastal waters around this area and is probably close to the background level. On this basis, the current background level in the coastal water off Sham Tseng is assumed to be 40 Nr /100 ml expressed as a geometric mean. Given the typical relationship of a factor of 2 between the geometric and arithmetic means, the background level expressed as an arithmetic mean is roughly 80 Nr/100 ml. In the long term, the background level will presumably decline as more of the sewage produced by neighbouring communities in HK is treated before discharge.

Table 3.2 : Comparison between Water Quality *E coli* Standards and Measured Values

Sampling station		*E coli* concentration (N/100 ml)			
		Min	Geometric mean	Arithmetic mean	Max
WQO	Beaches	-	<180	-	-
	Other controlled areas	-	<610	-	-
Lido beach		43	195	289	1800
Gemini beach		29	257	495	2500
Anglers' beach		19	720	1630	10 000
NM1		20	49	-	110
WM4		15	122	-	1200

pH Standard

3.7 Table 3.3 compares the pH values, nitrogen concentrations and DO values specified in the WQOs with values measured at NM1 and WM4. The measured values vary over a range presumably owing to the activity and growth of algae. Maximum pH values occur during the summer months when algal activity is highest.

3.8 The minimum value measured at the two sites is 7.3 which is safely above the minimum value of 6.3 specified in the WQO. However, the maximum measured value of 8.3 is very close to the maximum value of 8.5 allowed by the standard. Thus, a treatment process like lime treatment involving the elevation of sewage pH value will put at risk compliance with the pH standard unless the treated effluent can be either neutralised before discharge or sufficiently diluted after discharge.

Table 3.3: Values of Physical Pollution Parameters Measured at Various Stations

Station	pH	Nitrogen (mg N/l)			DO (% sat)	
		Unionised NH_3	Total Inorganic	Total	Surface	Bottom
WQO	(6.5 to 8.5)	<0.021	<0.4	-	>55	>22
NM1	7.9 (7.6 - 8.1)	-	0.48 (0.15 - 0.78)	0.73 (0.10 - 1.15)	102 (75 - 137)	100 (75 - 137)
WM4	8.0 (7.7 - 8.3)	-	0.32 (0.13 - 0.68)	0.74 (0.36 - 1.81)	86 (67 - 127)	87 (62 - 136)
Note: All concentrations are arithmetic means						

Nitrogen Standards

3.9 With regard to nitrogen, the WQO specifies two standards; compliance with the standard for inorganic nitrogen safeguards against algal growth, and compliance with the standard for unionized ammonia safeguards the health of fish.

3.10 The unionised ammonia concentration in water is approximately related to the total ammonia concentration by

$$R = 1 + 10^{(10.055 - 0.0324T - pH)} \quad 3.1$$

where R is the ratio of total to unionised ammonia, T is water temperature (°C) and pH refers to the value of the water in the gills of fish rather than in the bulk. Owing to the production of CO_2 by fish in their gills, the gill pH value is always slightly less than the value in the bulk value, especially when the water is slightly alkaline. Although Equation 3.1 is specifically applicable to fresh water, it is sufficiently accurate to be used for the purpose here.

3.11 The worst-case value of R, that is the minimum value giving the highest concentration of unionised ammonia, arises when the values of pH and T are high.

3.12 As explained previously, sea water pH in the coastal waters around Sham Tseng varies between about 7.6 and 8.3. On this basis, assume the maximum value in the gills is 8.0. Since the high pH values occur during summer when algal activity is high, they coincide with high water temperature. Substituting a pH value of 8 and a temperature of 28°C into Equation 1 gives a worst-case R value of 15.0. Thus, a value of 0.021 mg N/l specified in the WQO for unionised ammonia is approximately equivalent to a total ammonia concentration of 0.31 mg N/l. By comparison, the value of the Total Inorganic N concentration specified in the WQO is 0.4 mg N/l. Since most of this N can be assumed to be in the form of NH_4-N rather than NO_3-N, it follows that compliance with the unionised ammonia standard will automatically provide compliance with the Total Inorganic N standard.

3.13 The average concentrations of Total Inorganic N measured at NM1 and WM4 are greater than 0.31 mg/l, and the maxima are more than twice this concentration. Also, the Total Inorganic N concentrations measured at NM1 and WM4 are not compliant with the standard of 0.40 mg N/l. Similarly, Total Inorganic N concentrations measured at sampling sites to the east of the prospective works (and elsewhere in the coastal water around Hong Kong) are equally high indicating that the concentrations measured at NM1 and WM4 are close to the background levels. Such concentrations indicate a high degree of pollution, probably from industrial effluents, and the major source of this pollution is probably the Pearl River. Thus, any reduction in the discharge rate of nitrogen stemming from treating sewage at Sham Tseng sewage will not significantly reduce the level of nitrogen pollution in the coastal water.

Dissolved Oxygen Standard

3.14 The current values of DO at NM1 and WM4 are high compared with the values specified in the WQO. Even if treated effluent containing little or no dissolved oxygen is discharged from the prospective works, the dilution in the primary mixing zone will be sufficient to obtain compliance with this standard.

Implications of WQOS for Treatment

3.15 The review of the WQO's and the current concentrations of pollutants in the coastal waters around Sham Tseng has indicated that treatment at the prospective works will have to address, in particular, *E coli* and possibly nitrogen removal. The following investigates the implications for the quality of the works' effluent.

Nitrogen Standard

3.16 It has previously been shown that the coastal waters around Sham Tseng currently contain inorganic nitrogen concentrations well above the WQO values owing to the pollution load in the Pearl River. In the short term, any removal of nitrogen from Sham Tseng sewage will have little or no impact on water quality. Within the time horizon of the treatment works, however, the nitrogen load in the Pearl River is expected to decline as environmental improvements continue to be implemented in China. Eventually therefore, the removal of nitrogen from Sham Tseng sewage may make a crucial contribution to the alleviation of nitrogen pollution in the immediate coastal waters. Accordingly, the assumption is made here that nitrogen removal is included in the treatment. To obtain compliance with both the unionised ammonia and the Total Inorganic N standards, any NO_3-N as well as NH_4-N should be removed.

***E coli* Standard**

3.17 Compliance with the *E coli* standard will be obtained by a combination of treatment and dispersion.

Position of Outfall

3.18 The sea off the southern boundary of the prospective reclaimed area is about 18 m deep increasing to a maximum of about 40 m in a depression at a distance of about 400 m, that is, in mid-channel between Sham Tseng and Ma Wan. Dispersion of the effluent could probably be maximised by locating the diffusers (at the end of the outfall pipe) in this depression. However, in the direction from Sham Tseng to Ma Wan, the sea bed changes from colluvium rock to hard granite. Although comprehensive bore-hole data on the bed in the vicinity of the prospective reclaimed area is not yet available, it seems likely that the southern tip of the reclaimed area will be over the granite. Thus, the options of burying the outfall pipe in a trench or enclosing it in a tunnel are precluded on economic grounds. The only viable alternative is to lay the pipe on the sea bed, fixing it in position with concrete collars or some similar system. However, this method obstructs the sea bed so that the pipe may foul anchors and fishing nets. Thus, irrespective of the method used for the installation, the outfall pipe is likely to be relatively short, say, less than 250 m. At this distance offshore, sea depth is about 25 m.

Dispersion in Sea

3.19 The dispersion and treatment provided by such an outfall arrangement will, of course, depend on factors such as diffuser layout and the diurnal pattern of current velocity. Until data are available from the mathematical modelling of the dispersion, assumptions have been made to provide an estimate of the concentration of *E coli* necessary for compliance with the WQO. As previously explained, the standard specified for the beaches rather than for the other controlled areas will be controlling.

3.20 Given the inshore position of the pipe, it is assumed that the dispersion will be confined to a primary mixing zone and that the reduction of *E coli* concentration due to die-off will be small compared with the reduction due to the dispersion. To a good approximation, the (arithmetic) average concentration, C_a, of *E coli* at the beaches will then be given by

$$C_a = C_e/D + C_b \qquad 3.2$$

where C_e is their average concentration in the works' effluent, C_b is their average background concentration and D is the average dispersion.
Dispersion has been calculated on the basis of the information given in the *WRc Design Guide for Marine Treatment Schemes, May 1990* which gives the formula

$$D = 0.3\ U\ H^2/Q \qquad 3.3$$

where U is the current velocity, H is water depth and Q is the flow through each diffuser. Current velocities in the coastal waters off Sham Tseng reverse with the ebb and flood of the tide, the magnitude varying from zero at slack tide up to maximum of about 0.8 m/s at the location of the diffusers. Assume an average velocity of 0.4 m/s. Also assume a diffuser configuration comprising four segregated diffusers. It follows that, for a water depth of 25 m and an ADWF of 16 000 m3/day, the average dilution ratio resulting from the primary dispersion will be about 1000:1.

E coli in Works' Effluent

3.21 The background level of *E coli* has been determined to be roughly 80 Nr/100 ml. It may be further assumed that the geometric mean of 180 Nr/100 ml specified in the WQO is equivalent to an arithmetic mean concentration of 360 Nr/100 ml. Substituting these concentrations into Equation 3.2 suggests that the average concentration of *E coli* in the treated effluent from the works needs to be less than 280 kNr/100 ml. By comparison, the average concentration of *E coli* in the sewage is 13.2 MNr/100 ml. Thus, including a safety factor of say 2, the *E coli* concentration must be reduced by a factor of at least 100, equivalent to a removal of 99%.

pH Standard

3.22 The pH standard has to be taken into account only if the treatment involves a pH excursion. Since the only common form of treatment which falls into this category is associated with adding lime to the sewage, the implications are reviewed later in the section on lime treatment.

4. OVERVIEW OF WORKS' TREATMENT OPTIONS

4.1 The following reviews the various treatment options to provide a shortlist for a more detailed investigation.

Treatment Requirements

4.2 Some of the treatment requirements for the prospective works have been derived in Section 3. Other requirements apply generally to virtually all sea outfalls, while others stem from the constraints on treatment specified by the HK Drainage Services Department (DSD). The major requirements are listed as follows.

(a) the *E coli* concentration must be reduced by a factor of at least 50;

(b) nitrogen should preferably be removed from the sewage;

(c) the pH value of sea water at periphery of mixing zone must be between 6.5 to 8.5;

(d) the treated effluent must not contain any solids which may settle and accumulate on the sea bed, risking the health of the benthos. Similarly, the effluent must not contain significant concentrations any toxic metals or organic compounds;

(e) the effluent must not produce a visible plume in the sea;

(f) the sludge produced at the works must be disposed of to a landfill, in the form of a cake containing solids at a concentration of at least 30 w/w%;

(g) no odours or air emissions must be perceived inside and outside the works;

(h) no odours must be perceived during the transport of the cake to the landfill site; and

(i) the treatment technology should be established and have a proven performance record.

4.3 The first two of these requirements have been derived from the review of the WQOs and requirement (c) is reproduced from the WQOs.

4.4 Requirements (d) and (e) are generally applicable.

4.5 Requirement (f) is a DSD specification made so that the cake can be conveniently handled at the landfill site. An implication is that for most treatment processes, especially those producing a biological sludge, a filter press will be needed to dewater the sludge.

4.6 Requirements (g) and (h) arise because the works will be constructed in an environmentally sensitive area. On the same note, the view of the works must be aesthetic, which will almost certainly require the works to be enclosed in a building. Such a requirement will favour treatment processes with small footprints. Although the architecture of the building is not investigated in this part of the study, an allowance is made in the costings for a building of suitable constructed. An implication of

Requirement (i) is that the raw sludge should preferably be stabilised or disinfected before transport from the works.

4.7 Requirement (j) eliminates the consideration of options which may have uncertain performance or costs.

Appraisal of Treatment Options

4.8 Table 4.1 lists the major treatment options which largely comply technically with the requirements, giving the advantages and disadvantages. Although not shown in the table, each option would be preceded by preliminary treatment comprising screening, grit removal and, in some cases, grease removal. Similarly, odour control and pumping are not included in the table.

4.9 Of the options, lime-assisted sedimentation can probably satisfy all the requirements with the possible exception of (c). This particular option has attracted much attention in previous studies and seems to have become a yardstick for comparison against other types of treatment. Accordingly, lime treatment is included for further investigation.

4.10 *Full* treatment comprising primary sedimentation, biological treatment and disinfection can safely satisfy all the requirements. This type of treatment can take several forms depending on the processes involved and type of plant provided for each.

4.11 Primary sedimentation may be provided in the form of conventional tanks, lamella separators or *Swirlflo* tanks and may be implemented with or without the assistance of flocculating chemicals such as iron salts and polyelectrolytes. To reduce the number of options, lamella separators are specified for this study on the basis that they have the smallest footprint. Also, the study assumes that no flocculating chemicals would be used, although this might lead to a smaller overall footprint for the works.

4.12 The forms of biological treatment considered here are the activated sludge process and submerged aerated filtration. At this stage of the evaluation, it is not clear which options would be technically or financially more attractive so that both are investigated further.

4.13 The effluent from biological treatment could be disinfected by adding chemicals such as chlorine/hypochlorite, ozone or lime, by filtering through microsporous membranes or by UV radiation. For the size of works at Sham Tseng, UV radiation will almost certainly be the most cost-effective environmentally-friendly option and is therefore specified in the design.

Shortlist of Preferred Options

4.14 Table 4.2 gives the short-list of preferred options. These options are investigated further by preparing flowsheets and layouts and then determining the capital and operating costs.

Table 4.1 : Technical Appraisal of Treatment Options

Main treatment stages			Comments	
First	**Second**	**Third**	**Advantages**	**Disadvantages**
Chemically-assisted primary sedimentation			(a) Very small footprint if lamella sedimentation used	(a) Non-compliance with (i) and (ii)
Chemically-assisted primary sedimentation	Disinfection by chlorination		(a) Very small footprint	(a) Non-compliance with (ii) (b) Dosing of Cl^- environmentally questionable
Chemically-assisted primary sedimentation	Disinfection by membrane filtration		(a) Very small footprint if lamella sedimentation used	(a) Non-compliance with (ii) (b) Non-compliance with (ix)
Lime disinfection	Desorption of NH_3		(a) Small footprint	(a) Non-compliance with (iv) (b) Possible non-compliance with (iii) and (v) (c) Scaling problems
Lime-assisted sedimentation	Desorption of NH_3			(a) Possible non-compliance with (iii) (a) Scaling problems (b) Increased sludge production
Primary sedimentation	Biological filtration	Disinfection		(a) Large footprint
Primary sedimentation	Activated sludge	Disinfection	(a) Well established process	
Activated sludge	Disinfection			(a) Non-compliance with (vii)
Sequential batch AS	Disinfection			(a) Non-compliance with (vii) (b) Limited operational experience
Primary sedimentation	Submerged aerated filters	Disinfection	(a) Small footprint	

Table 4.2: Shortlist of Preferred Treatment Options

Number	Treatment
1	Lime-assisted sedimentation with desorption of NH_3
2	Primary sedimentation (lamella separation) followed by actived sludge and then by UV disinfection
3	As for 2 but using submerged aerated filters for the biological stage

5. PROCESS ENGINEERING OF TREATMENT OPTIONS

5.1 The following describes the main process features of the three preferred options, presenting for each option:

- calculation sheet;
- flowsheet; and
- layout plan.

Calculations and Drawings

Calculations

5.2 All the calculation sheets listing the assumptions and the major design criteria are presented in Appendix A. Each sheet, essentially a Lotus 1-2-3 Spreadsheet, gives the values of the various characteristics of the streams entering and leaving the treatment stages. Also, the sheets are interactive allowing the effect on performance of design changes or different assumptions.

Flowsheets

5.3 Flowsheets for the treatment options are presented at the back of the report. Drawings 1.1 to 1.5 are the flowsheet for Option 1 (lime treatment); Drawings 2.1 to 2.5 are the flowsheet for Option 2 (activated sludge) and Drawings 3.1 to 3.5 are the flowsheets for Option 3 (submerged filters). Drawing 1.0 is the common legend for all the flowsheets.

5.4 The flowsheets have been prepared to define treatment logic and for costing purposes. They were not intended for use in future detailed design. Values of stream characteristics and plant sizes are given in the calculation sheets.

Layouts

5.5 Layouts are also presented at the back of the report. Drawings 01, 02 and 03 are the layouts for Options 1 to 3 respectively.

Common Features between Options

5.6 The three treatment options have features in common; these are described as follows.

Sewage Flow

5.7 A pumping station lifts the sewage into the screens installed on an elevated platform. The main stream then flows by gravity through the treatment stages to an outfall pumping station.

5.8 The loss in hydraulic head over the works depends on the treatment option, the approximate values being 1.5 m, 2.5 m and 3 m for Options 1, 2 and 3 respectively. Such differences are accommodated by varying the elevation of the screens and final pumping station. The effect of such differences in head loss on the cost of pumping has been taken into account.

5.9 Any flow greater than 3xADWF bypasses treatment after screening and grit removal, flowing directly to the outfall pumping station.

Screens

5.10 The same type of moving-band screen is specified in each option. To eliminate operational problems, such as ragging of valves and instrumentation, and to minimise the risk of visible debris appearing in the treated effluent, the screens have an aperture size of about 6 mm.

5.11 The screening plant comprises two machines comprising duty and automatic standby, supported by a manually-raked 15 mm bar screen on an overflow. Capacity of each screen is 4xADWF.

5.12 The screenings are cleaned and then dewatered in a Jones & Attwood *Washpactor* or similar plant. In contrast to most screenings handling machinery, this type is capable of cleaning and then dewatering screenings into solid product without the prior need to comminute the screenings. The *Washpactor* is also reliable and cost-effective. The screenings would be deposited in a skip for transport to a landfill site.

Sludge Treatment

5.13 The sludge in all options is thickened by gravity and then dewatered in conventional chamber presses, producing cakes containing dry solids at a concentration of at least 30 w/w% suitable for disposal at a landfill site.

5.14 After release from the chambers, the cakes from each press travel on a conveyor belt fitted with a swivel end to one of two 6 m^3 skips. The number of skips either in place by the presses or on the road is equal to twice the number of presses. Disposal trucks fitted with an on-board loading and off-loading mechanism carry the skips to and from the landfill site.

5.15 Storage is also provided between the thickeners and the presses. A capacity of 4 days provided in two tanks allows the works to be run with little or no manning for short holiday periods.

Odour Control

5.16 As previously explained, the risk of odour nuisance is virtually eliminated by enclosing the works in a building. The strategy for controlling odours is as follows.

- Process units having the potential to produce odour are either covered or separated into rooms and the enclosed air space ventilated to an odour control plant, from where the cleaned air is discharged to a stack.

- Open space inside the building outside the covered areas is force ventilated but the air is not scrubbed.

5.17 This strategy minimises the cost of the ventilation and scrubbing system as well as the residual concentration of the odorous gases in the emission. The stack is placed on the roof of the building.

5.18 The odour control plant has been designed with two stages to remove H_2S and similar compounds. The first stage is a bioscrubber capable of reducing the H_2S concentration in the ventilated air to a concentration of about 100 to 200 ppb (v/v); the second stage is a fixed granular bed containing, for example, *Purafil* and capable of reducing the concentration to about 10 to 20 ppb. Atmospheric dispersion then reduces the concentration below the detectable limit.

5.19 Table 5.1 lists the air-change rates which have been used for calculating ventilation rates and the sizes of the components in the odour control plant.

Table 5.1 : Air-change Rates

Plant	Nr/hour
Covered sewage and sludge tanks	1
General space inside building	4
Inlet pumping station	4
Cowlings for screens	4
Lamella room and filter press area	6

Layout

5.20 For each option, treatment layouts have been compacted to reduce works' footprints and hence the size and cost of the building. The building is located adjacent to the southern perimeter of the reclaimed area to maximise the size of the buffer area between the building and the main inhabited areas.

5.21 Delivery and disposal vehicles would visit the building via a road running along the eastern and southern perimeters of the reclaimed area, disposal vehicles for the sludge, grit, and grease gaining entry to the building through plastic strip opening in the southern wall of the building. Chemicals including lime would be pumped from delivery vehicles outside the building to reception tanks and silos inside the building. Similarly, spent chemicals would be pumped from inside the building.

5.22 Internal roads are provided inside the buildings giving crainage access to all treatment units.

5.23 Car park and administrative areas are located on the northern side of the building, away from the delivery and disposal traffic.

<u>Lime Treatment</u>

Design Overview

5.24 Lime treatment can be implemented in several ways. The process specified in this study comprises separate flocculation and pH control tanks followed by upward flow blanket-type sedimentation tanks. Compared with conventional sedimentation without lime, the process gives a higher removal of suspended solids and a greatly enhanced removal of bacteria and other microorganisms.

5.25 The conventional pH value used for the process is 11, the value used in this study.

5.26 Ammonia may be readily air-stripped from sewage at a pH value of 11 either by bubbling air through the sewage or by passing the sewage through a packed column. An additional benefit of using bubble stripping in a desorption tank is an increased pathogen kill arising from the retention of the sewage at high pH value.

Removal Mechanisms

5.27 Two mechanisms are responsible for the enhanced bacterial removal in lime-assisted sedimentation. First, bacteria are trapped and adsorbed onto the lime floc, and, second, the increased pH value increases their death rate. Both these mechanisms are very effective when the pH value of the sewage is raised to 11.

5.28 A parameter used to quantify the death rate of pathogens is the time, T_{90}, required for 90% of the individuals to die. At a pH value of 11 and sewage temperature of 20°C, the T_{90} value for *E coli* is typically 0.5 to 1.0 hours, changing by a factor of 10 to 15 as the pH changes by one unit either side of 11. Thus, treatment at a pH value of 11 or above is needed to ensures a high degree of *kill* within the time provided by primary sedimentation.

5.29 A pH of 11 maximises the *removal* of *E coli* by causing virtually all the magnesium present in the sewage to precipitate as the hydroxide, adding to the precipitated calcium carbonate. The floc then becomes very voluminous and has good adsorption properties.

5.30 The solubility of $Mg(OH)_2$ is very sensitive to pH value. Equal to only 0.085 mg Mg/l at a pH value of 11, the solubility increases by a factor of 100 for every unit decrease in pH until the value reaches 9. Operating at reduced pH values can therefore leave significant concentrations of Mg^{++} in solution.

Sludge Production

5.31 A major problem associated with lime treatment is the increased sludge production from the precipitation of the calcium and magnesium compounds. The application of lime treatment at Sham Tseng (and many other sites in HK) will give a particularly high sludge production because sea water is used for toilet flushing. About 25% of Sham Tseng sewage is sea water.

5.32 Typically, sea water contains Ca^{++} and Mg^{++} at concentrations of about 400 mg/l and 1270 mg/l respectively. Making an allowance for their presence in the tap water as well as in the sea water, the Ca^{++} and Mg^{++} concentrations in Sham Tseng sewage have been calculated to be 110 mg/l and 325 mg/l respectively. Sewage also contains bicarbonate, typically at a concentration of 150 mg/l.

5.33 Adding lime to the sewage causes calcium carbonate to precipitate when the pH reaches about 8.3, according to the reaction:

$$Ca(HCO_3)_2 + Ca(OH)_2 = 2CaCO_3 + 2H_2O. \qquad 5.1$$

5.34 Because the Ca^{++} initially present in the sewage at Sham Tseng will exceed the stoichiometric amount, some will remain in solution. As more lime is added and the pH value reaches about 9.2, magnesium hydroxide will start to precipitate according to the reaction:

$$Mg^{++} + Ca(OH)_2 = Mg(OH)_2 + Ca^{++}. \quad 5.2$$

5.35 It follows from Equation 5.1 that 1 kg of HCO_3^- produces 1.64 kg of $CaCO_3$ precipitate and consumes 0.61 kg of $Ca(OH)_2$. Similarly, it follows from Equation 5.2 that 1 kg of Mg^{++} produces 2.40 kg of $Mg(OH)_2$ precipitate and consumes 3.05 kg of $Ca(OH)_2$. Thus, after the lime addition is complete and the pH raise to 11, the concentration of precipitate in the sewage will be 1030 mg/l comprising 23% calcium carbonate and 77% magnesium hydroxide.

5.36 Most (but not all) of this precipate will settle in the primary sedimentation tanks together with organic solids removed from the sewage. About 80% of the sewage solids will be removed, equivalent to a concentration in the sewage of about 100 mg/l. It follows that the mass of precipitated solids in the sludge will be greater by about a factor of 10 than the mass of sewage solids, increasing the volume of the sludge by a similar ratio.

Scaling

5.37 Surfaces in contact with the limed sewage and sludge will be susceptible to scaling from calcium carbonate and, to a lesser extent, magnesium carbonate. Scaling may occur for two reasons. First, primary sedimentation will not remove all the precipitated $CaCO_3$ and $Mg(OH)_2$ so that some will be carried downstream in the main flow. Second, the sewage will absorb carbon dioxide from the atmosphere causing further $CaCO_3$ to form. Exposed weirs where CO_2 can be readily absorbed are particularly vulnerable. Scaling of the outfall pipe may also be a problem, especially at the diffusers where the reaction with HCO_3^- in the sea water will cause carbonates to form.

5.38 Methods of alleviating the potential scaling problem are available. as follows:

- Sludge containing precipitate may be recycled to the flocculation tanks to promote the growth of comparatively large crystals which are less likely to adhere to surfaces;

- Polyphosphate may be dosed into the sewage at a concentration of about 0.5 mg/l to stabilise the suspended precipitate;

- Tanks and distribution boxes may be designed with submerged rather than exposed weirs; and

- The sewage may be neutralised using sulphuric acid or carbon dioxide before it enters the outfall pipe.

5.39 The first three of these methods can be implemented for a marginal cost, and sludge recirculation is included in the design. By comparison, neutralisation has major capital and operating cost implications and has not been included.

Odour Control

5.40 Two types of odorous gases will be emitted from the treatment units; H_2S and similar gases will be emitted from the preliminary units, and ammoniacal gases from all the other treatment units. Each type of gas will require a separate removal system.

5.41 The H_2S would be removed from the ventilated air using the system described previously. The ammoniacal gases would be removed using an acid scrubber. Spent acid will contain high concentrations of nitrogen and be suitable for use as a fertiliser.

5.42 A second acid scrubber will be needed to remove ammonia from the stripping air, allowing the clean air from the scrubber to be recycled to the desorption tank. Recycling of air in this way reduces the amount of CO_2 passing through the desorption tank and hence the production rate of calcium carbonate in the sewage.

pH Value in mixing zone

5.43 Discharging the treated effluent at a pH value of 11 will almost certainly cause the pH value of the sea water outside the primary mixing zone to rise above a value of 8.5 at certain times of the tide *and* year. Highest values will be obtained at slack tide in summer. The extent of the area affected by the high pH values will need to be investigated using a mathematical dispersion model.

Visibility of Plume

5.44 The formation of calcium carbonate in the sea around the diffusers could, in principle, give rise to a visible plume with a white colouration. This is investigated as follows.

5.45 The concentration of lime (including some calcium carbonate and magnesium hydroxide) in the treated effluent will be around 150 - 200 mg ($CaCO_3$)/l. At concentrations less than say 10 mg/l, the calcium carbonate should not be visible. Thus, a dilution of 20 will be sufficient to prevent visual detection and, at much higher dilutions, the calcium carbonate will redissolve. Since dilutions of at least 20 should always be obtained, even at slack tide, the plume should never be visible.

Optimisation

5.46 Operating costs for lime treatment are comparatively high owing to the high consumption rate of lime and the high treatment and disposal costs of the sludge. Such costs may, in principle, be reduced by lowering the operational pH value. Other advantages include compliance with the WQO for pH and possibly reduced scaling. However, if the pH is reduced to a value less than 10 to 10.5, ammonia stripping will not then be possible.

5.47 To make a significant saving in operating costs, the pH value must be lowered to about 9.5 when much of the Mg^{++} will remain in solution. The removal of *E coli* by flocculation would probably remain reasonably high but the kill would be negligible. Overall removal, however, may still be sufficient to obtain compliance with the WQO for *E coli*.

5.48 Provided ammonia stripping is not an essential requirement, operation at a pH value of about 9.5 should be investigated further. However, we have not been able to predict process performance under these conditions for a sewage containing 25% sea water since virtually no relevant data are available in the literature. Such data may have to be generated from pilot plant work or by making measurements at existing HK works using the same type of treatment.

Design of Treatment Units

5.49 The following describes the main process features of the treatment units.

Grit Treatment

5.50 Grit removal plant comprises two circular spiral-flow traps, each capable of handling 2xADWF. The grit is transferred from these tanks to duty and standby classifiers for cleaning. From the classifiers, the cleaned grit falls into skips for disposal.

Flocculation and pH Control

5.51 Lime slurry is dosed into the first of two flocculation tanks in series. The first tank contains a mixer for dispersing the slurry, and the second, a stirrer for promoting flocculation.

Primary sedimentation

5.52 Primary sedimentation comprises four upward-flow blanket type separators designed to give an upward velocity of 2 m/h at maximum hydraulic flow rate, with one tank out of service. Such a design gives 4 tanks, 10.5 m diameter.

5.53 Based on the best information available, the overall removals of the sewage suspended solids and *E coli* entering the treatment stage are estimated to be 80%, and 99.7% respectively. *E coli* removal safely accords with the required minimum removal of 99%.

5.54 Total production rate of sludge solids is calculated to be 18.3 tSS/day of which 89% stems from inorganic precipitate and 11% from the sewage solids.

Stripping Tank

5.55 The stripping or desorption tank provides a retention time of 1 hour at ADWF. Owing to the potential scaling problem, a coarse-bubble is specified. As previously explained, the stripping air is recirculated through the desorption tank and acid scrubber to minimise the amount of CO_2 passing through the tank. The concentration of inorganic nitrogen in the effluent is estimated to be 1.2 mg/l, all in the form of NH_4-N.

5.56 The extra disinfection in the desorption tank reduces the *E coli* concentration in the effluent to 4 kN/100 ml, giving a total reduction ratio of over 3 000.

Sludge Thickening

5.57 The continuous sludge thickeners are designed at a specific surface area of 20 m^2.day/tSS, giving four tanks, 11 m diameter. Concentration of the thickened sludge is assumed to be 5 w/w%.

Filter Pressing

5.58 Filter presses produce a cake with a solids concentration of 35 w/w%. For a plate size of 1.5 m by 1.5 m and a chamber thickness of 32 mm, three presses each containing 88 plates are required. A polyelectrolyte conditions the sludge.

5.59 The cakes are deposited into 6 m^3 skips for disposal.

Lime Storage

5.60 Lime consumption is estimated to be 20.8 t $Ca(OH)_2$/day. The largest silo which can be readily accommodated in building has a capacity of 33 t of slaked lime. The provision of 5 days storage to cover for interruptions in supply and holidays will require three silos.

Activated Sludge

Design Overview

5.61 The activated sludge works would use mostly conventional processes to produce a disinfected denitrified effluent.

5.62 The only aspect of the treatment not commonly found in practice is the combination of lamella separation for primary treatment with activated sludge. However, such a combination is technically sound and has been used previously in France and probably elsewhere.

5.63 Like Option 1, lime is used but only for disinfecting and stabilising the sludge. Lime consumption is consequently reduced by more than an order of magnitude.

Design of Treatment Units

Grease and grit removal

5.64 Generally, the use of lamella separators in primary treatment requires the prior removal of grease as well as grit. Two conventional aerated channels, 3 m wide by 21 m long are specified for the duty.

5.65 Grit removed from the sewage is cleaned in a classifier and then deposited in a skip for disposal. The separated grease is pumped to another skip.

Lamella Separation

5.66 Several proprietary lamella separators are commercially available from international companies such as OTV and Degremont in France and Biwater, PWT, John Brown Engineering and Water Engineering in the UK. Components such as lamella, weirs and sludge scrapers can also be purchased separately from several suppliers.

5.67 A conventional process design has been used, that is an upward velocity of 1.2 m/h at maximum flow on the vertically-projected area of the plates. Four tanks, 4 m by 16 m are required.

Activated Sludge

5.68 The aeration tank has a capacity of 3240 m^3 and depth of 6 m. It is configured into four lanes, each separated into three zones, headed by a common anoxic zone. Four clarifiers, 22.4 m diameter, are required.

5.69 Nitrate recycled with the clarifier underflow is removed in the anoxic zone. Further nitrate is removed by recycling mixed liquor from the end of the aeration lanes to the anoxic zone at a rate of up to 2xADWF. When recycling at the full rate, the Total Inorganic N concentration of the treated effluent is predicted to be 6.0 mg/l of which 1.5 mg/l is NH_4-N. If necessary, implementation of the internal recycling could be deferred until the removal of NO_3-N becomes beneficial to water quality.

5.70 Average power consumed for aeration is 52 kW.

Disinfection

5.71 The UV has a power rating of 40 Wh/m^3 which is sufficient to reduce the average *E coli* concentration in secondary effluent by a ratio of about 500, giving an average concentration in the works' effluent of about 1 kN/100 ml. The overall reduction in *E coli* over the works is therefore equal to a factor of more than 13 000.

5.72 The UV plant has four separate lamp units comprising three duty and one standby. Average power consumption is 40 kW.

Lime Stabilisation

5.73 A lime dose of 10 w/w% (CaO/SS) is sufficient to raise the pH of the sludge to a value of about 11 for a few days, minimising the risk of odour nuisance inside and outside the works and of operatives and others contracting an infection. Any ammonia liberated from the sludge in the various process units is vented to the bioscrubber where most would be removed.

5.74 Lime consumption is 0.34 t $Ca(OH)_2$/day, requiring only one small silo for storage. The lime is dosed into the thickener feed pipe.

Sludge Thickening

5.75 Two continuous consolidation tanks, 7.3 m diameter, thicken the mixed sludge to a solids concentration of 6 w/w%.

Filter Pressing

5.76 Only one filter press comprising 72 plates, 1.3 m by 1.3 m, with a chamber thickness of 32 mm is required. Three pressings would be performed daily, and the cake transported from site in 6 m^3 skips.

Submerged Aerated Filtration

Design Overview

5.77 Submerged aerated filtration is the newest form of treatment under consideration. Developed in France in the 1970's the process has become widely established in many countries. Interest in the process has developed largely because its footprint is comparatively small. Some systems need clarification tanks to produce a high quality effluent; these have not been seriously considered for this application owing to the increased size of the footprint.

5.78 Many filter systems are commercially available, each with unique features. The theme common to all the systems is that the process stream flows through a submerged bed containing a medium with a high surface area. Air bubbles created at the foot of the bed pass upwards through the bed, providing oxygen for the biochemical reaction occurring in the biofilm attached to medium surface. Collection of solids in the bed and the growth of the biofilm increases the hydraulic resistance over the bed. When the hydraulic resistance increased beyond a certain threshold, the bed is backwashed and intensely aerated to remove the accumulated matter and restore the permeability.

5.79 Differences between proprietary systems include:

- the direction of flow through the bed, whether up or down; and
- the nature of the medium, whether particulate or modular.

5.80 Only one system has been evaluated in this study, namely the *Biopur Process* which is supplied by John Brown Engineering. The choice of this process is not intended to indicate that this particular process is superior.

5.81 A unique feature of *Biopur* is that the modular medium can be stacked to a depth of 6.5 m, whereas other types are limited to a depth of about half this value. An implication of this increased bed depth is that, for certain applications, the footprint size of Biopur is comparatively small, even for submerged filters. The effect of this small footprint on the overall size of the works and costs is investigated in this study.

5.82 Very little information is available on the removal of *E coli* in submerged filters. Filtration inside the bed will contribute to the removal of *E coli*, but the short retention time will reduce the loss through death. In the absence of reliable information, a reduction of 90% is assumed. For comparison, the reduction assumed for the nitrifying activated sludge plant in Option 2 is 95%.

Design of Treatment Units

5.83 Apart from secondary treatment, the design and sizes of the treatment units are very similar to those specified for the activated sludge option.

Submerged Filters

5.84 The submerged filters comprise two stages in series, an anoxic stage comprising 4 filters followed by an aerobic stage comprising 5 filters. All the filters are the same size, that is 3 m wide by 7.8 m long by 6.5 m deep.

5.85 The aerobic filters oxidise 90% of the NH_4-N producing an effluent containing NH_4-N at a concentration of 1.8 mg/l. Effluent from the aerobic filter is recycled at a rate of 2.5xADWF to the inlet of the anoxic filters which remove 70% of the NO_3-N, giving a NO_3-N concentration in the effluent of 5 mg/l.

5.86 Both the aerobic and anoxic stages are aerated. The amount of oxygen in the air supplied to the anoxic stage is, of course, less than the biochemical oxygen demand, otherwise the NO_3^- is not reduced. This oxygen is required to remove some of the solid matter which collects in the bed thereby increasing the time between backwashings.

5.87 Average aeration power is 67 kW which, because of the lower aeration efficiency, is 29% higher than the power in Option 2.

UV Disinfection

5.88 The UV unit is identical to that specified in Option 2. Average concentration of *E coli* in the works' effluent is 2 kN/100 ml, equivalent to an overall reduction of 6 500.

Sludge Treatment

5.89 Sludge treatment is virtually identical to that specified for Option 2.

Size of Works

5.90 Sizes of the footprints for three options have determined from the layout plans given in Drawings Nos 01, 02 and 03. Table 5.2 summarises the findings; the metalled area refer to the roads, car parks and hardstandings.

Table 5.2: Sizes of Works Footprints for the Three Treatment Options

Option	Size of areas (hectares)			
	Reclaimed	Building	Metalled	Buffer
Lime treatment	4.46	0.48	0.52	3.46
Activated sludge	4.46	0.58	0.52	3.36
Submerged filters	4.46	0.32	0.47	3.67

5.91 The findings show that the footprints of all the treatment buildings are small compared with the size of the reclaimed area. It follows that the size of the building is unlikely to be an environmental issue in any of the options, although the size affects the cost and possibly the economic ranking of the option. Option 3 has the smallest footprint and Option 2 the largest.

6. ECONOMIC EVALUATION OF OPTIONS

6.1 The following explains how the capital and operating costs of the three options have been derived and makes a comparison between the costs to determine the most cost-effective option.

Derivation of Capital Costs

6.2 Civil and mechanical engineering costs have been derived from information obtained from the following sources:

- Spon's Price Books for Architects and Builders, Mechanical and Electrical Services and for Civil Engineering and Highway Works, 1994
- WRc Reports TR61 and UC1491
- quotations provided by plant suppliers
- cost data from similar schemes.

6.3 No account has been taken of any special geotechnical problems that could significantly affect the cost of constructing the treatment units or the building.

Derivation of Operating Costs

6.4 Operating costs have been derived for staffing, maintenance, electricity and water, chemicals, cake transport and landfill charges. Table 6.1 lists the unit cost data.

Table 6.1: Unit Costs for Consumables and Other Items

Item	Unit cost
Electricity	HK$ 0.6/kWh
Water	HK$ 6/m^3
Lime (90% $Ca(OH)_2$)	HK$ 600/t
Solid grade polyelectrolyte	HK$ 36/kg
96% Sulphuric acid	HK$ 600/t
Transport of cake	HK$ 50/t
Landfill charge	HK$ 200/t
Supervisor salary inc. on-costs	HK$ 480 000/year
Operator and technical salary inc. on-costs	HK$ 270 000/year

6.5 Staffing, assumed to be the same for each option, comprises 3 operatives, a technical officer and a supervisor.

6.6 Cost of maintenance covering labour and replacement plant is assumed to be a percentage of the cost of the mechanical plant as follows:

Lime treatment	4%
Activated sludge	4%
Submerged filtration	6%.

6.7 The higher percentage for submerged filtration reflects the increased cost of maintaining the high number of values, pumps and blowers.

6.8 Electricity and chemical consumption for the various treatment units are given in the calculation sheets. Minor electricity consumption arising from small motors less than 1 kW has not been included in the calculation.

6.9 Cake transport and disposal costs have been assumed to be directly proportional to the cake production rate.

Comparison of Costs

6.10 Appendix B gives the detailed results of the costings. Tables B1.1 to B1.3 list the results for Option 1, giving breakdowns of capital costs, operating costs and electricity consumption respectively. Similarly, Tables B2.1 to B2.3 and Tables B3.1 to B3.3 list the results for Options 2 and 3.

6.11 Net Present Costs for each option have been calculated assuming an accounting period of 40 years, discount rates of 5%, 7.5% and 10% and lifetimes for the civil and M&E plant of 40 years and 20 years respectively. Table 6.2 summarises all the results, giving breakdowns for the capital and operating costs and the results of the NPC calculations.

Capital Cost

6.12 The results show that the Option 1 has the lowest capital cost and Option 2 the highest, although the difference between these costs is 14%. Option 3 has the highest Civil and M&E costs but these are compensated by the low cost of the building associated with this option.

Operating Cost

6.13 Operating costs of Option 1 are more than twice those of the other two options, largely owing to the costs of the lime and the landfill charges which respectively account for 44% and 24% of the total operating costs for this particular option. The cost of cake transport is also substantial in this option, amounting to 6%.

6.14 Option 2 has lower operating costs than Option 3 owing to the lower maintenance and aeration costs.

Net Present Cost

6.15 The NPC calculations indicate that the overall costs of Options 2 and 3 are very similar, and, given the accuracy of the derived costs, the difference between these costs is probably not significant. However, the overall cost of Option 1 is some 50 % higher at a discount rate of 5% decreasing to 33% higher at a discount rate of 10%. The comparatively low capital cost of Option 1 is offset by the high operating cost.

Implications of pH Value

6.16 As previously explained, the design and costing of the treatment units for Option 1 have been undertaken assuming an operational pH value of 11, the value conventionally used. Operation at a reduced value of around 9.5 will substantially reduce the amount of magnesium hydroxide precipitated thereby reducing the capital costs of the sludge treatment plant and the building and the operating costs for chemicals and cake disposal. By careful control of pH, it may be possible to reduce the production of sludge solids by a factor of two while remaining compliant with the *E coli* concentration in the sea water. However, stripping of NH_4-N will not then be viable.

6.17 In Option 1, the operating costs associated with chemicals and cake disposal amount to an annual sum of HK$ 9.0M. If half of this can be saved, total operating costs will reduce to HK$ 7.7M/year Similarly, approximate capital saving may be made as follows:

Item	Saving (MHK$)
Building	6
M&E	4
Civil	3
Lime handling	1
Contingencies	5
Total	19.

6.18 This saving reduces the capital cost to HK$ 80M. The NPCs calculated for the reduced capital and operating costs, at the discount rates of 5%, 7.5% and 10%, are then HK$ 214M, HK$ 173M and HK$ 148M respectively.

6.19 If removal of nitrogen is not required, then saving can also be made in Options 2 and 3. However, the savings will be small, say 10% overall. On this basis, the NPCs for Options 2 and 3 without nitrification will be in the range HK$ 135M to HK$ 180M depending on the discount rate.

6.20 Option 1 performed at a reduced pH value would therefore have a slightly higher NPC compared with Options 2 and 3. Also, Option 1 offers no advantages over Options 2 or 3 in terms of effluent quality or operational reliability.

Table 6.2: Summary of Costs for Treatment Options

Cost centre		Option 1 Lime treatment		Option 2 Activated sludge		Option 3 Submerged filtration	
Capital (million HK$)	Civil & roads, etc.	21.4		25.3		32.9	
	Building	23.0		27.6		15.4	
	M&E	27.6		29.5		32.1	
	Contingency & design	26.7		30.6		29.6	
	Total		98.7		113		110
Operating (million HK$ /yr)	Staff	1.56		1.56		1.56	
	Maintenance	1.08		1.72		2.06	
	Electricity	0.39		0.89		0.94	
	Water	0.11		0.02		0.02	
	Chemicals	5.41		0.21		0.21	
	Cake transport	0.73		0.14		0.14	
	Landfill charge	2.92		0.56		0.55	
	Total		12.3		4.71		5.48
NPC (million HK$)	5%		308		201		211
	7.5%		246		172		178
	10%		207		154		159

7. CONCLUSIONS

7.1 Conclusions are listed as follows.

- The ADWF of the sewage in the Sham Tseng area is expected to increase to about 16 000 m^3/day within the time horizon of the prospective sewage treatment works. Similarly, the dry-weather BOD and SS loads are expected to increase to about 2.0 t/day.

- Hydrogen sulphide and similar odorous gases could be produced in the sewerage pumping mains. Of the several preventive or remedial measures available for dealing with this problem, dosing a proprietary solution of iron salts at both ends of the sewage system is probably the most attractive.

- The granite sea bed off the coast at Sham Tseng will probably make the construction of a long-sea outfall prohibitively expensive. A short outfall about 100 m long discharging into 20 m of water is likely to be preferred.

- A review of the Water Quality Standards has indicated that the main parameters controlling the type and degree of treatment at the prospective works will be the removal of *E coli* and the pH value of the effluent. Also, the removal of inorganic nitrogen from the sewage will be beneficial especially in the long term when the background level of nitrogen in the coastal water has been reduced by new treatment works elsewhere. The major source of the nitrogen pollution is almost certainly the Pearl River.

- The favoured forms of treatment for the prospective works are lime treatment (Option 1), activated sludge (Option 2) and submerged aerated filtration (Option 3). To reduce the size of the footprint for the activated sludge works, lamella separators would be specified for primary treatment. Lamella separators would also precede the submerged filters in Option 3.

- The treatment option of using activated sludge without primary sedimentation is generally attractive for small footprint works. However, it has been discounted as an option since such treatment cannot readily comply with the requirement to produce a cake containing solids at a concentration of at least 30 w/w%.

- All three treatment options can safely reduce the *E coli* content of the sewage by the necessary amount and remove inorganic nitrogen. In the case of lime treatment, ammoniacal nitrogen would be removed by stripping at high pH value rather than biochemically as in the other options.

- The conventional operational pH value of 11 has been specified for the lime treatment. The discharge of effluent at this pH value into the coastal water will almost certainly cause, at certain times of the tide *and* year, the pH value of the sea water to increase above the WQO limit of 8.5 within and possibly outside the primary mixing zone.

- Production rate of sludge solids from lime treatment performed at a pH value of 11 would be extremely high owing to the presence of sea water in the sewage at Sham Tseng. Assuming the typical volumetric concentration of the sea water in the sewage of 25%, the production rate of the calcium and magnesium salts precipitated by the lime would be some 10 times higher than the production rate of the organic solids removed from the sewage.

- Owing to the environmentally-sensitive nature of the area, the treatment works would be enclosed in a building. Assuming a compacted layout for the treatment units, the footprints of the buildings would be 0.48, 0.58 and 0.32 hectares for Options 1 to 3 respectively. These sizes are only about 10 % of the prospective reclaimed area.

- The capital and operating costs of the three options are as follows.

Cost	**Option 1**	**Option 2**	**Option 3**
Capital (MHK$)	99	113	110
Operating (MHK$/year)	12.3	4.71	5.48

  The high operating cost of Option 1 largely stems from the consumption of lime, the transport of cake and landfill charges.

- Net Present Costs for Options 2 and 3 are virtually equal whereas the NPC of Option 1 is 33 to 44% higher depending on the discount rate.

- It may be possible to reduce the operational pH value of lime treatment from 11 to 9.5 and retain compliance with the *E coli* standard, but removal of ammoniacal nitrogen from the sewage would not then be viable. Such operation would give substantial reductions in capital and operating costs, but approximate calculations shows that the NPC of the treatment would still be higher than that for Options 2 and 3 providing equivalent treatment. Also, the treatment would have no performance or operational advantages over the other treatment options.

8. RECOMMENDATIONS

8.1 If nitrogen removal is necessary as part of the treatment to be provided at the Sham Tseng Works, either in the immediate future or in the long term, the treatment should be based on either

- activated sludge or
- submerged aerated filtration.

8.2 If nitrogen removal is not necessary, then lime treatment at a pH value of about 9.5 could be considered on the basis that such treatment has been used previously and is familiar to the DSD. However, further evaluation work should be performed to establish that such treatment is capable of obtaining compliance with the *E coli* standard.

8.3 It will not be possible to differentiate between the Options 2 and 3 in terms of cost unless a detailed engineering study is undertaken. Either such a study should be undertaken or the works should be provided on the theme of a design, build, operate and transfer type of contract.

APPENDIX A
PROCESS CALCULATION SHEETS

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A1: Design Calculations for Option 1 - Lime Treatment

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Second
WORKS INFLUENT				**Main**				
Stream Characteristics				**Stream**				
Peak flow rate	m3/day			48000				
ADWF	m3/day			16000				
Minimum flow rate	m3/day			2400				
ADW BOD load	t/day			2.054				
ADW sewage SS load	t/day			1.952				
ADW NH4-N load	t/day			0.279				
ADW E coli load	GNr/day			2110				
Free bicarbonate load	t HCO3/day			0.000				
Attached bicarbonate load	t HCO3/day			2.400				
Dissolved Mg load	t Mg/day			5.200				
Precipitated load	t/day			0.000				
Total SS load	t/day			0.000				
ADW BOD	mg/l			128				
ADW sewage SS	mg/l			122				
ADW NH4-N concentration	mg/l			17.4				
ADW E coli concentration	kNr/100 ml			13188				
Free bicarbonate concentration	mg HCO3/l			0.0				
Attached bicarbonate concentration	mg HCO3/l			150				
Dissolved Mg concentration	mg Mg/l			325				
pH value				7.0				
SS	w/w%							
MIXING				**Main**	**Topwater**	**Filtrate**	**Main**	
Stream Characteristics				**Stream**			**Stream**	
Peak flow rate	m3/day			48000			48988	
ADWF	m3/day			16000	699	289	16988	
Minimum flow rate	m3/day			2400			3388	
ADW BOD load	t/day			2.054	0.056	0.012	2.121	
ADW sewage SS load	t/day			1.952	0.062	0.013	2.027	
ADW NH4-N load	t/day			0.279	0.014	0.006	0.299	
ADW E coli load	GNr/day			2110	0	0	2110	
Free bicarbonate load	t HCO3/day			0.000	0.000	0.000	0.000	
Attached bicarbonate load	t HCO3/day			2.400	0.000	0.000	2.400	
Dissolved Mg load	t Mg/day			5.200	0.000	0.000	5.200	
Preciptated load	t/day			0.000	0.497	0.103	0.600	
Total SS load	t/day			0.000	0.559	0.115	0.675	
ADW BOD	mg/l			128	80	40	125	
ADW sewage SS	mg/l			122	800	400	119	
ADW NH4-N concentration	mg/l			17.4	20.0	20.0	17.6	
ADW E coli concentration	kNr/100 ml			13188	0	25	124209	
Free bicarbonate concentration	mg HCO3/l			0.0	0.0	0.0	0.0	
Attached bicarbonate concentration	mg HCO3/l			150	0	0	141	
Dissolved Mg concentration	mg Mg/l			325	0	0	306	
pH value				7.0	11.0	11.0	7.0	
SS	w/w%							

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A1: Design Calculations for Option 1 - Lime Treatment

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
PRELIMINARY TREATMENT								
				Main Stream			Main Stream	
Stream Characteristics								
Peak flow rate	m3/day			48988			48988	
ADWF	m3/day			16988			16988	
Minimum flow rate	m3/day			3388			3388	
ADW BOD load	t/day			2.121			2.121	
ADW sewage SS load	t/day			2.027			2.027	
ADW NH4-N load	t/day			0.299			0.299	
ADW E coli load	GNr/day			2110			2110	
Free bicarbonate load	t HCO3/day			0.000			0.000	
Attached bicarbonate load	t HCO3/day			2.400			2.400	
Dissolved Mg load	t Mg/day			5.200			5.200	
Precipitated load	t/day			0.600			0.600	
Total SS load	t/day			0.675			0.675	
ADW BOD	mg/l			125			125	
ADW sewage SS	mg/l			119			119	
ADW NH4-N concentration	mg/l			17.6			18	
ADW E coli concentration	kNr/100 ml			124209			124209	
Free bicarbonate concentration	mg HCO3/l			0			0	
Attached bicarbonate concentration	mg HCO3/l			141			141	
Dissolved Mg concentration	mg Mg/l			306			306	
pH value				7.0			7.0	
SS	w/w%							
Design								
Screens								
Daily average screenings content of sewage	mg/l	25						
Maximum hourly average screenings content	x hourly average	5						
Average production rate of screenings	t/day		0.42					
Maximum production rate of screenings	t/hour		0.09					
Density of screenings	t/m3	1						
Capacity of each skip	m3	6						
Number of skips required per week	Nr		0.50					
Grit Removal (Centrigugal type with air pump)								
Maximum loading (Flow/dia3)	Litres/s.m3	10						
Number oif duty units		1						
Number of standby units		1						
Capacity	xADWF	4						
Diameter			4.22					
Installed duty air power	kW	1						
Grit Classifiers								
Daily average maximum grit content of sewage	mg/l	15						
Hourly average maximum grit content	x hourly average	4						
Number of duty machines	Nr	1						
Number of standby machines	Nr	1						
Average production rate of grit	t/day		0.25					
Maximum production rate of grit	t/hour		0.04					
Capacity of skips	m3	6						
Density of grit	t/m3	2.02						
Volume of grit produced	m3/d		0.13					
Number of skips required	Nr/week		1					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table A1: Design Calculations for Option 1 - Lime Treatment

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Seconda
FLOCCULATION AND pH CONTROL TANK				Main Stream	Lime	Recirculated Sludge	Main Stream	
Stream Characteristics								
Peak flow rate	m3/day			48988	681		49912	
ADWF	m3/day			16988	236	243.66	17467	
Minimum flow rate	m3/day			3388	47		3678	
ADW BOD load	t/day			2.121	0.017	0.243	2.381	
ADW sewage SS load	t/day			2.027	0.006	0.405	2.437	
ADW NH4-N load	t/day			0.299	0	0.003	0.241	
ADW E coli load	GNr/day			2110	0	0	2110	
Free bicarbonate load	t HCO3/day			0.000	0	0	0	
Attached bicarbonate load	t HCO3/day			2.400	0	0	0	
Dissolved Mg load	t Mg/day			5.200	0	0	0	
Precipitate load	t/day			0.600	0.002	3.250	16.416	
Total SS load	t/day			0.675	0.008	3.655	18.853	
ADW BOD	mg/l			125	72		136	
ADW sewage SS	mg/l			119	25		140	
ADW NH4-N concentration	mg/l			17.6	0	11.881	13.8	
ADW E coli concentration	kNr/100 ml			124209	0	0	12080	
Free bicarbonate concentration	mg HCO3/l			0	0	0	0.0	
Attached bicarbonate concentration	mg HCO3/l			141	0	0	0	
Dissolved Mg concentration	mg Mg/l			306	0	0	0	
pH value				7.0	12.0	11.0	11.0	
SS	w/w%					1.5		
Design								
Retention time in flocculation tanks at max flow	mins	10						
Volume of retention tanks	m3		340					
Number of tanks	Nr	2						
Volume per tank	m3		170					
Depth of tanks	m	4						
Diameter of tanks	m		7.36					
pH value of effluent		11						
Average removal of BOD	%	0						
Average removal of SS	%	0						
Average removal of NH4-N	%	10						
Average removal of E Coli	%	0						
Mass of CaCO3/Mass of free HCO3	kg/kg	1.64						
Mass of CaCO3/Mass of attached HCO3	kg/kg	1.64						
Mass of Mg(OH)2/Mass of Mg	kg/kg	2.4						
Mass of CaO/Mass of free HCO3	kg/kg	0.92						
Mass of CaO/Mass of attached HCO3	kg/kg	0.46						
Mass of CaO/Mass of Mg	kg/kg	2.3						
Concentration of lime to obtain pH = 11	mg CaO/l	65						
Lime required for pH rise	mg CaO/l		65.0					
Lime requireed for free HCO3 precipitation	mg CaO/l		0.00					
Lime required for attached HCO3 precipitation	mg CaO/l		65.0					
Lime required for Mg precipitation	mg CaO/l		704					
Total lime required	mg CaO/l		834					
Average lime consumption	t CaO/day		14.2					
Concentration of lime suspension	kg CaO/m3	60						
Average dosing rate of suspension	m3/h		9.84					
Maximum dosing rate of suspension	m3/h		28.37					
Minimum dosing rate of suspension	m3/h		1.96					
CaCO3 precipitated from free HCO3	mg/l		0.00					
CaCO3 precipitated from attached HCO3	mg/l		232					
Mg(OH)2 precipated	mg/l		735					
Total precipitate concentration	mg/l		966					
Average precipitate production rate	t/day		16.4					
Average destruction of E coli	%	0						
Average removal of NH4-N	%	20						
Recycle rate of sludge	% of sludge flow	20						

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A1: Design Calculations for Option 1 - Lime Treatment

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
PRIMARY SEDIMENTATION				Main			Main	Sludge
Stream Characteristics				Stream			Stream	
Peak flow rate	m3/day			49912			48694	
ADWF	m3/day			17467			16249	1218
Minimum flow rate	m3/day			3678			2460	
ADW BOD load	t/day			2.381			1.167	1.214
ADW sewage SS load	t/day			2.437			0.414	2.023
ADW NH4-N load	t/day			0.241			0.193	0.014
ADW E coli load	GNr/day			2110			6	0
Free bicarbonate load	t HCO3/day			0.000			0.000	0
Attached bicarbonate load	t HCO3/day			0.000			0.000	0
Dissolved Mg load	t Mg/day			0.000			0.000	0
Precipitate load	t/day			16.416			0.164	16.252
Total SS load	t/day			18.853			0.578	18.275
ADW BOD	mg/l			136			72	
ADW sewage SS	mg/l			140			25	
ADW NH4-N concentration	mg/l			13.8			11.9	11.9
ADW E coli concentration	kNr/100 ml			12080			39	0
Free bicarbonate concentration	mg HCO3/l			0.0			0.0	0
Attached bicarbonate concentration	mg HCO3/l			0			0	0
Dissolved Mg concentration	mg Mg/l			0			0	0
pH value				11.0			11.0	11.0
SS	w/w%							1.5
Design								
Upward velocity at max flow (one tank down)	m/h	2						
Number of tanks	Nr	4						
Total plan area	m2		347					
Plan area per tank	m2		86.7					
Diameter of tanks	m		10.50					
Wall depth of tanks	m	2.5						
Average removal of SS	%	83						
Average removal of NH4-N (by desorption)	%	20						
Average removal of E Coli	%	99.7						
Average removal of precipitate	%	99						
SS of sludge	w/w%	1.5						
Density of sludge	t/m3	1						
Average total SS production in sludge	t/day		18.27					
Average volumetric production rate	m3/day		1218					
BOD of sewage sludge solids	g(BOD)/g(SS)	0.6						

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A1: Design Calculations for Option 1 - Lime Treatment

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondar
STRIPPING/DISINFECTION TANK				Main			Main	
Stream Characteristics				Stream			Stream	
Peak flow rate	m3/day			48694			48694	
ADWF	m3/day			16249			16249	
Minimum flow rate	m3/day			2460			2460	
ADW BOD load	t/day			1.167			1.167	
ADW sewage SS load	t/day			0.414			0.414	
ADW NH4-N load	t/day			0.193			0.019	
ADW E coli load	GNr/day			6			1	
Free bicarbonate load	t HCO3/day			0.000			0.000	
Attached bicarbonate load	t HCO3/day			0.000			0.000	
Dissolved Mg load	t Mg/day			0.000			0.000	
Precipitate load	t/day			0.164			0.164	
Total SS load	t/day			0.578			0.578	
ADW BOD	mg/l			72			72	
ADW SS	mg/l			25			25	
ADW NH4-N concentration	mg/l			11.9			1.2	
ADW E coli concentration	kNr/100 ml			39			4	
Free bicarbonate concentration	mg HCO3/l			0.000			0.000	
Attached bicarbonate concentration	mg HCO3/l			0.000			0.000	
Dissolved Mg concentration	mg Mg/l			0.000			0.000	
pH value				11.0			11.0	
SS	w/w%							
Design - E Coli removal								
Retention time at average flow	hours	1						
Volume of tank	m3		677					
T90 for E coli	hours	1						
Average removal of E Coli	%		90.0					
Design - NH4-N removal								
Average removal of NH4-N from sewage	%	90						
Aeration intensity	W/m3	25						
Air flow rate	m3/h.kW	70						
Installed aeration power	kW		16.9					
Air flow rate	m3/h		1185					
Air flow rate	kg/h		1523					
Rate of ammonia desorption	t N/day		0.17					
Ammonia concentration in air	ppm v/v		8051					
Design - NH4-N absorption								
Flow rate of air through absorber	kg/m2.h	2000						
Diameter of absorber	m		0.98					
Flow rate of acid through absorber	kg/m2.h	15000						
Flow rate of acid through absorber	m3/h		11.4					
Head on acid pump	m		5.92					
Power of acid pump	kW		0.31					
Height of transfer unit	m	0.25						
Removal of ammonia of air stream	%	99.5						
Number of transfer units	Nr		5.30					
Total height of packing	m		1.92					
Total height of column	m		3.92					
Design - H2SO4 Consumption								
Average total removal rate of ammonia from sewage	t N/day		0.26					
H2SO4 consumed by ammonia	t H2SO4/day		0.91					
Strength of H2SO4	%	96						
Consumption of H2SO4 solution	t/day		0.95					
Design - BOD & SS removal								
Average removal of BOD	%	0						
Average removal of SS	%	0						

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A1: Design Calculations for Option 1 - Lime Treatment

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
SPLITTER				**Main**			**Works**	**Make-up**
Stream Characteristics				**Stream**			**Effluent**	
Peak flow rate	m3/day			48694			48013	681
ADWF	m3/day			16249			16013	236
Minimum flow rate	m3/day			2460			2413	47
ADW BOD load	t/day			1.167			1.150	0.017
ADW sewage SS load	t/day			0.414			0.408	0.006
ADW NH4-N load	t/day			0.019			0.019	0.000
ADW E coli load	GNr/day			1			1	0
Free bicarbonate load	t HCO3/day			0.000			0.000	0.000
Attached bicarbonate load	t HCO3/day			0.000			0.000	0.000
Dissolved Mg load	t Mg/day			0.000			0.000	0.000
Precipitate load	t/day			0.164			0.162	0.002
Total SS load	t/day			0.578			0.570	0.008
ADW BOD	mg/l			72			72	72
ADW sewage SS	mg/l			25			25	25
ADW NH4-N concentration	mg/l			1.2			1.2	1.2
ADW E coli concentration	kNr/100 ml			4			4	4
Free bicarbonate concentration	mg HCO3/l			0.0			0.0	0.0
Attached bicarbonate concentration	mg HCO3/l			0			0	0
Dissolved Mg concentration	mg Mg/l			0			0	0
pH value				11.0			11.0	11.0
SS	w/w%							
SPLITTER				**Main Sludge**			**Main Sludge**	**Recirculated**
Stream Characteristics				**Stream**			**Stream**	**Sludge**
Peak flow rate	m3/day							
ADWF	m3/day			1218			975	243.66387
Minimum flow rate	m3/day							
ADW BOD load	t/day			1.214			0.971	0.242754
ADW sewage SS load	t/day			2.023			1.618	0.40459
ADW NH4-N load	t/day			0.014			0.012	0.002895
ADW E coli load	GNr/day			0			0	0
Free bicarbonate load	t HCO3/day			0			0	0
Attached bicarbonate load	t HCO3/day			0			0	0
Dissolved Mg load	t Mg/day			0			0	0
Precipitate load	t/day			16.252			13.001	3.250368
Total SS load	t/day			18.275			14.620	3.654958
ADW BOD	mg/l							
ADW sewage SS	mg/l							
ADW NH4-N concentration	mg/l			11.881			11.881	11.881
ADW E coli concentration	kNr/100 ml			0			0	0
Free bicarbonate concentration	mg HCO3/l			0			0	0
Attached bicarbonate concentration	mg HCO3/l			0			0	0
Dissolved Mg concentration	mg Mg/l			0			0	0
pH value				11.000			11	11
SS	w/w%			1.500			1.5	1.5
Design								
Fraction recycled	%		20					
Flow rate of recycled sludge	m3/day		244					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A1: Design Calculations for Option 1 - Lime Treatment

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Seconda
SLUDGE THICKENING				**Raw sludge**			**Thickened Sludge**	**Topwate**
Stream Characteristics								
Peak flow rate	m3/day							
ADWF	m3/day			975			276	699
Minimum flow rate	m3/day							
ADW BOD load	t/day							0.056
ADW sewage SS load	t/day			1.618			1.556	0.062
ADW NH4-N load	t/day							0.014
ADW E coli load	GNr/day							0
Free bicarbonate load	t HCO3/day							0
Attached bicarbonate load	t HCO3/day							0
Dissolved Mg load	t Mg/day							0
Precipitate load	t/day			13.001			12.504	0.497
Total SS load	t/day			14.620			14.061	0.559
ADW BOD	mg/l							80
ADW sewage SS	mg/l							800
ADW NH4-N concentration	mg/l							20.0
ADW E coli concentration	kNr/100 ml							0
Free bicarbonate concentration	mg HCO3/l							0
Attached bicarbonate concentration	mg HCO3/l							0
Dissolved Mg concentration	mg Mg/l							0
pH value				11.0			11.0	11.0
SS	w/w%			1.5			5	
Design								
Specific surface area	m2.day/tDS	20						
Total solids load	t/day		14.6					
Thickening surface area	m2		292					
Number of duty tanks	Nr	3						
Number of standby tanks	Nr	1						
Total number of tanks	Nr		4					
Tank diameter	m		11.1					
Tank height	m	4						
Average upward velocity	m/h		0.14					
Thickened sludge concentration	w/w %	5						
SS of topwater	mg/l	800						
BOD of topwater	mg/l		80					
ADW E coli concentration in topwater	kNr/100 ml	50						
Density of thickened sludge	t/m3	1.02						
Average flow rate of thickened sludge	m3/day		276					
Average flow rate of topwater	m3/day		699					
SLUDGE STORAGE				**Thickened Sludge**			**Thickened Sludge**	
Stream Characteristics								
Peak flow rate	m3/day							
ADWF	m3/day			276			276	
Minimum flow rate	m3/day							
ADW BOD load	t/day							
ADW sewage SS load	t/day			1.556			1.556	
ADW NH4-N load	t/day							
ADW E coli load	GNr/day							
Free bicarbonate load	t HCO3/day							
Attached bicarbonate load	t HCO3/day							
Dissolved Mg load	t Mg/day							
Precipitate load	t/day			12.504			12.504	
Total SS load	t/day			14.061			14.061	
ADW BOD	mg/l							
ADW sewage SS	mg/l							
ADW NH4-N concentration	mg/l							
ADW E coli concentration	kNr/100 ml							
Free bicarbonate concentration	mg HCO3/l							
Attached bicarbonate concentration	mg HCO3/l							
Dissolved Mg concentration	mg Mg/l							
pH value				11.0			11.0	
DS	w/w%			5			5	
Design								
Rentention time	days	4						
Total volume	m3		1103					
No of tanks		2						
Depth of tanks	m	4						
Diameter of tanks	m		13.2					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A1: Design Calculations for Option 1 - Lime Treatment

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
				Influent			Effluent	
		Assumed	Derived	Primary	Secondary	Tertiary	Primary	Secondary
FILTER PRESSING				Thickened Sludge			Cake	Filtrate
Stream Characteristics								
Peak flow rate	m3/day							
ADWF	m3/day			276			36	289
Minimum flow rate	m3/day							
ADW BOD load	t/day							0.012
ADW sewage SS load	t/day			1.556			1.544	0.013
ADW NH4-N load	t/day							0.006
ADW E coli load	GNr/day							0
Free bicarbonate load	t HCO3/day							0.000
Attached bicarbonate load	t HCO3/day							0.000
Dissolved Mg load	t Mg/day							0.000
Precipitate load	t/day			12.504			12.402	0.103
Total SS load	t/day			14.061			13.945	0.115
ADW BOD	mg/l							40
ADW sewage SS	mg/l							400
ADW NH4-N concentration	mg/l							20.0
ADW E coli concentration	kNr/100 ml							25
Free bicarbonate concentration	mg HCO3/l							0.0
Attached bicarbonate concentration	mg HCO3/l							0
Dissolved Mg concentration	mg Mg/l							0
pH value				11.0			11.0	11.0
DS	w/w%			5			35	
Design								
Width of plates	m	1.5						
Depth of plates	m	1.5						
Nominal size of plates	m2	2.25						
Nominal chamber thickness	mm	32						
Actual chamber volume	m3		0.058					
DS of cake	w/w%	35						
SS of filtrate	mg/l	400						
BOD of filtrate	mg/l		40					
ADW E coli concentration in filtrate	kNr/100 ml	25						
Density of cake	t/m3	1.1						
Average total solids load	t/day		14.1					
Volumetric flow of cake	m3/day		36					
Mass flow rate of cake	t/day		40					
Number of pressings/day.press		3						
Spare capacity	%	25						
Nr of duty presses		3						
Nr of standby presses		0						
Nr of chambers			88					
Polyelectrolyte dose	kg/tSS	3.5						
Average polyelectrolyte consumption	kg/day		49					
Polyelectrolyte make-up water		Mains						
Concentration of polyelectrolyte in dosing solution	kg/m3	1						
Consumption of make-up water	m3/day		49					
LIME STORAGE AND PREPARATION								
Type of lime		Slaked						
Make-up water		Effluent						
Activity of lime		0.9						
Consumption rate	t Ca(OH)2/day		20.8					
Capacity of silo	t	33						
Number of silos	Nr	3						
Storage capacity of silo	days		4.8					
Maximum make-up rate	m3/h		28.4					
Cycle time of batches	mins	120						
Volume of batch tank	m3		56.7					
Nr of batch tanks	Nr	3						
Mixing intensity	W/m3	100						
Stirrer power	kW		5.67					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A2: Design Calculations for Option 2 - Activated Sludge

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondar
WORKS INFLUENT				**Main**				
Stream Characteristics				**Stream**				
Peak flow rate	m3/day			48000				
ADWF	m3/day			16000				
Minimum flow rate	m3/day			2400				
ADW BOD load	t/day			2.054				
ADW SS load	t/day			1.952				
ADW NH4-N load	t/day			0.279				
ADW E coli load	GNr/day			2110				
ADW BOD	mg/l			128				
ADW SS	mg/l			122				
ADW NH4-N concentration	mg/l			17.4				
ADW E coli concentration	kNr/100 ml			13188				
pH value				7.0				
SS	w/w%							
MIXING				**Main**	**Topwater**	**Filtrate**	**Main**	
Stream Characteristics				**Stream**			**Stream**	
Peak flow rate	m3/day			48000			48160	
ADWF	m3/day			16000	116	44	16160	
Minimum flow rate	m3/day			2400			2560	
ADW BOD load	t/day			2.054	0.046	0.009	2.109	
ADW SS load	t/day			1.952	0.092	0.018	2.062	
ADW NH4-N load	t/day			0.279	0.002	0.001	0.282	
ADW E coli load	GNr/day			2110	0.116	0.000	2110	
ADW BOD	mg/l			128	400	200	131	
ADW SS	mg/l			122	800	400	128	
ADW NH4-N concentration	mg/l			17.4	20.0	20.0	17.5	
ADW E coli concentration	kNr/100 ml			13188	100	0	130579	
pH value				7.0	11.0	10.0	7.0	
Solids Content	w/w%							

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A2: Design Calculations for Option 2 - Activated Sludge

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
PRELIMINARY TREATMENT				Main			Main	
Stream Characteristics				Stream			Stream	
Peak flow rate	m3/day			48160			48160	
ADWF	m3/day			16160			16160	
Minimum Flow Rate	m3/day			2560			2560	
ADW BOD load	t/day			2.109			2.109	
ADW SS load	t/day			2.062			2.062	
ADW NH4-N load	t/day			0.282			0.282	
ADW E coli Load	GNr/day			2110			2110	
ADW BOD	mg/l			131			131	
ADW SS	mg/l			128			128	
ADW NH4-N concentration	mg/l			17.5			17.5	
ADW E Coli concentration	kNr/100 ml			130579			130579	
pH value				7.0			7.0	
Solids Content	w/w%			0.0			0.0	
Design								
Screens								
Daily average screenings content of sewage	mg/l	25						
Maximum hourly average screenings content	x hourly average	5						
Average production rate of screenings	t/day		0.40					
Maximum production rate of screenings	t/hour		0.08					
Density of screenings	t/m3	1						
Capacity of each skip	m3	6						
Number of skips required per week	Nr		1					
Grit and grease channels								
Design flow	xADWF	4						
Maximum upward velocity	m/h	16						
Tank depth	m	3.5						
Aeration intensity	W/m3	30						
Tank width	m	3.5						
Number of tanks	Nr	2						
Total tank area	m2		167					
Length of each tank	m		23.81					
Installed duty aeration Power	kW		17.50					
Installed power of grit pumps	kW	3						
Grit Classifiers								
Daily average maximum grit content of sewage	mg/l	15						
Hourly average maximum grit content	x hourly average	4						
Number of duty machines	Nr	1						
Number of standby machines	Nr	1						
Average production rate of grit	t/day		0.24					
Maximum production rate of grit	t/hour		0.04					
Capacity of skips	m3	6						
Density of grit	t/m3	2.02						
Volume of grit produced	m3/d		0.12					
Number of skips required	Nr/week		1					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A2: Design Calculations for Option 2 - Activated Sludge

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Seconds
LAMELLA SEPARATORS				Main	Secondary		Main	Mixed
Stream Characteristics				Stream	Sludge		Stream	Sludge
Peak flow rate	m3/day			48160			48235	
ADWF	m3/day			16160	232		16235	156
Minimum flow rate	m3/day			2560			2635	
ADW BOD load	t/day			2.109	0.554		1.360	1.302
ADW SS load	t/day			2.062	1.107		0.832	2.337
ADW NH4-N load	t/day			0.282	0.000		0.282	
ADW E coli load	GNr/day			2110	12		1583	
ADW BOD	mg/l			131	2391		84	
ADW SS	mg/l			128	4782		51	
ADW NH4-N concentration	mg/l			17.5	1.5		17.4	
ADW E coli concentration	kNr/100 ml			130579	4980		9748	
pH value				7.0	7.0		7.0	7.0
SS	w/w%							1.5
Design								
Maximum allowable upward velocity over plate area	m/h	1.6						
Normal maximum upward velocity over plate area	m/h	1.2						
Plate angle (55 to 60 degrees)	degrees	60						
Perpendicular spacing between plates (70 to 100 mm)	mm	80						
Length of plates (1.5 to 2.5 m)	m	2						
Length of inlet area	m	1.5						
Calculated Active Ratio	Ratio		9.37					
Assumed Active Ratio	Ratio	8.50						
Total duty plate area	m2		1672					
Total duty tank area	m2		197					
Number of duty tanks	Nr	3						
Depth of tanks (4.5 to 5 m)	m	4.8						
Width of tanks	m	4						
Length of tanks	m		16.4					
Number of working standby tanks	Nr	1						
Total number of tanks	Nr		4					
Total plate area	m2		1672					
Peak operating upward flow velocity	m/h		1.20					
ADF operating upward flow velocity	m/h		0.40					
Peak upward flow velocity,(duty tanks only)	m/h		1.60					
Primary solids loading	t/day		2.06					
Secondary solids loading	t/day		1.11					
Average removal of primary solids	%	65.00						
Average removal of secondary solids	%	90.00						
Average removal of NH4-N	%	0.00						
Average removal of E-coli	%	25.00						
Primary solids production rate	t/day		1.34					
Secondary solids production rate	t/day		1.00					
Total solids production rate	t/day		2.34					
BOD of primary sludge	g(BOD)/g(SS)	0.6						
BOD of secondary sludge	g(BOD)/g(SS)	0.5						
BOD load of mixed sludge	t/day		1.30					
BOD remaining	t/day		1.36					
BOD removed from main stream	%		35.5					
Sludge solids content	%w/w	1.50						
Density of sludge	t/m3	1.00						
Sludge production rate	m3/d		156					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A2: Design Calculations for Option 2 - Activated Sludge

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
				Influent			Effluent	
		Assumed	Derived	Primary	Secondary	Tertiary	Primary	Secondary
ACTIVATED SLUDGE				Main Stream			Main Stream	Secondary Sludge
Stream Characteristics								
Peak flow rate	m3/day			48235			48004	
ADWF	m3/day			16235			16004	232
Minimum flow rate	m3/day			2635			2404	
ADW BOD load	t/day			1.360			0.128	0.554
ADW SS load	t/day			0.832			0.192	1.107
ADW NH4-N load	t/day			0.282			0.024	0.000
ADW E coli load	GNr/day			1583			80	12
ADW BOD	mg/l			84			8	2391
ADW SS	mg/l			51			12	4782
ADW NH4-N concentration	mg/l			17.4			1.5	1.5
ADW NO3-N concentration	mg/l			0.0			4.5	0.0
ADW E coli concentration	kNr/100 ml			9748			498	4980
pH value				7.0			7.0	7.0
SS	w/w%							
Design - Aeration tanks								
BOD/MLSS ratio	kg/kg.day	0.15						
Depth of aeration tanks	m	6						
MLSS	mg/l	2800						
Average BOD load	t/day		1.36					
Volume of aeration tanks	m3		3239					
Surface area of aeration tanks	m2		540					
Average retention time in aeration tanks	h		4.8					
Internal recycle ratio	Rate/ADWF	2						
Internal recycle rate	m3/day		32000					
Pumping head for internal recycle	m	1						
Installed duty pumping power for internal recycle	kW		6.1					
Design - Clarifiers								
Design SSVI	ml/g	125						
Critical underflow rate	m/h		0.78					
Design underflow rate	m/h	0.6						
Max solids flux	kg/m2.h		5.27					
Maximum underflow concentration	mg/l		8776					
Total clarification area	m2		1569					
Number of clarification tanks	Nr	4						
Plan area of each clarification tank	m2		392					
Diameter of clarification tanks	m		22.4					
Wall depth	m	3						
Maximum upward velocity	m/h		1.28					
Average retention time in clarifiers	h		6.96					
External recycle rate	m3/h		942					
External recycle ratio	Rate/ADWF		1.41					
Pumping head on external recycle	m	3						
Installed duty pumping power on external recycle	kW		12.8					
Average underflow concentration	mg/l		4782					
Design - Performance								
Average BOD of effluent	mg/l	8						
Average SS of effluent	mg/l	12						
Removal of E coli	%	95						
Average NH4-N concentration of effluent	mg/l	1.5						
Removal of NO3-N in anoxic zone	%	80						
Average NO3-N in effluent	mg/l		4.50					
Design - Sludge production								
Average BOD removal rate	t/day		1.23					
SS yield per unit BOD removed	kg/kg	0.9						
Average SS production	t SS/day		1.11					
Sludge age	days		8.19					
Design - Aeration								
Average oxygen consumed per unit BOD removed	kg/kg		1.03					
Average oxygen consumption for BOD removal	t/day		1.27					
Average removal rate of ammonia	t/day		0.26					
Average oxygen consumption for NH4-N removal	t/day		1.11					
Average removal rate of NO3-N	t/day		0.18					
Average rate of oxygen recovered	t/day		0.52					
Average oxygen consumption	t/day		1.86					
Average aeration efficiency	kg O2/kWh	1.5						
Average electricity consumption	kWh/day		1242					
Maximum/average oxygen consumption	Ratio	1.6						
Maximum aeration efficiency	kg O2/kWh	1.8						
Installed duty aeration capacity	kW		69					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A2: Design Calculations for Option 2 - Activated Sludge

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondai
UV DISINFECTION				Main			Final	
Stream Characteristics				Stream			Effluent	
Peak flow rate	m3/day			48004			48004	
ADWF	m3/day			16004			16004	
Minimum flow rate	m3/day			2404			2404	
ADW BOD load	t/day			0.128			0.128	
ADW SS load	t/day			0.192			0.192	
ADW NH4-N load	t/day			0.024			0.024	
ADW E coli load	GNr/day			80			0.159	
ADW BOD	mg/l			8			8	
ADW SS	mg/l			12			12	
ADW NH4-N concentration	mg/l			1.5			1.5	
ADW NO3-N concentration	mg/l			4.5			4.5	
ADW E coli concentration	kNr/100 ml			498			1	
pH value				7.0			7.0	
SS	w/w%							
Design								
Superficial retention time at maximum flow	secs	18						
Volume of plant	m3		10.0					
Superficial velocity through plant	m/s	0.5						
X-sectional area	m2		1.11					
Total length of plant	m		9.00					
Nr of duty units	Nr	3						
Nr of standby units	Nr	1						
Total number of units	Nr		4					
Power requirement	Wh/m3	40						
Installed duty power	kW		80					
Power load factor		0.5						
Average power consumption	kW		40					
Average kill ratio of E coli		500						
SPLITTER				Filtrate			Filtrate	Lime
Stream Characteristics								make-up
Peak flow rate	m3/day							
ADWF	m3/day			48			44	4
Minimum flow rate	m3/day							
ADW BOD load	t/day			0.010			0.009	0.001
ADW SS load	t/day			0.019			0.018	0.002
ADW NH4-N load	t/day			0.001			0.001	0.000
ADW E coli load	GNr/day			0			0	0
ADW BOD	mg/l			200			200	200
ADW SS	mg/l			400			400	400
ADW NH4-N concentration	mg/l			20.0			20.0	20.0
ADW NO3-N concentration	mg/l							
ADW E coli concentration	kNr/100 ml			10			10	10
pH value				11.0			11.0	11.0
SS	w/w%							

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table A2: Design Calculations for Option 2 - Activated Sludge

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
LIME STABILISATION				Mixed Sludge	Lime		Limed Sludge	
Stream characteristics								
Peak flow rate	m3/day							
ADWF	m3/day			156	4		160	
Minimum flow rate	m3/day							
ADW BOD load	t/day			1.302				
ADW sewage SS load	t/day			2.337	0.343		2.801	
ADW NH4-N load	t/day							
ADW E coli load	GNr/day							
ADW BOD	mg/l							
ADW sewage SS	mg/l							
ADW NH4-N concentration	mg/l							
ADW E coli concentration	kNr/100 ml							
pH value				7.0	12.5		11.0	
SS	w/w%			1.5	8.0		1.7	
Design								
Dose of lime, CaO/SS	w/w%	10						
Slurry concentration	w/w%	8						
Density	t/m3	1.07						
Activity of lime	%	90						
Lime consumption rate	t Ca(OH)2/day		0.34					
Carbonate production	t CaCO3/day		0.46					
Lime consumption rate	m3/day		4.01					
Lime storage capacity	t Ca(OH)2	15						
Lime storage	days		43.7					
Density of lime (Ca(OH)2)	t/m3	0.48						
Volume of silo	m3	31.25						
Diameter of silo	m	4						
Height of silo	m		5.2					
Cycle time of batches	mins	240						
Capacity of batch tanks	m3		0.7					
Number of batch tanks		2						
Density of limed sludge	t/m3	1.01						

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A2: Design Calculations for Option 2 - Activated Sludge

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Seconda
SLUDGE THICKENING				**Raw sludge**			**Thickened Sludge**	**Topwate**
Stream Characteristics								
Peak flow rate	m3/day							
ADWF	m3/day			160			44	116
Minimum flow rate	m3/day							
ADW BOD load	t/day							0.046
ADW SS load	t/day			2.801			2.708	0.092
ADW NH4-N load	t/day							0.002
ADW E coli load	GNr/day							0
ADW BOD	mg/l							400
ADW sewage SS	mg/l							800
ADW NH4-N concentration	mg/l							20.0
ADW E coli concentration	kNr/100 ml							100
pH value				11.0			11.0	11.0
SS	w/w%			1.7			6.0	
Design								
Specific surface area	m2.day/tDS	15						
Thickening surface area	m2		42.0					
Number of duty tanks	Nr	1						
Number of standby tanks	Nr	1						
Total number of tanks	Nr		2					
Tank diameter	m		7.31					
Tank height	m	4						
Average upward velocity	m/h		0.16					
Thickened sludge concentration	w/w %	6						
SS of topwater	mg/l	800						
BOD of topwater	mg/l		400					
ADW E coli concentration in topwater	kNr/100 ml	100						
Density of thickened sludge	t/m3	1.02						
Average flow rate of thickened sludge	m3/day		44.3					
Average flow rate of topwater	m3/day		116					
SLUDGE STORAGE				**Thickened Sludge**			**Thickened Sludge**	
Stream Characteristics								
Peak flow rate	m3/day							
ADWF	m3/day			44			44	
Minimum flow rate	m3/day							
ADW BOD load	t/day							
ADW SS load	t/day			2.708			2.708	
ADW NH4-N load	t/day							
ADW E coli load	GNr/day							
ADW BOD	mg/l							
ADW SS	mg/l							
ADW NH4-N concentration	mg/l							
ADW E coli concentration	kNr/100 ml							
pH value				11.0			11.0	
DS	w/w%			6.0			6.0	
Design								
Rentention time	days	4						
Total volume	m3		177					
Number of tanks	Nr	2						
Depth of tanks	m	4						
Diameter of tanks	m		5.31					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT Table A2: Design Calculations for Option 2 - Activated Sludge								
CHARACTERISTIC/PARAMETER	**UNITS**	**DESIGN CALCULATIONS**		**EFFLUENT CHARACTERISTICS**				
		Assumed	**Derived**	**Influent**			**Effluent**	
				Primary	**Secondary**	**Tertiary**	**Primary**	**Secondary**
FILTER PRESSING				**Thickened Sludge**			**Cake**	**Filtrate**
Stream Characteristics								
Peak flow rate	m3/day							
ADWF	m3/day			44			7	48
Minimum flow rate	m3/day							
ADW BOD load	t/day							0.010
ADW SS load	t/day			2.708			2.689	0.019
ADW NH4-N load	t/day							0.001
ADW E coli load	GNr/day							0
ADW BOD	mg/l							200
ADW sewage SS	mg/l							400
ADW NH4-N concentration	mg/l							20.0
ADW E coli concentration	kNr/100 ml							10
pH value				11.0			11.0	11.0
DS	w/w%			6.0			35.0	
Design								
Width of plates	m	1.3						
Depth of plates	m	1.3						
Nominal size of plates	m2	1.69						
Nominal chamber thickness	mm	32						
Actual chamber volume	m3		0.043					
DS of cake	w/w%	35						
SS of filtrate	mg/l	400						
BOD of filtrate	mg/l		200					
ADW E coli concentration in filtrate	kNr/100 ml	10						
Density of cake	t/m3	1.1						
Average total solids load	t/day		2.71					
Volumetric flow of cake	m3/day		7.00					
Mass flow rate of cake	t/day		7.69					
Number of pressings/day.press	Nr	3						
Spare capacity	%	33						
Nr of duty presses	Nr	1						
Nr of standby presses	Nr	0						
Nr of chambers	Nr		72					
Polyelectrolyte dose	kg/tSS	4						
Average polyelectrolyte consumption	kg/day		10.8					
Polyelectrolyte make-up water		Mains						
Concentration of polyelectrolyte in dosing solution	kg/m3	1						
Consumption of make-up water	m3/day		10.8					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table A3: Design Calculations for Option 3 - Submerged Aerated Filters

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Second.
WORKS INFLUENT				**Main Stream**				
Stream Characteristics								
Peak flow rate	m3/day			48000				
ADWF	m3/day			16000				
Minimum flow rate	m3/day			2400				
ADW BOD load	t/day			2.054				
ADW SS load	t/day			1.952				
ADW NH4-N load	t/day			0.279				
ADW E coli load	GNr/day			2110				
ADW BOD	mg/l			128				
ADW SS	mg/l			122				
ADW NH4-N concentration	mg/l			17.4				
ADW E coli concentration	kNr/100 ml			13188				
pH value				7.0				
SS	w/w%							
MIXING				**Main Stream**	**Topwater**	**Filtrate**	**Main Stream**	
Stream Characteristics								
Peak flow rate	m3/day			48000			48159	
ADWF	m3/day			16000	115	43	16159	
Minimum flow rate	m3/day			2400			2559	
ADW BOD load	t/day			2.054	0.046	0.009	2.109	
ADW SS load	t/day			1.952	0.092	0.017	2.061	
ADW NH4-N load	t/day			0.279	0.002	0.001	0.282	
ADW E coli load	GNr/day			2110	0.12	0.00	2110	
ADW BOD	mg/l			128	400	200	131	
ADW SS	mg/l			122	800	400	128	
ADW NH4-N concentration	mg/l			17.4	20.0	20.0	17.5	
ADW E coli concentration	kNr/100 ml			13188	100	10	130588	
pH value				7.0	11.0	11.0	7.0	
Solids Content	w/w%							

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A3: Design Calculations for Option 3 - Submerged Aerated Filters

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
PRELIMINARY TREATMENT				**Main**			**Main**	
Stream Characteristics				**Stream**			**Stream**	
Peak flow rate	m3/day			48159			48159	
ADWF	m3/day			16159			16159	
Minimum Flow Rate	m3/day			2559			2559	
ADW BOD load	t/day			2.109			2.109	
ADW SS load	t/day			2.061			2.061	
ADW NH4-N load	t/day			0.282			0.282	
ADW E coli Load	GNr/day			2110			2110	
ADW BOD	mg/l			131			131	
ADW SS	mg/l			128			128	
ADW NH4-N concentration	mg/l			17.5			17.5	
ADW E Coli concentration	kNr/100 ml			130588			130588	
pH value				7.0			7.0	
Solids Content	w/w%			0.0			0.0	
Design								
Screens								
Daily average screenings content of sewage	mg/l	25						
Maximum hourly average screenings content	x hourly average	5						
Average production rate of screenings	t/day		0.40					
Maximum production rate of screenings	t/hour		0.08					
Density of screenings	t/m3	1						
Capacity of each skip	m3	6						
Number of skips required per week	Nr		1					
Grit and grease channels								
Design flow	xADWF	4						
Maximum upward velocity	m/h	16						
Tank depth	m	3.5						
Aeration intensity	W/m3	30						
Tank width	m	3.5						
Number of tanks	Nr	2						
Total tank area	m2		167					
Length of each tank	m		23.81					
Installed duty aeration Power	kW		17.50					
Installed power of grit pumps	kW	3						
Grit Classifiers								
Daily average maximum grit content of sewage	mg/l	15						
Hourly average maximum grit content	x hourly average	4						
Number of duty machines	Nr	1						
Number of standby machines	Nr	1						
Average production rate of grit	t/day		0.24					
Maximum production rate of grit	t/hour		0.04					
Capacity of skips	m3	6						
Density of grit	t/m3	2.02						
Volume of grit produced	m3/d		0.12					
Number of skips required	Nr/week		1					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table A3: Design Calculations for Option 3 - Submerged Aerated Filters

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Second
LAMELLA SEPARATORS				Main Stream	Dirty Backwash		Main Stream	Mixe Sludge
Stream Characteristics								
Peak flow rate	m3/day			48159			49007	
ADWF	m3/day			16159	1003		17007	154.8
Minimum flow rate	m3/day			2559			3407	
ADW BOD load	t/day			2.109	0.674		1.488	1.295
ADW SS load	t/day			2.061	1.091		0.831	2.322
ADW NH4-N load	t/day			0.282	0.002		0.282	
ADW E coli load	GNr/day			2110	99		1583	
ADW BOD	mg/l			131	672		87	
ADW SS	mg/l			128	1339		49	
ADW NH4-N concentration	mg/l			17.5	1.763		17	
ADW E coli concentration	kNr/100 ml			130588	9889		9306	
pH value				7	7		7	7
SS	w/w%							1.5
Design								
Maximum allowable upward velocity over plate area	m/h	1.6						
Normal maximum upward velocity over plate area	m/h	1.2						
Plate angle (55 to 60 degrees)	degrees	60						
Perpendicular spacing between plates (70 to 100 mm	mm	80						
Length of plates (1.5 to 2.5 m)	m	2						
Length of inlet area	m	1.5						
Calculated Active Ratio	Ratio		9.37					
Assumed Active Ratio	Ratio	8.50						
Total duty plate area	m2		1672					
Total duty tank area	m2		197					
Number of duty tanks	Nr	3						
Depth of tanks (4.5 to 5 m)	m	4.8						
Width of tanks	m	4						
Length of tanks	m		16.39					
Number of working standby tanks	Nr	1						
Total number of tanks	Nr		4					
Total plate area	m2		1672					
Peak operating upward flow velocity	m/h		1.20					
ADF operating upward flow velocity	m/h		0.40					
Peak upward flow velocity (duty tanks only)	m/h		1.60					
Primary solids loading	t/day		2.06					
Secondary solids loading	t/day		1.09					
Average removal of primary solids	%	65.00						
Average removal of secondary solids	%	90.00						
Average removal of NH4-N	%	0.00						
Average removal of E-coli	%	25.00						
Primary solids production rate	t/day		1.34					
Secondary solids production rate	t/day		0.98					
Total solids production rate	t/day		2.32					
BOD of primary sludge	g(BOD)/g(SS)	0.6						
BOD of secondary sludge	g(BOD)/g(SS)	0.5						
BOD load of mixed sludge	t/day		1.29					
BOD remaining	t/day		1.49					
BOD removed from main stream	%		29.45					
Sludge solids content	%w/w	1.50						
Density of sludge	t/m3	1.00						
Sludge production rate	m3/d		155					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table A3: Design Calculations for Option 3 - Submerged Aerated Filters

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
BIOLOGICAL AERATED FLOODED FILTERS				**Main**			**Main**	**Dirty**
Stream Characteristics				**Stream**			**Stream**	**Backwash**
Peak flow rate	m3/day			49007			48004	
ADWF	m3/day			17007			16004	1003
Minimum flow rate	m3/day			3407			2404	
ADW BOD load	t/day			1.488			0.160	0.674
ADW SS load	t/day			0.831			0.240	1.343
ADW NH4-N load	t/day			0.282			0.028	0.002
ADW E coli load	GNr/day			1583			158	99
ADW BOD	mg/l			87			10	672
ADW SS	mg/l			49			15	1339
ADW NH4-N concentration	mg/l			16.6			1.8	1.8
ADW NO3-N concentration	mg/l			0			5	5
ADW E coli concentration	kNr/100 ml			9305.6			988.9	9888.8
pH value				7.0			7.0	7.0
SS	w/w%							
Design - General								
Maximum bed depth	m	6.5						
Maximum velocity through bed	m/h	20						
Maximum unit plan area	m2	80						
Air scour velocity	m/h	100						
Water backwash velocity	m/h	100						
Consumption of backwash water per backwash	m3/m3 (bed)	2						
Frequency of backwash	/d	0.5						
Head on backwash pump	m	9						
Head on backwash blower	m	7						
Volume of backwash water	x bed volume	2.5						
Volume of backwash tank	x bed volume	3						
Design - Anoxic Filters								
Recycle ratio	Rate/ADWF	2.5						
Recycle rate	m3/day		40000					
BOD loading on aerobic filters	kg/m3/day	2.65						
Duty volume of media	m3		561.38					
Bed depth	m	6						
Total plan area of filters	m2		93.56					
Number of duty filters	Nr	4						
Number of standby filters	Nr	0						
Total number of filters	Nr		4					
Volume of media in each filter	m3		140					
Plan area per filter	m2		23.39					
Width of each unit	m	3.00						
Length of each unit	m		7.80					
Average NO3-N removal over anoxic filter	%	70						
Rate of NO3-N removal	t/day		0.16					
Rate of BOD removal	t/day		0.60					
Backwash frequency	per day	0.5						
Rate of washwater useage	m3/day		702					
Volume of backwash tank	m3		421					
Design - aerobic filters								
BOD loading on second stage	t/day		0.89					
Ammonia loading on filters	kg N/m3.day	0.4						
Duty volume of filters	m3		705					
Bed depth	m	6						
Total plan area of filters	m2		118					
Stage BOD loading (based on settled sewage)	kg/m3.day		2.11					
Stage BOD loading (based on stage influent)	kg/m3.day		1.26					
Number of duty filters	Nr	5						
Number of standby filters	Nr	0						
Total number of filters	Nr	5						
Volume of media in each filter	m3		141					
Plan area each filter	m2		23.51					
Width of each filter	m		3.00					
Length of each filter	m		7.84					
Average removal of ammonia	%	90						
NO3-N concentration of effluent	mg/l		5.43					
Backwash frequency	per day	0.33						
Rate of backwash useage	m3/day		582					
Design - General Performance								
Average BOD of treated effluent	mg/l	10						
Average SS of treated effluent	mg/l	15						
Removal of E Coli	%	90						

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A3: Design Calculations for Option 3 - Submerged Aerated Filters

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secon
Design - Sludge and Backwashing								
Overall BOD removed	t/day		1.33					
Sludge solids yield	kg/kg BOD removed	1						
Solids production	t/day		1.33					
Production rate of backwash water	m3/day		1003					
Addition SS of backwash water	mg/l		1324					
BOD of backwash solids	kg/kg	0.5						
Additional BOD of backwash solids	t/day		662					
Maximum bed volume	m3		141					
Volume of dirty and clean backwash tanks	m3		423					
Maximum bed plan area	m2		23.5					
Backwash rate	m/h	100						
Capacity of backwash pumps	m3/h		2351					
Installed duty power of backwash pumps	kW		96					
Air scour rate	m/h	100						
Capacity of air scour blowers	m3/h		2351					
Installed duty power of air scour blowers	kW	55						
Design - aeration								
Oxygen for carbonaceous oxidation	kg O2/kg BOD remvd	0.9						
Oxygen consumed for carbonaceous oxidation	t/day		1.19					
Oxygen for ammonia removal	kg O2/kg NH4-N remv	4.5						
Oxygen consumed for ammonia removal	t/day		1.14					
Oxygen recovered in denitification	kg O2/kg NO3-N	2.8						
Oxygen recovered in denitrification	t/day		0.45					
Overall average oxygen consumption	t/day		1.89					
Average aeration efficiency	kg O2/kWh	1.20						
Average electricity consumption	kWh/day		1575					
Max/average oxygen demand	Ratio	2						
Peak aeration efficiency	kg O2/kWh	1.5						
Installed duty aeration power	kW		105					
Design - Recycle pump								
Capacity	l/s		463					
Pumping head	m	2						
Installed duty pumping power	kW		15.14					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table A3: Design Calculations for Option 3 - Submerged Aerated Filters

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
UV DISINFECTION				**Main**			**Final**	
Stream Characteristics				**Stream**			**Effluent**	
Peak flow rate	m3/day			48004			48004	
ADWF	m3/day			16004			16004	
Minimum flow rate	m3/day			2404			2404	
ADW BOD load	t/day			0.160			0.160	
ADW SS load	t/day			0.240			0.240	
ADW NH4-N load	t/day			0.028			0.028	
ADW E coli load	GNr/day			158			0.160	
ADW BOD	mg/l			10			10	
ADW SS	mg/l			15			15	
ADW NH4-N concentration	mg/l			1.8			1.8	
ADW NO3-N concentration	mg/l			5			5.4	
ADW E coli concentration	kNr/100 ml			988.9			1.98	
pH value				7.0			7.0	
SS	w/w%							
Design								
Superficial retention time at maximum flow	secs	18						
Volume of plant	m3		10.00					
Superficial velocity through plant	m/s	0.5						
X-sectional area	m2		1.11					
Total length of plant	m		9					
Nr of duty units	Nr	3						
Nr of standby units	Nr	1						
Total number of units	Nr		4					
Power requirement	Wh/m3	40						
Installed duty power	kW		80					
Power load factor		0.5						
Average power consumption	kW		40					
Average kill ratio of E coli		500						
SPLITTER				**Filtrate**			**Filtrate**	**Lime**
Stream Characteristics								**Make-up**
Peak flow rate	m3/day							
ADWF	m3/day			46.96			43.37	3.58
Minimum flow rate	m3/day							
ADW BOD load	t/day			0.009			0.009	0.001
ADW SS load	t/day			0.019			0.017	0.001
ADW NH4-N load	t/day			0.001			0.001	0.000
ADW E coli load	GNr/day			0.000			0.000	0.000
ADW BOD	mg/l			200			200	200
ADW SS	mg/l			400			400	400
ADW NH4-N concentration	mg/l			20			20	20
ADW E coli concentration	kNr/100 ml			10.0			10.0	10.0
pH value				11.0			11.0	11.0
SS	w/w%							
LIME STABILISATION				**Mixed**	**Lime**		**Limed**	
Stream Characteristics				**Sludge**			**Sludge**	
Peak flow rate	m3/day							
ADWF	m3/day			155	3.58		158	
Minimum flow rate	m3/day							
ADW BOD load	t/day							
ADW sewage SS load	t/day			2.322	0.307		2.736	
ADW NH4-N load	t/day							
ADW E coli load	GNr/day							
ADW BOD	mg/l							
ADW sewage SS	mg/l							
ADW NH4-N concentration	mg/l							
ADW E coli concentration	kNr/100 ml							
pH value				7.0	12.5		11.0	
SS	w/w%			1.5	8.0		1.7	
Design								
Dose of lime, CaO/SS	w/w%	10						
Slurry concentration	w/w%	8						
Density	t/m3	1.07						
Lime consumption rate	t Ca(OH)2/day		0.31					
Carbonate production	t CaCO3/day		0.41					
Lime consumption rate	m3/day		3.58					
Lime storage capacity	t Ca(OH)2	15						
Lime storage	days		48.9					
Cycle time of batches	mins	240						
Capacity of batch tanks	m3		0.6					
Number of batch tanks	Nr	2						
Density of limed sludge	t/m3	1.01						

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A3: Design Calculations for Option 3 - Submerged Aerated Filters

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
				Influent			Effluent	
		Assumed	Derived	Primary	Secondary	Tertiary	Primary	Seconda
SLUDGE THICKENING				**Raw**			**Thickened**	**Topwat**
Stream Characteristics				**Sludge**			**Sludge**	
Peak flow rate	m3/day							
ADWF	m3/day			158			43.21	115
Minimum flow rate	m3/day							
ADW BOD load	t/day							0.046
ADW SS load	t/day			2.736			2.644	0.092
ADW NH4-N load	t/day							0.002
ADW E coli load	GNr/day							0.115
ADW BOD	mg/l							400
ADW sewage SS	mg/l							800
ADW NH4-N concentration	mg/l							20
ADW E coli concentration	kNr/100 ml							100
pH value				11			11	11
SS	w/w%			1.7			6.0	
Design								
Specific surface area	m2.day/tDS	15						
Thickening surface area	m2		41.05					
Number of duty tanks	Nr	1						
Number of standby tanks	Nr	1						
Total number of tanks	Nr		2					
Tank diameter	m		7.23					
Tank height	m	4						
Average upward velocity	m/h		0.16					
Thickened sludge concentration	w/w %	6						
SS of topwater	mg/l	800						
BOD of topwater	mg/l		400					
ADW E coli concentration in topwater	kNr/100 ml	100						
Density of thickened sludge	t/m3	1.02						
Average flow rate of thickened sludge	m3/day		43.21					
Average flow rate of topwater	m3/day		115					
SLUDGE STORAGE				**Thickened**			**Thickened**	
Stream Characteristics				**Sludge**			**Sludge**	
Peak flow rate	m3/day							
ADWF	m3/day			43.21			43.21	
Minimum flow rate	m3/day							
ADW BOD load	t/day							
ADW SS load	t/day			2.644			2.644	
ADW NH4-N load	t/day							
ADW E coli load	GNr/day							
ADW BOD	mg/l							
ADW SS	mg/l							
ADW NH4-N concentration	mg/l							
ADW E coli concentration	kNr/100 ml							
pH value				11			11	
DS	w/w%			6			6	
Design								
Rentention time	days	4						
Total volume	m3		173					
Number of tanks	Nr	2						
Depth of tanks	m	4						
Diameter of tanks	m		5.24					

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table A3: Design Calculations for Option 3 - Submerged Aerated Filters

CHARACTERISTIC/PARAMETER	UNITS	DESIGN CALCULATIONS		EFFLUENT CHARACTERISTICS				
		Assumed	Derived	Influent			Effluent	
				Primary	Secondary	Tertiary	Primary	Secondary
FILTER PRESSING				**Thickened Sludge**			**Cake**	**Filtrate**
Stream Characteristics								
Peak flow rate	m3/day							
ADWF	m3/day			43.21			6.83	46.96
Minimum flow rate	m3/day							
ADW BOD load	t/day							0.009
ADW SS load	t/day			2.644			2.626	0.019
ADW NH4-N load	t/day							0.001
ADW E coli load	GNr/day							0.000
ADW BOD	mg/l							200
ADW sewage SS	mg/l							400
ADW NH4-N concentration	mg/l							20
ADW E coli concentration	kNr/100 ml							10
pH value				11			11	11
DS	w/w%			6			35	
Design								
Width of plates	m	1.3						
Depth of plates	m	1.3						
Nominal size of plates	m2		1.69					
Nominal chamber thickness	mm	32						
Actual chamber volume	m3		0.04					
DS of cake	w/w%	35						
SS of filtrate	mg/l	400						
BOD of filtrate	mg/l		200					
ADW E coli concentration in filtrate	kNr/100 ml	10						
Density of cake	t/m3	1.1						
Average total solids load	t/day		2.64					
Volumetric flow of cake	m3/day		6.83					
Mass flow rate of cake	t/day		7.51					
Number of pressings/day.press	Nr	3						
Spare capacity	%	33						
Nr of duty presses	Nr	1						
Nr of standby presses	Nr	0						
Nr of chambers	Nr		70					
Polyelectrolyte dose	kg/tSS	4						
Average polyelectrolyte consumption	kg/day		10.58					
Polyelectrolyte make-up water		Mains						
Concentration of polyelectrolyte in dosing solution	kg/m3	1						
Consumption of make-up water	m3/day		10.58					

APPENDIX B
COST CALCULATION SHEETS

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table B1.1: Capital Costs for Option 1 - Lime Treatment

Item	Number		Cost Parameter			Cost (thousands HK$)		No
	Duty	Stdby	Parameter	Value	Units	Civil	M&E	Total
Inlet Works								
Influent Pumping	4	1	Total installed power	23	kW	469.6	655.7	
Inlet Works - Civil	1		Dry Weather Flow	16000	m3/d	1561.2		
			Length	9	m			
Screens	1		Dry Weather Flow	16000	m3/d		1114.5	
Washpactor	1		Screenings throughput	0.42	t/d		876.0	
Grit Traps/Classifiers	2		Grit throughput	0.25	t/d		1080.0	
								5757.0
pH Correction/Flocculation								
Lime Storage Silos	3		Capacity	33	t lime	1560.0		
Batch Mixing Tanks	3		Volume of each tank	56.7	m3	550.0		
Lime Slurry Pumps	3		Total installed power	9	kW		364.5	
Flocculation/pH Control Tanks	2		Total volume	340	m3	649.0		
Stirrer/Mixer	2		Diameter	7.4	m		503.4	
								3627.0
Primary Treatment								
Primary Sedimentation Tanks	4		Diameter	10.50	m	1713.5	1955.4	
Sludge Pumps	4	4	Total installed power	24	kW		1603.1	
								5272.1
Disinfection and Outfall								
Stripping/Disinfection Tank	1		Total Volume	677	m3	665.7		
Disinfection Tank Aeration System	1	1	Total installed power	34	kW		1029.2	
Outfall Pumps	2	1	Total installed power	18	kW	425.8	344.3	
Marine Outfall	1		Length	0.1	km	2248.3		
			Diameter	0.750	m			
								4713.3
Sludge Treatment								
Sludge Recirculation Pumps	1	1	Total installed power	6	kW	262.9	197.6	
Continuous Sludge Thickeners	3	1	Volume of each tank	389	m3	1376.5	1944.2	
Sludge Pumps	2	2	Total installed power	6	kW		364.2	
Sludge Storage Tanks	4		Total volume	1103	m3	1192.9		
Polyelectrolyte Dosing System	3							
Press Feed Pumps	3	1	Total installed power	60	kW		816.0	
Filter Press	3		Cake throughput	14.1	tDS/day		4680.0	
Conveyor System	3		Cake throughput	14.1	t/d		828.0	
Skips	6						72.0	
								11734.3
Odour Control and Ventilation								
Cowlings, and Covers			Covered area	1439	m2	1122.4		
Ductwork	1							
Odour Control Fans	2	1	Total installed power	5.3	kW			
Sulphuric Acid Tank	1		Total capacity	5	tonnes		58.6	
Ammonia Scrubber	2		Total air flow rate	2510	m3/h		1800.0	
Spent Acid Tank	1		Total capacity	5	tonnes		58.6	
Bioscrubber	1		Air flow rate	3556	m3/h		888.3	
Roof Extractor Fans	8		Total installed power	14	kW		146.2	
								4074.1
Associated Civils Works								
Buildings:								
Control Buildings			Plan Area	50	m2	320.9		
Treatment Buildings			Plan Area	4800	m2	23040		
Mess/Administration			Plan Area	50	m2	322.5		
Indirect Civil Costs:								
Roads/hardstandings								
Inter-process Pipework								
Drainage								
Fencing								
Sub-total						6996.4		
								30679.8
Indirect M&E Costs								
Plant Control, Cabling								
Delivery								
Sub-total							6212.3	6212.3
Land Reclaimation			Area	4.45	ha	NOT INCLUDED		
Sub-total						44477.7	27592.1	72069.8
Contingencies	30		% of Subtotal					21620.9
Design and Supervision	7		% of Subtotal					5044.9
OVERALL TOTAL								98735.6

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table B1.2: Operating Cost for Option 1 - Lime Treatment

Cost/Revenue Items	Quantity (per annum)	Units	Rates (HK$ per unit)	Total (HK$)	Notes
Staff Costs					
Managerial	1	manyear	300000	300000	
Technical	1	manyear	168000	168000	
Labour	3	manyear	168000	504000	
Employment Costs (0.6xSalary)				583200	
Maintenance					
Maintenance (Consumables and Labour)				1103684	1
Site Vehicles	0.25	Item	408000	102000	
Services					
Clean Water	17885	m3	6.12	109456	
Imported Electricity	657000	kWh	0.6	394200	
Rates					
Chemical Costs					
Polyelectrolyte	17885	kg	36	643860	
Sulphuric Acid	347	Tonnes	600	208050	
Hydrated Lime	7592	Tonnes	600	4555200	
Transport and Disposal Costs					
Cake Export	14600	Tonnes	50.04	730584	
Disposal	14600	Tonnes	200.04	2920584	
TOTAL COST				12322818	

Notes
1. Maintenance of mechanical plant assumed at 4% per annum of total plant cost

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT
Table B1.3: Power Consumption for Option 1 - Lime Treatment

Item	Total Installed Power (kW)	Operating Power (kW)	Usage (h/day)	Consumption (kWh/day)	Notes
Inlet Works					
Influent Pumping	23	6	24	144	
Screens/Grit Classifiers	1	1	24	24	
pH Correction/Flocculation					
Batch Tank Stirrers	9	6	24	144	
Lime Slurry Pumps	9	1.5	24	36	
Primary Treatment					
Primary Sedimentation Tanks	4	2	24	48	
Sludge Pumps	24	6	24	144	
Disinfection and Outfall					
Disinfection Tank AerationSystem	34	12	24	288	
Outfall Pumps	18	6	24	144	
Sludge Treatment					
Sludge Recirculation Pumps	6	3	24	72	
Continuous Sludge Thickeners	1	1	24	24	
Sludge Pumps	6	1.5	24	36	
Press Feed Pumps	60	40	6	240	
Conveyor System	3	3	24	72	
Odour Control and Ventilation					
Odour Control Fans	5	8	24	192	
Roof Fans	14	8	24	192	
TOTAL				1800	

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table B2.1: Capital Costs for Option 2 - Activated Sludge

Item	Number		Cost Parameters			Cost (thousands HK$)		
	Duty	Stdby	Parameter	Value	Units	Civil	M&E	Total
Inlet Works								
Influent Pumping	4	1	Total installed power	35	kW	570.1	852.9	
Inlet Works - Civil	1		Dry Weather Flow	16000	m3/d	1561.2		
			Length	9	m			
Screens	1		Dry Weather Flow	16000	m3/d		1114.5	
Washpactor	1		Screenings throughput	0.4	t/d		876.0	
Grit/Grease Channels	2		Dry Weather Flow	16000	m3/d		1638.4	
Grit/Grease Channels Blower	1	1	Total installed power	35	kW		628.2	
Grit Classifiers	1	1	Grit throughput	0.24	t/d			
								7241.3
Primary Treatment								
Lamella Separator Tanks	3	1	Width	4.00	m			
			Depth	4.80	m			
			Length	16.4	m	1532.5	1100.2	
Lamella Plates	3	1	Volume of plates	192	m3	978.0		
Weirs	3	1				120		
Sludge Pumps	1	1	Total installed power	6	kW		197.6	
								3928.3
Secondary Treatment								
Aeration Tank (including Anoxic Zone)	1		Volume of aeration tank	3239	m3	2034.5		
Mixers	6		Total installed power	6	kW		576.0	
Blowers/Aeration System	3	1	Total installed power	92	kW		2393.8	
Internal Recycle Pumps	1	1	Total installed power	12	kW		373.1	
Clarifiers	4		Diameter	22.4	m	4268.1	1700.1	
Return Activated Sludge Pumps	4	1	Total installed power	19	kW	433.5	515.1	
								12294.3
Disinfection and Outfall								
UV Disinfection Units	3	1	Dry Weather Flow	16000	m3/d	1561.2	4983.6	
			Length	9	m			
			Total installed power	80	kW			
Outfall Pumps	2	1	Total installed power	18	kW	425.8	344.3	
Marine Outfall	1		Length	0.1	km	2248.3		
			Diameter	0.750	m			
								9563.2
Sludge Treatment								
Lime Storage Silos	1	1	Capacity of each Silo	7.50	t lime		600.0	
Batch Mixing Tanks	1	1	Volume of each tank	0.70	m3	37.3		
Lime Slurry Pumps	2		Total installed power	6	kW		197.6	
Continuous Sludge Thickeners	1	1	Volume of each tank	168	m3	485.1	696.2	
Sludge Pumps	1	1	Total installed power	6	kW		197.6	
Sludge Storage Tanks	2		Total volume	177	m3	372.2		
Polyelectrolyte Dosing System	1							
Press Feed Pumps	1	1	Total installed power	20	kW		408.0	
Filter Press	1		Cake throughput	2.71	tDS/day		1260.0	
Conveyor System	1		Cake throughput	2.71	t/d		276.0	
Skips	2							
								4530.1
Odour Control and Ventilation								
Cowlings, and Covers			Covered area	125	m2	97.5		
Ductwork	1							
Odour Control Fans	2	1	Total installed power	17.1	kW			
Bioscrubber	2		Total air flow rate	11400	m3/h		1786.9	
Roof Extractor Fans	8		Total installed power	14	kW		146.2	
								2030.6
Associated Civils Works								
Buildings:								
Control Buildings			Plan Area	50	m2	320.9		
Treatment Buildings			Plan Area	5750	m2	27600		
Mess/Administration			Plan Area	50	m2	322.5		
Indirect Civil Costs:								
Roads/hardstandings								
Inter-process Pipework								
Drainage								
Fencing								
Sub-total						8288.9		
								36532.3
Indirect M&E Costs								
Plant Control, Cabling								
Delivery								
Sub-total							6615.8	6615.8
Land Reclaimation			Area	4.45	ha	NOT INCLUDED		
Sub-total						53257.5	29478.3	82735.8
Contingencies	30		% of Subtotal					24820.8
Design and Supervision	7		% of Subtotal					5791.5
OVERALL TOTAL								113348.1

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table B2.2: Operating Cost for Option 2 - Activated Sludge

Cost/Revenue Items	Quantity (per annum)	Units	Rates (HK$ per unit)	Total (HK$)	Notes
Staff Costs					
Managerial	1	manyear	300000	300000	
Technical	1	manyear	168000	168000	
Labour	3	manyear	168000	504000	
Employment Costs (0.6xSalary)				583200	
Maintenance					
Maintenance (Consumables and Labour)				1179133	1
UV Lamp Replacement	100	Nr	444	44400	
Site Vehicles	0.25	Item	408000	102000	
Services					
Clean Water	3942	m3	6.12	24125	
Imported Electricity	1484820	kWh	0.6	890892	
Rates					
Chemical Costs					
Polyelectrolyte	3942.0	kg	36	141912	
Hydrated Lime	124.1	Tonnes	600	74460	
Transport and Disposal Costs					
Cake Export	2806.9	Tonnes	50.04	140455	
Disposal	2806.9	Tonnes	200.04	561482	
TOTAL COST				4714059	

Notes

2. Maintenance of mechanical plant assumed at 4% per annum of total plant cost

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table B2.3: Power Consumption for Option 2 - Activated Sludge

Item	Total Installed Power (kW)	Operating Power (kW)	Usage (h/day)	Consumption (kWh/day)	Notes
Inlet Works					
Influent Pumping	35	7	24	168	
Screens/Grit Classifiers	1	1	24	24	
Grit/Grease Channels Blower	35	14	24	336	
Primary Treatment					
Sludge Pumps	6	3	24	72	
Secondary Treatment					
Blowers	92	51.5	24	1236	
Mixers	6	4	24	96	
Internal Recycle Pumps	15	6	24	144	
Return Activated Sludge Pumps	19	12	24	288	
Disinfection and Outfall					
UV Disinfection Units	80	40	24	960	
Outfall Pumps	18	6	24	144	
Sludge Treatment					
Lime Slurry Pumps	6	1.5	24	36	
Continuous Sludge Thickeners	1	1	24	24	
Sludge Pumps	6	1.5	24	36	
Press Feed Pumps	20	8	6	48	
Conveyor System	1	1	24	24	
Odour Control and Ventilation					
Odour Control Fans	17	10	24	240	
Roof Fans	14	8	24	192	
TOTAL				4068	

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table B3.1: Capital Costs for Option 3 - Submerged Aerated Filters

Item	Number		Cost Parameter			Cost (thousands HK$)			No
	Duty	Stdby	Parameter	Value	Units	Civil	M&E	Total	
Inlet Works									
Influent Pumping	4	1	Total installed power	44	W	628.8	974.0		
Inlet Works - Civil	1		Dry Weather Flow	16000	m3/d	1561.2			
			Length	9	m				
Screens	1		Dry Weather Flow	16000	m3/d		1114.5		
Washpactor	1		Screenings throughput	0.4	t/d		876.0		
Grit/Grease Channels	2		Dry Weather Flow	16000	m3/d		1638.4		
Grit/Grease Channels Blower	1	1	Total installed power	35	kW		628.2		
Grit Classifiers	1	1	Grit throughput	0.24	t/d				
								7421.0	
Primary Treatment									
Lamella Separator Tanks	3	1	Width	4.00	m				
			Depth	4.80	m				
			Length	16.4	m	1532.5	1100.2		
Lamella Plates	3	1	Volume of plates	192	m3	978.0			
Weirs	3	1				120			
Sludge Pumps	1	1	Total installed power	6	kW		197.6		
								3928.3	
Secondary Treatment									
Anoxic BAFFs	4		Total volume of tanks	842	m3	2326.8			
Aerobic BAFFs	5		Total volume of tanks	1058	m3	4024.4			
Blowers/Aeration System	3	1	Total installed power	140	kW		3079.6		
Internal Recycle Pumps	1	1	Total installed power	30	kW	535.0	640.8		
Air Scour Blowers	4	1	Total installed power	69	kW		2089.3		
Backwash Pumps	3	1	Total installed power	128	kW		1589.3		
Washwater Tank	1		Volume	423	m3	521.3			
Dirty Washwater Tank	1		Volume	423	m3	521.3			
Dirty Washwater Pumps	1	1	Total installed power	3	kW		161.9		
Pipework						3600			
								19089.8	
Disinfection and Outfall									
UV Disinfection Units	3	1	Dry Weather Flow	16000	m3/d	1561.2	4983.6		
			Length	9	m				
			Total installed power	80	kW				
Outfall Pumps	2	1	Total installed power	18	kW	425.8	344.3		
Marine Outfall	1		Length	0.1	km	2248.3			
			Diameter	0.750	m				
								9563.2	
Sludge Treatment									
Lime Storage Silos	1	1	Capacity of each silo	7.50	t lime		600.0		
Batch Mixing Tanks	1	1	Volume of each tank	1.00	m3	44.9			
Lime Slurry Pumps	2		Total installed power	6	kW		197.6		
Continuous Sludge Thickeners	1	1	Volume of each tank	164	m3	481.0	690.6		
Sludge Pumps	1	1	Total installed power	6	kW		197.6		
Sludge Storage Tanks	2		Total volume	173	m3	368.5			
Polyelectrolyte Dosing System	1								
Press Feed Pumps	1	1	Total installed power	20	kW		408.0		
Filter Press	1		Cake throughput	2.64	tDS/day		1260.0		
Conveyor System	1		Cake throughput	2.64	t/d		276.0		
Skips	2						24.0		
								4548.3	
Odour Control and Ventilation									
Cowlings and Covers			Covered area	125	m2	97.5			
Ductwork	1								
Odour Control Fans	2	1	Total installed power	17.1	kW				
Bioscrubber	2		Total air flow rate	11400	m3/h		1786.9		
Roof Extractor Fans	4		Total installed power	7	kW		73.1		
								1957.5	
Associated Civils Works									
Buildings:									
Control Buildings			Plan Area	50	m2	320.9			
Treatment Buildings			Plan Area	3200	m2	15360			
Mess/Administration			Plan Area	50	m2	322.5			
Indirect Civil Costs:									
Roads/hardstandings									
Inter-process Pipework									
Drainage									
Fencing									
Sub-total						10430.9			
								26434.3	
Indirect M&E Costs									
Plant Control, Cabling									
Delivery									
Sub-total							7178.9	7178.9	
Land Reclamation			Area	4.45	ha	NOT INCLUDED			
Sub-total						48010.8	32110.5	80121.3	
Contingencies	30		% of Subtotal					24036.4	
Design and Supervision	7		% of Subtotal					5608.5	
OVERALL TOTAL								109766.2	

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table B3.2: Operating Cost for Option 3 - Submerged Aerated Filters

Cost/Revenue Items	Quantity (per annum)	Units	Rates (HK$ per unit)	Total (HK$)	Notes
Staff Costs					
Managerial	1	manyear	300000	300000	
Technical	1	manyear	168000	168000	
Labour	3	manyear	168000	504000	
Employment Costs (0.6xSalary)				583200	
Maintenance					
Maintenance (Consumables and Labour)				1926631	1
UV Lamp Replacement	100	Nr	444	44400	
Site Vehicles	0.25	Item	408000	102000	
Services					
Clean Water	3862	m3	6.12	23634	
Imported Electricity	1563113	kWh	0.6	937868	
Rates					
Chemical Costs					
Polyelectrolyte	3862	kg	36	139021	
Hydrated Lime	113	Tonnes	600	67890	
Transport and Disposal Costs					
Cake Export	2741	Tonnes	50.04	137167	
Disposal	2741	Tonnes	200.04	548340	
TOTAL COST				5482150	

Notes
1. Maintenance of mechanical plant assumed at 6% per annum of total plant cost

SHAM TSENG SEWERAGE AND SEWAGE TREATMENT

Table B3.3: Power Consumption for Option 3 - Submerged Aerated Filters

Item	Total Installed Power (kW)	Operating Power (kW)	Usage (h/day)	Consumption (kWh/day)	Notes
Inlet Works					
Influent Pumping	44	9	24	216	
Screens/Grit Classifiers	1	1	24	24	
Grit/Grease Channels Blower	35	14	24	336	
Primary Treatment					
Sludge Pumps	6	3	24	72	
Secondary Treatment					
Blowers/Aeration System	140	66	24	1575	
Internal Recycle Pumps	30	15	24	360	
Air Scour Blowers	69	50	0.5	25	
Backwash Pumps	128	85	0.5	42.5	
Dirty Washwater Pumps	3	1	24	24	
Disinfection and Outfall					
UV Disinfection Units	80	40	24	960	
Outfall Pumps	18	6	24	144	
Sludge Treatment					
Lime Slurry Pumps	6	1.5	24	36	
Continuous Sludge Thickeners	1	1	24	24	
Sludge Pumps	6	1.5	24	36	
Press Feed Pumps	20	8	6	48	
Conveyor System	1	1	24	24	
Odour Control and Ventilation					
Odour Control Fans	17	10	24	240	
Roof Fans	7	4	24	96	
TOTAL				4282.5	

APPENDIX C
EVALUATION OF H_2S GENERATION IN SEWERS

C1 INTRODUCTION

The new sewerage system at Sham Tseng will contain about 7 km of new pipelines of which about 3 km will transfer sewage under pressure from seven pumping stations. There is potential within these pipes, especially those containing pumped sewage, to produce H_2S and give rise to the associated problems of odour nuisance and corrosion inside and outside the sewerage system.

The following investigates this potential problem and the strategies for a solution.

C2 SEWERAGE DESCRIPTION

C2.1 Diagram

Figure C1 shows a schematic layout of the new sewerage system based on the information given in report {5}. The pumping stations and manholes have been labelled to designate the different sections of pipe, each referring to the section immediately downstream. Pumping station (-E) is at the western end of the sewerage and station (+H) at the eastern end.

C2.2 Pipe Diameters

As explained later, virtually all the sulphide produced in sewers arises from the reduction of sulphate by specific groups of bacteria growing in the anaerobic slimes attached to the sewer walls. To minimise the amount of slime and hence the sulphate-reducing potential, pipes should be designed so that the shear stress at the wall is greater than a critical value {6}. Subjecting the pipe walls to this critical shear stress, say, once per day controls the build-up of the slime layer although the layer is generally not eliminated. The thickness and distribution of the residual layer depends on factors such as wall roughness and the number of bends in the pipe.

The critical stress is different for gravity pipes and pumped pipes (pumping mains) having values of 3.35 Pa and 3.85 Pa respectively; these values are greater than needed for self-cleansing of loose solids. The flow velocity required to obtain such values is approximately the same in the two types of pipes for the same pipe diameter when the gravity flow has

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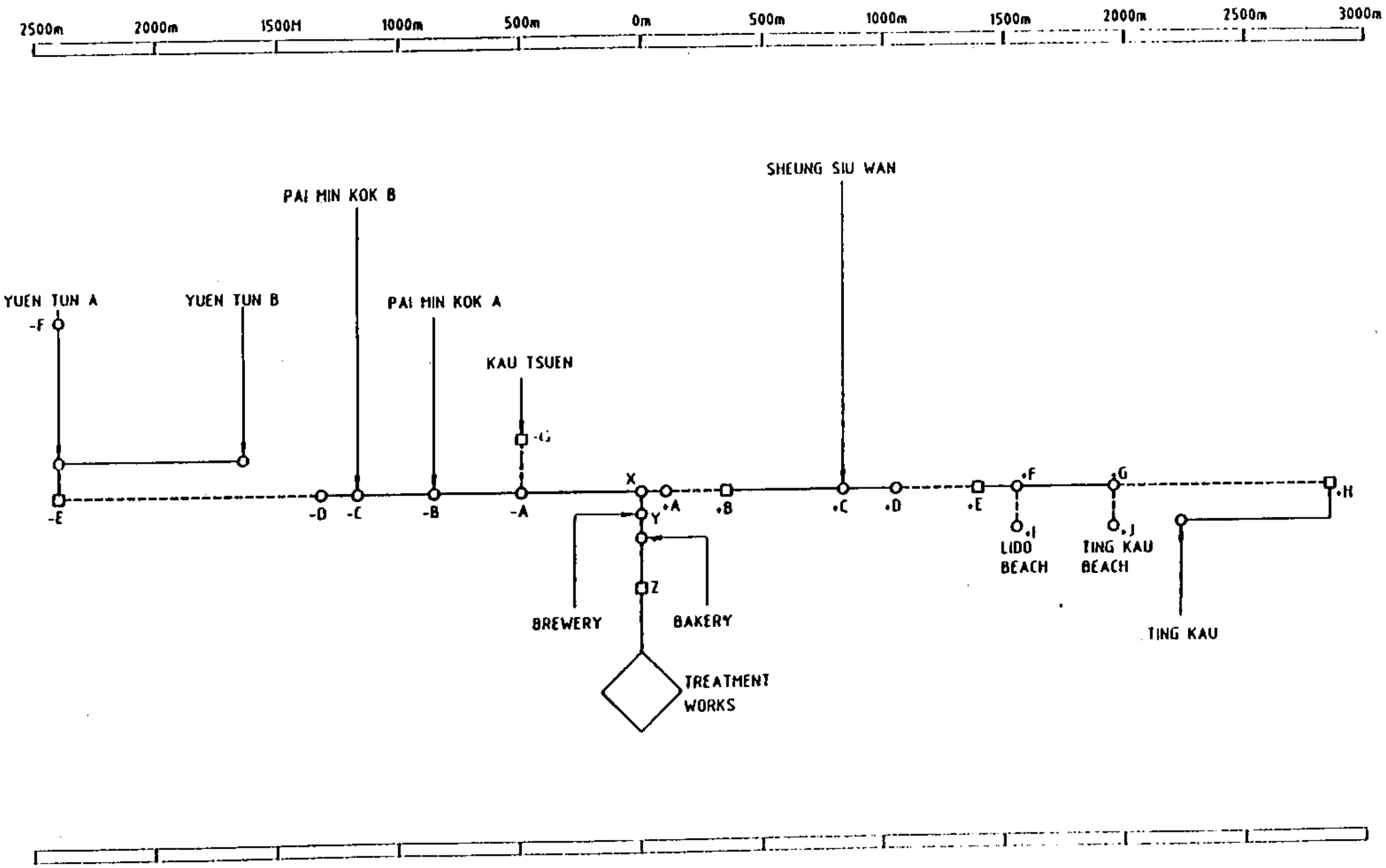
{5} *Sham Tseng Sewerage & Sewage Treatment: Underground Cavern Options*, prepared for Hong Kong Government EPD by Pypun-Howard Humphreys Ltd, January 1993

{6} *Hydrogen Sulphide Control Manual: Septicity, Corrosion and Odour Control in Sewerage Systems*, Technical Standing Committee on Hydrogen Sulphide Corrosion in Sewerage Works, Melbourne and Metropolitan Board of Works, 1989



O MANHOLE

□ PUMPING STATION

SHAM TSENG SEWERAGE
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FIGURE C1 SCHEMATIC
LAYOUT OF NEW SEWERAGE

a proportional depth of 0.8. This flow velocity varies with pipe diameter and the relationship is shown in Table C1.

Table C1: Critical flow velocities for controlling slime build-up						
Diameter (mm)	200	400	600	800	1000	1200
Velocity (m/s)	1.0	1.12	1.2	1.25	1.31	1.35

For this investigation, the simplifying assumption is made that the design velocity is 1.5 m/s at peak flow for both types of pipes, assuming all the gravity pipes are full. Pipe diameters calculated on this basis are listed in Table C2, Page 1 and are shown to range from 200 to 800 mm depending on the particular pipe.

Calculations have been performed for all the pipes in the main flow. None has been performed for the branched pipes, although calculations will, of course, be needed at a later stage.

C2.3 Other Sewerage Data

Table C2, Page 1 also lists the lengths of the various pipe sections and the peak flows in each calculated from values of the peaking factors taken from report {7}. The minimum gradients in the gravity pipe sections are also listed.

C3 HYDROGEN SULPHIDE PRODUCTION

C3.1 Mechanism

As previously explained, specific bacteria present in the anaerobic region of the slime attached to the sewer walls reduce SO_4^{--} to H_2S. When the sewage is anaerobic, SO_4^{--} reduction can also occur in the bulk of the sewage although the rate is comparativelv low. Reduction in slimes can occur even through the sewage may contain low concentrations of dissolved oxygen because the inner region of the slime may be anaerobic while the outer region is aerobic. However, under such conditions, the H_2S produced in the inner region can be subsequently oxidised to sulphuric acid and other oxidation products by specific bacteria growing in the outer region . The soluble oxidation products then diffuse into the sewage to be carried away.

Problems associated with H_2S arise when the production rate exceeds the destruction rate allowing H_2S to diffuse into the sewage and then desorb into the atmosphere above the sewage. The H_2S can then cause odour nuisance and corrode exposed surfaces of metal

{7} *Draft Drainage Works Manual*, HK Government, Drainage Services Department

Table C2, Page 1 of 2: H2S Assessment

PARAMETER			MANHOLE/PUMPING STATION IDENTIFICATION																
			-F	-E	-D	-C	-B	-A	+H	+G	+F	+E	+D	+C	+B	+A	X	Y	Z
FLOW RATES AND PIPELINE SIZES																			
Additional population			20250	3240	0	5670	5670	3500	1620	0	2430	0	0	1620	0	0			
Total population			20250	23490	23490	29160	34830	38330	1620	1620	4050	4050	4050	5670	5670	5670	44000		
Per capital flow	l/c.day		370	370		370	370	240	370	0	370			370					
Additional flow	m3/day	Residential	7493	1199		2098	2098	840	599.4	0	899.1			599.4				0	0
		Office & service workers						210											
		Industrial workers																0	0
		Commercial activities						145											
		Beach goers								120									
		Industrial effluent																0	0
		Total	7493	1199	0	2098	2098	1195	599.4	120	899.1	0	0	599.4	0	0	0	0	0
Total ADWF	m3/day		7493	8691	8691	10789	12887	14082	599.4	719.4	1619	1619	1619	2218	2218	2218	16300	16300	16300
Peaking factor			4	4	4	4	4	4	6	6	6	6	6	5	5	5	4	4	4
Peak flow rate	l/s		346.9	402.4	402.4	499.5	596.6	651.9	41.63	49.96	112.4	112.4	112.4	128.4	128 4	128.4	754.6	754.6	754.6
Pipeline type			G	P	G	G	G	G	P	G	G	P	G	G	P	G	G	G	G
Minimum pipe gradient					0.048	0.0034	0.0034	0.0034		0.012	0.012		0.014	0.028		0.016			
Max flow velocity	m/s		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Pipe diameter	mm		542.6	584.4	584.4	651.1	711.6	743.9	188	205.9	308.9	308.9	308.9	330.1	330.1	330.1	800.3	800.3	800.3
Chainage from manhole at X	m			2400	1320	1170	980	480	2850	1950	1550	1390	1050	830	350	100	0		
Length of stretch	m			1080	150	190	500	480	900	400	160	340	220	480	250	100			

GENERAL DATA FOR H2S PRODUCTION

Normal respiration in sewage at 15C	g O2/m3.h	6
Normal respiration at walls at 15C	g O2/m2.h	0.7
Normal sulphide production at 20C and BOD of 200 mg/l	g S/m2.h	0.2
Solubility of sulphide at 20C in sewage	mg/l.bar	3700
Temperature coefficient for solubility	%/degreeC	2.5
Sewage temperature	C	25
Normal respiration in sewage at sewage temp	g O2/m3.h	11.80
Normal respiration at walls at sewage temp	g O2/m2.h	0.94
Normal sulphide production at sewage temp and BOD of 200 mg/l	g S/m2.h	0.28
Solubility of H2S at sewage temp	mg/l.bar	3237.50
Partition cefficient for H2S in sewage		0.5

Table C2, Page 2 of 2: H2S Assessment

PARAMETER		MANHOLE/PUMPING STATION IDENTIFICATION																
		-F	-E	-D	-C	-B	-A	+H	+G	+F	+E	+D	+C	+B	+A	X	Y	Z
CALCULATIONS FOR PEAK DIURNAL DWF																		
Flow rate	x ADWF		2	2	2	2	2	3	3	3	3	3	2.5	2.5	2.5			
BOD of sewage	mg/l		150	150	150	150	150	150	150	150	150	150	150	150	150			
Sulphate reduction activity coefficient (0.1 to 1.5)			0.5					0.5			0.5			0.5				
Respiration activity coefficient at walls (0.1 to 1.5)			0.5					0.5			0.5			0.5				
Respiration activity coefficient in sewage (0.5 to 2.0)			1					1			1			1				
DO at pumping station	g/m3		5					5			5			5				
Av. flow rate	m3/h		724.3	724.3	899.1	1074	1174	74.93	89.93	202.3	202.3	202.3	231	231	231			
Av. flow velocity	m/s		0.75					0.75			0.75			0.75				
Retention time	mins		24					20			7.556			5.556				
Total respiration over x-section	g O2/m.h		4.03					0.883			1.797			1.985				
Length of aerobic section	m		898.7					424.2			562.8			581.8				
Length of anaerobic section	m		181.3					475.8			0			0				
Sulphide production	g/h		35.02					29.55			0			0				
Sulphide concentration in sewage	mg/l		0.048					0.394			0			0				
Equilibrium conc. in atmosphere	ppm (v/v)		7.468					60.92			0			0				
Wetted perimeter/surface width				3	3	3	3		3	3		3	3		3			
US EPA Z-factor (no sulphide when <5000)				64.46	225.5	212.7	206.5		256.6	196.4		181.8	123.1		162.8			
CALCULATIONS FOR ADWF																		
Flow rate	x ADWF		1	1	1	1	1	1	1	1	1	1	1	1	1			
BOD of sewage	mg/l		130	130	130	130	130	130	130	130	130	130	130	130	130			
Sulphate reduction activity coefficient (0.1 to 1.5)			0.25					0.25			0.25			0.35				
Respiration activity coefficient at walls (0.1 to 1.5)			0.25					0.25			0.25			0.25				
Respiration activity coefficient in sewage (0.5 to 2.0)			1					1			1			1				
DO at pumping station	g/m3		6					6			6			6				
Av. flow rate	m3/h		362.1	362.1	449.6	537	586.8	24.98	29.98	67.44	67.44	67.44	92.41	92.41	92.41			
Av. flow velocity	m/s		0.375					0.25			0.25			0.3				
Retention time	mins		48					60			22.67			13.89				
Total respiration over x-section	g O2/m.h		3.598					0.883			1.797			1.985				
Length of aerobic section	m		603.9					169.7			225.1			279.3				
Length of anaerobic section	m		476.1					730.3			114.9			0				
Sulphide production	g/h		61.3					19.66			5.081			0				
Sulphide concentration in sewage	mg/l		0.169					0.787			0.075			0				
Equilibrium conc. in atmosphere	ppm (v/v)		26.14					121.6			11.64			0				
Wetted perimeter/surface width				1.6	1.6	1.6	1.6		1.6	1.6		1.6	1.6		1.6			
US EPA Z-factor (no sulphide when <5000)				37.45	131	123.6	120		170.5	130.4		120.8	76.96		101.8			
CALCULATIONS FOR MINIMUM FLOW																		
Flow rate	x ADWF		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15			
BOD of sewage	mg/l		75	75	75	75	75	75	75	75	75	75	75	75	75			
Sulphate reduction activity coefficient (0.1 to 1.5)			0.1					0.1			0.1			0.1				
Respiration activity coefficient at walls (0.1 to 1.5)			0.1					0.1			0.1			0.1				
Respiration activity coefficient in sewage (0.5 to 2.0)			1					1			1			1				
DO at pumping station	g/m3		7					7			7			7				
Av. flow rate	m3/h		54.32	54.32	67.43	80.54	88.01	3.746	4.496	10.12	10.12	10.12	13.86	13.86	13.86			
Av. flow velocity	m/s		0.056					0.038			0.038			0.045				
Retention time	mins		320					400			151.1			92.59				
Total respiration over x-section	g O2/m.h		3.339					0.883			1.797			1.985				
Length of aerobic section	m		113.9					29.7			39.4			48.87				
Length of anaerobic section	m		966.1					870.3			300.6			201.1				
Sulphide production	g/h		49.76					5.406			3.068			2.194				
Sulphide concentration in sewage	mg/l		0.916					1.443			0.303			0.158				
Equilibrium conc. in atmosphere	ppm (v/v)		141.5					222.9			46.85			24.44				
Wetted perimeter/surface width				1.1	1.1	1.1	1.1		1.1	1.1		1.1	1.1		1.1			
US EPA Z-factor (no sulphide when <5000)				27.78	97.2	91.66	89.02		126.4	96.76		89.58	57.09		75.52			

fittings. Also, any H_2S re-absorbing on damp surfaces oxidises to sulphuric acid which is corrosive to cement and concrete as well as being highly corrosive to most metals.

C3.2 Range of Calculations

The potential for H_2S production has been investigated for both the pumped and gravity pipes, although any production of H_2S is only likely to arise in the pumped pipes.

Calculations have been performed for three flow rates as follows:

- recurring peak diurnal flow occurring during dry-weather
- design ADWF
- an estimated minimum diurnal flow

The conditions in pumped pipes at peak flow is normally the least favourable for H_2S production, since the amount of dissolved oxygen entering the pipes is then at its maximum. Thus, the probability of obtaining anaerobic conditions conducive to the reduction of SO_4^{--} is minimised. The peak flow of most relevance is that which is produced regularly from day to day. Taking into account that the design ADWF will not arise for a decade or more and that at certain times of year rain is infrequent, the recurring peak flow is assumed to 50% of the ultimate design peak flow. Such a flow for most of the pipes is equal to two times the design ADWF.

The calculations for the future ADWF have been performed to represent average conditions.

The most favourable conditions for H_2S production in the pumped pipes usually occurs at night when retention times are comparatively high. Minimum flow in all the pipes is assumed to be 0.15ADWF.

A sewage temperature of 25° C has been assumed. Any H_2S problem will be exacerbated at higher temperatures.

C3.3 Production in Gravity Pipes

C3.3.1 Z Factor

An indication of whether H_2S is likely to be a problem in gravity pipes can be deduced from the value of a Z factor which has been developed by the US.EPA {8} and is defined by

$$Z = 0.3\ BOD\ G^{-0.5}\ Q^{-0.33}\ R\ 1.07^{(T-20)}$$

where BOD is the BOD_5 (mg/l) of the sewage
G is the pipe gradient (m/m)
Q is sewage flow rate (l/s)
R is the ratio of the wetted perimeter to the surface width
and T is sewage temperature (°C).

Sewers having Z values less than 5 000 will not generally give rise to a H_2S problems and the sewage will be well aerated. Problems of odour nuisance and corrosion generally arise when the value exceeds 10 000.

C3.3.2 Results

Z values have been calculated for the three flow rates and each gravity pipe section in the main flow. The calculations are based on the lowest gradient in each section so that the worst-case values of Z have been determined. Results in Table C2, Page 2 show that all the values are generally around 200 or less. Thus, it can be safely assumed that none of the gravity pipes will give rise to H_2S production and that the degree of oxygen saturation in the sewage at the end of the sections will be high.

C3.4 Production in Pumped Pipes

C3.4.1 Anaerobic Length

In pumped pipes (rising mains), the concentration of oxygen dissolved in the sewage declines with the distance from the inlet. Most of the oxygen is consumed by heterotrophic microorganisms suspended in the sewage as well as resident in the slime and the sediment at the pipe bottom. When all the oxygen has been consumed, the sewage turns anaerobic. Pumped pipes can therefore be divided into an initial aerobic length followed, in problem pipes, by an anaerobic length.

As in gravity pipes, H_2S production can occur in aerobic lengths when the slime has anaerobic layers. However, production rate in the anaerobic length of the pipe is several

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{8} Pomeroy, Johnson and Bailey, 1974, *Sulphide Control in Sanitary Sewerage Systems*, published by US EPA fold higher and none of the H_2S is subsequently oxidised within the length. A simplifying assumption made here is that H_2S production occurs only in the anaerobic length and that the production rate is uniform along the length.

C3.4.2 Reaction Rates

Rates for the various biochemical reactions occurring in the aerobic and anaerobic parts have been taken from Pomeroy {9} and are listed in Table C3. These rates pertain to favourable reaction conditions, such as reasonably constant oxygen potential and nutrient supply and a continuous flow of sewage. However, these conditions will not be found in the pumped pipes in the Sham Tseng sewerage for several reasons as follows.

- Sewage will be pumped intermittently reducing the supply of nutrients to the wall slime.
- Flow velocity during pumping will be comparatively high (1.5 m/s) reducing the thickness and coverage of the slime.
- The aerobic and anaerobic lengths in any particular pipe may vary diurnally as the amount of dissolved oxygen entering the pipe and other factors vary. Thus, reaction rates in pipe lengths subjected to alternating aerobic and anaerobic conditions will be reduced owing to a reduction in the concentration of SO_4^{--}-reducing bacteria in the slimes.

Table C3: Assumptions for calculating H_2S production in pumped pipes

Parameter	Value
Normal respiration rate in sewage at 15°C (g O_2/m^3.h)	6.0
Normal respiration rate in slime at 15°C (g O_2/m^2.h)	0.7
Normal sulphide production rate in slime at 20°C (g $S^{=}/m^2$.h)	0.001 sewage BOD (mg/l)

An allowance has been made for these factors by multiplying the reaction rates in Table C3 by activity coefficients. For simplicity, the coefficient values vary only with flow rate; they do not model the effect of any alternating oxygen potential on reaction rate. Table C4 lists a value of unity for the coefficient of respiration in the bulk sewage, indicating that such respiration is not influenced by the flow conditions in the pipe as would be expected. However, the coefficients for the slime reactions are assumed to decrease from a value of 0.5 at peak flow to 0.1 at minimum flow. These values are based on judgement and could contain large positive or negative errors.

{9} Pomeroy R D, 1992, The Problem of Hydrogen Sulphide in Sewers, 2nd Edition, Clay pipe Association, Chesham, Bucks, England

Table C4: Activity coefficients for modifying reaction rates			
Flow	**Activity coefficient**		
	Bulk respiration	**Slime respiration**	**SO_4^{--} reduction**
Peak	1.0	0.5	0.5
Average	1.0	0.25	0.25
Minimum	1.0	0.1	0.1

C3.4.3 Dissolved Oxygen at Inlet

Assumptions also have to be made regarding the concentration of dissolved oxygen in the sewage at the pumping stations. For simplicity, it is assumed that the DO value is the same at each station but inversely related to flow rate. Since previous calculations have shown that the sewage is likely to be well aerated in the gravity sections, the assumed DO values are 5 mg/l, 6 mg/l and 7 mg/l for peak, average and minimum flows respectively.

In principle, the DO values at the pumping stations can be calculated from the aeration and respiration rates; these calculations are complex but should be undertaken at a later stage in the design.

C3.4.4 Sulphide at Inlet

The sulphide concentration in the sewage at the inlet of each pumped pipe is assumed to be zero. Thus, the calculations predict the additional sulphide which may be produced in any particular pipe.

C3.4.5 Results

Table C2, Page 2 shows the results of the calculations for the four main pumped pipes at (-E), (+H), (+E) and (+B). Table C5 summarises the main results.

None of the predicted H_2S concentrations in the sewage is particularly high. Nevertheless, the concentrations are sufficiently high to cause odour and corrosion problems.

Two pipes, namely (-E) and (+H) at the two ends of the sewerage network, are predicted to have anaerobic lengths at all (dry-weather) flows indicating that they are likely to be a potential source of sulphide most of the time. Although some of the sulphide will be sequestered by compounds of metals such as Fe, Cu, Zn and Pb present in the sewage, the residual concentration of soluble H_2S will probably be sufficiently high to cause problems.

At average flow, three of the pipes are predicted to produce H_2S. The exception is the comparatively short length of pipe at (+B).

At minimum flow, all four pipes are predicted to have anaerobic sections. The sulphide concentration from pipe (+H) is predicted to be 1.4 mg/l. The volumetric H_2S concentration in the atmosphere in equilibrium with this aqueous concentration is 223 ppm (as S) which is about 500 000 times higher than the standard detection limit for people. Such atmospheric concentrations would, of course, not be obtained in practice since the desorption of H_2S is very slow.

In terms of the H_2S production potential of each pipe, the following conclusions are drawn.

- Pipe (+H) is likely to be a source of H_2S throughout the day, the concentration of sulphide in the sewage varying up to a maximum of about 1.4 mg/l at night. Sulphide production rate is predicted to peak at a value of about 30 g/h at high sewage flow.
- Pipe (-E) could also be a continuous source of H_2S. Although the sulphide concentrations in the sewage would be lower than in pipe (+H), the sulphide production rate could be appreciably higher having a maximum value of 61 g/h at average sewage flow.
- Pipe (+E) would be anaerobic only at flows less than average. The long periods of aerobicity would therefore suppress the presence of sulphate -reducing bacteria in the slime. Any significant production of H_2S would probably only arise at night at a rate of about 3 g/h.
- Pipe (+B) would be aerobic for most of the time and unlikely to be a source of significant quantities of H_2S, although the occasional production at night may arise.

Table C5: Summary of main results for H_2S production in pumped pipes			
Pipe	**Flow**	**Sulphide**	
		Production (g/h)	**Concentration (mg/l)**
-E	Peak	35	0.05
	Average	61	0.2
	Minimum	50	0.9
+H	Peak	30	0.4
	Average	20	0.8
	Minimum	5.4	1.4
+E	Peak	0	0
	Average	5.0	0.1
	Minimum	3.1	0.3
+B	Peak	0	0
	Average	0	0
	Minimum	2.2	0.2

Table C6: Substances for controlling H_2S		
Basis of technique		**Substances**
Preventive	Maintain aerobicity	Air, Pure oxygen
	Maintain anoxicity	Nitrate salt
	Disinfection	Chlorine, Hypochlorite, Hydrogen peroxide
Remedial	Sequestration	Ferrous salt, Ferric salt, Mixture of these
	Chemical/biochemical oxidation	Pure oxygen
	Chemical oxidation	Chlorine, Hypochlorite, Hydrogen peroxide

C4 CONTROL STRATEGY

H_2S could be produced in sufficient quantities, particularly at the two ends of the sewerage system, to cause odour and corrosion problems. The following investigates the various techniques and strategies for controlling such problems.

C4.1 Options

Techniques can be classed as either preventive or remedial. Two preventive techniques have already been mentioned, these are to design the pipes for a velocity of at least 1.5 m/s and to use pipes with comparative smooth walls. However, such techniques only reduce the size of the problem rather than eliminate it.

Table C6 lists other techniques, all of which rely on dosing a substance into the sewage. In the preventive techniques, the substance is dosed into the pipe immediately downstream of the pumping station, and, in the remedial techniques, is dosed at the end of the pipe into say a tank or chamber. These success of these techniques varies depending on the specific conditions in the sewerage system.

Another remedial option is to allow the H_2S to escape from the sewage and then collect and treat the gases, and use materials resistant to corrosion by H_2S and sulphuric acid for the pipes and fittings. In many cases, a combination of techniques is needed.

C4.2 Preferred Option

An evaluation of the numerous options is beyond the scope of this report. Instead, one option which has some attractions and could be implemented for a comparatively small addition capital investment is described.

In this option, a solution of an iron salt would be dosed at pumping stations (-E) and (+H), that is at both ends of the sewage system. Thus, only two dosing points would be involved. A disadvantage of iron is that it reacts or combines with other substances such as phosphates so that high doses up to say 20 mg/l are necessary. Mixtures of ferric and ferrous salts give the best performance per unit dose and ferrous salts the worst. However, the efficacy of iron salts is improved when the sewage contains oxygen since the iron has a dual role; serving as a catalyst in the oxidation of the H_2S to sulphur as well sequestering the sulphide. The gravity pipes in the Sham Tseng sewerage system will serve as efficient aerators in this respect.

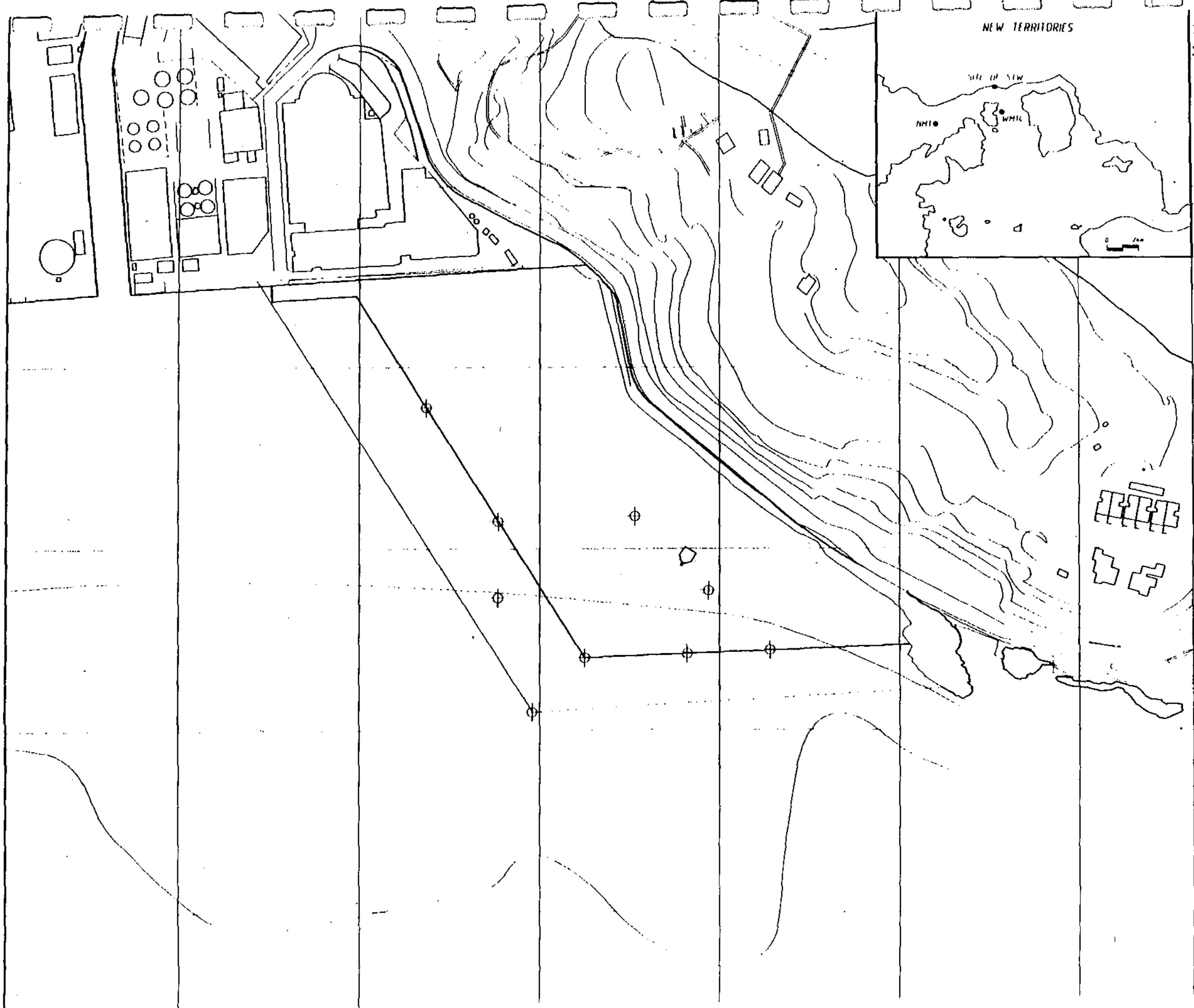
In spite of iron dosing, precautions will have to be taken as follows.

- All the pumping stations will, of course, have to be force ventilated. In particular, the ventilation system at stations at (+B) and (+E) will have to be designed so that the station and the adjoining gravity pipes receive an air-change rate of at least 6 per hour and the air vented in open space well away from buildings.
- One of the manholes at either (-B), (-C) or (-D) will probably have to be forced ventilated and the air similarly vented.
- To eliminate the possibility of odours at manhole (X) which is in an extremely sensitive area, the gravity pipe downstream of (X) should be vented to the treatment works where the air can then pass through the works odour removal system.
- The material of construction of the pipes especially the gravity pipes should be polypropylene. Similarly, the all the manholes and covers downstream of the pumped pipes should be protected from H_2S and sulphuric acid corrosion.

C5 CONCLUSIONS

Calculations have shown that the two pumped pipes at either end of the sewerage have the potential to produce H_2S in sufficient quantities to cause odour and corrosion problems. The two intermediate pumped pipes are only likely to produce H_2S at times of low flow and in much reduced quantities.

The preferred option for dealing with the potential problems associated with the H_2S is to dose a solution of an iron salt, preferably a proprietary mixture of ferric and ferrous salts or a ferric salt, at the two pumping stations at either end of the sewerage system. Pumping stations and some manholes would need to be ventilated and the air released in open space well away from buildings. Also, the gravity pipes near the treatment works and the inlet pumping station would be vented into the works and treated in the works odour removal system. As described in the main text, the odour control system has been designed and costed accordingly.



Notes

Reference Drawings

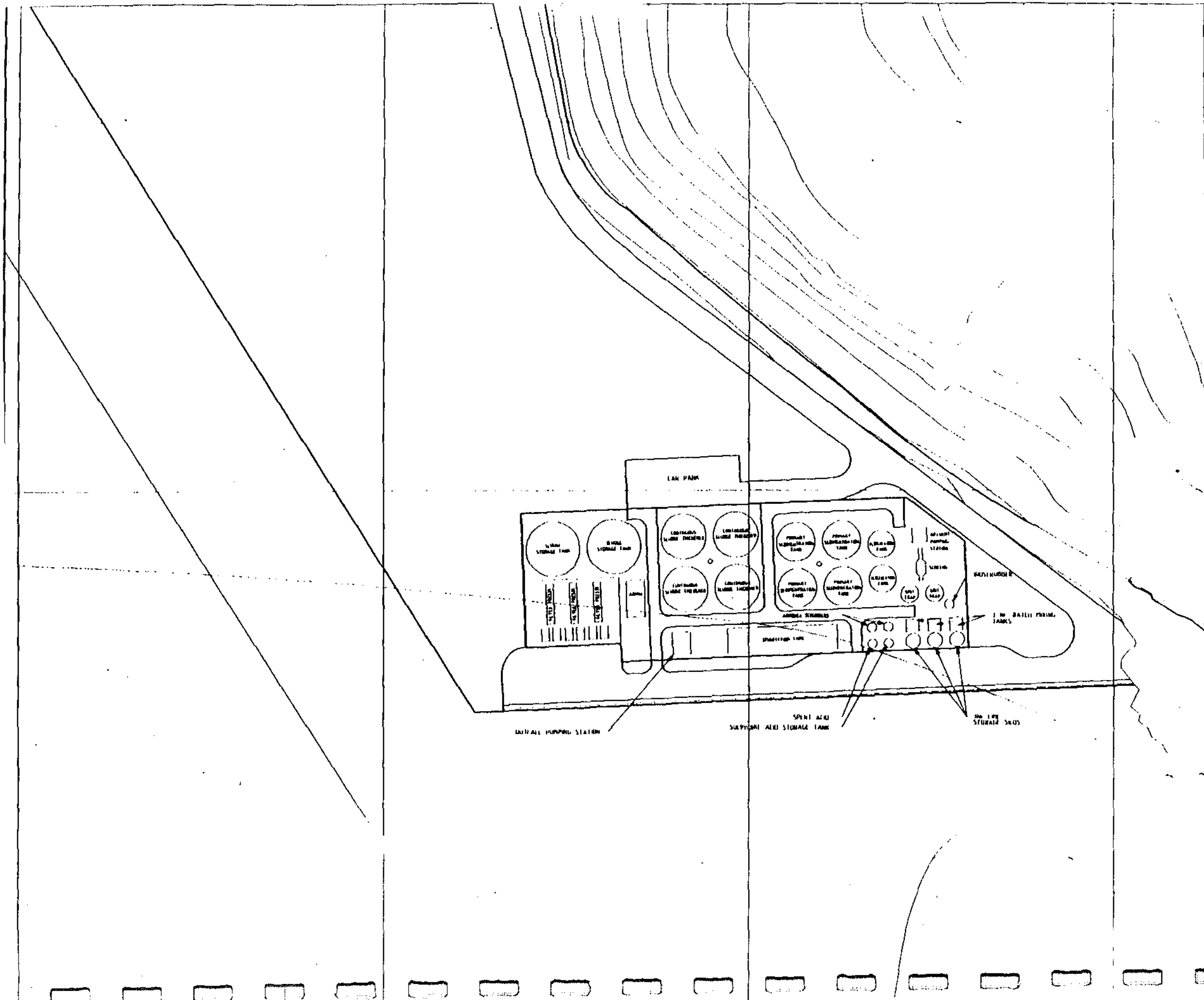
P1	11/10/94	RJR	PRELIMINARY ISSUE

Mott MacDonald

TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

MAP OF SURROUNDING AREA

Designed		S. LOYLAND
Drawn		N. ROLFE



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Reference Drawings

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Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	06/11/96		PRELIMINARY ISSUE		

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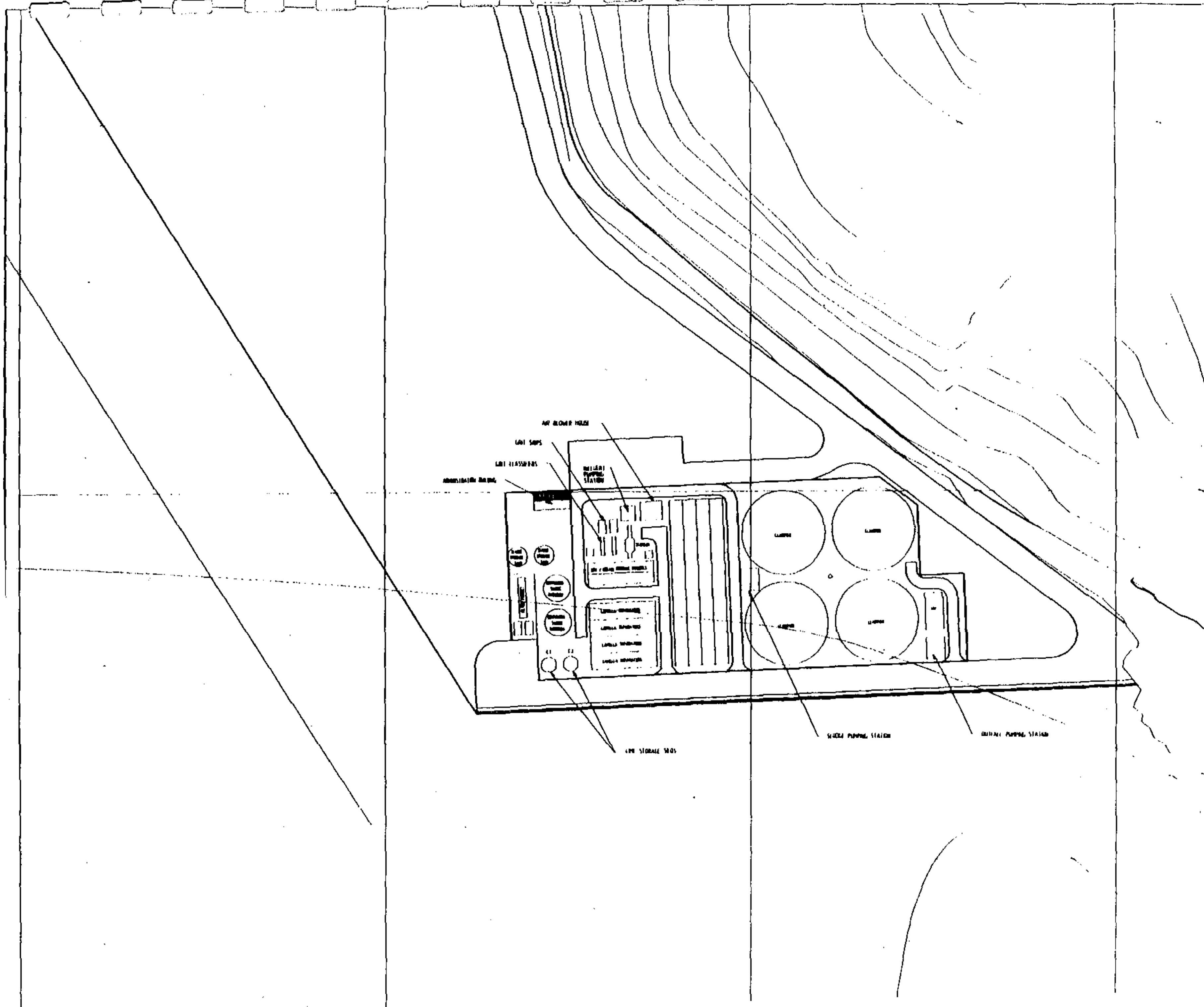
TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

OPTION 1
LIME TREATMENT



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Reference Drawings

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P1 | PRELIMINARY ISSUE

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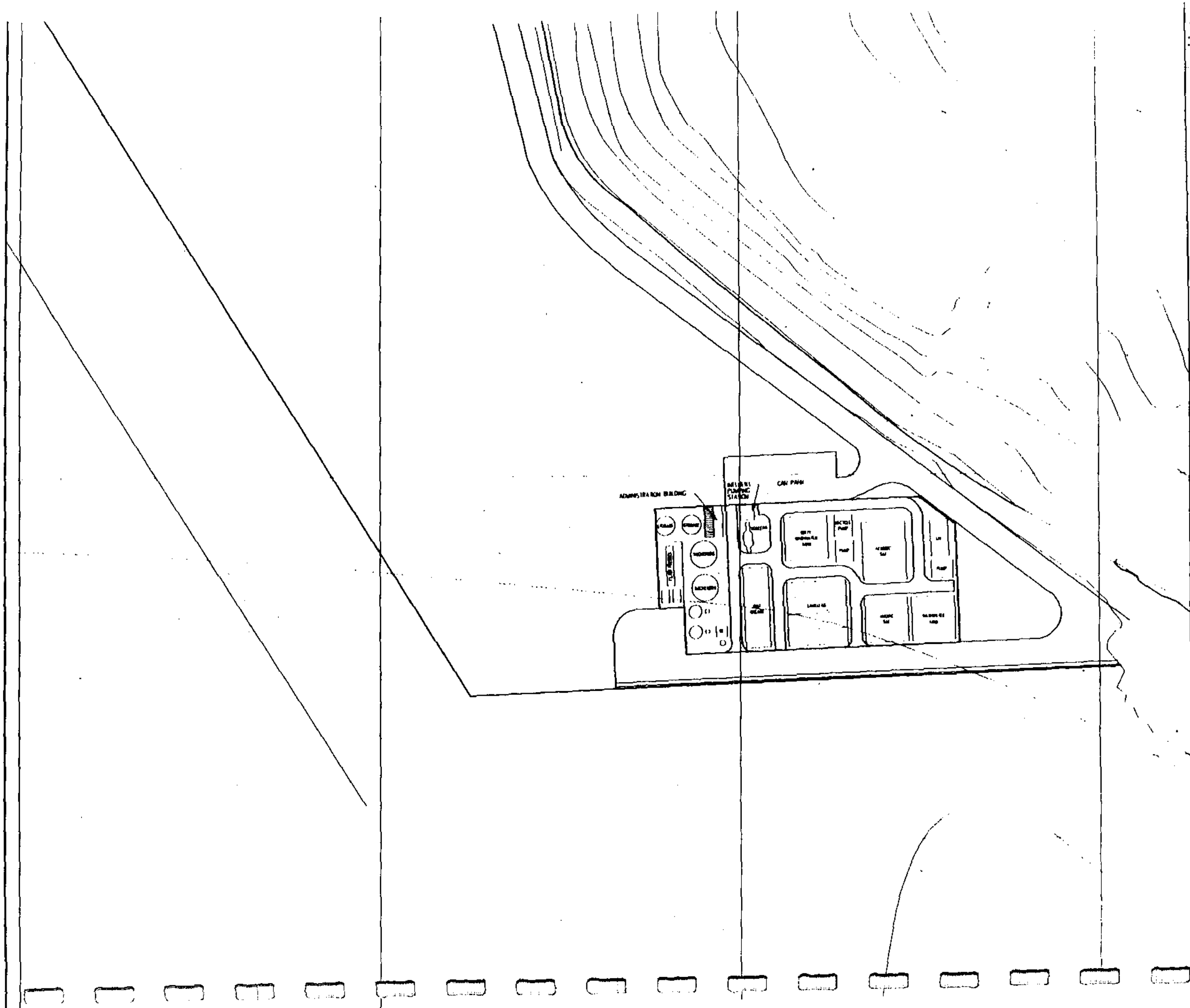
TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

OPTION 2
ACTIVATED SLUDGE

Notes

Reference Drawings



P1	04/11/94	RJR	PRELIMINARY ISSUE

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TIN KAU AND SHAM TSENG SEWERAGE MA
SEWERAGE AND SEWAGE TREATMENT

OPTION 3
LAMELLA SEPARATORS AND
SUBMERGED AERATED FILTRATION

VALVES

VALVE NORMALLY OPEN (GENERAL)

VALVE NORMALLY CLOSED

NON RETURN VALVE

PRESSURE RELIEF VALVE (ANGLED)

PRESSURE RELIEF VALVE IN LINE

BUTTERFLY VALVE

PRESSURE REGULATING VALVE

PENSTOCK OPEN

PENSTOCK CLOSED

ACTUATORS

MOTORISED ACTUATOR

FLOAT ACTUATOR

PUMPS

CENTRIFUGAL PUMP

POSITIVE DISPLACEMENT PUMP

POSITIVE DISPLACEMENT RECIPROCATING PUMP

RECIPROCATING COMPRESSOR

CENTRIFUGAL PUMP

POSITIVE DISPLACEMENT PUMP

AIR BLOWER

TANKS

TANK WITH BOTTOM ENTRY/EXIT

TANK WITH TOP ENTRY/EXIT

MISCELLANEOUS

AIR FILTER

CONDENSATE RELEASE

FLEXIBLE HOSE

ELECTRIC MOTOR

STIRRER (PROPELLER TYPE)

BLANK FLANGE

WEIR

SCREEN

EXHAUST STACK

SUBMERSIBLE MIXER

AXIAL FLOW FAN

SENSORS/DETECTORS

FUNCTION PROPERTY — SENSOR/DETECTOR (GENERAL)
FUNCTION - SEE LETTER CODES FOR MEASURED VARIABLES
PROPERTY - i.e. pH, COLOUR etc.

ELECTROMAGNETIC FLOWMETER

PITOT TUBE FLOWMETER

VARIABLE AREA FLOWMETER

ULTRASONIC LEVEL SENSOR

FLOAT LEVEL SENSOR

INSTRUMENT SIGNAL LINES

LETTER CODE FOR IDENTIFICATION OF INSTRUMENT FUNCTIONS

1st LETTER (MEASURED OR INITIATING VARIABLE)

SYMBOL	DESCRIPTION
C	CURRENT
D	DENSITY
F	FLOW
G	GAUGING, POSITION or LENGTH
H	HAND (MANUALLY INITIATED) OPERATED
K	TIME OR TIME PROGRAMME
L	LEVEL
M	MOISTURE or HUMIDITY
N	STATUS INDICATION (ON/OFF)
P	PRESSURE or VACUUM
Q	QUALITY (PROPERTY AS NOTED)
S	SPEED or FREQUENCY
T	TEMPERATURE
V	VISCOSITY
W	WEIGHT
Y	ULTRA VIOLET

SUCCEEDING LETTERS (MODIFIER, DISPLAY or OUTPUT FUNCTIONS)

SYMBOL	DESCRIPTION
A	ALARM
C	CONTROLLING
D	DIFFERENCE
E	SENSING ELEMENT
F	RATIO
H	HIGH
	INDICATING
J	SCAN
L	LOW
P	TEST POINT CONNECTION
Q	INTEGRATE, TOTALISE or SUMMATING
R	RECORDING
S	SWITCHING
T	TRANSMITTING
V	VALVE, DAMPER ACTUATING ELEMENT
Y	RELAY
Z	EMERGENCY or SAFETY ACTING

IDENTIFICATION OF PLANT TAG NUMBERS

CODE REF

LETTER CODE FOR IDENTIFICATION OF INSTRUMENT FUNCTIONS (SEE TABLES)

Notes

Reference Drawings

PRELIMINARY ISSUE

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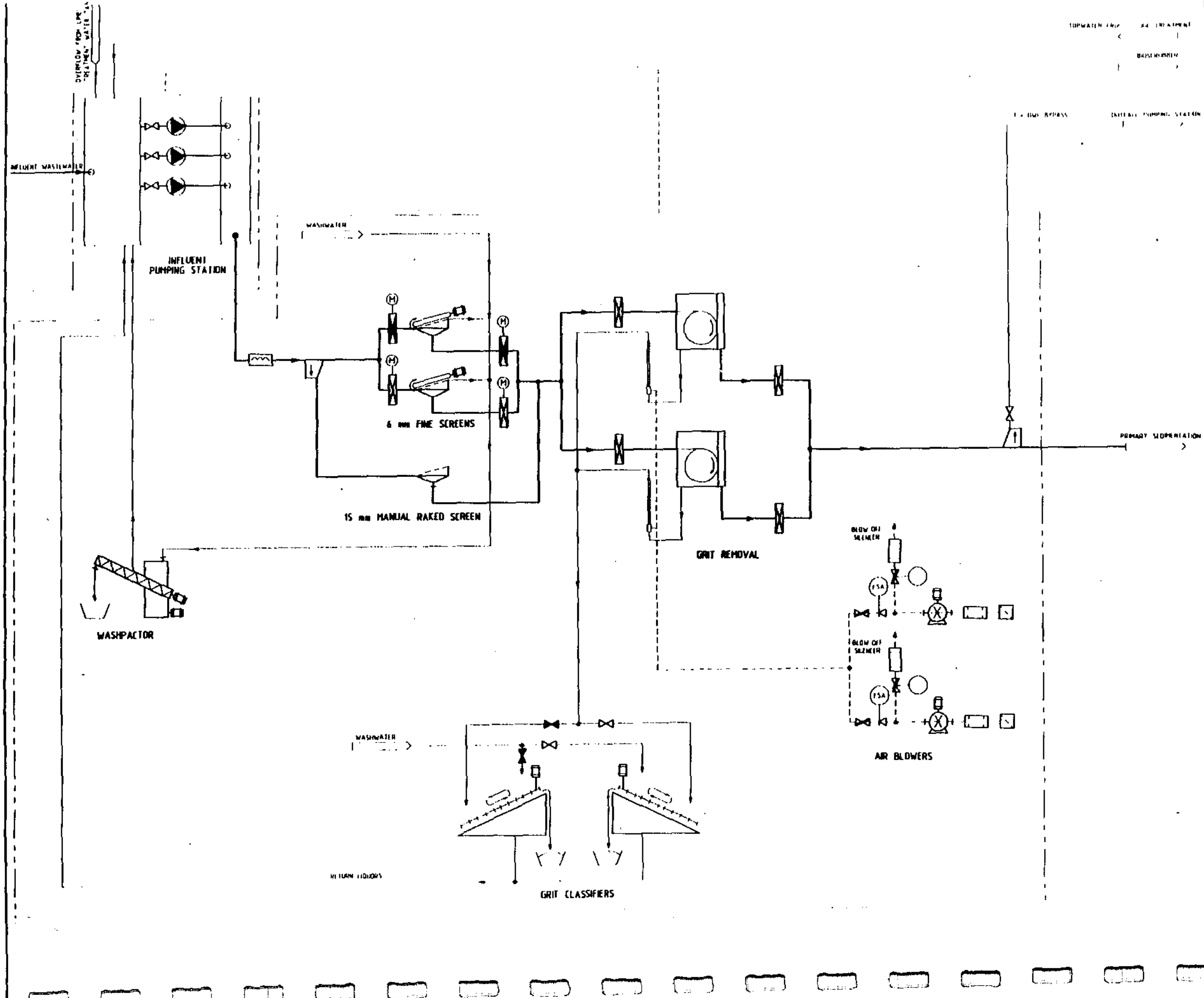
TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

PROCESS FLOWSHEET
LEGEND

L. HOTLAND

I B SMITH



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Reference Drawings

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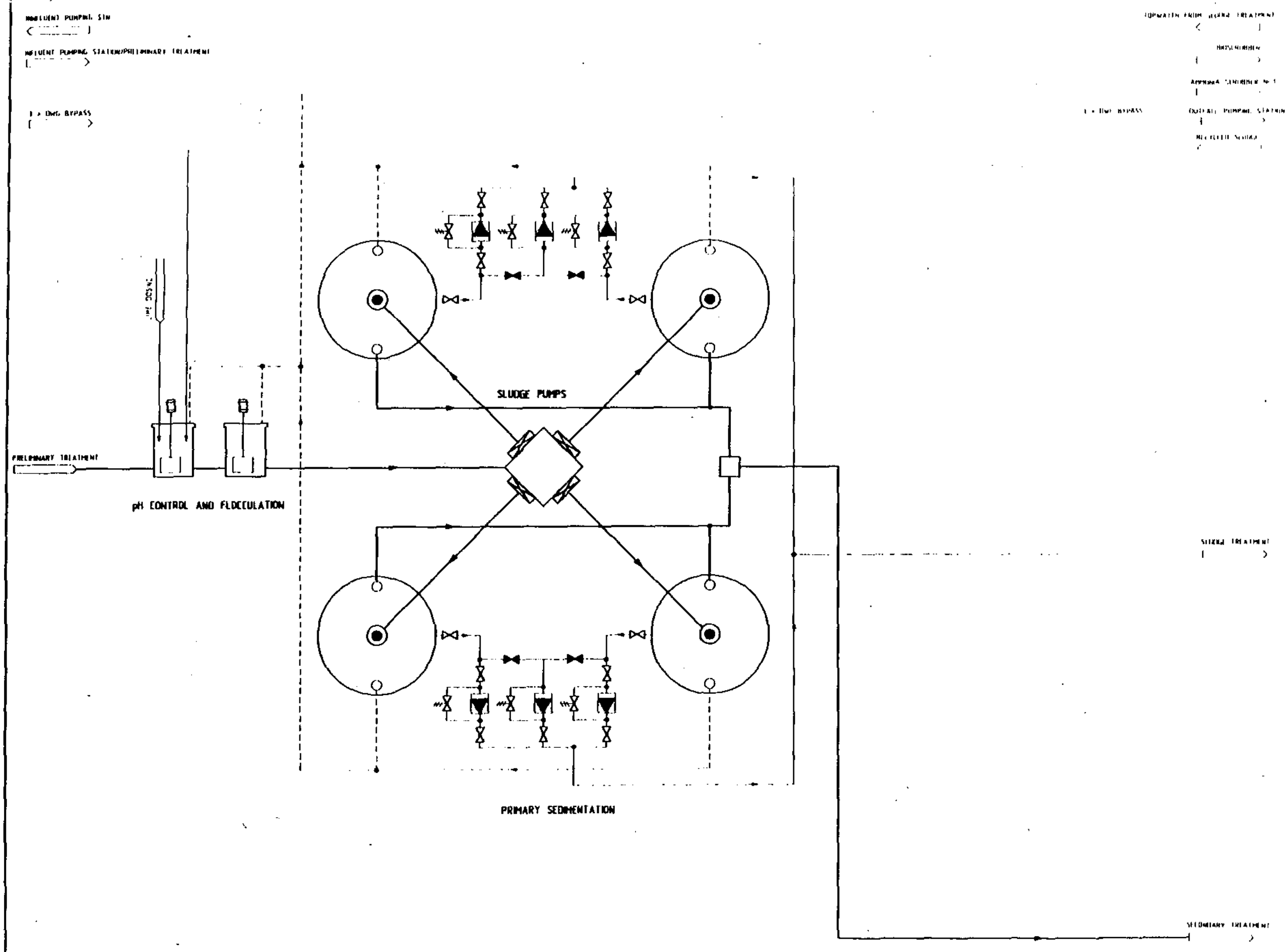
TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

Title
OPTION 1
LIME TREATMENT

PROCESS FLOWSHEET
SHEET 1 OF 5



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Reference Drawings

Legend

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Rev	Date		Description	Chk'd	App'd

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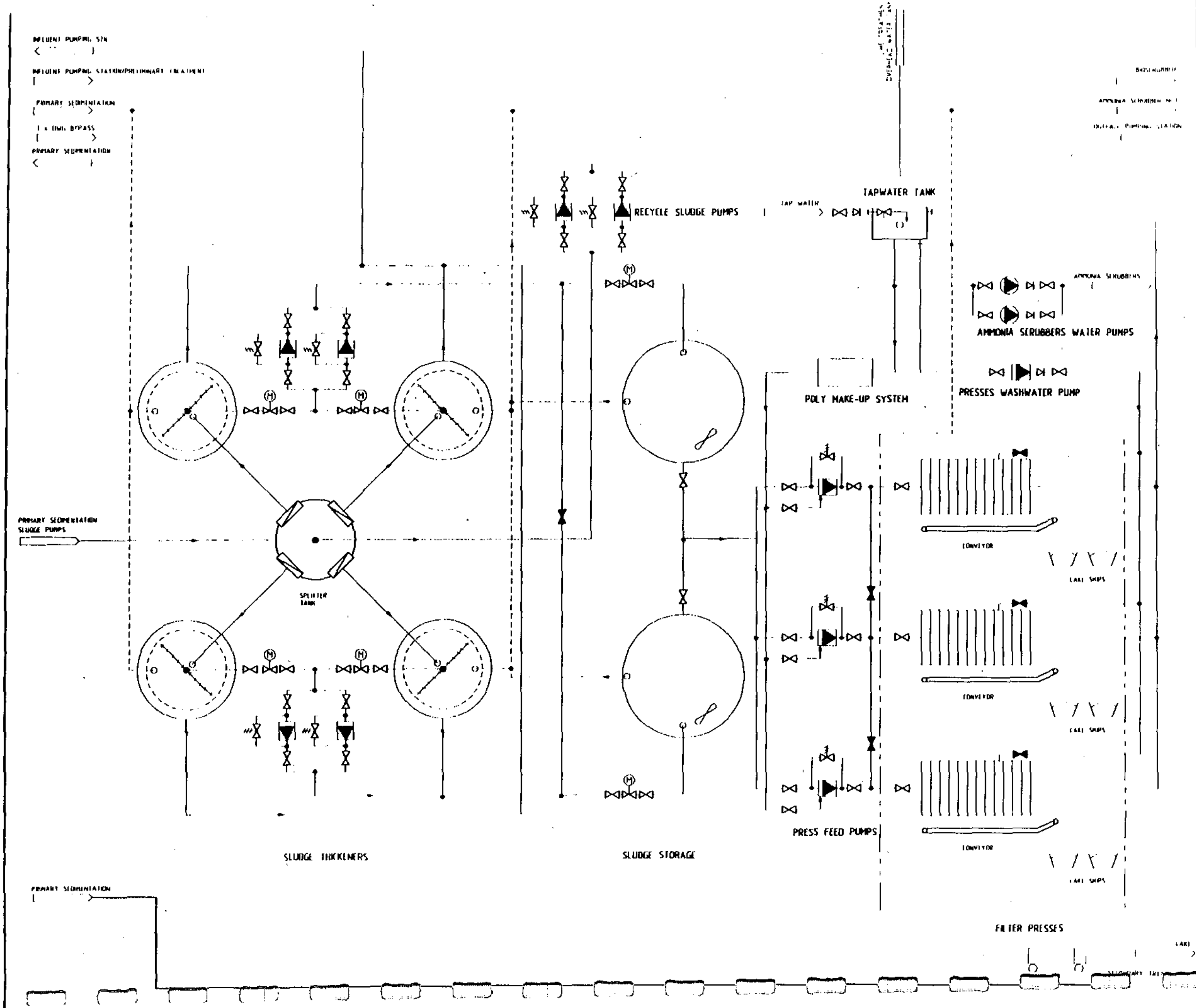
TIN KAU AND SHAM TSENG SEWERAGE EIA SEWERAGE AND SEWAGE TREATMENT

Title

OPTION 1
LIME TREATMENT

PROCESS FLOWSHEET
SHEET 2 OF 6

Designed		S. HOTLAND	
Drawn		J. B. SMITH	
Dwg. No.			



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Reference Drawings

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P1 OCT 1994 PRELIMINARY ISSUE

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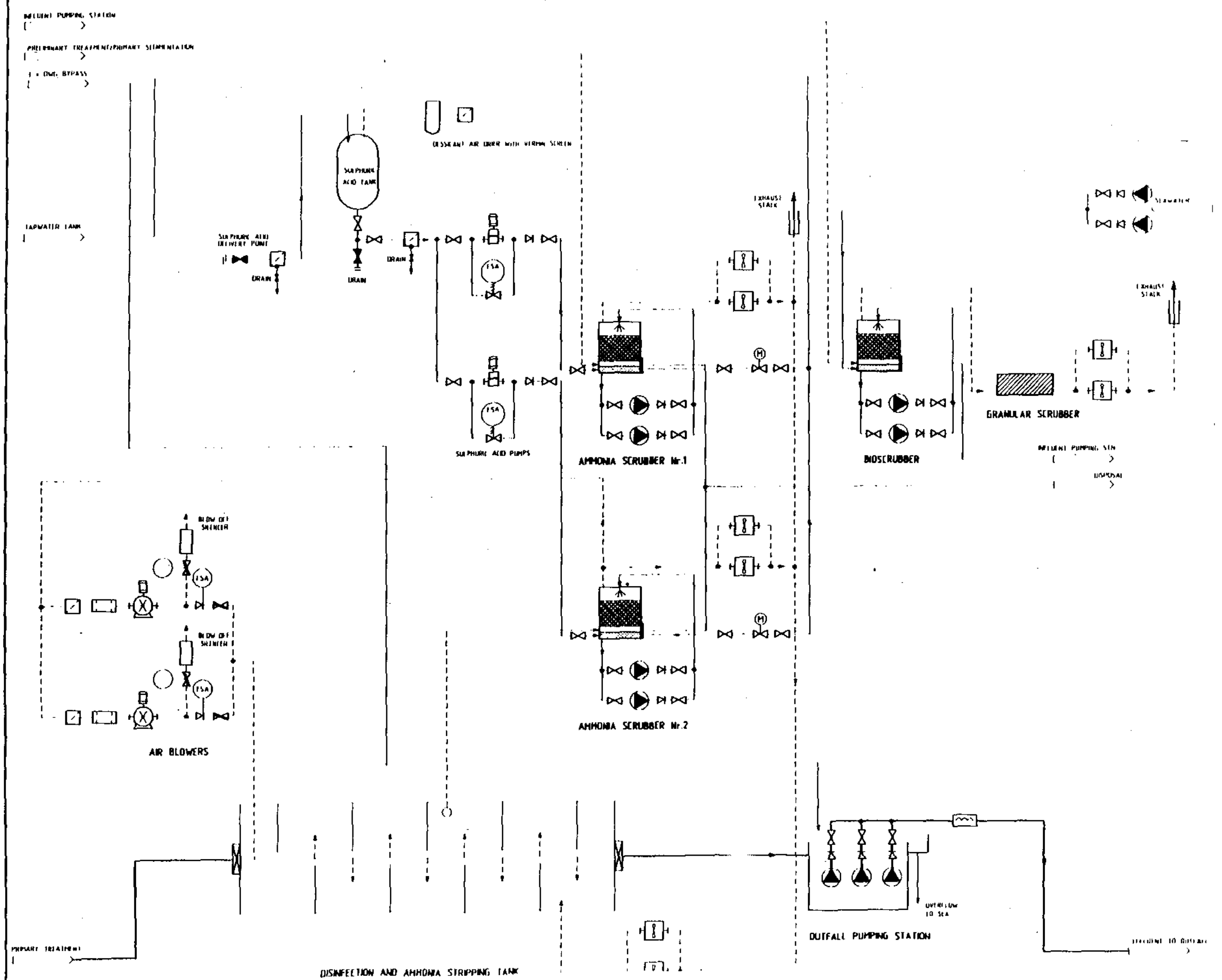
TIN KAU AND SHAM TSENG SEWERAGE SEWERAGE AND SEWAGE TREATMENT

OPTION 1
LIME TREATMENT

PROCESS FLOWSHEET
SHEET 3 OF 5



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Reference Drawings

Legend 27176/P1/010

P1 OCT 1994 MS PRELIMINARY ISSUE

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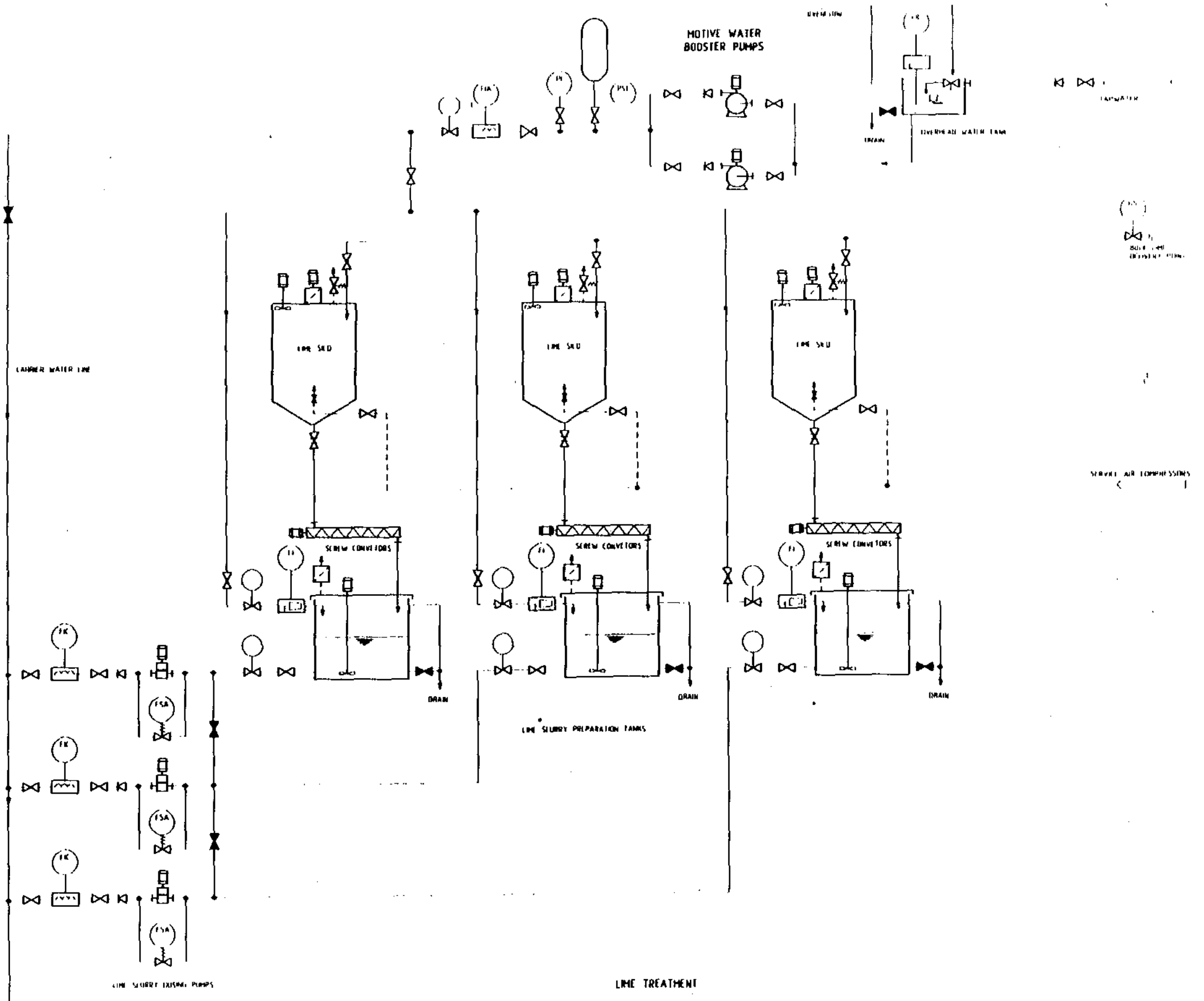
TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

OPTION 1
LIME TREATMENT

PROCESS FLOWSHEET
SHEET 4 OF 5



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Reference Drawings

Legend 21776/P1/810

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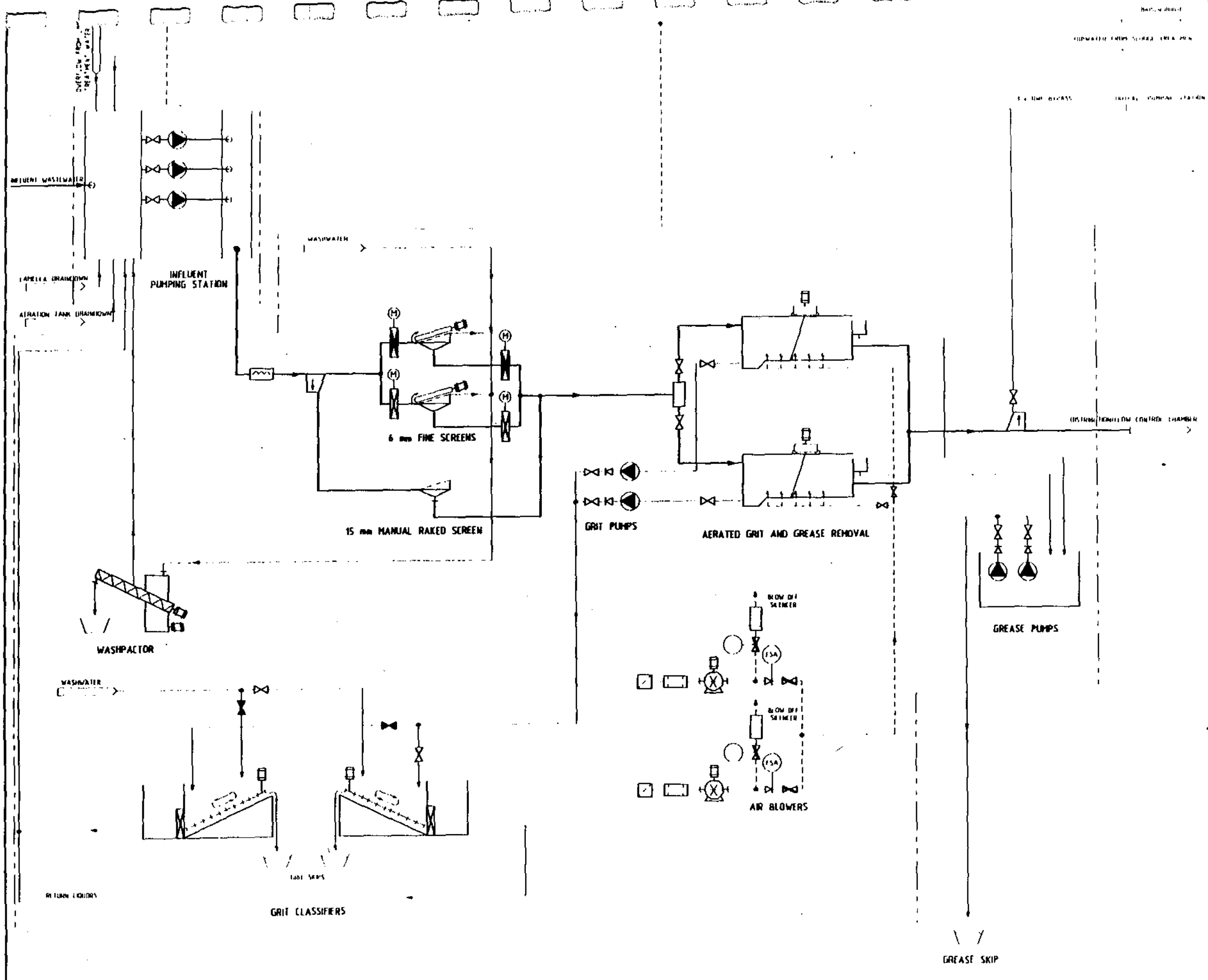
TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

Title
OPTION 1
LIME TREATMENT

PROCESS FLOWSHEET
SHEET 5 OF 5



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Reference Drawings

Legend 27776/P1/010

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P1	OCT 1994	JBS	PRELIMINARY ISSUE		

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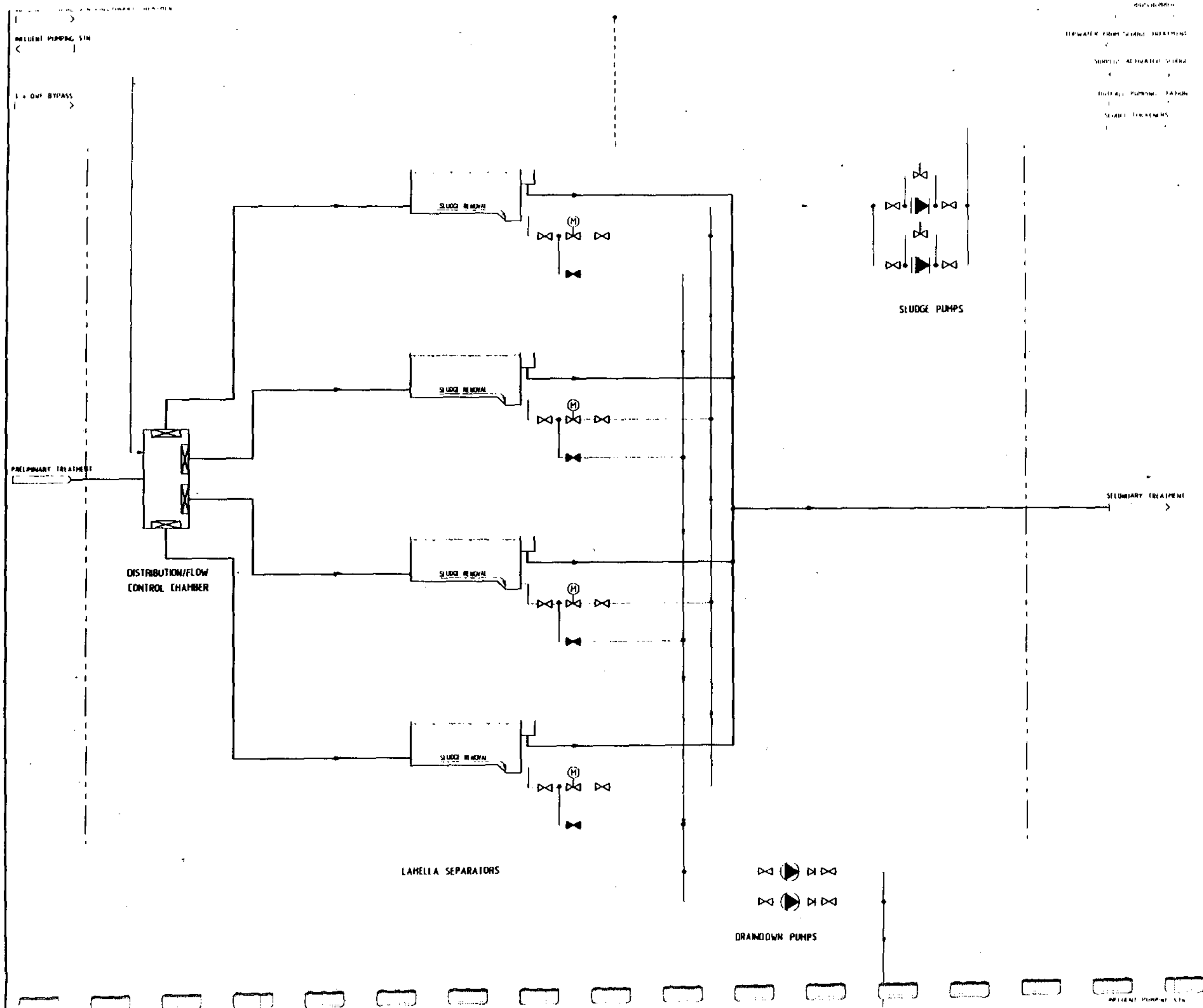
TIN KAU AND SHAM TSENG SEWERAGE MA SEWERAGE AND SEWAGE TREATMENT

Title

OPTION 2
ACTIVATED SLUDGE

PROCESS FLOWSHEET
SHEET 1 OF 6



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Reference Drawings

Legend 27116/PL/010

P1 OCT 1994 PRELIMINARY ISSUE

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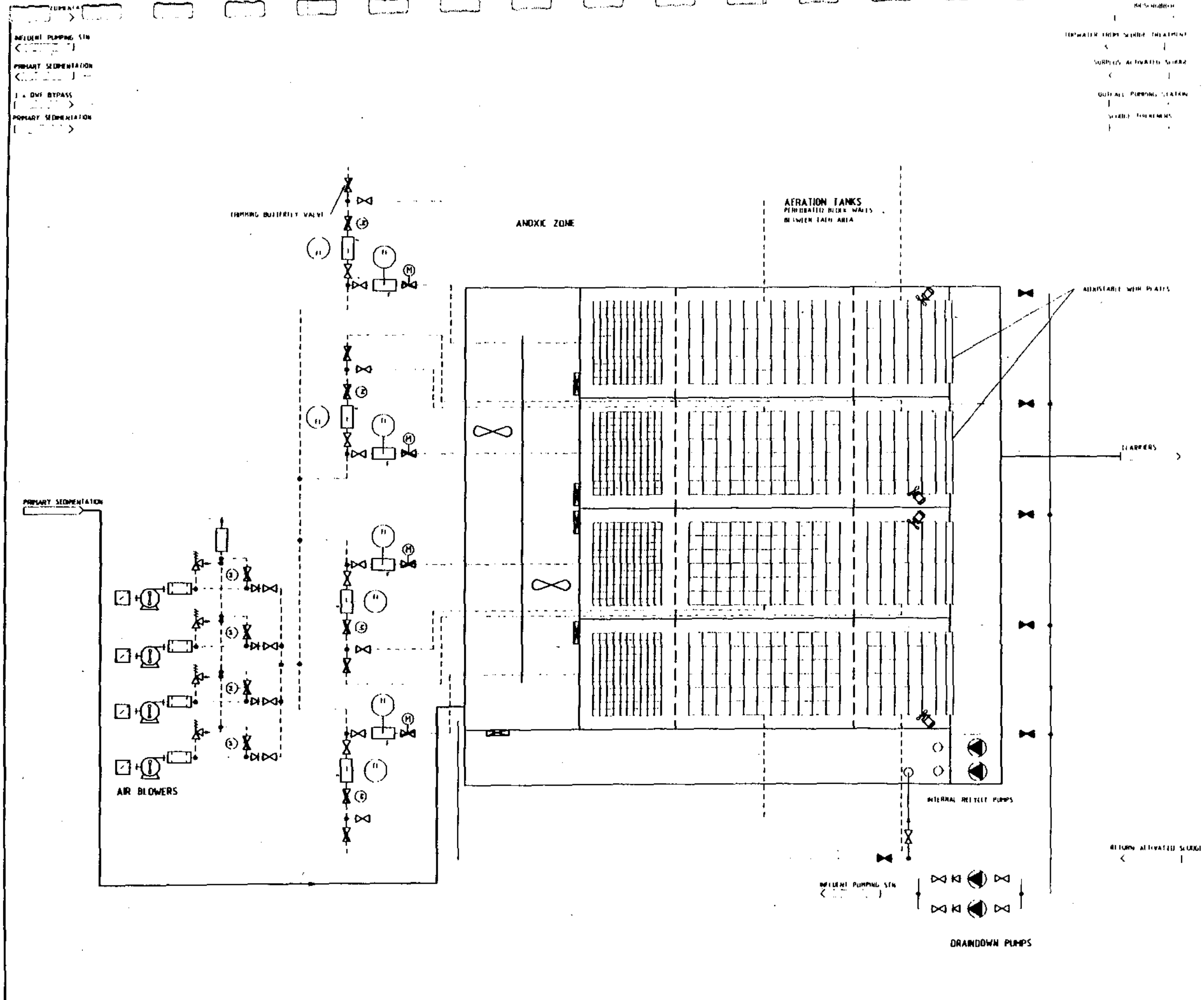
TIN KAU AND SHAM TSENG SEWERAGE MA
SEWERAGE AND SEWAGE TREATMENT

OPTION 2
ACTIVATED SLUDGE

PROCESS FLOWSHEET
SHEET 2 OF 8



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Reference Drawings

Legend 22136/P1/BR

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P1	OCT 1994	JBS	PRELIMINARY ISSUE		

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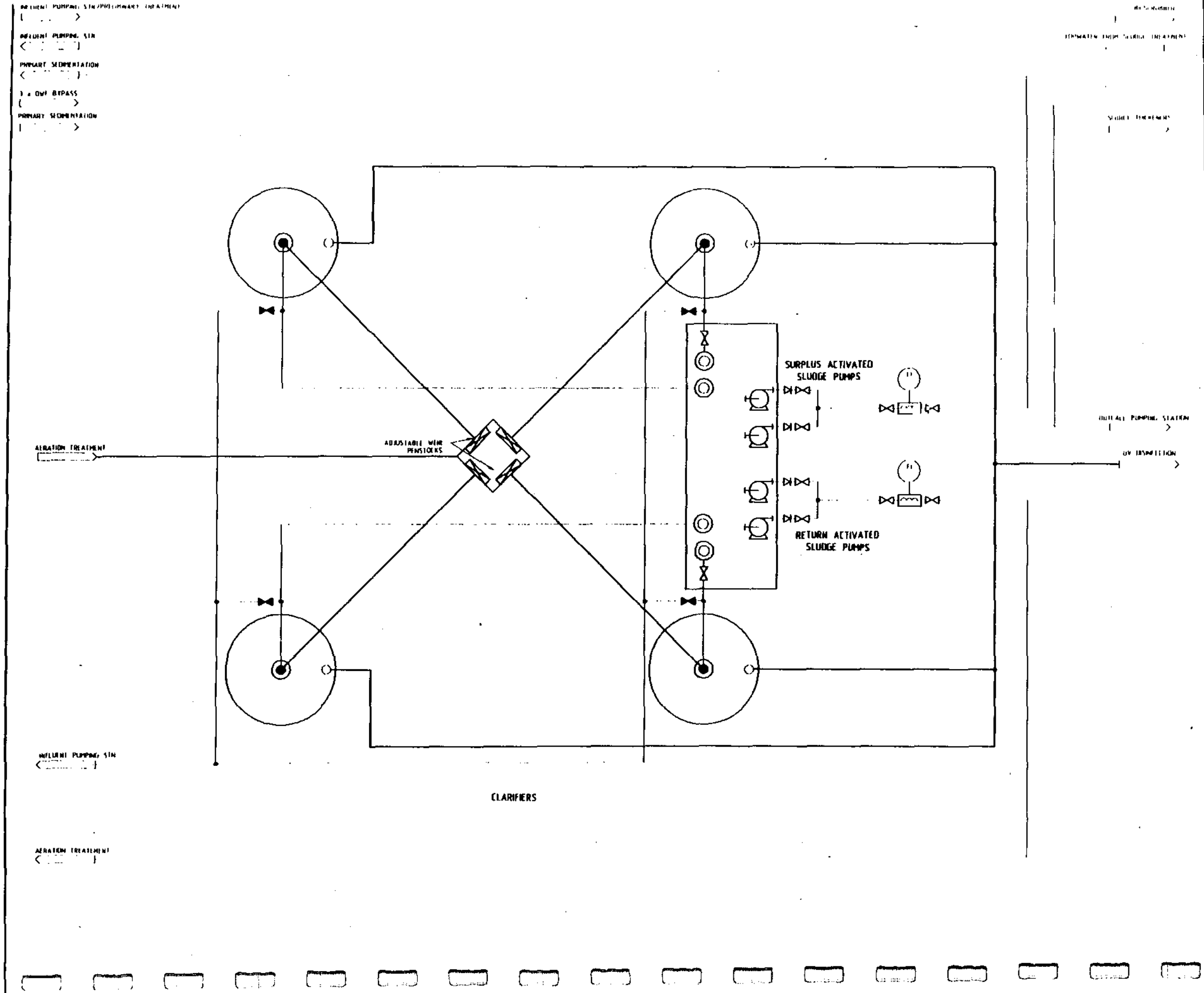
TIN KAU AND SHAM TSENG SEWERAGE MA
SEWERAGE AND SEWAGE TREATMENT

Title
OPTION 2
ACTIVATED SLUDGE

PROCESS FLOWSHEET
SHEET 3 OF 6

Designed		L. HOTLAND	
Drawn		J. A. SMITH	



Notes

Reference Drawings

Legend 21716/PL/010

P1	OCT 1996	JRS	PRELIMINARY ISSUE		
Rev	Date	Drawn	Description	Ch'k'd	App'd

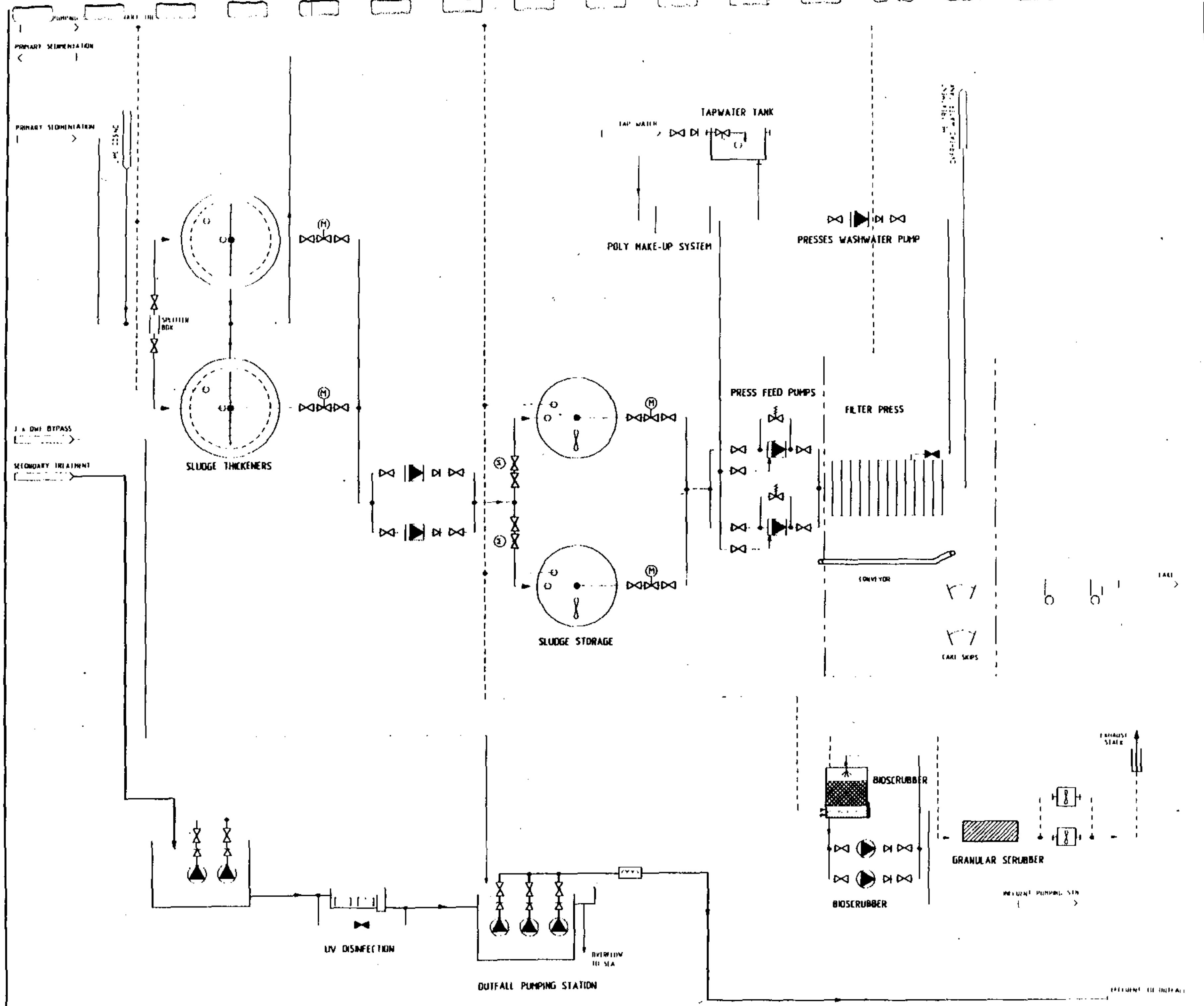
Mott MacDonald

Client

TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

Title
OPTION 2
ACTIVATED SLUDGE

PROCESS FLOWSHEET
SHEET 4 OF 6



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Reference Drawings

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Rev	Date		Description	Chk'd	App'd

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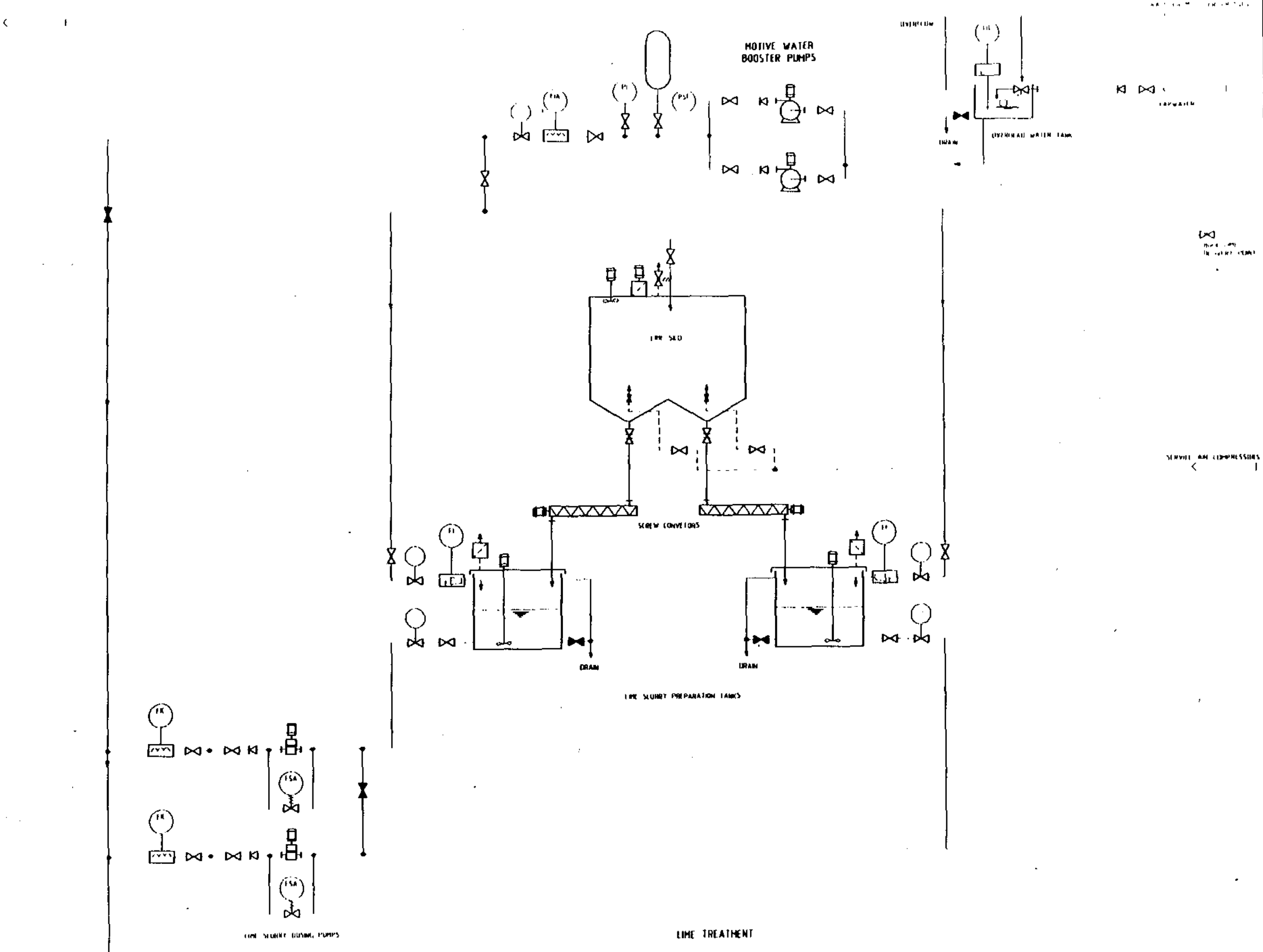
SEWERAGE AND SEWAGE TREATMENT

OPTION 2
ACTIVATED SLUDGE

PROCESS FLOWSHEET
SHEET 6 OF 6



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Reference Drawings

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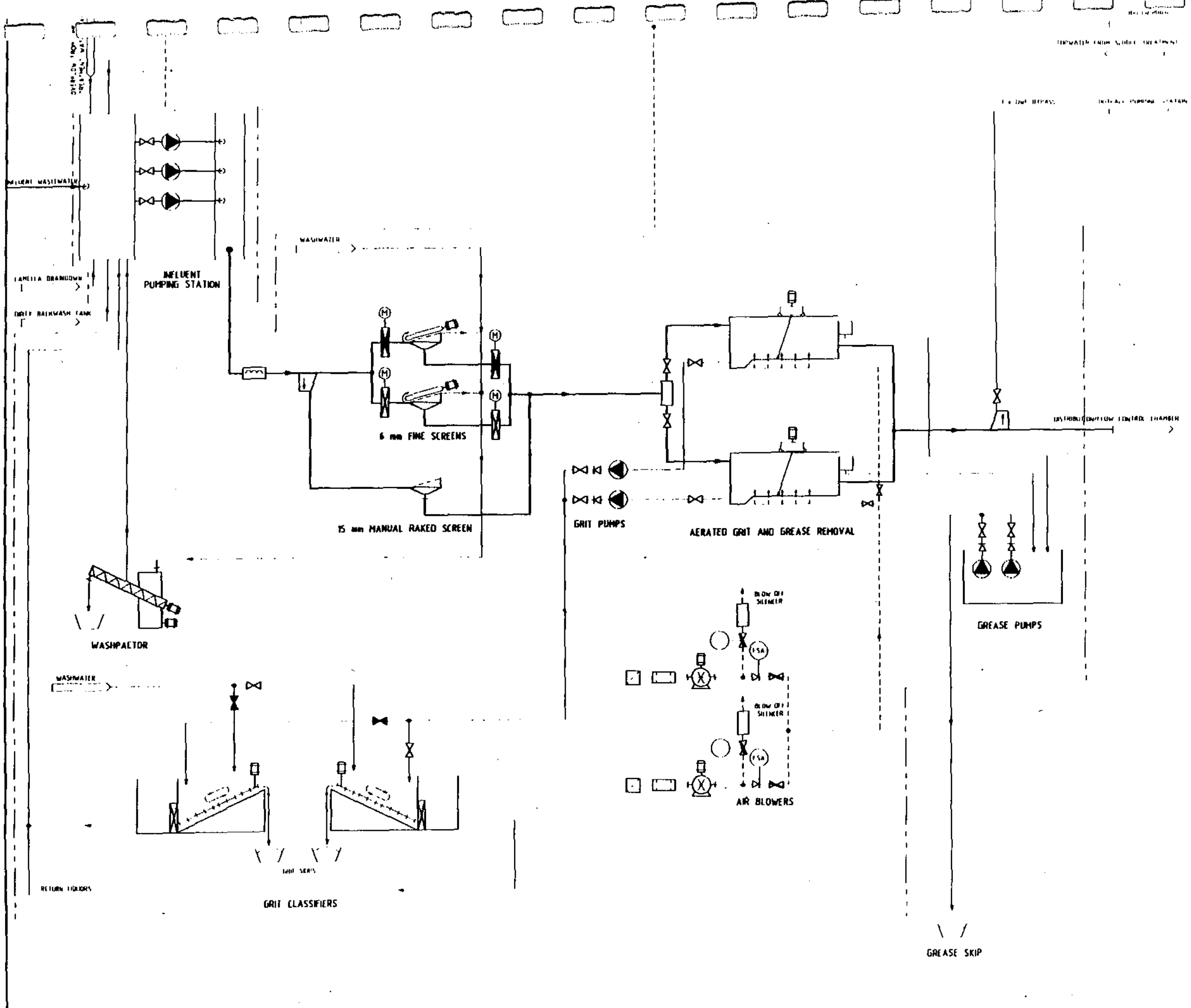
SEWERAGE AND SEWAGE TREATMENT

OPTION 2
ACTIVATED SLUDGE

PROCESS FLOWSHEET
SHEET 6 OF 6



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Reference Drawings

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P1	OCT 1994	JRS	PRELIMINARY ISSUE		

Mott MacDonald

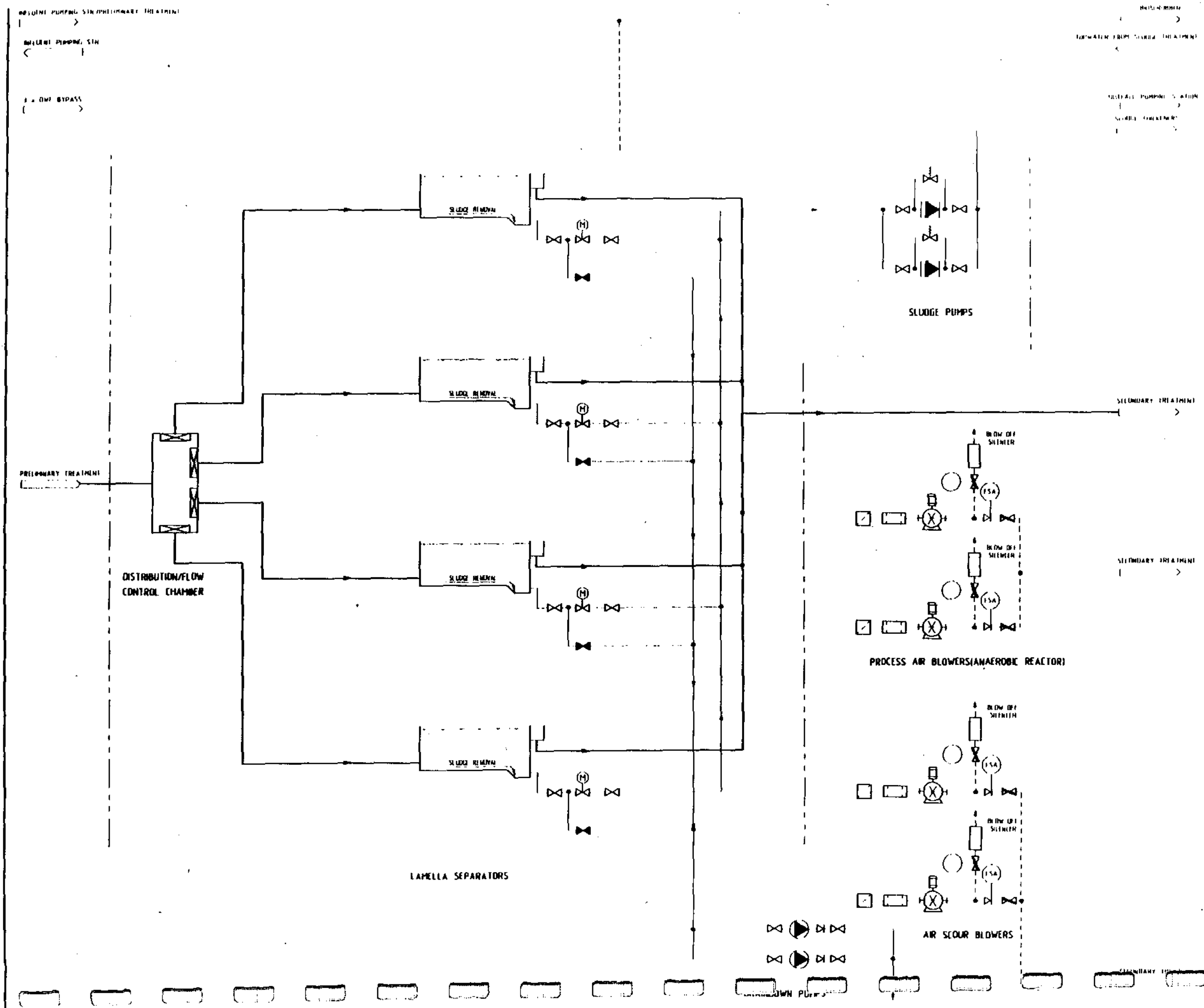
Client

TIN KAU AND SHAM TSENG SEWERAGE SIA SEWERAGE AND SEWAGE TREATMENT

Title

OPTION 3
LAMELLA SEPARATORS AND SUBMERGED AERATED FILTRATION PROCESS FLOWSHEET
SHEET 1 OF 6

Designed		I. HOTLAND	Eng Chk
Drawn		J B SMITH	Interface Chk
Eng Chk			



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Reference Drawings

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P1	OCT 1994	JWS	PRELIMINARY ISSUE		

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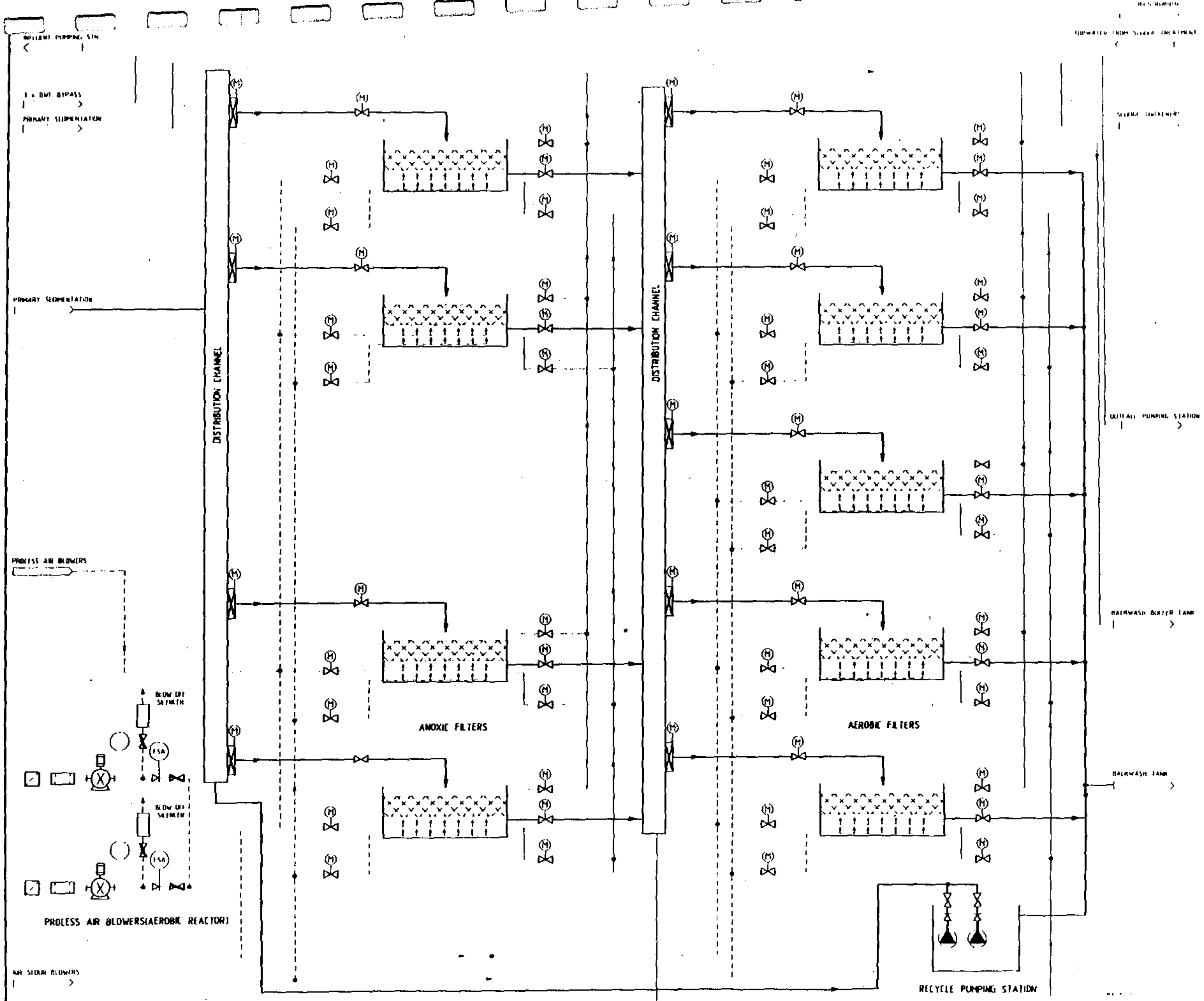
TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

Title

OPTION 3
LAMELLA SEPARATORS AND
SUBMERGED AERATED FILTRATION
PROCESS FLOWSHEET
SHEET 2 OF 5



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Reference Drawings

Legend 27776/PL/818

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P1	OCT 1995	JWS	PRELIMINARY ISSUE		

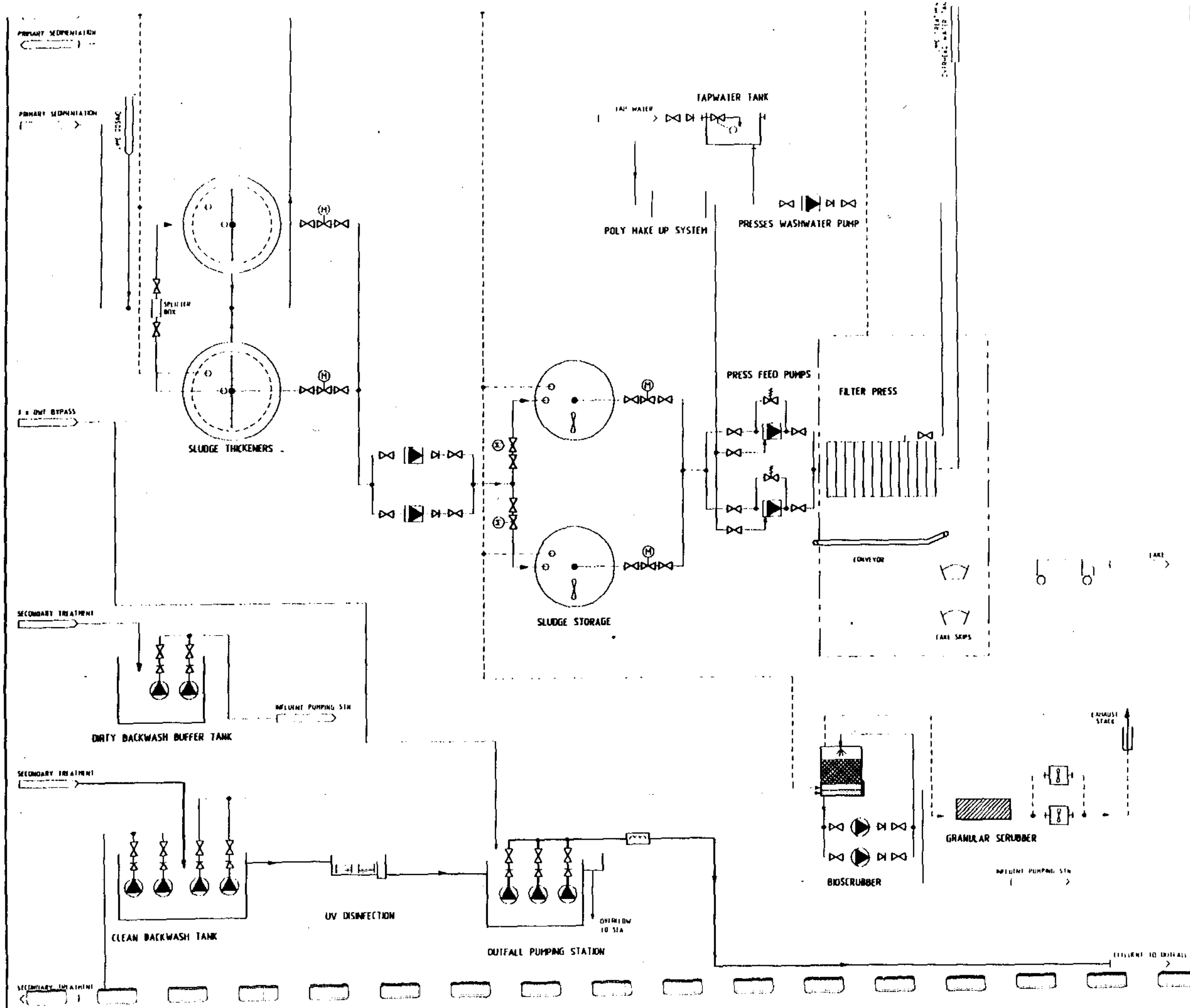
Mott MacDonald

Client

TIN KAU AND SHAM TSENG SEWERAGE EIA
SEWERAGE AND SEWAGE TREATMENT

Title

OPTION 3
LAMELLA SEPARATORS AND
SUBMERGED AERATED FILTRATION
PROCESS FLOWSHEET
SHEET 3 OF 6



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Reference Drawings

Legend 22716/PL/010

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	OCT 1994	JRS	PRELIMINARY ISSUE		

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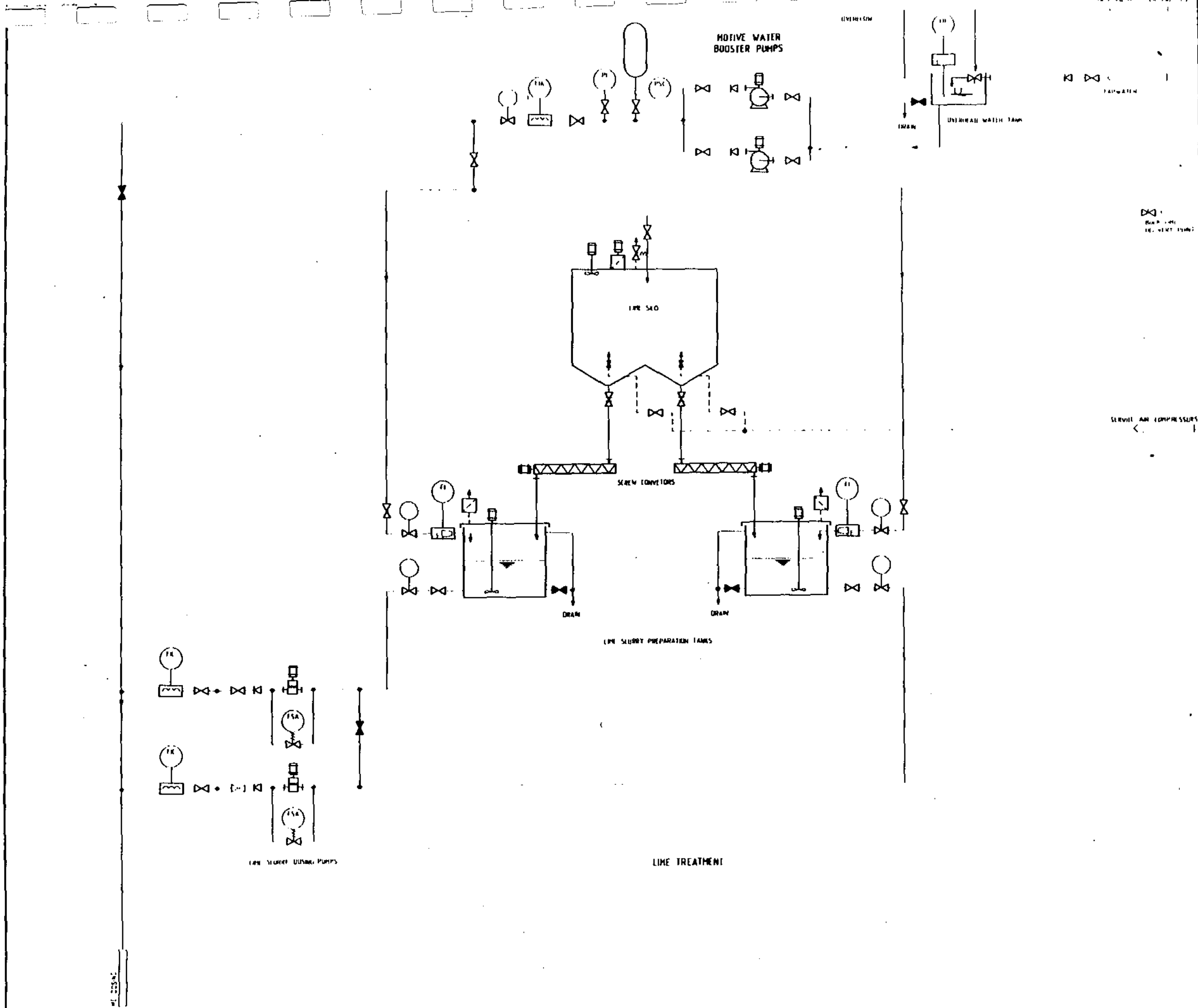
Client

TIN KAU AND SHAM TSENG SEWERAGE SIA
SEWERAGE AND SEWAGE TREATMENT

Title
OPTION 3
LAMELLA SEPARATORS AND
SUBMERGED AERATED FILTRATION
PROCESS FLOWSHEET
SHEET 4 OF 5

Designed | Eng Chk
Drawn | L. HOYLAND
Drg Chk



Notes

Reference Drawings

Legend 27776/P1/818

Rev	Date	Drawn	Description	Chk'd	App'd
P1	OCT 1994	JRS	PRELIMINARY ISSUE		

Mott MacDonald

Client

TIN KAU AND SHAM TSENG SEWERAGE [illegible]
SEWERAGE AND SEWAGE TREATMENT

Title

OPTION 3
LAMELLA SEPARATORS AND
SUBMERGED AERATED FILTRATION
PROCESS FLOWSHEET
SHEET 6 OF 6

Designed		C. MOTLAND	Eng. Chk
Drawn		J. B. SMITH	

Appendix M

Comments and Responses

AGREEMENT NO. CE 35/94
TING KAU AND SHAM TSENG SEWERAGE SCHEME
ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Revised Water Quality Working Paper - WP4
Draft Final Report and Executive Summary, and
Draft Environmental Monitoring & Audit Manual

Comments	Responses
Drainage Services Department **Ref: (66) in CM 10/30/1 VII** **Dated 15 May 1995**	
My comments on the Draft Final Report and the Draft Executive Summary are as follows:-	
Draft Final Report	
(i) Figures 1.1, 2.1, 12.1 & 4.1	
In the light of the recommendation on the outfall's location in Section 6, please amend the alignment of the outfall in the figures for clarity.	Agreed. These will be revised accordingly.
(ii) Section 7	
The recommended level of treatment differs substantially from that proposed in the Interim Report on Sewage Treatment Options. As such, please elaborate more on the overview of works treatment options and the process engineering of the treatment options with illustrations.	The recommended level of treatment provided in the Interim Report was derived before the modelling was undertaken for reasons of programming. The text will be supplemented for the Final Report.
(iii) Figure 7.1	
I have reservation in the order of the magnitude of the DWF for the beach goers. Please check.	These figures have been checked and approved at the Study Group Meeting.
Besides, please review the methodology used in the flow estimate as stated in my earlier letter ref (5) in the even series dated 14.3.95.	The methodology adopted is based upon the Draft Drainage Manual issued by HK Government Drainage Services Department, which we were instructed by the client to use for this project.
(iv) Table 8.1	
The submarine outfall will be constructed after the completion of the reclamation contract. Please amend the assumption for the submarine outfall works and its implications accordingly.	It was stressed in S.6.37 that the outfall must be constructed before the reclamation is completed. However, suggestions will be put forward to indicate methods by which the outfall, can be constructed after the completion of the reclamation.

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ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Revised Water Quality Working Paper - WP4
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Draft Environmental Monitoring & Audit Manual

Comments	Responses
(v) Figures 8.1, 8.2, 8.3, 8.4, 8.5 & 8.6	
The programme for the implementation works is unrealistic. According to the latest information, the tentative programmes for the commencement of the works packages are as follows:	The programmes were devised to illustrate the worst case scenario, particularly with reference to noise and air impacts and therefore presents a programme where the highest environmental impacts will occur. In terms of the tentative programmes, it is stressed that the outfall must be constructed before the reclamation is completed.
reclamation - early 1996 sewerage reticulation - early 1997 pumping station - early 1997 sewage treatment plant and outfall - mid 1997	The tentative programme gives here will be stated in the EM+A Manual and also section 8 of the Final Report.
(vi) Section 10	
Please address the option for the sludge treatment and disposal strategy.	Agreed. An additional section has been included in the Report.
(vii) Section 12.32	
The tentative programme for the commencement of the sewer laying is early 1997.	Noted. The text has been amended accordingly.
(viii) Table 14.3	
It is doubtful that the operating costs for the activated sludge and submerged sludge options are less than that for the primary treatment with long outfall taking into consideration of the staff costs, maintenance costs and the chemical cost. Please clarify.	The costs estimates included in the report were only preliminary estimates which have been revised.

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ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

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Comments	Responses
(ix) Table 14.4	
It is quite surprising to note that the capital cost for the secondary treatment with short outfall differs less than 10% when compared with the capital cost for the long outfall with primary treatment. Given the enhanced water quality benefit that can be achieved if secondary treatment with short outfall is adopted, it may not be justified to rule out the secondary treatment option. Please elaborate more on how you arrive at the recommendation of the proposed level of treatment.	The cost estimates have been revised and elaborated upon in the Final Report.
Draft Executive Summary	
(x) Figure 1.1 & 2	
Please refer to my comments in (i) above.	Noted. These figures will be amended.
(xi) Environmental Monitoring and Audit	
Please include a section on the Environmental Monitoring and Audit requirement.	A separate EM&A manual has been issued.
Drainage Services Department **Ref. (19) in DSD/EM/P123 III** **Dated 15 May 1995**	
I refer to the memo from DEP dated 24 April 1995 together with a copy of the above 4 reports and would comment on the reports as follows:-	
I. Revised Water Quality Working Paper - WP4	
I have no comment on this Working Paper.	Noted.
II. Draft Environmental Monitoring & Audit Manual	

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ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Revised Water Quality Working Paper - WP4
Draft Final Report and Executive Summary, and
Draft Environmental Monitoring & Audit Manual

Comments	Responses
The above manual only covers the construction phase. The issues for post project monitoring and audit as highlighted in Section 7 of the manual should be resolved.	It is not customary to include operation phase monitoring and audit in the same manual. Details of operation phase monitoring requirements have been set out in Chapter 15 and will be repeated in one chapter in teh EM+A manual entitles "Post Project Monitoring".
III. <u>Draft Executive Summary</u>	
A. <u>Section E.12. Page E.3</u>	
The estimated maximum design flow for the sewage treatment plant (STP) was stated in the Brief as 22,000 m^3/day. The effluent flow rate mentioned in this section for the design horizon of 2011 will be 13,367 m^3/day. Please clarify the maximum design flow rate for the STP.	The correct design flow rate is 13,367m^3/day.
B. <u>Section E.25. Page E.5</u>	
It is mentioned in this section that the construction and operating costs for secondary treatment would be higher than primary treatment. The costs shown in Page 14.3 of the draft Final Report for activated sludge and submerged aerated options are however lower than the primary treatment. Please clarify.	The cost estimates included in the report were only preliminary estimates which have been revised and elaborated upon in the Final Report.
IV. <u>Draft Final Report</u>	
A. <u>Section 1.4. Page 1.1</u>	
See comments in Item IIIA.	The design flow rate is 13,367m^3/day.
B. <u>Section 1.17. Page 1.4</u>	
From a maintenance point of view, 4m headroom may not be sufficient for pumping stations with large capacity pumps. The actual sizes of the pumping stations will be determined at the detailed design stage. As vehicular access will be required for each pumping station, traffic impact during the operation phase should also be addressed.	Traffic impacts during the operation phase are not significant because they should all be installed with automatic systems. Perhaps only one vehicle per day will be going to the pumping stations. This has been stated in the final report.

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Draft Environmental Monitoring & Audit Manual

Comments	Responses
C. Section 6.5, Page 6.2	
As the proposed long sea outfall will be laid in the Ma Wan Channel, it may cause difficulties in carrying out dredging work for the fairway in the future. As such, comments on the design of the outfall from D of M and CE/Port Works, CED should be sought.	The Final Report will state that consultation with D of M, CE/Port Works and CED should sought during the detailed design stated.
D. Section 6.7(b), Page 6.2	
Should 'reduce' be read as 'increase'?	Agreed.
E. Section 8.2, Page 8.1	
The construction programme outlined in Figures 8.1 to 8.6 is not in line with the current programme.	The programmes outlined in Figures 8.1 to 8.6 were included to indicate the worst case scenario particularily for the air quality and noise impacts. This has been outlined in section 8.2.
F. Table 8.1, Page 8.2	
With regard to the assumptions on the overall building dimensions, please refer to comments in Item IVB.	This should be dealt with during the detailed design.
G. Section 4.5, Page 8.15	
Please clarify the ventilation systems to be used at the pumping stations (natural or forced)? Furthermore, other types of deodorisation equipment such as biofilter, potassium permanganate based type filter, etc. should be considered and compared before the chemically treated activated carbon type is selected.	The text should read natural ventilation. The choice of deodorisation plant was based on the methods already accepted for the Strategic Sewage Disposal Strategy studies. However, the conclusions that any system adopted should be capable of achieving. The 99.9% odour removal efficiency has been added to the Final Report.
H. Section 9.40(d)(i), Page 9.13	
At least 2 pumps (1 duty + 1 standby) should be provided at each pumping station.	Noted. This has been added to the Final Report.

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Comments	Responses
I. Section 10.10, Page 10.2	
It seems that the amount of screenings and grit produced from the STP is overestimated and the amount of sludge is underestimated. Please qualify the figures shown in Table 10.1.	Estimates are currently being revised and amendments will made in the Final Report.
J. Section 10.11, Page 10.3	
Should '30% moisture content' be read as '30% solid content'?	Noted, and agreed.
K. Section 11.2, Page 11.1	
Please specify the requirements of the gas detection system.	A sentence reading "The gas detection system should be in compliance with Regulations, Standards and Guidelines enforced by Hong Kong Government, Factory Inspectorate, Labour Department", shall be added to this Chapter.
L. Section 11.4, Page 11.1	
Please explain why basic treatment can still be provided in the event of a total power failure at the Works.	Basic treatment refers to coarse screening as this does not require power.
M. Section 11.11, Page 11.2	
Please refer to comments in Item IVH.	Noted.
N. Section 11.15, Page 11.2	
Sudden failure of pumps can still occur even with close monitoring. Please further elaborate on the diagnostic system with which sudden failure of pumps can be avoided.	Further details have been added to the Final Report. Details of fail safe systems have been discussed.

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Revised Water Quality Working Paper - WP4
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Comments	Responses
O. <u>Cost Benefit Analysis</u>	
1. <u>General Comment</u>	
The exercise carried out in this section is only a cost comparison among the feasible options and an option is recommended on this basis. The recommended option with a just acceptable standard may not be the best especially if more stringent requirements are to be imposed on the treated effluent in the future.	Noted.
In a cost benefit analysis, the lifetime of the plant, the capital and the total operating costs throughout the lifetime of the plant, the associated environmental benefits, etc. should also be considered and compared. The analysis should then come up with an optimum solution between costs and benefits. In this study, the primary treatment and the secondary treatment options can both meet the present water quality objectives. The anticipated performance of the latter is however superior than the former, e.g. the E Coli count for the latter is an order of magnitude lower than that of the former, with a difference in the capital cost of about $10M. This difference is only a small percentage when comparing with the overall cost of the project. In view of the above, the conclusion of this section should be reviewed if a cost benefit analysis approach is to be adopted.	The cost estimates included in the report were only preliminary estimates which have been reviewed and elaborated upon in the Final Report.
2. <u>Table 14.1 (1), Page 14.2</u>	
'213.5' should read '2135'.	Agreed.
3. <u>Table 14.4 Page 14.3 and Appendix J</u>	
In the cost comparison, the O&M cost should be further broken down into cost for plant operation, plant maintenance, outfall maintenance/repair, etc. for reference.	With the absence of any detailed design information this cannot be carried out.
This is a consolidated reply of the ST and E&MP Divisions of DSD.	

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Comments	Responses
Chief Engineer/Sewerage Projects, Drainage Services Department Ref (3) in SW 7/1/14 Dated 17 May 1995	
I refer to your memo under reference. I have no comment on the captioned documents.	
Chief Engineer/Mainland South, DSD Ref. ( ) in MS 10/5/34 Dated 22 May 1995	
I have the following comments on the Draft Final Report. Where applicable, these comments shall apply to the other reports as well:-	
<u>Air & Noise Sensitive Receivers</u>	
Para 2.28, 2.31 - It is expected that the trunk sewer to be constructed under this project should follow the alignment of the new Castle Peak Road to be constructed under the Castle Peak Road Improvement project. According to the latest information (the preferred alignment proposed under the Castle Peak Road Improvement Feasibility Study), the longitudinal profile of this road will be somewhat different from the alignment of the existing Castle Peak Road. The positions of the pumping stations shown in the Report may have to be revised, and some pumping stations may even be omitted (e.g. PS2, PS3 & PS4). the noise and odour sensitive receivers for Environmental Monitoring and Audit purposes (see Figure 2.2, Table 2.4 & Table 2.6) should therefore be subject to review at the detailed design stage.	Noted, at earlier Study Group meetings we were instructed to discount details regarding the Castle Peak Road Improvement Study as it had not yet been completed. Hence it was agreed that any impact from that study should be reviewed at the Detailed Design Stage.

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Comments	Responses
The Outfall and Diffuser Section	
Figure 6.6 - This figure shows the I.L. of the outfall pipe outside the Sewage Treatment Works to be -22.8mPD which is 29m below the ground level. This is far too deep for construction of the terminal manhole of the outfall pipe. The Consultants should address this problem and suggest solutions that are feasible from the construction point of view.	Whilst not entering into the engineering issues for this environmental impact assessment we would point out that this issue has been addressed and resolved for the Strategic Sewage Disposal Scheme which has terminal manholes/drop shafts approximately 100m below G.L.
Para. 6.46 - The Consultants should clarify whether the proposed diffuser caps will be able to withstand impact from ship anchors and dredging operations, or whether the caps should be designed for repair or replacement if damage really occurs.	See response to para 6.9 to 6.10 presented by EPD (page 30).
Estimates for the "Long" Outfall	
Table 14.1 - The quantity of rock requiring blasting appears to have been underestimated. From the rock profile shown in Figure 6.6 and assuming a trench width of 4m (for placing bedding and armour around the outfall pipes), the quantity of rock is already 200m^3.	The quoted figure is 120 lineal meters of trenching rock at a rate of HK$20 per lin meter.
Disposal of Marine Mud	
Para. 15.16, Appendix K. Cl. 33(4) & 35(1) - The Dumping at Sea Act (Overseas Territories) Order 1975 is now superseded by the Dumping at Sea Ordinance.	Noted. The text will be amended.
Evaluation of Potential H_2S Problem in Sewerage	
Appendix G Para. 2.1 - Figure 1 is missing. The Consultants appear to have used the sewerage layout of the previous study instead of the current layout shown in Figure 2.1/2.2.	Figure 1 will be included. The study has been based upon the Tsuen Wan, Kwai Chung, Tsing Yi Sewerage Master Plan Study, Final Report.

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Comments	Responses
Appendix G Para. 4.2 - The effect of dosing of iron salts on the operation of the sewage treatment plant should be checked. In addition, the Consultants should explain the choice of polypropylene pipes which had not been used in Hong Kong before, instead of, say, sulphate-resistant concrete pipes.	The choice of pipe is not of great significance to the EIA and this sort of detailing would be best dealt with during the detailed design.
Environmental Protection Department **E(LP)1** **Ref. (2) in EP20/08/26X** **Dated 8 May 1995**	
I refer to your above memo and my comments on the draft Final Report and draft Executive Summary are given in the following paragraphs.	
2. Comments on the draft Final Report:	
a. Section 2.25 - WQO's have statutory meaning and could not be proposed by the Consultants for use in the EIA study.	Agreed. The text has been amended to read "the WQO's which are applicable for this Study...".
b. Section 4.25, 2nd paragraph - The recommended measures for protecting the dolphins did not make much sense:	
- What is the practical meaning of asking the contractor to undertake dolphin spotting? If dolphin is spotted, does it mean that any subsequent operation will do the creature no harm? If it is not spotted, shall the contractor stop his work waiting for one to appear?	These measures have been incorporated on other Contracts in Hong Kong and have been proven successful as the Contractor is more aware of the impact his operations could have on marine life. It is the intention that if a dolphin is spotted the course taken by the work boat will be such that no injuries will be incurred.
- It would not be possible for the contractor to fix the routes for operation as it would depend on the stage and location of work and very much dictated by the need to minimize disturbance to the busy navigation channel.	The best practical approach is to require the contractor to reconnoitre the works area before marine works commence. If dolphins are in the vicinity these should be watched and once they have left, then work should begin.
- What are the objective criteria for defining the so called buffer/safety zone for dolphin?	It is unlikely that the dolphins will frequent this area, however this should be confirmed by the contractor with inter alia in AFD and the Swire laboratory.

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	Comments	Responses
c.	Section 6.4(c) - Could the Consultants elaborate on the cause, frequency and environmental impacts of the emergency overflow during a typhoon surge. Could the overflow be controlled by appropriate measures?	The frequency of typhoon surges is difficult to predict. The environmental impacts pertains to the discharge of partially treated effluent (screened). The discharge of screened effluent will have only a short term effect on water quality.
d.	Section 7.18 - It has been shown in the report that secondary treatment with short outfall not only could meet the WQO's but also could reduce significantly the pollution loading on the receiving water body. The summary of costs on Table 14.4 indicated that the difference in capital and operating costs for the primary treatment with long outfall and the secondary treatment plus short outfall is insignificant given the crude nature of the costing exercise. I think that the secondary treatment option would be as good as, if not better than, the primary treatment option and the Consultants shall therefore provide the discharge consents the former as well.	The costing exercise is presently being refined and the comments made are being taken into consideration. Discharge consents could be provided for effluent treated to a secondary standard. However the design Brief was to achieve the criteria set out by DSD. These can be achieved through the combination of primary treatment and the longer outfall, which was considered to be acceptable in terms of receiving water quality, reduced maintenance and operational costs.
	As regards the proposed discharge standard, its fairly uncommon (at least in Hong Kong) to have organic nitrogen specified in the discharge licence. Should it be total nitrogen, or oxidized nitrogen?	Noted, however the results obtained included organic nitrogen and thus this criterion was provided. To avoid confusion this criterion has been removed from the text.
e.	Sections 7.23 and 7.24 - The Consultants shall provide the resulting water qualities for the secondary treatment option as well.	The water quality modelling schedule was agreed step by step with EPD and from the bacteriological model results it was agreed to proceed with the full water quality modelling for only the primary treatment option.
f.	Section 13.16 - It seems that the section on pumping stations has not finished yet and there are a few missing pages.	Noted, this shall be expanded upon in the Final Report.

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	Comments	Responses
g.	Section 14.12, last sentence - I cannot agree with the conclusion that the costs of providing secondary treatment is significantly different from those for the primary treatment option. Table 14.4 showed that the difference in capital cost between the activated sludge treatment option and the primary treatment option is less than 10% and the operating cost of the activated sludge treatment option is even lower than the primary treatment option. Given the very crude nature of this costing exercise, the conclusion is unfounded.	Noted. The cost estimates are being revised at present and an updated section of cost benefit analyses will be included in the Final report.
h.	Section 14 in general - The section is titled "cost benefit analysis" but other than some cost figures, there is no mention and comparison of benefit resulting from the two alternative treatment options. The Consultants should carry out a more comprehensive analysis of cost effective and risk associated with the different treatment and disposal options. In particular, the Consultants has ignored the risk and uncertainty inherent in the laying of long submarine outfall in the Ma Wan Channel (please note that there is still not a definite programme for the Ma Wan Channel Improvement Project).	Noted. This section is being revised at present and will take into consideration the points raised herein. In particular the difficulties inherent in the laying of a long submarine outfall in the Ma Wan Channel will be emphasised.
	Other aspects of pollution reduction benefits other than bacteria including, inter alia, construction programmes and risk, STW operation, flexibility for future extension/upgrade, and sludge treatment/ disposal should be considered and discussed. The recommendation for treatment option should be based on an assessment of all the above aspects.	Noted. This section is being revised at present and will be included in the Final Report.

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Comments	Responses
Although it would be difficult to assess environmental benefits in real terms, the Consultants should give a qualitative assessment of the relative merits of the two options and compare their cost effectiveness. The recommendation based on a capital cost difference of less than 10% is rather trivial.	This point has been noted and the section on Cost Benefit Analysis will be revised for the Final Report.
i. Section 16.7 - Same as d. above and the Consultants shall provide the discharge contents for the secondary treatment option.	Noted. The discharge consents can be provided for secondary treatment but not resulting water quality for parameters other than bacteria.
k. The report did not provide information in respect of the background water quality and the cumulative effects due to other nearby discharges. The information is important as it may entail a higher level of treatment at the Sham Tseng STW.	Cumulative impact assessments were implicitly included in the water quality modelling further details will be provided in the Final Report.
3. Comments on the draft Executive Summary:	
a. Section E.21 - Same as 2.d above and the Consultants shall provide the discharge contents for the secondary treatment option.	Noted, see above.
b. Section E.23 - Same as 2.e above and the Consultants shall provide the resulting water qualities for the secondary treatment option.	Noted, see above.
c. Section E.25 - See 2.h above and I do not agree with the conclusion drawn.	Noted, see above.

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Comments	Responses
4. By copy of this memo, CE/CM, DSD is requested to review the size of the reclamation required. In Figure 8.7 of the draft Final Report, it was indicated that the area required for the STW is much less than that assumed by DSD. If the reclamation size is retained, the buffer distance will be more than 130m (we originally proposed a buffer distance of 80m). The report has proved that mitigation measures are needed for odour control and the buffer is largely psychological. The primary purpose of the reclamation should be to provide land for the STW and now a very large portion of the reclamation will not be used for this purpose (and no specific use indeed).	CE/CM DSD to respond.
Environmental Protection Department **Ref (11) in Annex (1) to EP 2/N2/16 VI** **Dated 18 May 1995**	
<u>Comments from the Environmental Protection Department</u>	
A. <u>Draft Final Report (DFR)</u>	
<u>General</u>	
1. Please amend "Dumping at Sea Act 1974 (Overseas Territories) 1975 in the above mentioned documents to read "Dumping at Sea Ordinance (1995)".	Noted and agreed.
<u>Wastes and Water Aspect</u>	
<u>Section 4.25</u>	
2. "Born Convention" should read "Bonn Convention".	Note and agreed.

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Comments	Responses
3. Before any blasting operation, the area must be carefully monitored to ensure that there is no white dolphin in the buffer zone (which is 500/1000 m depending on the size of charges). If white dolphin is spotted when blasting operation is in progress, blasting should be stopped immediately and should not be resumed until such time it is ascertained that no white dolphin remains in the buffer area.	Noted, this will be added to the Final Report.
Section 4.28	
4. Based on site conditions and types of backfilling materials, silt curtain should be used during backfilling of the trench in order to minimise release of fines into water column.	Noted this will be added to the report. It should be noted that silt curtains would be difficult to install and maintain in deep water. The silt curtains would need to be installed around seawater intakes if found to be necessary.
Table 4.3 : Measures to Protect Water Quality During Construction	
5. Please add "identify spill prevention measures" to Spillage of Materials Used Directly or Indirectly During Construction.	Noted and agreed.
Section 10.3 (d)	
6. Please elaborate on accidental spillage in terms of type of spillage, preventive measures, clean up and proper disposal arrangements.	Agreed, further elaboration will be provided to the Final Report.
Section 10.4	
7. Construction waste should be sorted into either inert materials suitable for reclamation and non-inert materials unsuitable for reclamation, through good site practice.	Noted this will be added to the Final Report.

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Comments	Responses
Section 10.6	
8. Please amend the 2nd & 3rd sentences to read:	
"Waste oil, grease, lubricants and batteries arising from the construction phase are classified as chemical wastes. Their storage, transportation and disposal are subject to control under the Chemical Waste (General) Regulation. Waste oil, grease and lubricants should be delivered to the Chemical Waste Treatment Centre in Tsing Yi for treatment and waste batteries to landfill for co-disposal".	Noted and agreed.
The above comment also applies to the operational phase, please incorporate accordingly.	
Section 12	
9. Traffic Assessment	
(i) The marine traffic impact of the construction activities on the busy navigation channel should be assessed and mitigation measures should be proposed.	Noted this will be supplemented in the Traffic Assessment.
(ii) Marine traffic watchmen/guard in marine waters within the vicinity of construction activities to provide necessary monitoring on the busy shipping route should be considered in order to avoid shipping accidents and to minimise disturbance to the marine traffic.	This will be stated in the Final Report.
(iii) In case of oil/fuel spillage to the marine waters due to shipping accident related to the construction activities, Marine Department should be informed of the accident immediately.	This will be stated in the Final Report.

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Comments	Responses
Section 16.10	
10. Air curtain may need to be provided to reduce.minimise the wave shock impacts of blasting on the marine fisheries in the vicinity of the blasting area.	Noted, this will be added to the Final Report.
Section 16.23	
11. "30% day solids" should read "30% dry solids".	Noted and agreed.
Air Quality	
Figure 2.2	
12. Location for SR3 (Lido Garden) is not correct.	SR3 should read, Sham Tseng Tsuen
Table 8.4, page 8.5	
13. Construction Works affecting SR4 (Garden Bakery) is missing.	Noted the table will be corrected.
Section 8.21, page 8.8	
14. As general fill of the reclamation will cause extremely high dust conditions exceeding in AQO, the use of marine fill is strongly supported. However, this should not be limited to the above sea level layer of fill as the assessment is based on all marine sand fill. Thus, please amend the Report.	Noted and agreed.
Section 8.23 & Appendix K	
15. The use of marine sand fill should be specified in section 8.23 and appendix K.	Noted and agreed.

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Comments	Responses
Section 8.32, page 8.11	
16. As shown in Table 8.10, the H_2S emission rate for the rising mains is 125 $\mu g/s$, would the Consultants please clarify why these source are not likely to cause odour nuisance to any sensitive receivers.	All possible sensitive receivers are some distance from the manholes the dilution will reduce odours to an insignificant level.
Section 8.41, page 8.14	
17. The odour threshold for H_2S is 0.47 ppb instead of 0.5 ppb. Would the Consultants please amend the Report and all the calculations and tables accordingly.	Noted and agreed.
Section 8.45, 8.47 and 8.49	
18. As the anticipated H_2S removal efficiency for the deodorisation units will be 99.9% (5 ppm to 5 ppb), would the Consultants please clarify whether such products are commercially available. Details of the products should be submitted.	Agreed, these have been provided.
Section 8.47	
19. Should the recommended H_2S removal efficiency of the deodorisation plant for the preliminary treatment facilities be the same as others, that is 5 ppm to 5 ppb. Please clarify.	Affirmative.
Section 8.52	
20. Apart from the identified sensitive receivers, there would be open space and GIC developments on the reclaimed area in front of the Garden Bakery. Would the Consultants please clarify what's the impact from the proposed sewerage treatment works to the uses during operational phase.	In the absence of any details of the open space or GIC development the boundary of these receivers cannot be assessed. Furthermore, the locations of sensitive receivers have previously been agreed at Working Group Meeting.

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Comments	Responses
Table 15.1 (odours), page 15.2	
21. As stated in section 3.13, for odour monitoring, the EPD's recommended odour nuisance criteria is 2 odour units at the site boundary. Thus, "5 odour units" should read "2 odour units".	Noted and agreed.
Section 15.38	
22. The frequency for one hour TSP monitoring should be "at least 3 times for every 6 days at the highest dust impact occasion" instead of over 3 periods on the same day of the 24 hour TSP sampling.	This will be amendment will be made to the Final Report.
Para. 15.42, page 15.11	
23. The comments as para. 21 are also applicable.	Noted and agreed.
Section 16.21, page 16.3	
24. Deodorisation plant should also be provided for sludge treatment facilities.	Noted and agreed, the text will be amended.
Appendix K	
25. As neither concrete batching nor cement plant is suggested in the EIA, it is more appropriate to replace Clauses 11 to 21 by the "no concrete batching plant" and "no cement plant" clauses.	These clauses have been retained as the exclusion of concrete batching plant (which are controlled under the license system by EPD) would be particular onerous on the Contractor. The requirement to bring all concrete on-site ready batched would have the knock-on effect of increasing traffic flows.
Solid Waste	
Section 10.11	
26. "30% moisture content" should read "30% dry solids content".	Noted and agreed.

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Comments	Responses
Flow and Pollution Loads Data	
Figure 7.1	
27. It seems that the Consultants are still using the under-estimated flow and pollution loads data in Figure 7.1 for the bacterial dispersion model simulations. The Consultants should follow up this issue closely.	The flows and loads have not been underestimated. The figures have been checked and no errors found. All calculations are based on the HK Government Draft Drainage Manual which we were instructed to user by the client. Furthermore at a recent ad hoc meeting it was agreed that the flows and loads are correct.
Noise	
28. As far as noise is concerned, the construction and operation noise of the facilities to the nearby NSRs would be the subjects of the study.	Agreed. This has been carried out.
29. Noise emission from construction works is of transient nature, the Consultants are advised to observe the non-statutory daytime noise limits for general construction work as far as possible by the use of appropriate noise mitigation measures. Whereas, the operational noise of the facilities is subject to statutory control under the NCO, the project proponent and Consultants are obliged to design and operate the treatment plants to satisfy the HKPSG noise limits as well as the NCO.	Noted and agreed. This will be added to the Final Report.

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Comments	Responses
B. Draft Environmental Monitoring & Audit Manual	
General	
30. In general, the following sections/items are missed in the Manual:	
(i) The project programme.	It is considered more relevant to include the programme for the final revision of the document which would be issued by the Engineers. At this stage only a tentative construction programme is available. This will be stated in the EM&A manual.
(ii) An implementation schedule, summarizing all recommended environmentalmitigationmeasures with reference to the programme for their implementation. (a Table similar to the format of Table 2.1 but with the items suitably referenced for fitting with the project programme may do)	This can only be provided by the Engineers and it should be noted that most issues should be complemented prior to the commencement of works.
(iii) The implementation programme and impact prediction review procedures.	These should be provided in later revisions issued by the Engineer.
(iv) Site inspection, deficiency and action reporting procedures.	These details are highly dependant on staffing resources and management structure. Any details should be provided by the Engineer.
(v) The baseline, monthly, quarterly and any other reporting format and procedures. Please refer to sections 7, 9 and 10 of the attached "Engineer's Guidelines for Implementation of EM&A Programme" for the reports format.	The "Engineer's Guidelines" will be provided in the main body of the text.

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31. In Figure 1.3, the Consultants proposed a party "Environmental Specialists", in parallel with the RSS, to be appointed under the Engineer to undertake EM&A duties for all contracts of the project. This will have a significant implication to the administration and executive structure for the project, and the exact EM&A duties of different parties will greatly depend on the ultimate organisation structure. The Consultants should be advised that confirmation from the project proponent should be sought before the organisation proposal can be incorporated in to the Manual. Also, environmental staff structure should be included in the Manual.	These details can only be finalised by the Engineers. Any confirmation should be sought when the organisation structure is available.
32. In association with the organisation chart, the responsibility of each party in the project should be clearly stated with respect to environmental requirements. The EM&A reporting, communication, and instruction flow chart should also be provided. With reference to the identified responsibility of each party, any confusion in their specific duties in different aspects in the Manual should be cleared up.	These will be added to the Manual. However, at this stage the information can only be in general terms.
Marine Mud	
33. From the marine dumping control point of view, there is no comment on the EM&A Manual as it was mentioned in Section 1.11 that no dredging will be required for either the construction of the seawall or prior to land formation. Should there be any works which involve the marine disposal of dredged sediment, the Project Proponent is required to follow the procedures in the Works Branch Technical Circular No. 22/92 (or AP's practice Note PNAP 155, if appropriate).	Noted, this will be added to the Manual.

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Comments	Responses
Wastes and Water Aspects	
Section 2.21	
34. According to the ex-gratia allowances programme administered by Agriculture and Fishery Department (A&FD), there is a different standard of suspended solids (SS). The criteria in the standard are used to determine the eligibility of ex-gratia allowances for mariculturlist being affected by dredging or dumping activities. They are described as follows:-	Noted, this will be elaborated upon in the Manual. However dredging or dumping will not be required.
(i) When the SS level reaches 100% more than the highest level recorded at the zone during the five years prior to the commencement of construction works in the vicinity; or	
(ii) When the SS level reaches 50 mg/litre.	
The Consultants should also address the above standard in the report and review the trigger, action and target requirements for SS at monitoring stations adjacent to fish culture zone. Consult A&FD if required.	Noted and agreed.
Appendix B	
Section 25(6)	
35. "other waste material" should read "general refuse other than chemical wastes".	Noted and agreed.
Section 25	
36. Add (7) for chemical wastes by referring to the comments in para 8 above.	Noted and agreed.

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<u>Section 2.1 & table 2.1</u>	
37. Same as comments in para 10.	Noted.
<u>Air Quality</u>	
38. The draft EM&A manual only covers the EM&A requirements of the construction phase (dust) of the project. On odour impact monitoring, it is suggested that regular odour patrols supplemented by formal odour monitoring at the site boundary be carried out. Regarding the TAT levels, please refer to para 7.2 of AMG "Draft Guidelines on Odour Monitoring and Measurement" (attached for easy reference).	These will be stated in the Final Report. The purpose of the EM&A manual is for the Construction Phase only. However, a section on post project monitoring will be included.
<u>C. Working Paper No. 4</u>	
<u>Section 3.9</u>	
39. Same as Comment in para 34 above.	Noted.
<u>D. Draft Executive Summary</u>	
<u>Air Quality</u>	
40. Similar comment as on the DFR.	Noted.
<u>Waste and Water</u>	
<u>Section E.22</u>	
41. Same as Comment in para 34 above.	Noted.
<u>Section E.28</u>	
42. Same as Comment in para 10 above.	Noted.
<u>Section E. 39</u>	
43. Same as Comment in para 9 above.	Noted.

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Comments	Responses
Chief Engineer/Planning **Water Supplies Department** **Ref (2) in WWO 24/1409/95 II** **Dated 2 May 1995**	
I refer to your above quoted memo and have no specific comment on the enclosed EIA study. However, during the planning of the captioned project, the following comments should be taken into account:-	
(1) One proposed future watermain might be laid along the proposed widening of Castle Peak Road between Sham Tseng and Yau Kom Tau for improvement of water transfer facility, and	Noted. This should be reviewed at the detailed design stage.
(2) It is noted that the land base source of fill has not yet been identified. Please note that, in order not to impair the safety of the existing waterworks tunnels, no excavation shall be carried out within 60 metres horizontally from either side of the centre line of any waterworks tunnel. No blasting shall be carried out close to existing waterworks installations and tunnels without prior agreement by WSD.	Noted. This will be stated in the Final Report as a constraint which the designer should consider.

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Comments	Responses
Environmental Protection Department, Headquarters **Ref. (24) in Annex (1) to EP 2/N2/16 VI** **Dated 9 June 1995**	
<u>Reclamation for the Sewerage Treatment Works Site</u>	
Fig 5.1 indicates that the seaward edge of the reclamation will be up to the 15m contour. Reclamation up to the 15m contour is unacceptable because it would seriously affect the flow in the major tidal flow channel. This channel is crucial because all flow through Victoria Harbour and Lamma Channel converges here. Any reclamation proposal that may affect its flow capacity has serious implications and must be studied in details in the EIA stage before any implementation works.	It was agreed at an ad hoc meeting that additional information relating to reduction in cross sectional flows and changes in bulk flows.
<u>Outfall and Diffuser</u>	
There are some major problems with the proposed outfall and diffuser configuration which will affect performance, operation and maintenance. The very large outfall proposed for this very low flow rate means that the desired initial dilution will never be achieved and there will be associated operation and maintenance problems. The diffuser configuration was determined solely on the "trapping level" criterion. This is completely inappropriate and inadequate. Other factors such as initial dilution, decay/die-off rate for bacteria, distance of the inner-most cap from sensitive receivers and flow pattern must be considered. There was also no systematic analysis on initial dilution and no analysis of the likelihood and consequences of interference between plumes for different ports under the same cap.	Outfall Diameter : maintenance. As grit removal is an integral component of the treatment process (preliminary treatment will automatically include grit removal) the velocity will drop to 0.3m/s. Provided the velocity in the outfall achieves 0.3m/s at least once per day there will be no settlement in the outfall from the effluent. The recommended outfall diameter is 600mm which gives an area of 0.3m^2, and with a daily peak flow rate of 0.5m^3/s the outfall will be well scoured. In terms of the concern expressed about low flow rates, there are many precedents elsewhere where even lower flow rates have been adopted without any operational or maintenance problems. Reasons for this have included reduced pumping and other running costs.

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Comments	Responses
	Initial dilution is determined by very many factors some of which are directly influenced by the Designer. These include the port (not outfall) diameter and the number of ports. In the EIA Report it was recommended that Red Valves (non-return valves) be used, these ensure that whatever the port characteristics are the Froude Number cannot fall below 1. It should be noted that the diffuser configuration was not actually determined by the "trapping level criterion". Interference of plumes from ports on the same cap were considered carefully and are included in the cited references. It was demonstrated by Roberts (author of the RSB models) that 8 is an optimum number of ports but for higher numbers an asymmetrical configuration may be advantageous under cetain conditions.
<u>Water Quality Analysis</u> There is a number of deficiencies in the water quality impact assessment. First of all, a large part of the full water quality modelling results (the spring tide results) have not yet been submitted. The results of the most important parameter, E.coli, were not presented in geometric mean values for comparison with the WQO. The mixing zone impacts were very roughly calculated and showed alarmingly high level of E.coli in the mixing zone but no viable mitigation measures or further studies have been recommended.	When the Report was submitted it was acknowledged that the results of the spring tide model simulations were outstanding. It was however agreed at informal Working Group Meetings that the results of the spring tide simulations would be very unlikely to affect the decisions made on treatment levels as the worst case scenario had been evaluated and reported upon in the draft EIA and at Working Group Meetings.

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Comments	Responses
Level of Treatment	
The full water quality results show that many predicted E.coli values are high. The reliability of the estimated future sewage strength has not yet been confirmed. A safety factor in the design is necessary to take into account all these uncertainties. In view of the need for a safety factor, the conventional primary treatment plus long outfall option recommended by the Consultants is unlikely to be sufficient.	A safety factor has been included in an recommendations which has taken account of inter alia, water quality objectives, marine conditions, velocity of modelling results as well as giving consideration to natural phenomena (such as tidal ranges etc) cannot be simulated without incurring massive expenditure and time implications. Having considered all the various factors in concert, it was considered that the combination of long outfall and primary treatment would be adequate to achieve the objectives of this scheme.
Detailed comments on water quality assessment	
The Consultants need to calculate the E.coli model predictions in geometric mean values, the % samples exceeding the 1000/100mL criterion, include the spring tide modelling results, present the DO values in mg/L for comparison with WQO before concluding on the level of treatment.	The predicted E.coli counts are provided both as geometric mean values and as arithmetic means. As the design criteria refer to geometric mean values (at the bathing beaches) the criteria focused upon (in addition to the WQO's) were <180 E.coli counts at the bathing beaches using primarily the results of the dispersion model for reference.
Table 2.2	
The same WQOs should apply to all cases to matter whether the proposed treatment is full or partial. The Consultants should check the WQOs relevant to each sensitive receivers. For example, the WQO for pH applies to all sensitive receivers rather than just the marine water and the ammonia WQO applies in all cases of marine water rather than only the case of partial treatment.	Noted. The WQOs relevant to each sensitive receiver has already been adopted Table 2.2 has been amended.
Table 4.3	
(i) For the impact of sediment release during dredging/excavation, mitigation measures to reduce S.S. are required even if mud or dredged materials is uncontaminated.	(i) Agreed this shall be included in Table 4.3 for completeness.

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Comments	Responses
(ii) For the impact of domestic effluent disposal, an effluent disposal method which results in no discharge is preferred unless it is demonstrated that such measure is not feasible for the site.	(ii) Agreed. At this site it may be difficult to provide such facilities which was the reason for suggesting the use of package plants.
<u>Fig 5.1</u>	
The note do not match the figure. Where are the stations 1-8 and 23-25?	Noted the updated figure is attached for information. Stations 1 - 8 were the original beach station locations, Stations 23 - 25 are seawater intakes.
<u>Para 6.64 and 6.65</u>	
The estimated concentration of E.coli is very high. If we believe the worst case estimation of E.coli at $2*10^4$/100ml, then upgrading the treatment level is certainly necessary because trapping the effluent in the lower layers depends on marine conditions and will not be possible during some time in the year.	The concentration of <u>E.coli</u> refers to the raw effluent and treatment will indeed need to be applied to ensure the loads are reduced. The mean initial dilution of the fully mixed plume will in fact result in very low <u>E.coli</u> counts. On account of the volume of water in the main channel.
<u>Para 6.69</u>	
How was the Average Dry Weather Flow (ADWF) of $0.185m^3/s$ estimated?	The synthesis of ADWF is based on the production of flow rates occurring on working days. No calculations have been performed for non working days since the general assumption is that the flows and loads on such days are not greater. Furthermore, the annual average per capita production rates for the various population groups are taken from HK Government Draft Drainage Manual.
<u>Para 6.73</u>	
Do the Consultants mean that the actual flow, rather then the Dry Weather Flow (DWF), will vary in the range 0.5 to 3 times the ADWF? Why has the ADWF become $0.155m^3/s$ here?	Agreed. The diurnal flow rate will vary according to the proportion of industrial to domestic, size of the catchment, surface area of the sewage treatment plant. To test the sensitivity of the outfall to the diurnal variation 0.5 (nightly flow rates between 01.00 to 06.00hours) to 3x (morning peak flow between 09.00 and 11.00 hours) are considered to be typical for a small system such as this.

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Comments	Responses
Para 6.82	
The effluent discharge rates indicated here are completely different from those in Section 6.73. Which ones are correct?	The rate given in para 6.82 is correct. The typographical errors in this connection will be corrected in the Final Report.
Para 7.8	
Table 7.1 does not show a geometric mean value of up to 500 E.coli/100mL for primary treated effluent for the short outfall.	The reference made to the E.coli count related to the colour contour plots which were not included in the Report but had been used for illustration at working group meetings with DSD and EPD.
Para 7.10	
Table 7.1 again does not indicate that the E.coli concentrations is 100-500/100mL for the case of the short outfall.	This refers also to the colour contour plots which were not included in the Report but described in the text.
Para 7.18	
How was the concentration of Org N calculated? The load estimation for Org N was not shown in Fig 7.1.	OrgN concentration was related to the BOD load as common practice to the input to the WAHMO models.
Table 7.6	
The Consultants need to substantiate the 10% removal rate for Org N. This was not indicated in Table 7.5. The influent value for Org N has been wrongly calculated. The Consultants need to check.	The 10% removal of Org.N is based on a series of reduction factors provided in the Strategic Sewage Disposal Strategy. The level of organic nitrogen remaining is 10 mg/l, which 104 kg/day which is equivalent to 10% reduction. This was removed from the main body of the text to eliminate confusion.
Fig 7.1	
The estimated future sewage strength appears to be low. We have raised our doubts on the reliability of these flow and load estimates in our previous comments and working group meetings. However, the Drainage Services Department (DSD) should also be requested to confirm the accuracy of the estimates.	The estimated flows and loads have been synthesised based on figures contained in the HK Government Draft Drainage Manual, which was adopted by strict instruction by DSD. The figures have been checked and are correct.

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Comments	Responses
Para 7.21	
Where is Table 7.7?	Table 7.7 was inadvertently eliminated from the Report. A full set of results have been included in the updated version of Section 7 following receipt of the remaining results of the water quality modelling.
Para 7.23	
How was the mixing zone diameter of 500m estimated? Para 6.64 mentions that the effluent plume width is 600m.	The extremely conservative estimate of the mixing zone was made on the basis of the model results obtained to provide an indication of the maximum extent of the plume. To provide a more accurate definition of the mixing zone the length of diffuser and the recommended configuration were computed to give xi of 56m. The mixing zone is xi to the east and west of the outfall and the diffuser length spreading at an angle of 5 degrees. The conservative estimate of 500m is at least 5 times larger than that computed using the RSB model, but was included to illustrate that even in extremis the mixing zone would not impinge on the bathing beaches. A section will be included in the Report to demonstrate now oil and grease can be removed.
Appendix D	
A figure showing the locations of modelling stations 1-25 is required. The DO values should be expressed in mg/L rather than % saturation as the WQO is in mg/L.	Agreed. Appendix D provided the preliminary results which have now been reworked to give the DO values in mg/l.

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Comments	Responses
Para 11.4, 11.5, 11.11 and 11.12	
Discharge of untreated effluent is unacceptable even for short duration. What are the mitigation measures to minimize the impacts of emergency overflow of effluent at the STW and pumping stations? The Consultants should include the following measures: (a) standby power supply; (b) standby pumps; (c) emergency storage for 2 hours if possible; (d) telemetric warning system to warn operators of failures; (e) if emergency discharge is unavoidable, provide screening before discharge; (f) emergency discharge should be below the low water mark to minimize nuisance. (g) emergency overflows should be discharged at least 100m away from the boundaries of a gazetted beach and 100m away from any seawater intake point as stated in Section 9.1 of the TM.	It is fully agreed that the discharge of untreated effluent even in the short term is unacceptable. It is emphasised in para 11.4 that even in the unlikely event of a total power failure basic treatment, removal of gross solids would still be provided. As guit removal will not require power. The suggested measures a) to e) have already been incorporated in the Report, f) and g) will also be defined in the Final EIA.
Detailed comments on water quality modelling	
Para 5.2	
(i) The stations shown in Figure 5.1 are not related to the stations (1-12 and A-E) referred in the text. The Consultants shall show on a map the locations of all these stations together with the location and size of the "rock outcrop" mentioned in para 5.2.	(i) Noted. This figure was included inadvertently and shall be replaced with the correct figure in the Final Report.

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(ii) The Consultants must state clearly what reclamations were assumed in the baseline and reclamation scenarios and how the effects of reclamation for this project were interpreted from them.	(ii) Noted. The outline of the reclamations were illustrated in Appendix D, however a paragraph will be added to the Final Report which will clearly state the assumptions used.
Para 5.3	
It stated that reclamation will be formed within 5m contour, but Fig 5.1 indicates up to 15m. Reclamation within 5m contour is considered acceptable. However, reclamation up to 15m contour is unacceptable because it would seriously affect the flow in the major tidal flow channel. Water depth of 15m is clearly in the main tidal stream and the statement that "This area is also located out with the main tidal stream" is not true.	It should be noted that although the outline of the reclamation extends beyond the 5m contour line and thus the statement that the area is outwith the main tidal stream is still correct. The assessment of the reduction in cross sectional area is being carried out at present and will be included in the Final Report.
Para 5.5 - 5.8	
It stated that the flow velocities at the nearby stations (A and C) can be reduced by 20 to 25% (above 4 hours at station A). This is unacceptable. The Consultants must reconsider the reclamation configuration to minimise the impact on flow. The Consultants must also provide data on the change in total flow volume, not tidal speed, across the channel to illustrate the degree of total flow reduction. The channel is very important to HK because all flow through Victoria Harbour and Lamma Channel converges here, therefore any proposal that might affect is flow capacity must be studies in detail.	Both the extent and duration of the slight changes in the peak velocities (not flows) by less than 0.1m/s are considered to be minor. While we fully agree that the channel is vitally important to the flows in Victoria Harbour, the model results (and the size of the reclamation) do not suggest that there will be any impact on mainstream flows.
Para. 5.7, 4th line	
Should "increase" be replaced by "decrease"?	Agreed. The words will be interchanged to reflect the correct meaning.

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Comments	Responses
Para. 5.9	
(i) The Consultants have grossly underestimated the far field impact of reducing flow in Ma Wan Channel. In essence, the Consultants have not studied the global impact, in particular to the very important self cleaning ability of Victoria Harbour. Therefore, the Consultants must critically review the followings: (a) the reduction of total flow across the flow channel. (b) the corresponding reduction in flow through Victoria Harbour. (c) the water quality impact of such reduction to Victoria Harbour. (d) the volume of residual and storm event pollutant discharging into the embayment adjacent to the reclamation upon completion of sewerage scheme and its impact to the local water quality. (e) the actual space requirement for the treatment work and the possibility to reduce and realign reclamation.	We fully agree that the points raised should be examined critically however the extent of the reclamation and the results obtained certainly confirm the conclusions drawn in Section 5.
(ii) The report neither states nor was there any previous agreement between the Consultants and EPD on the type of boundary conditions used for modelling the impact of reclamation. It is presumed that soft boundary technique was used.	The boundary conditions which were used were agreed with EPD and DSD at informal working group meetings and for the flow model a soft boundary technique was adopted.
Figure 5.1	
There are two station 20 in the figure, and station 9 (that was supposed to be at a beach) is shown in the middle of a tidal channel.	Noted this figure has been amended to reflect the correct situation.

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Comments	Responses
Para. 6.3	
In the absence of a clear definition for "dredging reserve", it is presumed that it is Marine Department's specified minimum depth for the diffuser so that it will not affect their future maintenance dredging works.	The proposed dredged depth (-20mPD) is given in the "Ma Wan Channel Improvement Study - February 1991, Mott MacDonald". The instruction which was given at the commencement of the present Study was that the defined limits for deepening the Channel and the proposed improvements should be taken as fundamental assumptions. The seabed level in the vicinity of the diffuser is rock and even if the depth is increased by several metres the bed level will still be geologically controlled. There is no maintenance dredging in the conventional sense of this term.
Para. 6.9 to 6.10 and Fig. 6.6	
The diffuser ports for the short outfall are shown below the future and natural seabed level. Siltation and maintenance dredging might therefore seriously affect their efficiency and proper function. Figures 6.3 and 6.4 also show that the rock armours are laid very close to the diffuser. This would interfere with the outfall's initial dilution efficiency.	The tops of the caps were designed to be below the level of the adjacent natural or dredged rocky seabed was so that it would be impossible for a ship following a normal passage through the channel to come into contact with them, as illustrated in Figures 6.3 and 6.4. As it is known, from frequent observation in this area that dumb barges towed by tugs drag their anchors to maintain control, the risk of diffusers being damaged by small anchors (for example 2 tonne) at this site is a serious concern. The most practical solution is to provide very robust but easily replaceable caps and to bring the rock armour as close to the caps as practical. The suggestion that the proximity of the rock could affect initial dilution is contrary to what has been actually measured in the field (impact monitoring of Urmston Road for example) and indeed there is much evidence to suggest that the initial dilution will in fact be greater rather than less than the theoretical figure. However for the avoidance of confusion the figure will be amended without indication of rock armour.

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Comments	Responses
<u>Para. 6.11</u>	
Any proposal to lay pipes on the sea bed would reduce the water depth by 3m (12%). This would decrease the flow across the channel and the Consultants should assess the effect of this to tidal flow and water quality in the locality and more critically to Victoria Harbour. As stated in comments on para. 5.9 above, the channel between Sham Tseng and Ma Wan is a very important channel and this must be considered with extreme care.	The design recommends that the waterway will not be adversely affected because if a gully or a depression cannot be found to accommodate the pipe then a trench will be dug in which to lay the pipe. The requirement to carry out a bathymetric survey to confirm whether or not a trench would need to be excavated was stated in the Report.
<u>Para. 6.49</u>	
(i) The apparent positive effect of a trapped plume is inconclusive. The negative side of this is to lower the rate of initial dilution, lower the bacteria decay the from 4 hours to 40 hours, and consequently the beaches will still be affected by the upwelling of this concentrated plume from the lower layer.	See responds to comments on paragraph 6.70 to 6.90.
(ii) The initial dilution must also be systematically analysed and the percentile achievement for different rate of initial dilution illustrated.	
<u>Para. 6.52</u>	
(i) The ADWF of 13367 m^3/day is equivalent to 0.155m^3/s instead of 0.185m^3/s (ref. para. 6.4(a)).	This is a typographical error and has been amended.
(ii) A very large outfall (1.25m dia.) is proposed for this very low discharge are (0.155m^3/s). In addition, the flow velocity through the diffuser ports (at 6x 200mm dia.) is 0.82 m/s (and not 3 m/s). The desired initial dilution will never be achieved and there will also be operational related problem such as siltation within the pipes.	The recommended outfall diameter is 600mm id. (ref 6.14, 6.15 and figure 6.5) which is adequate for the situation according to the current information on peaking factors, ADWF and the treatment plant design (ie the top level of the last tank and the potential storage capacity in the plant). The diameter will only be finalised by the Detail Designer.

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Para. 6.54 and 6.64	
The manner the cap spacing was derived in this report has grossly and overly simplified the physical processes involved in the dilution and dispersion of the sewage discharge. For this particular case, if the length of outfall is fixed, any reduction in the 'cap spacing' will have the benefit of increasing the 'gap' between the innermost cap and sensitive receivers. The Consultants must therefore reconsider the optimal cap spacing in a more vigorous manner.	Extreme care was taken when considering the spacing of the caps and thus the benefits of increasing the distance between the centre of the plume and the shore. The distance between the centre of the plume of the short outfall and Anglers Beach is half the distance for the long outfall. The corresponding reduction in the bathing season geometric mean E.coli count is 2.5 fold. The distance between the centre of the plume of the short outfall and Gemini Beach is 25% of the distance for the long outfall and the corresponding reduction in the bathing season geometric mean E.coli count is more than threefold. If the cap spacing is reduced to 30 metres (refer to para 6.75) the initial dilutions will begin to diminish in the dry season and be reflected by an elevation in the effluent in the wet season, and are thus undesirable if the bathing beaches are to be protected. Reducing the cap spacing from 50 to 30m would move the centre of the plume away from Gemini Beach by 10m (an increase of 3%) and assuming initial dilutions were maintained the decrease in E.coli counts would be less than 3%. The differences associated with this aspect of the design are very much less than other components of the overall assessment.
Para. 6.65	
See comments on para. 6.49 above.	see above
Para. 6.69	
(i) Which station and under what tidal condition were the ambient current referred to for which 92% of the time the current exceeds 0.4 m/s.	As noted in 6.57[i] the meter was almost exactly over the discharge position. The percentage quoted was for all tidal conditions. The data set in question was particularly important in the overall assessment as it conclusively demonstrates there is no simplistic relationship between tidal range and tidal currents, or between the rate of change of water level and tidal current.

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(ii) The Consultants must clarify the exact arrangement of diffuser ports. Para. 6.69 stated that the six ports are grouped into three pairs, however the concluding para. 6.88(b) stated that there will be 3 ports in each cap.	From detailed analysis of the optimal arrangements of ports and caps using the physical model in the research station in the US where this model was developed, it was concluded that two number three port caps would be appropriate based on the output from the models and observations of the behaviour of diffusers in the physical model which supports the RSB model predictions.
(iii) There was also no analysis of the likelihood and consequences of interference between plumes for different ports under the same cap.	This is a topic which has been discussed at great length with many designers and eminent outfall modellers who have concluded that the development of a model to realistically examine this concept is at present beyond the state of the art. Guidance was provided by the results of the Roberts physical model which is located in a research station in the US.
<u>Para 6.70 to 6.90</u>	
Further to comments on para 6.49 above, it is inappropriate and inadequate to rely solely on "trapping level" to determine diffuser configuration. Other considerations such as initial dilution, decay/die-off rate for bacteria, distance of the inner-most cap from sensitive receivers, the flow pattern (whether there is upwelling of sewage plume) must also be considered.	All of these aspects were considered very carefully and recorded in the Report. It should be stressed that for a given density gradient the field thickness directly leads to dilution at a given velocity. The constantly changing velocity input by the WAHMO model results in dilutions as the plume spreads horizontally and vertically. The stratification is so stable that the concept of upwelling is not appropriate.
<u>Para 7.6(d)</u>	
What is the basis for the different definition for "day" under different seasons and tides?	The definitions of day given in 7.6 are standard assumptions which have been used in other modelling studies in Hong Kong.
<u>Para 7.11 and 7.13</u>	
The E.coli concentration shown in Tables 7.1-3 are those due to the outfall discharge alone. The Consultants must add to it also be background concentration for comparison against WQO.	Noted. This issue will be considered in the Final Report.

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Table 7.1, 7.2 and 7.3	
There should be a value each for long and short outfall for every sensitive receiver. However, there is only one value for dry spring and wet spring tidal condition only.	The reason for this was that there were no model runs carried out for the dry and wet seasons spring tide for the bacterial dispersion modelling as the decision on the recommended combination of treatment and discharge point had already been reached.
Para 7.15	
It is presumed that "bathing season" refers to in Table 7.4 covers the same period as that for WQO.	Agreed.
Para 7.16	
The paragraph shows that E.coli concentration is the major factor that determines whether long outfall with primary treatment level or short outfall with secondary treatment level should be used. Although CEPT was not adopted in the modelling test, Table 7.5 shows that it is very effective in removing E.coli (even better than biological treatment!) The Consultants should further evaluate/assess the desirability of CEPT and disinfection options.	Agreed. The application of chemically enhanced treatment options are very effective in removing bacterial loads. The evaluation of this option is for the Detail Designer to undertake. The purpose of the present assessment was to provide the guidance on the level of treatment which is required to achieve the water quality standards, which was demonstrated, while not restricting the Detail Designer (or Contractor) to a limited option. As noted in the Report, the level of E.coli is due to background levels and the introduction of CEPT at this STW would have no bearing on external loads.
Para 7.18	
Based on Table 7.6 and Figure 7.1, the NH_3-N and org N concentrations of raw sewage are 22.8 mg/l and 8.6 mg/l respectively. These are already lower than the effluent standards set for primary treatment (NH_3-N (25 mg/l) and org-N (10 mg/l)).	Noted. It has been previously identified that the loads are quite small for this catchment area however the estimation and the methods of defining flow build up has been agreed at the working group meetings. The estimation of loads was based on the DSD Drainage Manual which we were instructed by the client to use for this project.

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Para 7.20	
(i) "Figure 5.2" should be "Figure 5.1".	(i) Agreed. The amendment will be made to the text.
(ii) The Consultants must provide the loading assumption (in the form of loading table) and coastline configuration of the baseline scenario.	(ii) Noted this will be included in the Final Report.
Para 7.23	
The WQO with respect to DO for fish culture zones is 5 mg/l instead of 4 mg/l. Is this then still achievable?	DO levels were not directly measured precisely at the fish culture zones. However, in the area the levels were extracted from the contour plots in Appendix D. Further analysis of the full Water Quality Modelling results (wet and dry seasons spring and neap tides) will be provided in the Final Report, which will related to the relevant WQOs/
Appendix D	
The results are not clearly shown in the report. For example the concentration of the contour lines are not given and the cvt lines for outfall scenario cannot be seen clearly.	Noted a fair copy shall be prepared for the Final Report.
Environmental Protection Department Headquarters **Ref (24) in Annex 1 to EP2/N2/16 VI** **Dated 9 June 1995**	
The operational outfall monitoring is missing. Detailed monitoring of environmental impact is still required in the operational stage (including pre-commissioning baseline). The project proponent should discuss the requirements of this work with EPD separately. He can contact our Mr. Adrian Dawes at 2835 1244 direct for this purpose.	Noted, elaboration on the text will be included in the Final Report.

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Comments	Responses
Para 1.7 in page 2	
The Executive Summary mentioned here is a non-technical statement of the EIA findings and recommendations. It is considered as technically inadequate for the purpose of EM&A. Therefore, it should be revised and the mitigation measures should be addressed at later sections.	The text be amended to read "The Final Report" instead of Executive Summary. The mitigation measures will be appendix in the form of an implementation status form for completion by the Engineer.
Para 1.11 in Page 3 and Figure 1.3	
An individual Environmental Team (ET) is considered as mandatory. Although the ET may be formed by a group of Resident Site Staff (RSS) under the supervision of Engineer, it is required to clearly specify the ET's responsibilities and the reporting route(s) in the organisation. Paragraph 1.11 and figure 1.3 should be revised to incorporate these requirements.	A list of responsibilities can be included, but only in general terms and figure 1.3 will be expanded.
Para 2.1 in page 4	
The possible water quality impacts and the corresponding mitigatory measures are not fully described in this manual. More details of the impact prediction and mitigation should be extracted from Section 4, Water quality - Construction Activities, of the EIA reports (Doc. Ref T399/DFR, Rev. A) and attached here, such as Table 4.2 and paragraphs 4.7 to 4.28	Noted and agreed.
Para 2.3 in page 6	
Possible spillage of surface runoff contaminated with oils/grease in identified in EIA. Why the monitoring parameters do not include oils/grease?	The likelihood of spillage is very low and does not warrant inclusion in the sampling programme. However, the RSS will be required to carry out visual inspections to control this parameter.

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Comments	Responses
<u>Para 2.4 in page 6</u>	
The procedures for all in-situ measurement and sampling should be well described here so that the contract specification can be drafted accordingly. Moreover, the methods mentioned for SS determination is not consistent with paragraph 2.6(c). Either 17th edition or 18 edition should be followed.	The 18th Edition should be followed, therefore the text will be amended. It is considered sufficient to quote the reference source for the sampling procedure. The contract specifications can be drawn up using the actual procedure rather than a summary.
<u>Para 2.5 in page 6</u>	
(i) There are totally 3 control stations instead of 2. The monitoring in the vicinity of reclamation region is insufficient. The design of monitoring stations should aim at detection of possible impacts, assessment of mitigatory measures and protection of sensitive receivers. The Consultants should reconsider the proposed monitoring stations and include a justification for setting up those of them.	The text will be amended to read 3 control stations. The current monitoring stations identified will show the impacts from the works affecting sensitive receivers, which in this location is the beaches and the fish culture zone. MS3 and MS4 will indicate the impacts from the reclamation and dredging activities.
(ii) Baseline, impact and post monitoring should also be undertaken at the same monitoring stations.	Noted and agreed.
(iii) Please delete the last second sentence of this paragraph.	I assume this should read second last sentence ie "As the control station approach ...". This sentence will be removed.
<u>Para 2.8 and 2.9 in page 8</u>	
The baseline monitoring should be carried out immediately prior to the commencement of the marine work. Therefore, all the monitoring equipment should be ready preferably 6 weeks before the date of commencement.	Noted and agreed, the text will be amended.

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Comments	Responses
Para 2.11 in page 8	
After collecting the baseline monitoring data, statistical analysis of the data should be undertaken. For each station and monitoring parameter, the analysis should look for the relevance between the control and impact stations; mean, range and standard deviation; data distribution against time. In addition, TAT levels should also be calculated. Graphical presentations such as data distribution graphs, frequent charts or percentile charts are highly preferred.	This will be added to the manual.
Para 2.12 to 2.14 in page 8	
Auditing is not described here or some else in the manual. This manual should address the "procedures for auditing of the implementation of respective environmental mitigation measures recommended for detail design" captioned in paragraph 1.5(b). It is suggested that the auditing should consist of audit of impact prediction, effectiveness of mitigation measures, site activities and monitoring data.	Noted and agreed the text will be elaborated to include these subjects.
Table 2.4 in page 9	
Percentile should be referred. For SS and Turbidity, 90%-ile and 110% of control station should be used in Trigger level while 95%-ile and 120% in Action level and 99%-ile and 130% in Target level. The phase "for 2 consecutive occasions" should be deleted.	Noted and agreed.
Table 2.5 in page 10	
As comments on para 1.11 above, an individual environmental team (ET) is required. The responsibility of the ET should also be well defined here. This table should be revised accordingly. A typical action plan is attached in Appendix A for reference.	It is considered sufficient to include the responsibilities of the ET in the introduction sections and not the Action Plan. However, the Table 2.5 will be amended to reflect suggestions set out in Appendix A.

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Traffic Engineering (NTW) Division **Transport Department** **Ref: ( ) in NR 181/180-11** **Dated 2 May 1995**	
I refer to your above memo enclosed with a copy of the above report.	
2. Concerning Traffic Impacts ad depicted in; para. E39 in the Executive Summary para 12.34 to 12.36 together with 16.16 & 16.17 in the Final Report.	
I suggest the laying of sewers along Castle Peak Road should be restricted between 1000-1600 hrs everyday and after 1600 the trench to be covered with secure metal plates and be released for normal traffic so as to avoid traffic disruption.	This recommendation will be added to the Final Report.
3. The Tuen Mun Road Bus Only Lane at present is still on trial and may become a permanent scheme in which during its operation between 0700-0900 hrs the eastbound traffic along Castle Peak Road would be very busy. I regard the sewer works arrangement must well aware the adverse traffic impact along Castle Peak Road and the nearby road network.	Noted, this point has already been reflected in the Report.
Fire Services Department **Planning and Development Branch** **Ref (19) in CP P&D 151/18** **Dated 3 May 1995**	
I have no comments.	Noted.

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Comments	Responses
Planning Department Hong Kong **Ref (13) in PD/TW S/SEW/1 VI** **Dated 10 May 1995**	
I refer to the subject EIA reports circulated by DEP on 24.4.95.	
My comments to the draft final report are as follows:	
(a) <u>Figure 2.2 and Tables 2.4, 2.6, 8.13 to 8.15 and 9.12</u>	
According to the draft Tsuen Wan West OZP No. S/TWW/5, Garden Bakery, San Miguel Brewery, and Union Carbide Depot are zoned 'Comprehensive Development Area'. The planning intention is to encourage redevelopment of the existing industrial operations to residential and/or commercial uses. The proposed landuses of the proposed Sham Tseng Further Reclamation include residential use which may be sensitive to noise pollution. As such, Figure 2.2, Tables 2.4, 2.6, 8.13 to 8.15 and 9.12 which outline the odour and noise sensitive receivers of the Sham Tseng Sewage Treatment Works and the associated pumping stations should be amended to include other sites in the CDA, namely the San Miguel Brewery, and the Union Carbide Depot. The proposed Sham Tseng Further Reclamation should also be taken into account in the EIA.	Of the sensitive receivers within the various CDAs the Garden Bakery site will be the worst affected. The Sham Tseng Further Reclamation has been taken account of in the EIA in that the estimate population has been included in the future flows and loads determination but it was not necessary to single it out as a sensitive receiver because the Garden bakery site is exposed to much greater environmental impacts and it is considered appropriate to assess the Garden Bakery site only. Hence, the choice of the Garden Bakery as the assessed sensitive receiver as opposed to the Union Carbide site or San Miguel Brewery site.
(b) I presume the sensitive receivers as shown in Figure 2.2 would include Lido Garden and Sham Tseng Village. It is noted in Figure 2.2 that the location of SR3 does not tally with Tables 2.3 to 2.6 Ref. No. 3, i.e. Lido Garden.	SR3 should read "Sham Tseng Tsuen". It was assessed that impacts at Sham Tseng Tsuen would be worst affected compared with Lido Garden.
(c) The lot number of Garden Bakery indicated on Tables 2.6, 8.13 to 8.15 should be amended to 'Lot 193 & 194 in DD 390' instead of 'Lot 94'.	Noted. The text has been amended.

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(d) As regards Section 13 on Landscape and Visual Assessment, the draft final report should also set out design criteria so as to provide guidelines for the detailed design of the STW on the reclamation. Presumably, a detailed Visual Impact Assessment of the STW would be carried out at the detailed design stage.	The section 13 will be amended to include guidelines for the designer to follow.
Director of Regional Services **Ref (25) in RSD 8/HQ 410/94** **Dated 13 May 1995**	
I have the following comments on the Draft Final Report -	
(1) The sewage treatment works at Sham Tseng may have a direct impact on the water quality of the adjacent bathing beaches of the Regional Council (RC) such as Gemini, Ho Mei Wan, etc. On the understanding that the water quality within the area will be closely monitored, I suggested RSD should be immediately alerted if the conditions are found unacceptable.	This will be stated in the Environmental Monitoring and audit manual.
(2) This Department also wishes to know the locations of the monitoring stations relative to the bathing beaches so that we may be able to step up immediately the monitoring/testing of the water of the beaches concerned in case there are indications from the monitoring station that the water quality deteriorates.	These are given in Table 2.3 and Figure 2.1 of the Environmental Monitoring and Audit Manual.
(3) If the locations of the gravity sewer, rising main, pumping station, monitoring stations are to be constructed within the boundary of the RC gardens or gazetted beaches (i.e. Anglers' Gemini, Hoi Mei Wan, Casam, Lido, Approach and Ting Kau) prior permission from this Department must be obtained.	Noted.

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Comments	Responses
Principal Government Geotechnical Engineer **Ref (12) in GCP 1/4/468 II** **Dated 15 May 1995**	
Thank you for your memo and the associated draft final report captioned above. The Geotechnical Engineering Office has the following comments.	
Draft Final Report	
2. Section 1.12, Reclamation	
(a) The adequacy of the assumed final formation level of +6.0mPD will have to be justified at a later stage to account for the effects of wave overtopping on the reclaimed land;	Noted. This will be stated in the Final Report.
(b) Please replace "(subject to confirmation by the FMC)" with "depending on the availability of land based fill."	Agreed. This amendment was made in the Final Report.
3. Section 4.20 and 4.23, Construction of the Seawalls, Sourcing and Placing of Fill	
Rainbowing or the use of sand pumps have been commonly used for placing fill in many reclamation projects, e.g. West Kowloon Reclamation and Wanchai Reclamation. The consultants should clarify why this method should be avoided at this site.	The reason why rainbowing is not the favoured option in that the accuracy involved is not as good as other methods of placing fill and the potential for greater fugitive dust emissions and adverse impacts on receiving water quality exists.

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4. Section 6, The Outfall and Diffuser Section	
To facilitate future maintenance of seabed over the submarine outfall and diffusers, they should be laid at least 3 metres below the Director of Marine's proposed navigation level; this should allow for future navigation needs plus protection cushion thickness and laying out/ construction tolerance. The protection to the outfall and diffusers should be designed and constructed to accommodate impact loads from grab dredgers and other loads caused by such dredging operations. The consultants should carry out a thorough review of the design consideration for the submarine outfall and diffusers.	This is an issue to be taken up at the Detailed Design Stage.
5. Figure 6.5	
Please refer to the attached "Interim Concrete Specification for Reinforced Concrete Structures in Marine Environment" issued by the Chairman of the Standing Committee on Concrete Technology.	Noted.
6. Section 1.9, The Proposed Development	
Based on Figure 1.1, the new treatment works should be located to the east of the Garden Bakery Site. The proposed sewer reticulation system should be laid under Castle Peak Road from Tsing Lung Tau in the west and from Ting Kau in the east.	Noted. The text has been amended accordingly.
Draft Executive Summary	
7. Paragraph E.4, The Proposed Development	
As from Item 6 above.	

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Comments	Responses
Director of Marine **Ref. (3) in PA/S 915/11/36 (10)** **Dated 11 May 1995**	
I refer to your MUR and the attached reports.	
2. I have no adverse comment on the reports.	Noted.
3. From Marine point of view, our concern will major on the marine traffic during reclamation period and the layout of the outfall. As the project is still at a preliminary stage, a more detailed proposal/programme should be sent to us for comment as soon as it is finalized by the awarded contractor.	Noted and Agreed.
4. Finally, I would like to remind you that apart from the 2 Government projects as mentioned in para. E9 in the draft executive summary, you should also take into account the Route-3 Country Park section project. In which a conveyor system and a barging jetty will be located right to the East of the reclamation site.	This will be mentioned in the executive summary.
District Officer (Tsuen Wan) **Ref. (5) in TW D/13/67 IV** **Dated 22 May 1995**	
I have no comment on the above reports. Please arrange for presentation of the Executive Summary to the Environmental Affairs Committee of the Tsuen Wan District Board after it is finalised. The Committee meets every two months.	Noted.

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Comments	Responses
Chief Engineer/Planning **Water Supplies Department** **Ref (2) in WWO 24/1409/95 II** **Dated 2 May 1995**	
I refer to your above quoted memo and have no specific comment on the enclosed EIA study. However, during the planning of the captioned project, the following comments should be taken into account:-	
(1) One proposed future watermain might be laid along the proposed widening of Castle Peak Road between Sham Tseng and Yau Kom Tau for improvement of water transfer facility, and	Noted.
(2) It is noted that the land base source of fill has not yet been identified. Please note that, in order not to impair the safety of the existing waterworks tunnels, no excavation shall be carried out within 60 metres horizontally from either side of the centre line of any waterworks tunnel. No blasting shall be carried out close to existing waterworks installations and tunnels without prior agreement by WSD.	Noted.

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Director Agriculture and Fisheries **Ref (11) in AF DVL 10/18 II** **Dated 17 May 1995**	
I refer to your MUR and to the captioned Progress Reports.	
2. I have not received a reply to my previous memo dated 25.4.95 regarding my concerns on the levels of ammoniacal nitrogen at Ting Kau and Sham Tseng. The draft EIA Final Report also fails to discuss the impacts in relation to background levels that ammonia discharges will have on local waters. Chapter 7, in this document, should discuss the implications that zero ammonia reduction, for primary treated sewage, will have on local marine waters which have been identified as a sensitive receiver.	Noted. Responses to these comments have been prepared and the Final Report will include full details of the impacts on marine water quality of discharging effluent.
3. According to the plots provided in Appendix C of the draft EIA Final Report the predicted increase in ammonia dry season levels at stations SR08 and MC14 (the only plots near the outfall to show significant increase) would not result in exceedance of the WQO. I would be grateful if these predictions could be stated in the text of the EIA Final Report.	Agreed. The Final Report has been updated to incorporate the full suite of results from the modelling study will be included in the Final Report.
4. In the Executive Summary, E.21, it is stated that the WQOs will be achieved from a 350m long outfall. At the point of discharge this statement is incorrect. Details of the size of the mixing zone required to achieve WQOs under worst case conditions should be given in both the EIA Final Report and the Executive Summary.	Noted. This point will be clarified in the Final Report.

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Comments	Responses
Director Agriculture and Fisheries **Ref: (9) in AF DVL 10/18 II** **Dated 25 April 1995 (for reference)**	
Given the high pH and high temperature that occur during the summer months in the Hong Kong marine environment the loading of significant quantities of ammonia may prove damaging to local fisheries. Primary treatment will remove none of the ammonia loading. Will the objective of 0.021 mg/l total un-ionized ammonia be met outside the mixing zone during worst case scenario i.e. neap tide, surface temperature 30°C and pH 8.5 and what is the proposed size of the mixing zone?	the WQO for ammonia will be achieved, as demonstrated in the Report. The mixing zone is less than 60m, as noted in Section 6 of the Report.
It was stated in Appendix II (h) of Working Paper No. 4 that the designer by means of mathematical modelling would demonstrate that the un-ionized ammonia standard would be met with the treatment facilities proposed. The table presented Appendix E of W.P. No. 6, page 2 does not provide sufficient information to answer the queries raised above and there is no discussion of the ammonia data in Appendix D. I would be grateful for further clarification of the potential impact of un-ionized ammonia on local fisheries.	Agreed. The report was not complete when it was issued (in Draft) as the result of modelling were still being provided. The full suite of results are given in the Final Report.
Drainage Services Department **Ref: (1) in DSD CM 8/4052DS/26** **Dated 14 October 1995**	
Thank you for the Final Report (Volume 1) and the Executive Summary sent to me on 6.10.95. I note that some of the following comments from the relevant parties have not been incorporated:	
<u>Final Report</u>	
(i) Section 7.55 "emergency outfalls" should read "outfall";	Noted and amended.

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(ii) Table 7.9 I doubt whether the figures for the differences of the averaged water quality results are in absolute terms or in percentage. Please check;	No, they are not percentage. Titles amended.
Please also amend the TABLES list in the Tables of Content;	Amended.
(iii) Section 16.6 This appears to be an incomplete sentence.	The sentence is complete.
<u>Executive Summary</u>	
(i) EPD Air Policy Group's comments ref (10) in An (1) to EP2/N2/16 IX (see enclosure) are not incorporated;	The text has been amended.
• Please confirm the residual odour impacts associated with the regeneration and replacement of activated carbon are also within odour criteria specified by EPD.	
• About the phrase "(5 odour units averaged over 5 seconds measured at odour sensitive receivers)", this 5 odour units limit is applicable to odour impact prediction by means of modelling technique and for odour monitoring, 2 odour units is the recommended limit. It is suggested to replace the phrase by "predicted 5 odour units averaged over 5 seconds at odour sensitive receivers".	
(ii) E.2(a) "proposed Project and outfall" should read "proposed STW and outfall";	Noted and amended.

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	Comments	Responses
(iii)	E.5 & 46 EPD Water Policy and Planning Group's comments ref (4) in An (1) to EP2/N2/16 IX (see enclosure) are not incorporated; In paragraph E.5, it has mentioned the recommendations of outfall monitoring or, more exactly, the EM&A of the outfall in operation phase. However, E.46 did not fully reflect the provisions of the EM&A arrangement of operation phase, which has been passed to the consultant vide ref. (52) in Annex (1) to EP2/N2/16 VI. This paragraph should include the view that the EM&A of operation phase is to determine the actual performance of the outfall following commissioning and that the details of the EM&A need not be determined in this EIA but should be agreed with EPD prior to operation of the outfall and in good time to enable a suitable baseline to be determined. Moreover, the outfall operator shall ensure sufficient funds for this purpose. It should not present in this paragraph an image that the EM&A of operation phase is going to be finalised in the EM&A manual by the Engineers at the commencement of Works Contract which do only cover the construction.	The text referred to has been amended to reflect these issues.
(iv)	E.11 Delete "be" in the 6th line;	Noted and amended.
(v)	E.20 Figures 3 and 4 (should they be Figures 4 & 5?) are not seen;	The figure numbers has been amended to coordinate these figures discussed with the figures presented.
(vi)	Please amend the Chinese translation of Executive Summary in line with the English revised text.	Noted.

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I should be grateful if you would incorporate the comments into the Final Report and Executive Summary. It will be useful if you would scrutinize the whole reports and have a detailed proof reading before sending them out for final printing.	