SECTION FOUR

IMPACT ON WATER QUALITY

SECTION FOUR

4. IMPACT ON WATER QUALITY

4.1 Introduction and Present Water Quality

Sections Twelve and Thirteen describe the present condition of the water environment in the Castletown Estuary. As part of the background investigations for the Project, Dr. Dermot Douglas was commissioned by Patrick J Tobin & Co Ltd to carry out water sample analyses throughout the Estuary.

The results of the analyses suggest that, while pH levels in the river generally fall within a narrow range, results at low neap tide near the Landfill Site show elevated values in the range 8.08 - 9.17.

Results recorded near St. Helena's Pumping Station and the Docks gave values of 8.15 and 7.8 respectively, indicating that the higher values were a local effect - probably related to leachate from the landfill.

Measurement of the nutrient levels in the estuary show that average values increase as one proceeds downstream. Silica is exceptional in that its concentration decreases as fresh water is diluted by sea water.

Nutrient levels in the estuarine area, with the exception of nitrate, are considerably higher than the average values recorded for St. John's Bridge which would be typical of the Castletown River itself. The conservative behaviour of nitrate as fresh water is diluted by the incoming tide was also noted in an earlier study in 1981 / 1984 survey and can be seen again in the 1992 survey. Only at the Newry Road bridge does the ratio of nitrate to ammonia exceed unity. This predominance of nitrogen in the form of ammonia clearly demonstrates the effects of the present effluent discharge on the estuarine region.

Comparison of the BOD and nutrient results obtained during this survey with those obtained during the 1981 / 1984 survey show an increase in the levels of BOD, Ammonia and Phosphate, but a decrease in the level of Nitrate. The low level of Nitrate seems to prevent any significant eutrophication problem occuring. In summary the need for effluent treatment is clear and the data needed to establish its effectiveness have already been collected.

The next question to be established is where the treated effluent ought to be discharged so as to meet the design objectives in the most cost effective manner.

4.2 Treated Effluent Discharge Point

In order to select the optimum discharge point, and treated effluent release strategy, a mathematical model of Dundalk Bay was prepared, calibrated and verified by MCS Internation Ltd, our Associates on this project. In checking the bathymetry of the Bay, considerable variation from the Admiralty Chart data for the seaward extremity of the Ship Channel was detected. Control points for tide level at Giles Quay, Blackrock and offshore in the centre of the survey area were used and the model was verified satisfactorily on reproduction of measured tide level and current velocity. Lateral dispersal coefficients were measured by dye test releases and were found to be very low, lower than for most other Irish coastal sites, and similar to values which we have determined in independent marine measurements at Giles Quay. Dye Test releases were made on both the Spring and Neap Tides and the model calibrated on Spring Tide data successfully predicted and recorded Neap Tide dye patch movement.

4.3 Background Conditions

The Castletown and Fane Rivers, the Landfill Site runoff and the Blackrock effluent discharge are background inputs to the Survey Area in addition to the proposed treated effluent discharge. The Castletown River itself is the predominant external influence.

The following background data were used as inputs to the model, following direct measurment or similar parameter values determined elsewhere.

Treated Effluent Total Coliform Counts	3.364×10^6 / 100ml
Treated Effluent Faecal Coliform Counts	0.324×10^6 / 100ml
Castletown River Total Coliform Counts	1.0×10^4 / 100ml
Castletown River Faecal Coliform Counts	4.4×10^4 / 100ml
Castletown River BOD levels	Max. 2.9 mg/l
Castletown River BOD levels	Min. 0.6 mg/l
Castletown River BOD levels	Mean 1.6 mg/l
Castletown River 90 Percentile Low Flow	2.0 cumecs

4.4 Discharge Conditions Examined

4.4.1 Existing Discharge - Model Runs 1 to 3

The plume of the existing untreated effluent discharge was modelled using a T90 for Faecal Coliforms of 15 hours and a T90 for Total Coliforms of 9 hours. The plume of effluent was also modelled for BOD dispersal.

These analyses, detailed in the Appendices to this Section, clearly show the need for secondary treatment with highly elevated levels of BOD and Faecal Coliforms in the Ship Channel and levels in excess of Approved Shellfish water quality drifting onshore in areas north of Blackrock.

4.4.2 Future Conditions

It was assumed that secondary treatment would bring a 90% reduction in the numbers of Faecal Coliforms, this being typical of kill rates for activated sludge systems.

(i) Run No. 4

A tidally balanced discharge of 3 DWF from Soldiers Point was initially modelled, releasing from 1.25 hours before High Water to 1 hour before Low Water.

Mean onshore winds of 5m/sec from the south east were included and background inputs were as previously listed. The model was run for Spring Tide conditions and was run over several simulated tides to ensure a steady state condition was reached.

(ii) Run No. 5

This run followed the same general conditions as No. 4 but the Discharge Point was in the middle reach of the Ship Channel.

In general it can be seen from Appendix C that the Ship Channel focuses the effluent stream on the ebb tide, with little predilution along the Channel so that the plume effectively begins to disperse and broaden at the Channel

end. This circumstance is little different from delivering the effluent by pipeline to the same location; if anything plume movement onshore is less significant in the Blackrock - Soldiers Point area with the release at Soldiers Point.

We conclude from Runs 4 and 5 that there is no merit in a treated effluent pipeline to any point on the Ship Channel or offshore. A release at Soldiers Point itself is of equal value from the water quality viewpoint.

(iii) Runs 6 and 7 (Appendix 4A and Appendix 4B)

Once the optimum discharge point is determined the question arises as to whether a continuous or tidally balanced discharge is preferable. Run No. 6 examines the discharge of 3 DWF under the same conditions of wind and tide as Runs 4 and 5, but discharging continuously rather than on the ebb tide alone.

Water quality impact is one consideration, the avoidance of a visible discharge at low tide is also an important visual impact consideration. Even when the discharge is a treated effluent, the public perception of a visible discharge near the Navvy Bank amenity walk may well detract from the positive achievements of the Plant.

The model runs designed to test the benefits of tidal balancing have shown:

(i) Tidal streams passing Soldiers Point at the discharge location are strong and are focussed by the Estuary profile there

(ii) The ebb tide stream velocities are stronger than the flood tide stream velocities.

(iii) With a continuous discharge the flood tidal stream tends to pre-dilute the effluent into the incoming tidal stream filling the Castletown - Flurry Estuary upstream of Soldiers Point. The bacterial levels offshore when this area of the Estuary empties are lower than if the effluent had been tidally balanced and released in greater volume on the ebb tide.

Since background bacterial levels in the Castletown are high in any case, the use of the Estuary as a predilution area in this way is reasonable. It generally results in a less concentrated effluent plume being drawn down the Ship Channel on the ebb tide than would be the case with full half cycle tidal balancing. Tidal balancing has accordingly not been included in the proposed Plant. If at some stage in the future, through catchment wide measures, bacterial levels (due to other inputs) in the Castletown Estuary were reduced, then a review of continuous discharge of treated effluent would be warranted. Such a review might then conclude that tidal balancing was worth while, accordingly we have reserved space on the Site for such a Tank in future.

Further questions in relation to Tidal Balancing are discussed in Section Fifteen of this Statement.

In summary the optimum Treatment Effluent Discharge Location is at the constriction in the Estuary at Soldiers Point itself.

4.5 Alternative Designs

Any alternative treatment processes considered at Tender Stage would have to achieve the same treated effluent standards and the treated effluent would continue to be discharged to the Estuary at the same location.

SECTION FOUR

APPENDIX 4A

MODEL RUNS 1 - 6

by: *MCS International*
Lismoyle House
Merchants Road
Galway

DUNDALK MAIN DRAINAGE SCHEME

Hydrodynamic Model Calibration and Validation

1.0 Introduction

Patrick J Tobin & Co Ltd commissioned MCS International to develop a computer mdoel of Dundalk Bay in County Louth and to use the model to predict environmental effects caused by effluent discharge at selected locations. The most suitable location could then be determined.

Before any computer based hydrodynamic model can be used for predicutive purposes it must firstly be calibrated and then validated. This is carried out by comparing computed versus measured:

(i) Current speeds
(ii) Current directions
(iii) Water surface elevations

at certain locations in the domain. The model is tuned by varying the coefficients of friction until good agreement is obtained between computed and measured values for the environmental conditions that prevailed when the measurements were recorded.

2.0 Environmental Conditions

In order to validated the hydrodynamic model, current measurements were taken at six locations in Dundalk Bay and water surface elevations were measured at two locations - Cooley Point and the Pile Lighthouse. Figure 1 shows the locations of these measurements.

One calibration run and seven validation runs were carried out. The calibration run used the data at Site C3 for the environmental conditons measured on the 28th January 1992, (a neap tide). The validation runs used the data at Sites C1, C2, C3, C4 and T1 for the environmental conditions measured between the 17th and 20th May 1992, (spring tides).

The measured environmental conditions which are input to the calibration analysis may be summarised under the following headings:-

(i) boundary tidal amplitude
(ii) wind conditions

(i) *Boundary Tidal Amplitude:* On the 17th, 18th, 19th and 20th of May 1992, tidal amplitude measurements were taken at Cooley Point for use as open sea boundary tidal amplitude input for the hydrodynamic model. All water height values are given in metres above LAT, where LAT is the lowest astronomical tide, which is 3.0m below Ordnance Datum (Malin Head). In the hydrodynamic module, each analysis begins at high water, which is arbitrarily defined as the time datum (t=0).

(ii) *Wind Conditions:* Average wind speeds and directions were recorded for the appropriate calbration and validation dates and were used as input to the hydrodynamic model runs.

3.0 Current Measurements

At each site, current measurements were taken at three or four depths below the water surface (when a sufficient depth of water was present), and at approximately hourly intervals over a tidal cycle. Since the hydrodynamic model is depth integrated, the results from the model represent an average current speed and direction at any grid point. In order to compare the measured values against the computed values, the measured values were therefore averaged over the depth. Current directions were measured to Magnetic north and these were adjusted to True north to correspond with predicted values.

4.0 Calibration and Validation Results

The calibration analysis was carried out for the environmental conditions on the 28th January 1992. A number of runs of the hydrodynamic model were necessary before sufficiently good correlations were obtained between the predicted and measured current and water suface elevation values. The bed roughness length coefficient (1) was adjusted until good agreement was obtained. A number of fine adjustments were also applied to the other empirical coefficients. Final values of the empirical hydrodynamic coefficients for which the model was considered calibrated are:-

Bed roughness length	= 100mm
Eddy viscosity coefficient	= 1.00
Air-water interfacial resistance coefficent	= 0.0026
Momentum correction factor	= 1.016

Figures 2 and 3 present the comparison between predicted and measured data for Site C3, 28 January 1992.

The calibration hydrodynamic model was then run for four further analyses. These analyses were for the environmental conditions that exist on the 17th, 18th, 19th and 20th May 1992 when comprehensive current and water surface elevation measurements were carried out. Excellent agreement was found to exist between predicted and measured data, these data are available for inspection on request but are omitted here for reasons of space.

The several runs collectively validate the choice of parameters employed in the model.

5.0 Dispersion Analyses

Six dispersion analyses have been carried out to date.
Their details are as follows:-

Analysis 1 Existing Situation	- Discharge of Untreated Effluent from an Outfall at Soldiers Point, Outfall 'A'. Dispersal of Biochemical Oxygen Demand (BOD).
Analysis 2 Existing Situation	- Discharge of Untreated Effluent from an Outfall at Soldiers Point, Outfall 'A'. Dispersal of Total Coliforms (TCL).
Analysis 3 Existing Situation	- Discharge of Untreated Effluent from an Outfall at Soldiers Point, Outfall 'A'. Dispersal of Faecal Coliforms (FCL).
Analysis 4 Proposed Situation	- Discharge of Treated Effluent from an Outfall at Soldiers Point, Outfall 'A'. Dispersal of Faecal Coliforms (FCL).
Analysis 5 Proposed Situation	- Discharge of Treated Effluent from Outfall 'B' approx. 1900m south-east of Soldiers Point. Dispersal of Faecal Coliforms (FCL).
Analysis 6 Proposed Situation	- Discharge of Treated Effluent from Outfall 'A' at Soldiers Point, Dispersal of Faecal Coliforms (FCL). Continuous Discharge.

Note that each analysis has been run until steady state conditons have been reached.

The results of these analyses are presented in the following pages.

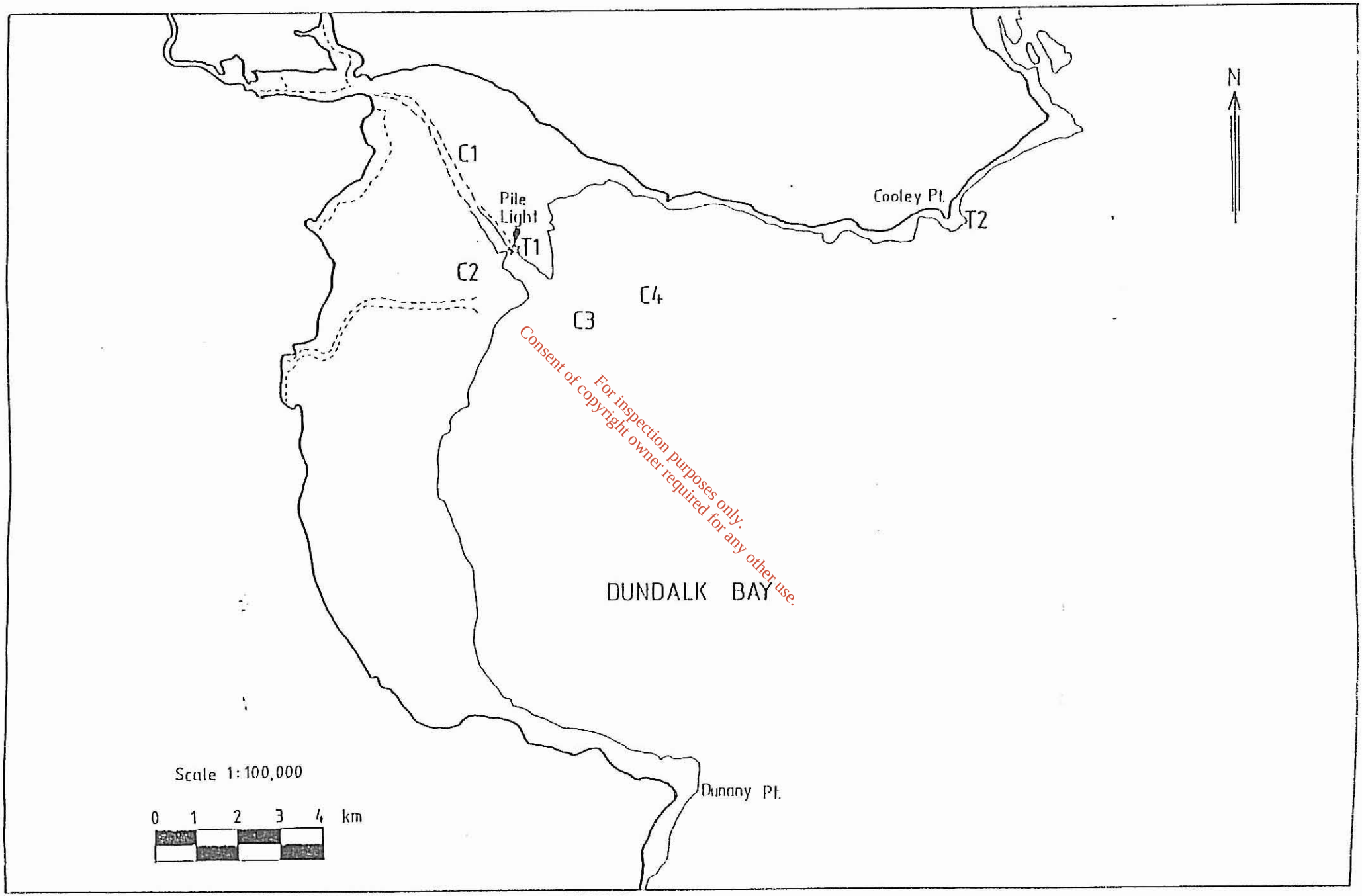

Figure 1 Current and Water Elevation Measurement Locations.

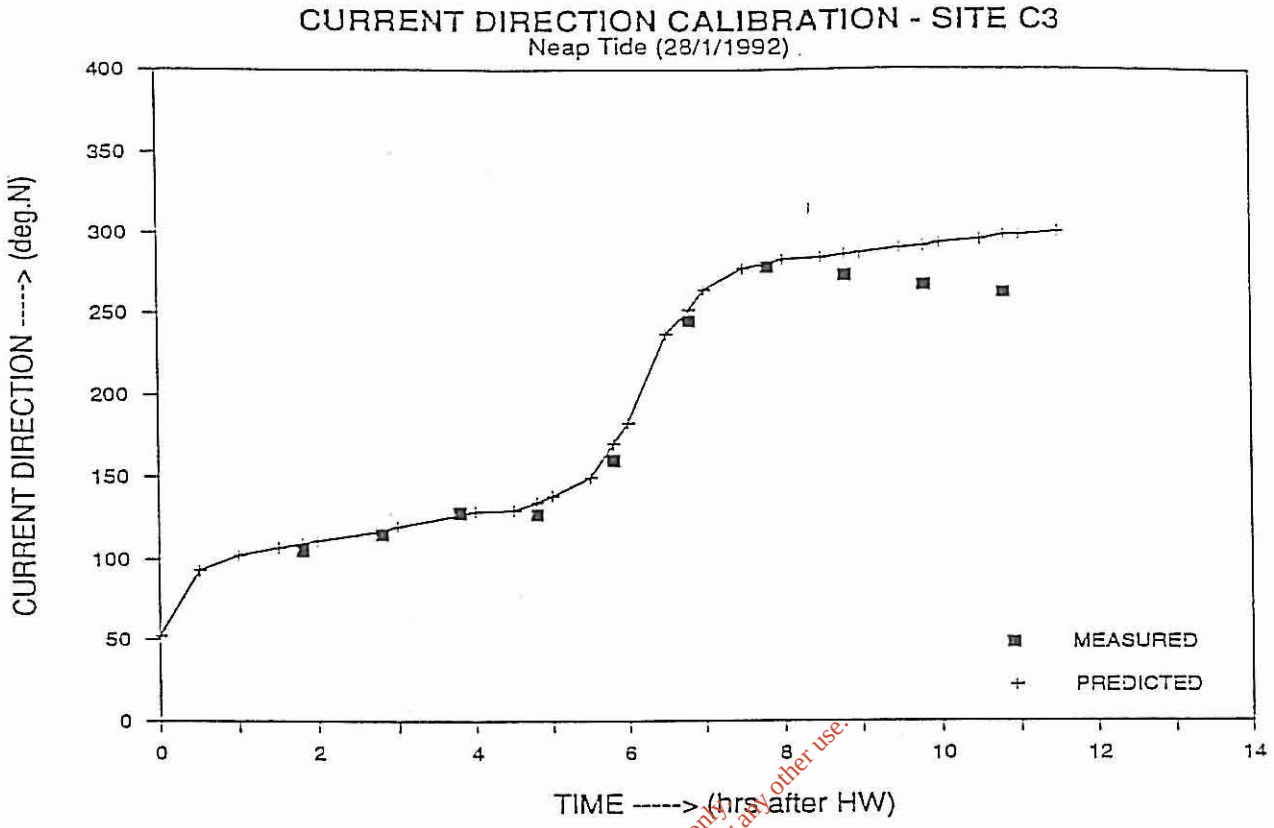

Figure 2 Current Direction Calibration.

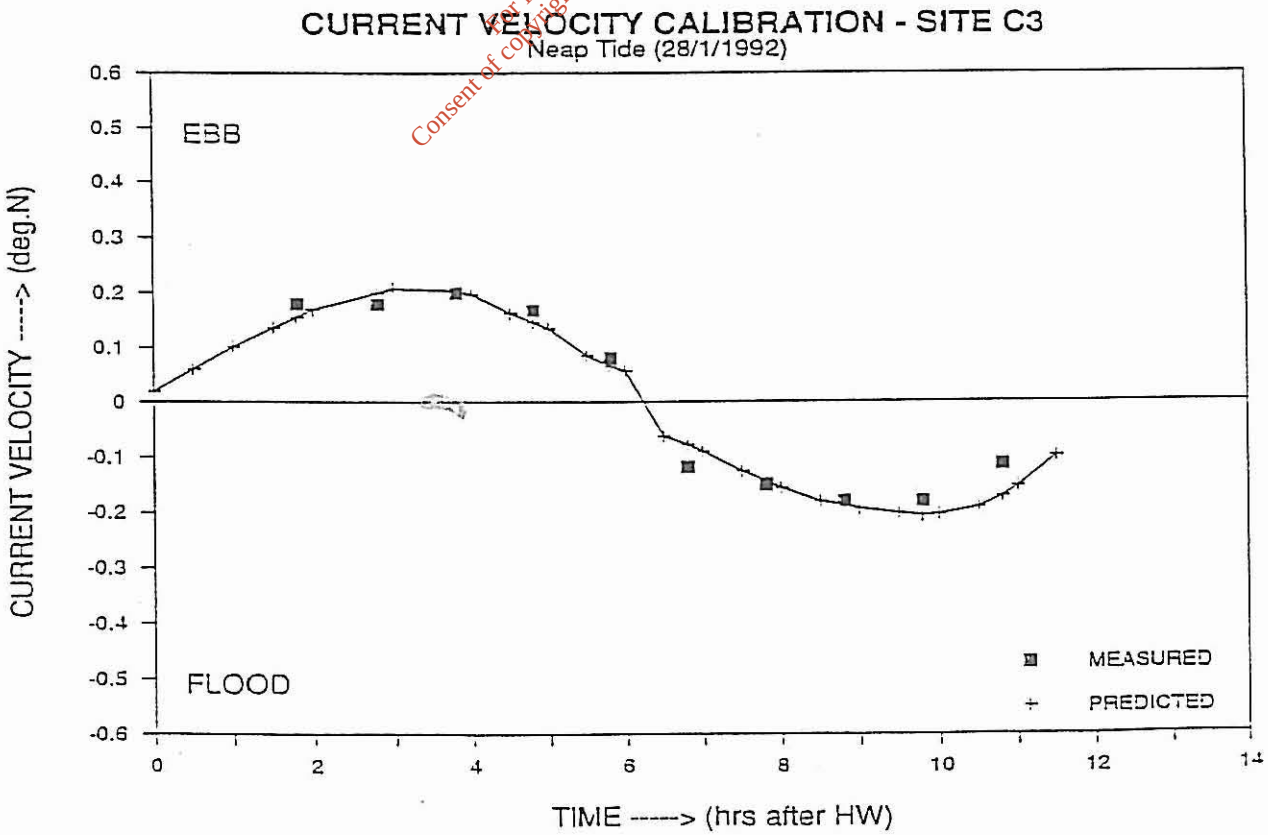

Figure 3 Current Velocity Calibration.

Outfall	Latitude	Longitude	Description
Outfall A	54° 00.51' N	6° 20.42' W	Soldiers Point
Outfall B	53° 59.87' N	6° 19.33' W	1900m SE of Soldiers Point

Table 10 Outfall Sites - Location and Description.

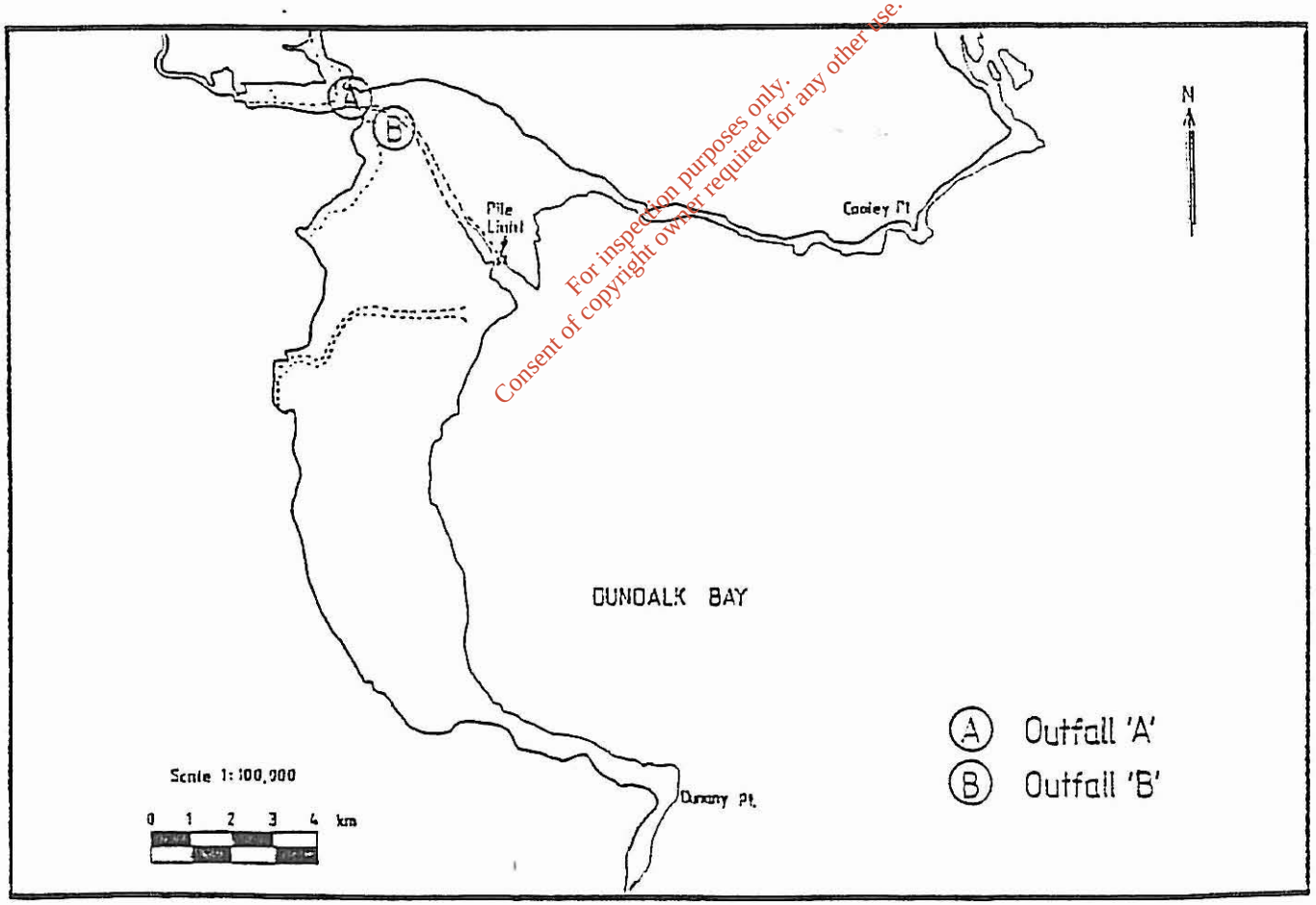

Figure 15 Locations of Outfall Sites.

DISPERSION ANALYSIS No. 1

Description :- Analysis of BOD levels due to river flows and existing discharge at Outfall 'A' of untreated effluent.

Tidal Conditions :- Spring Tide.

Wind Conditions :- Mean on-shore wind (5m/sec from south-east).

River Flows :- (Castletown River) Estimated flow = 2.0 cumec

'Background' BOD concentration = 2.0 mg/l

Discharge :- (Untreated effluent from tidal tank at Outfall 'A', Soldiers Point.)

Released from 0.5 to 5.75 hours after each High Water.

Release Rate = 0.38 cumec

Effluent BOD level = 750 mg/l

Results:- Figures 17, 18, 19 and 20 present 'snapshots' of BOD concentrations at High Water, mid-ebb, Low Water and mid-flood.

The maximum, minimum and mean BOD concentrations at the observation sites are as shown below in Table 12.

Location	Maximum	Minimum	Mean *
Site 1	0.011	0.0083	0.0096
Site 2	0.199	0.159	0.179
Site 3	1.557	0.555	1.056
Site 4	0.385	0.038	0.211
Site 5	0.486	0.417	0.451
Site 6	0.009	0.0058	0.0075

* Note:- Mean values are calculated when cell is submerged.

Table 12 Analysis No.1 - Maximum, Minimum and Mean BOD concentrations (mg/l).

Location	Latitude	Longitude	Significance
Site 1	53° 59.17' N	6° 14.60' W	Limit of Giles Quay bathing Area
Site 2	53° 58.78' N	6° 21.65' W	Limit of Blackrock bathing Area
Site 3	54° 0062' N	6° 20.47' W	Bird Sanctuary
Site4	53° 57.35' N	6° 16.58' W	White Fish Nursery Grounds
Site 5	53° 56.62' N	6°21.18' W	Area of Potential Mariculture
Site 6	53° 59.02' N	6° 13.40' W	Area of Potential Mariculture
Site 7	54° 00.49' N	6° 20.42' W	Adjacent to Soldiers Point

Table 11 Observation Sites for Model Output Time Series.

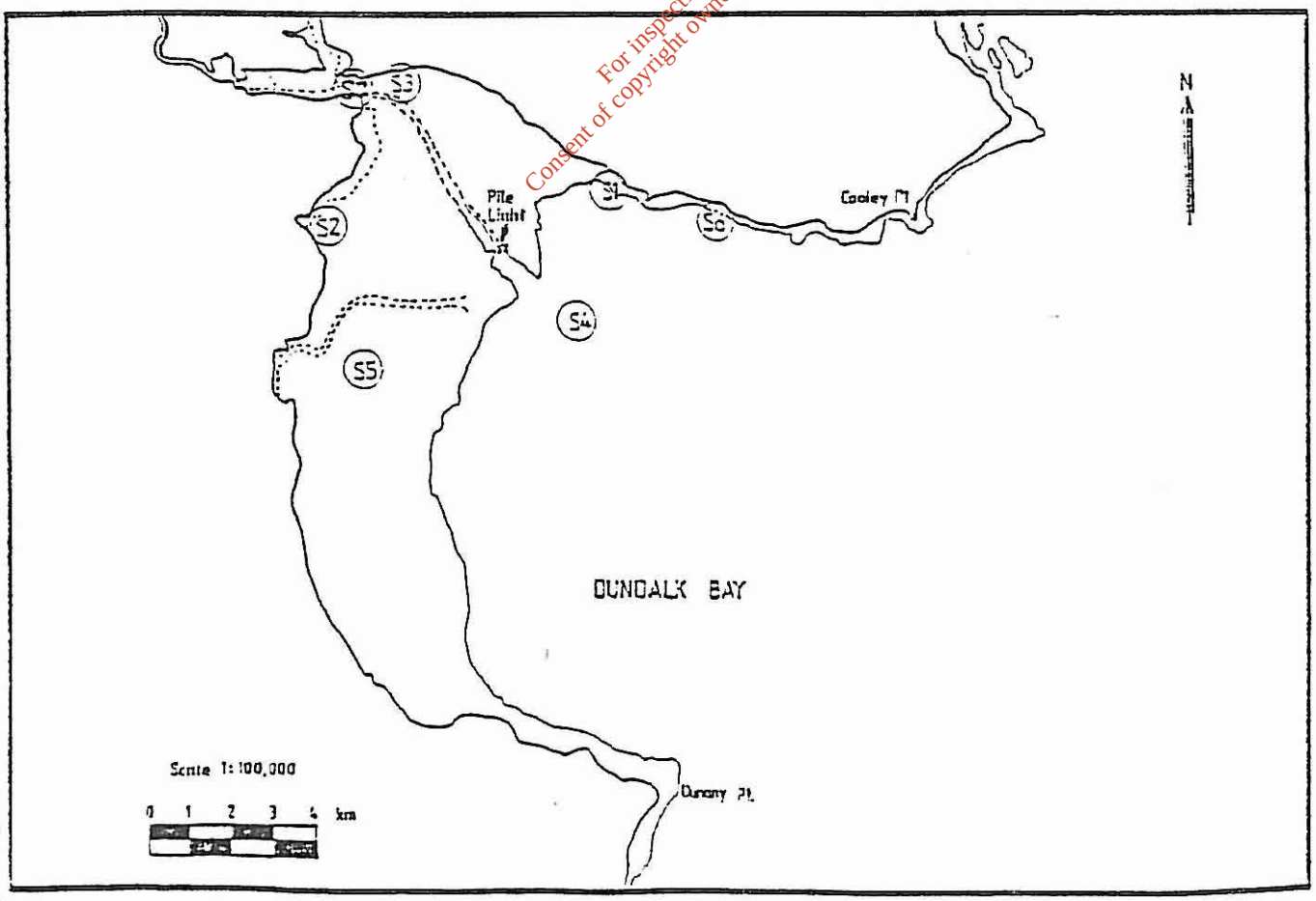

Figure 16 Locations of Observation Sites.

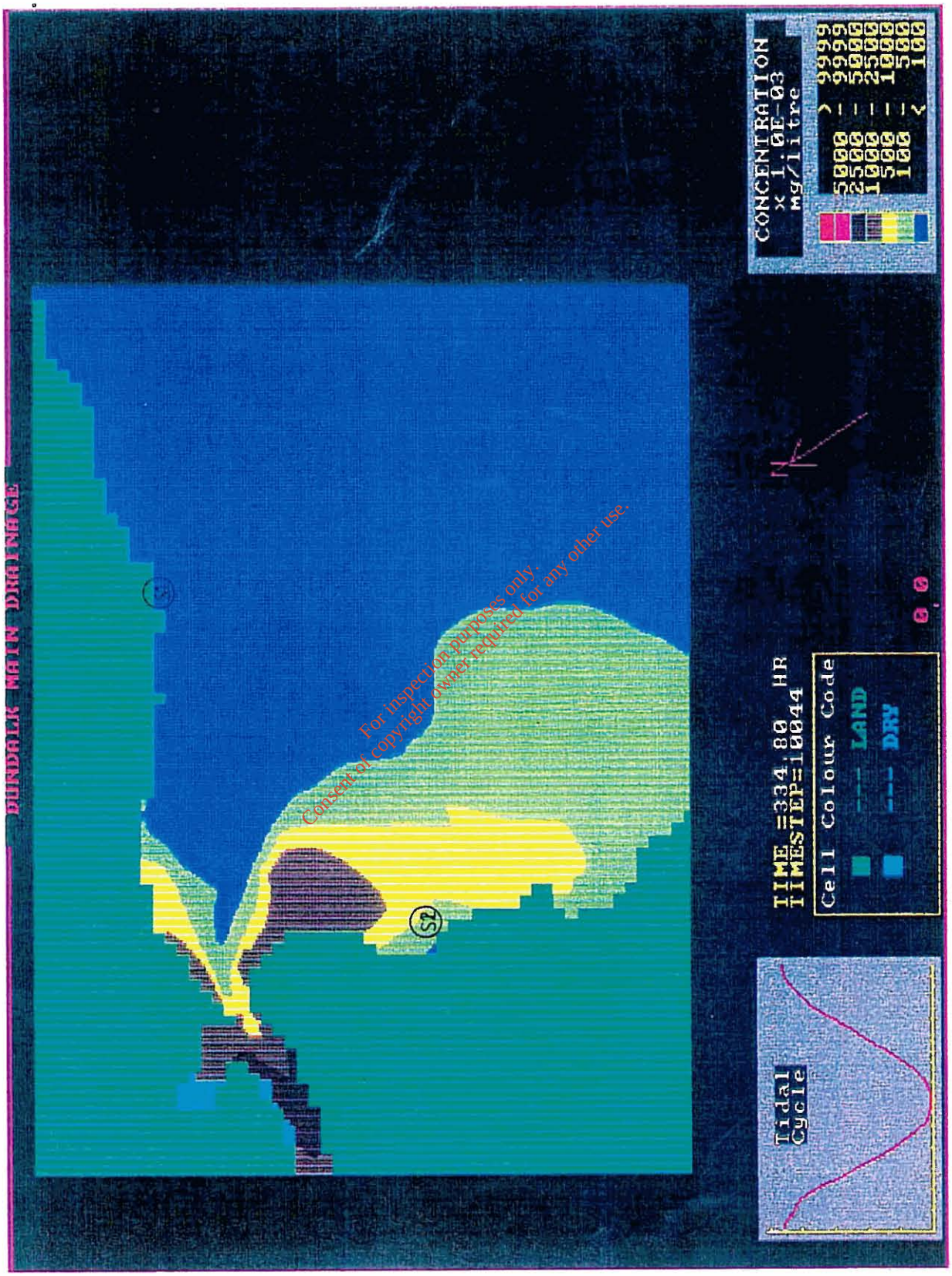

Figure 17 **Analysis 1 BOD Dispersal at High Water.**

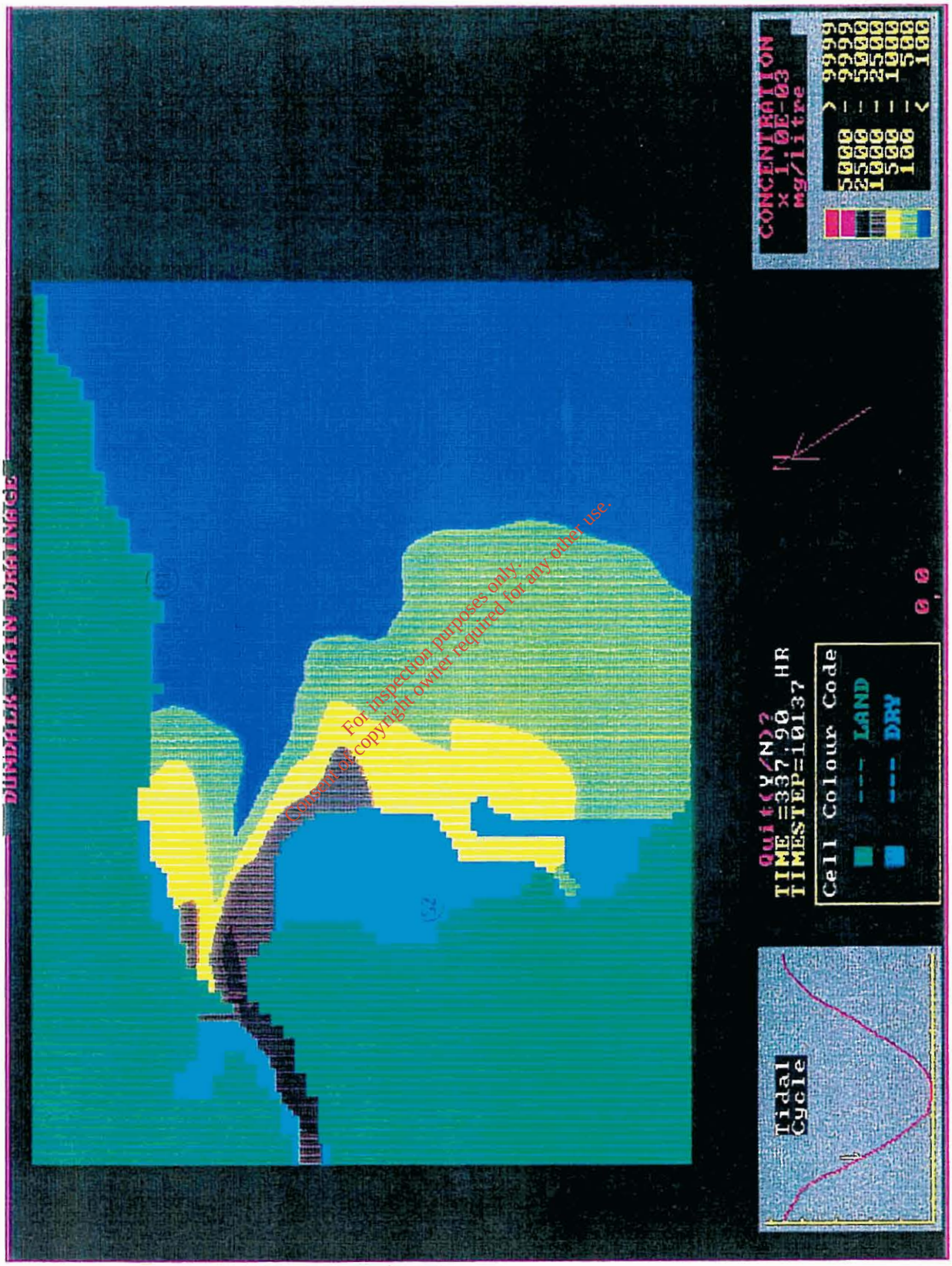

Figure 18 **Analysis 1 BOD Dispersal at Mid Ebb.**

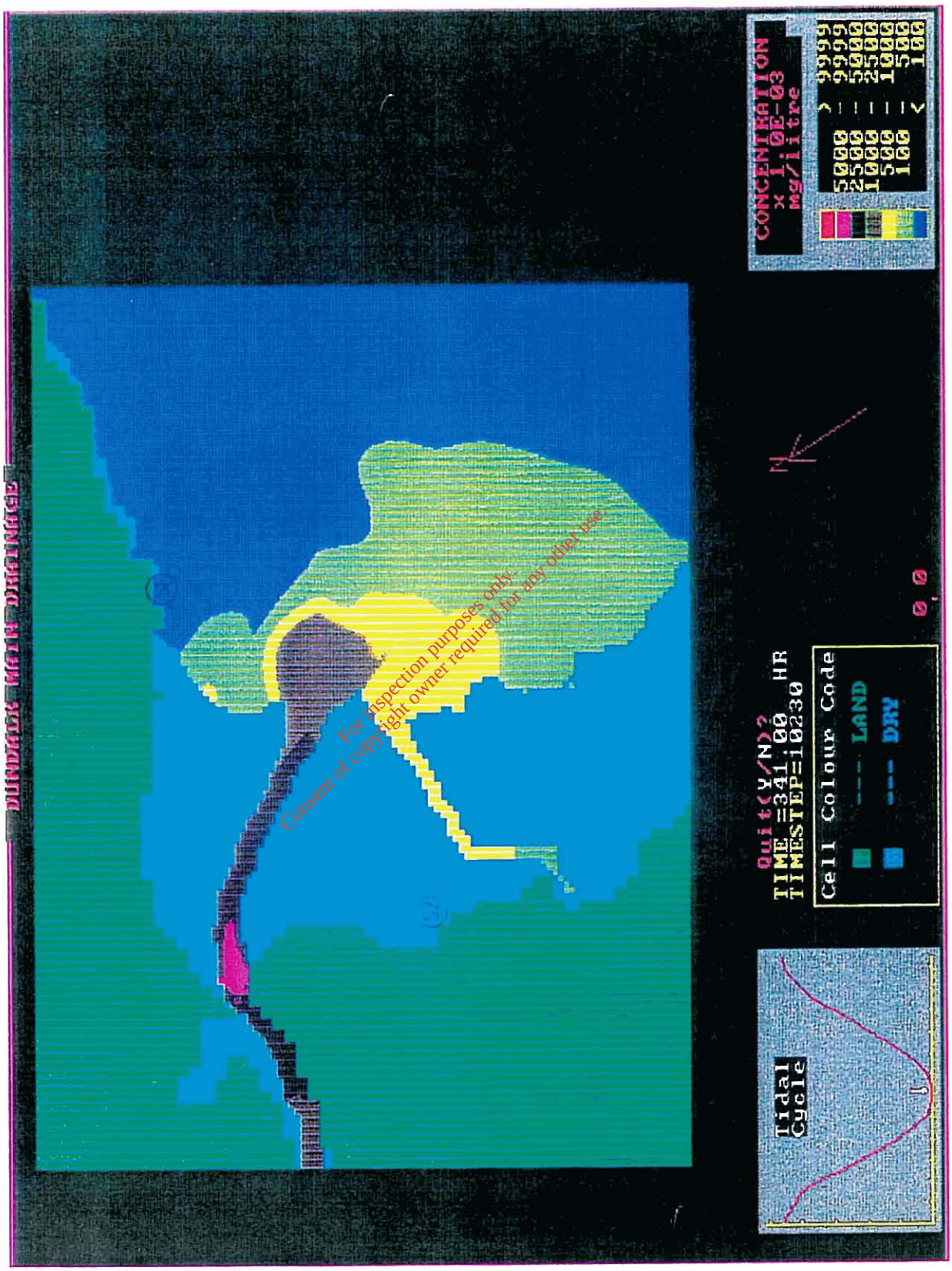

Figure 19 **Analysis 1 BOD Dispersal at Low Water.**

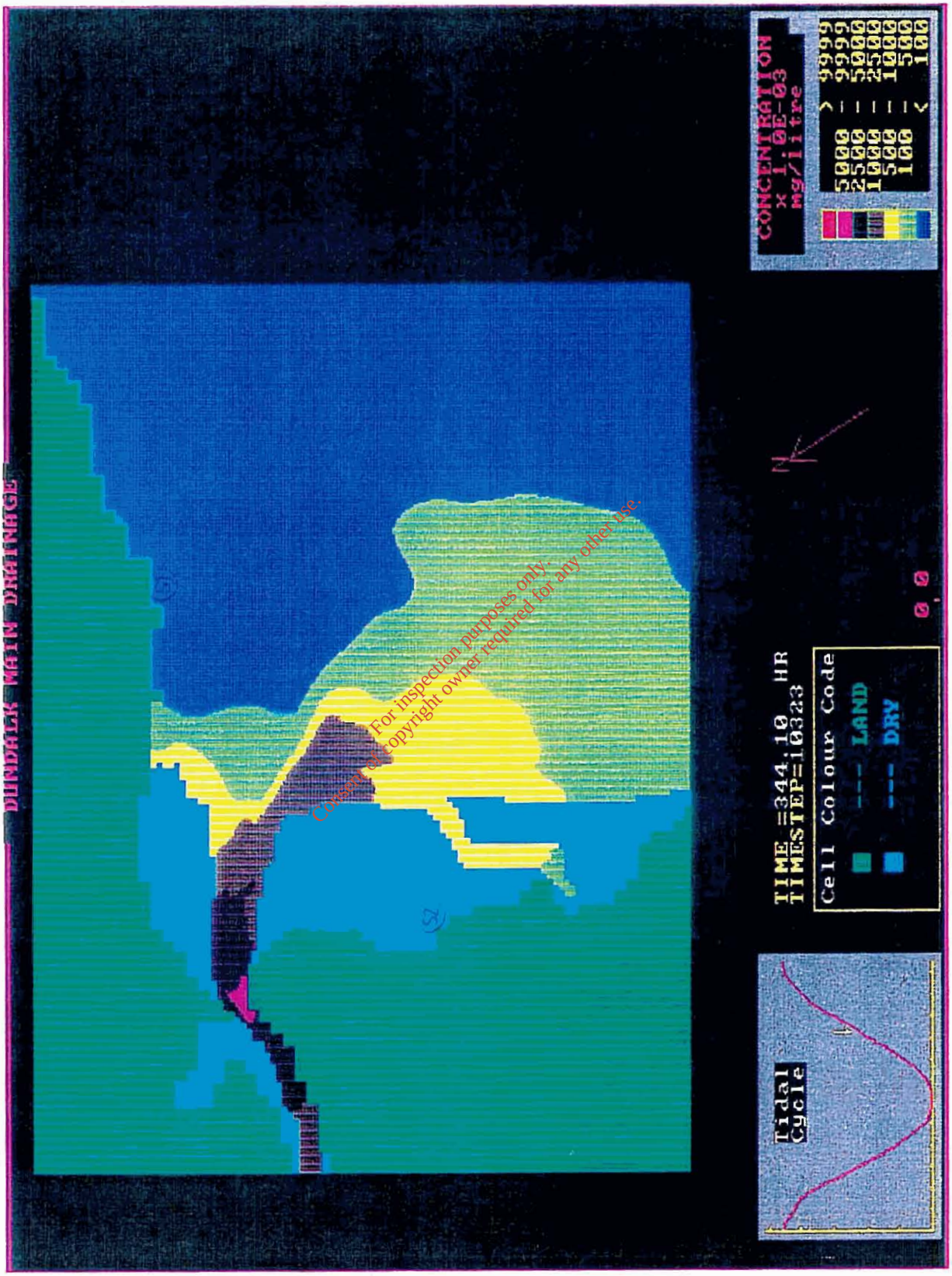

Figure 20 **Analysis 1 BOD Dispersal at Mid Flood.**

DISPERSION ANALYSIS No. 2

Description :- Analysis of Total Coliform levels (TCL) due to river flows and existing discharge at Outfall 'A' of untreated effluent.

Tidal Conditions :- Spring Tide.

Wind Conditions :- Mean on-shore wind (5m/sec from south-east).

River Flows :- (Castletown River) Estimated flow = 2.0 cumec

'Background' TCL = 10000/100ml

Discharge :- (Untreated effluent from tidal tank at Outfall 'A', Soldiers Point.)

Released from 0.5 to 5.75 hours after each High Water.

Release Rate = 0.38 cumec, Effluent TCL = 33,640,000/100ml

Decay Rate = 6.14, (T90 = 9 hours)

Results:- Figures 21, 22, 23 and 24 present 'snapshots' of TCL concentrations at High Water, mid-ebb, Low Water and mid-flood.

The maximum, minimum and median TCL concentrations at the observation sites are as shown below in Table 13.

Location	Maximum	Minimum	Median *
Site 1	0.0	0.0	0.0
Site 2	4.86	1.91	1.937
Site 3	8008.70	1627.52	2575.09
Site 4	28.49	0.0	0.0147
Site 5	0.370	0.0558	0.0994
Site 6	0.0	0.0	0.0

* Note:- Median values are calculated when cell is submerged.

Table 13 Analysis No.2 - Maximum, Minimum and Median TCL concentrations (No./100ml).

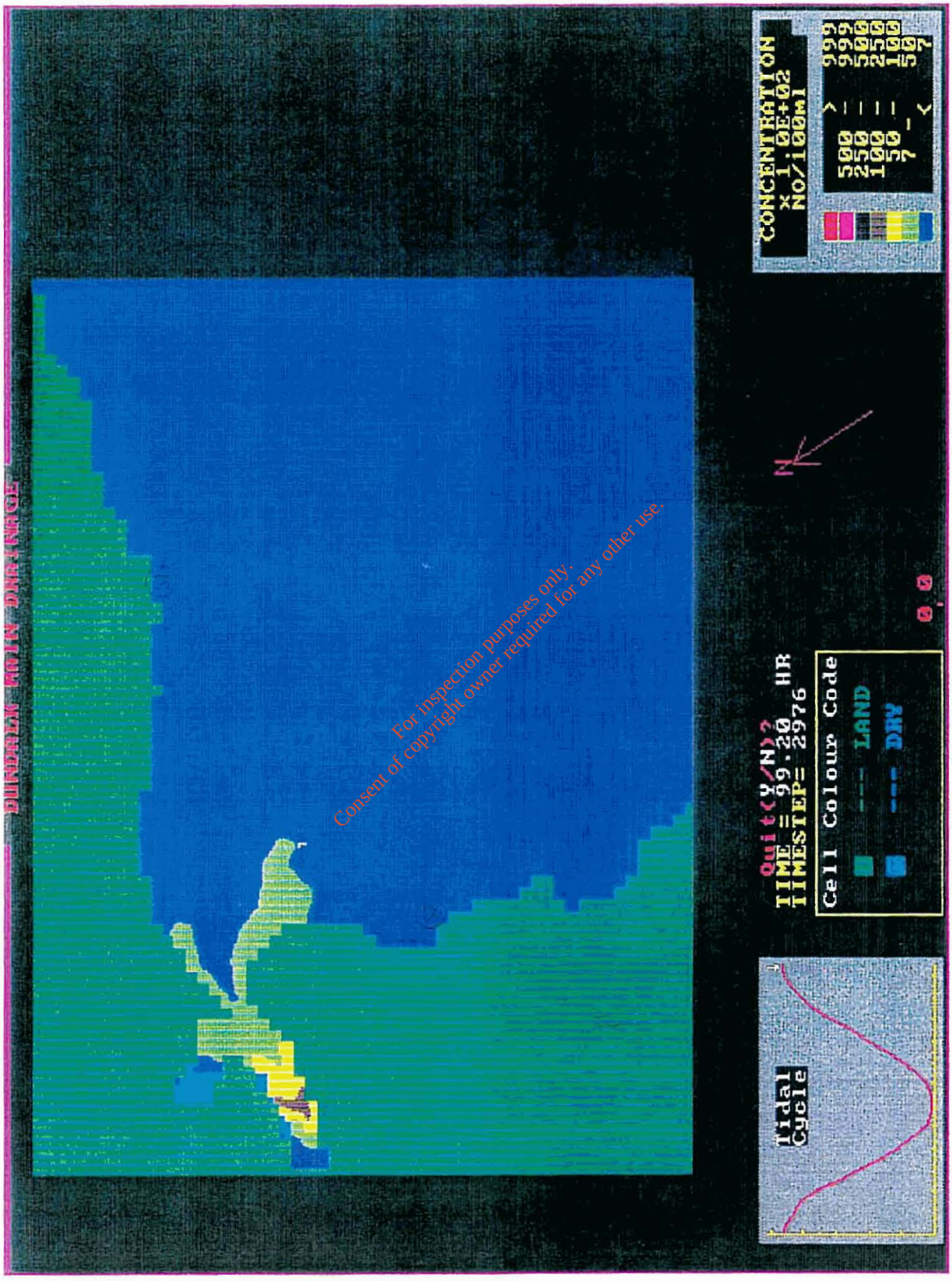

Figure 21 Analysis 2 TCL Dispersal at High Water.

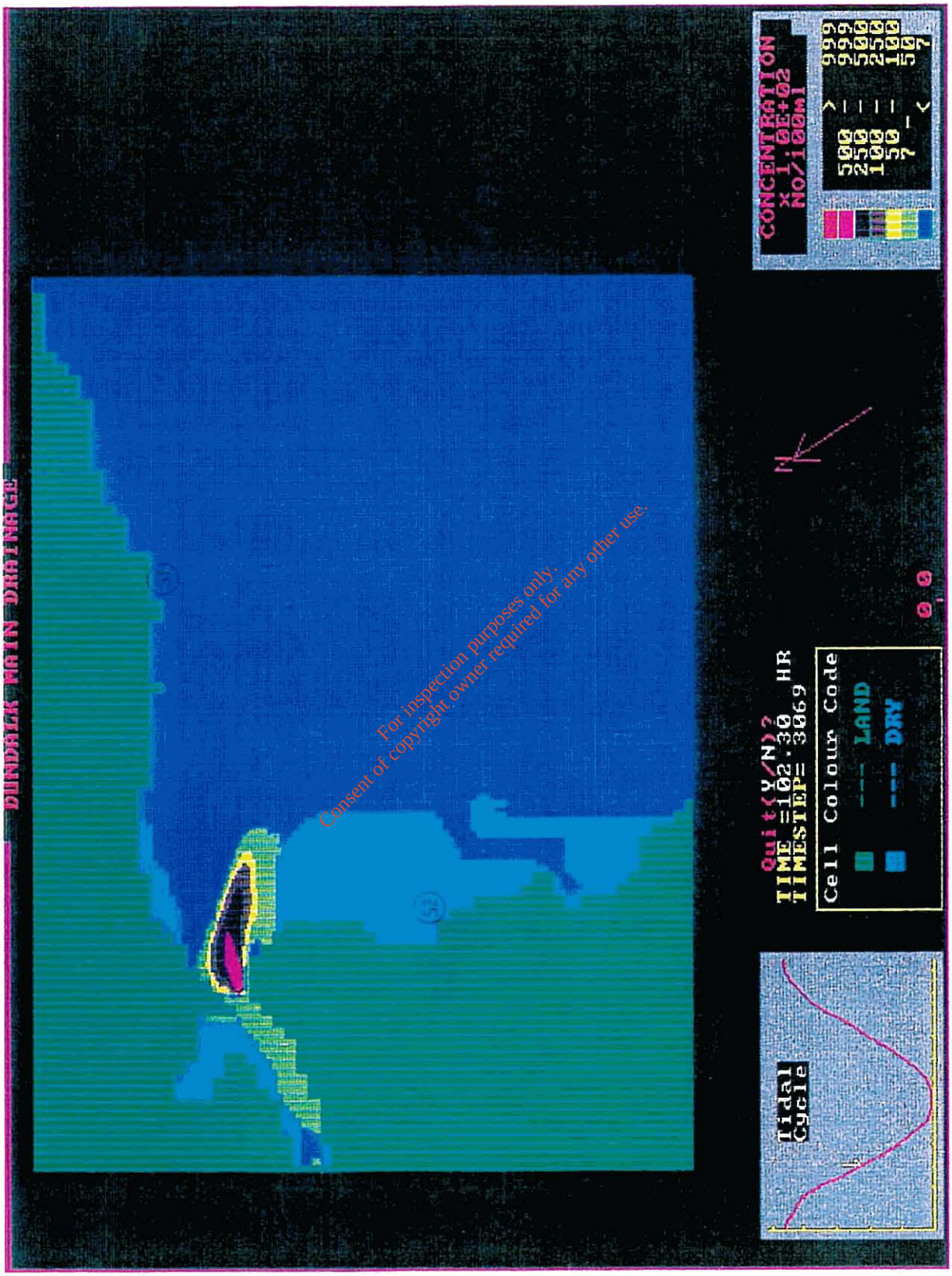

Figure 22 **Analysis 2 TCL Dispersal at Mid Ebb.**

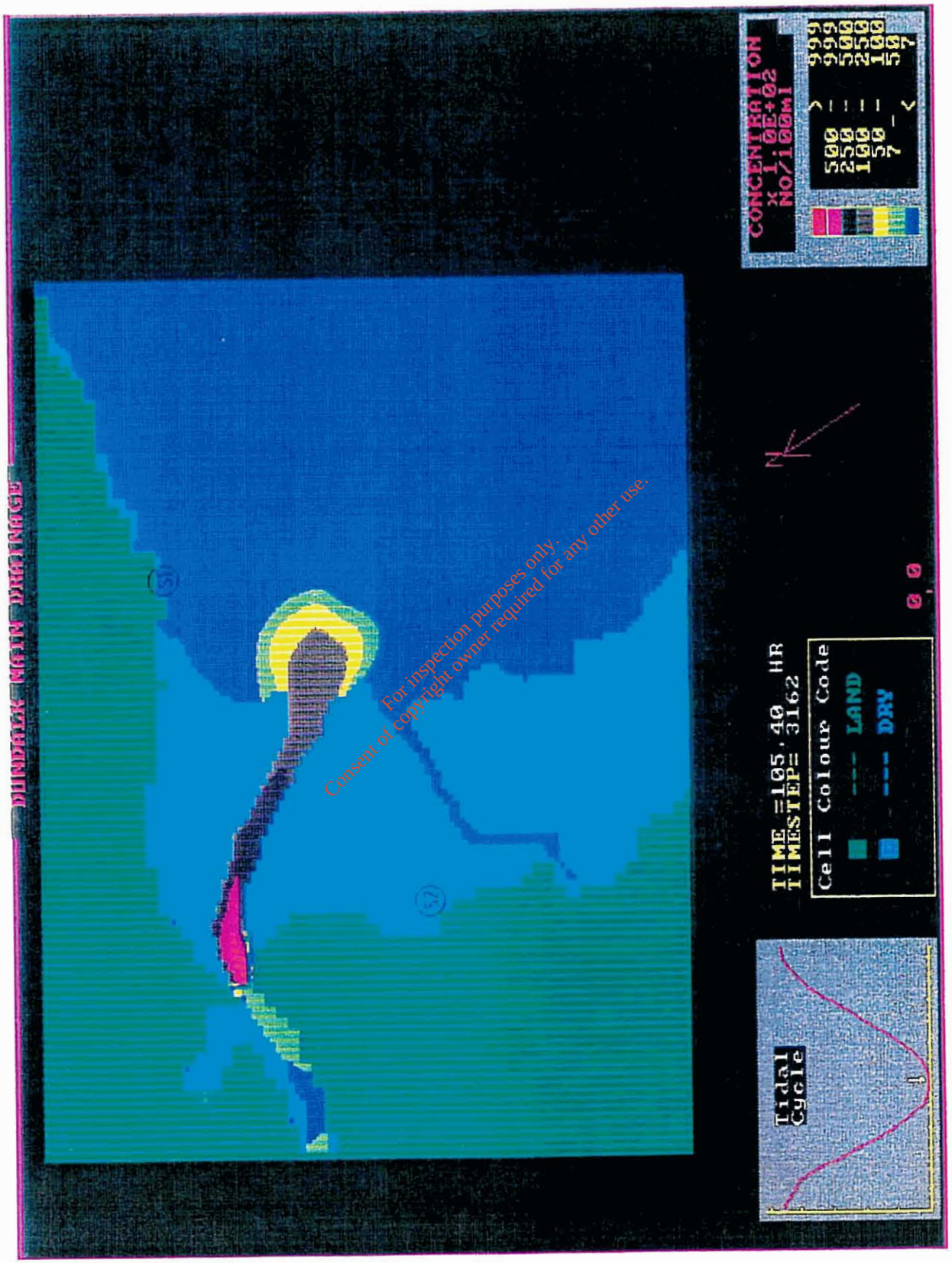

Figure 23 **Analysis 2 TCL Dispersal at Low Water.**

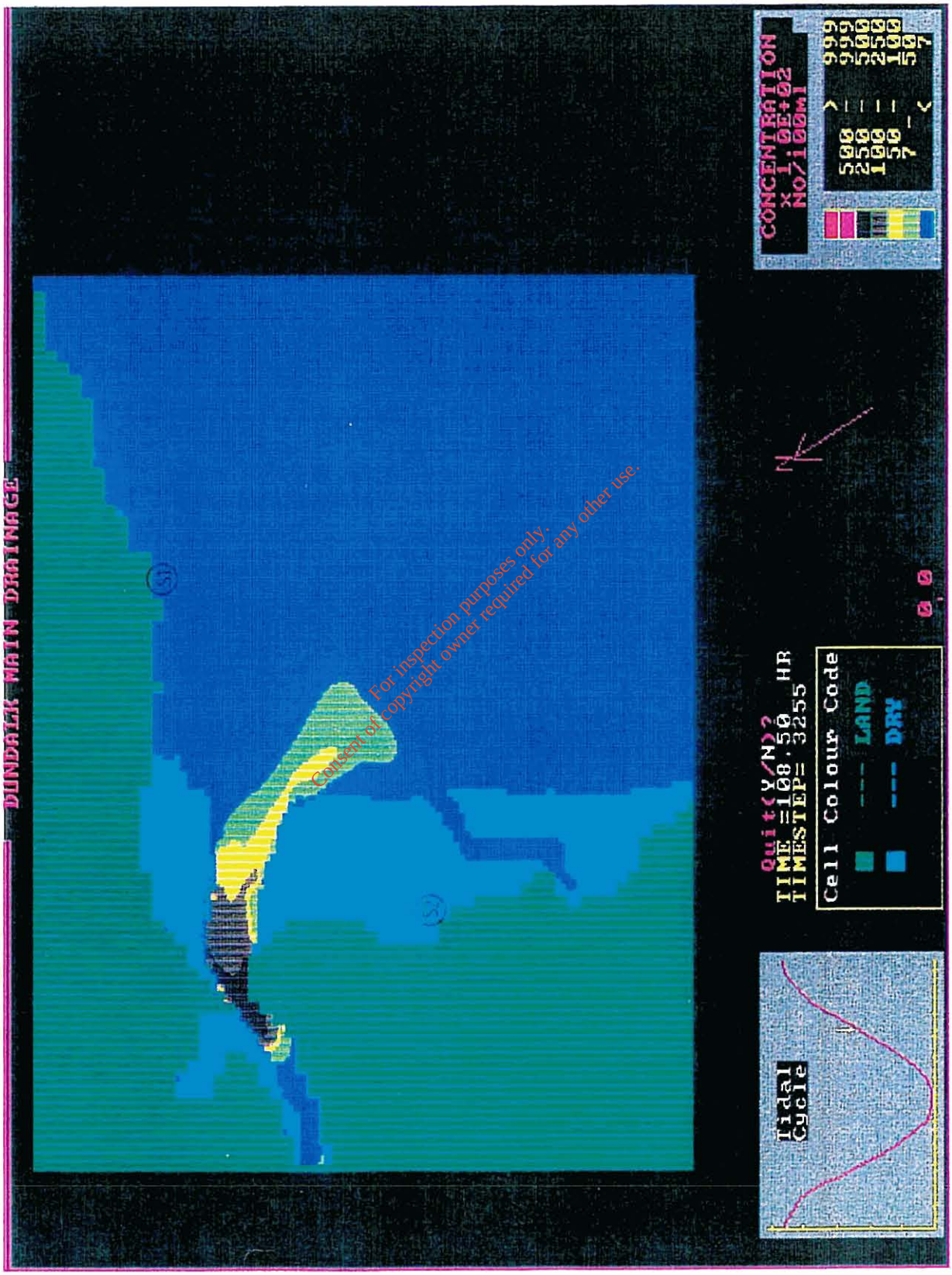

Figure 24 **Analysis 2 TCL Dispersal at Mid Flood.**

DISPERSION ANALYSIS No. 3

Description :- Analysis of Faecal Coliform levels (FCL) due to river flows and existing discharge at Outfall 'A' of untreated effluent.

Tidal Conditions :- Spring Tide.

Wind Conditions :- Mean on-shore wind (5m/sec from south-east).

River Flows :- (Castletown River) Estimated flow = 2.0 cumec

'Background' FCL = 4400/100ml

Discharge :- (Untreated effluent from tidal tank at Outfall 'A', Soldiers Point.)

Released from 0.5 to 5.75 hours after each High Water.

Release Rate = 0.38 cumec, Effluent FCL = 3,240,000/100ml

Decay Rate = 3.68, (T90 = 15 hours)

Results:- Figures 25, 26, 27 and 28 present 'snapshots' of FCL concentrations at High Water, mid-ebb, Low Water and mid-flood.

The maximum, minimum and median FCL concentrations at the observation sites are as shown below in Table 14.

Location	Maximum	Minimum	Median *
Site 1	0.0	0.0	0.0
Site 2	0.395	0.348	0.353
Site 3	815.55	165.87	278.81
Site 4	22.998	0.0	0.0146
Site 5	0.745	0.163	0.262
Site 6	0.0	0.0	0.0

* Note:- Median values are calculated when cell is submerged.

Table 14 Analysis No.3 - Maximum, Minimum and Median FCL concentrations (No./100ml).

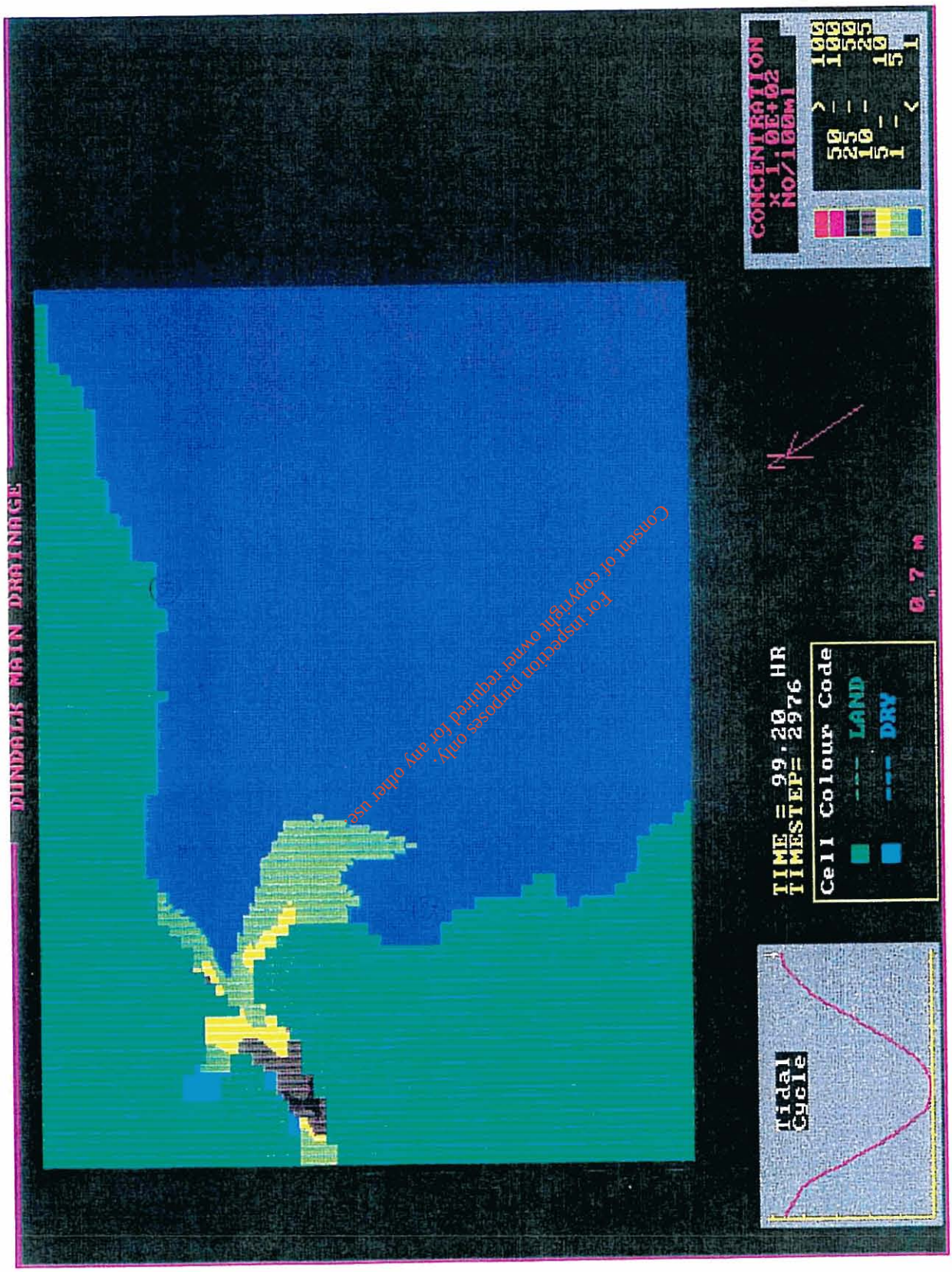

Figure 25 Analysis 3 FCL Dispersal at High Water.

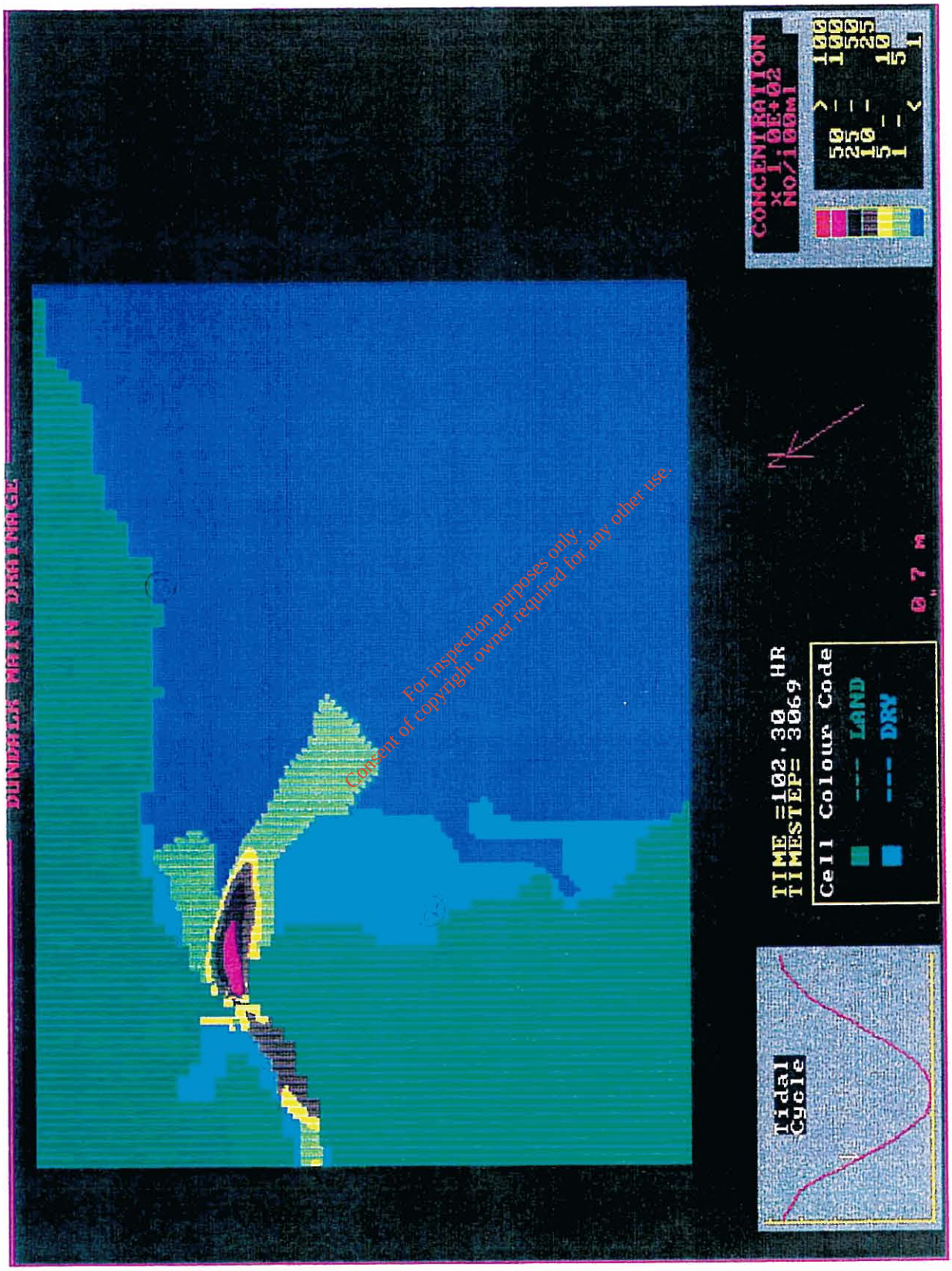

Figure 26 Analysis 3 FCL Dispersal at Mid Ebb.

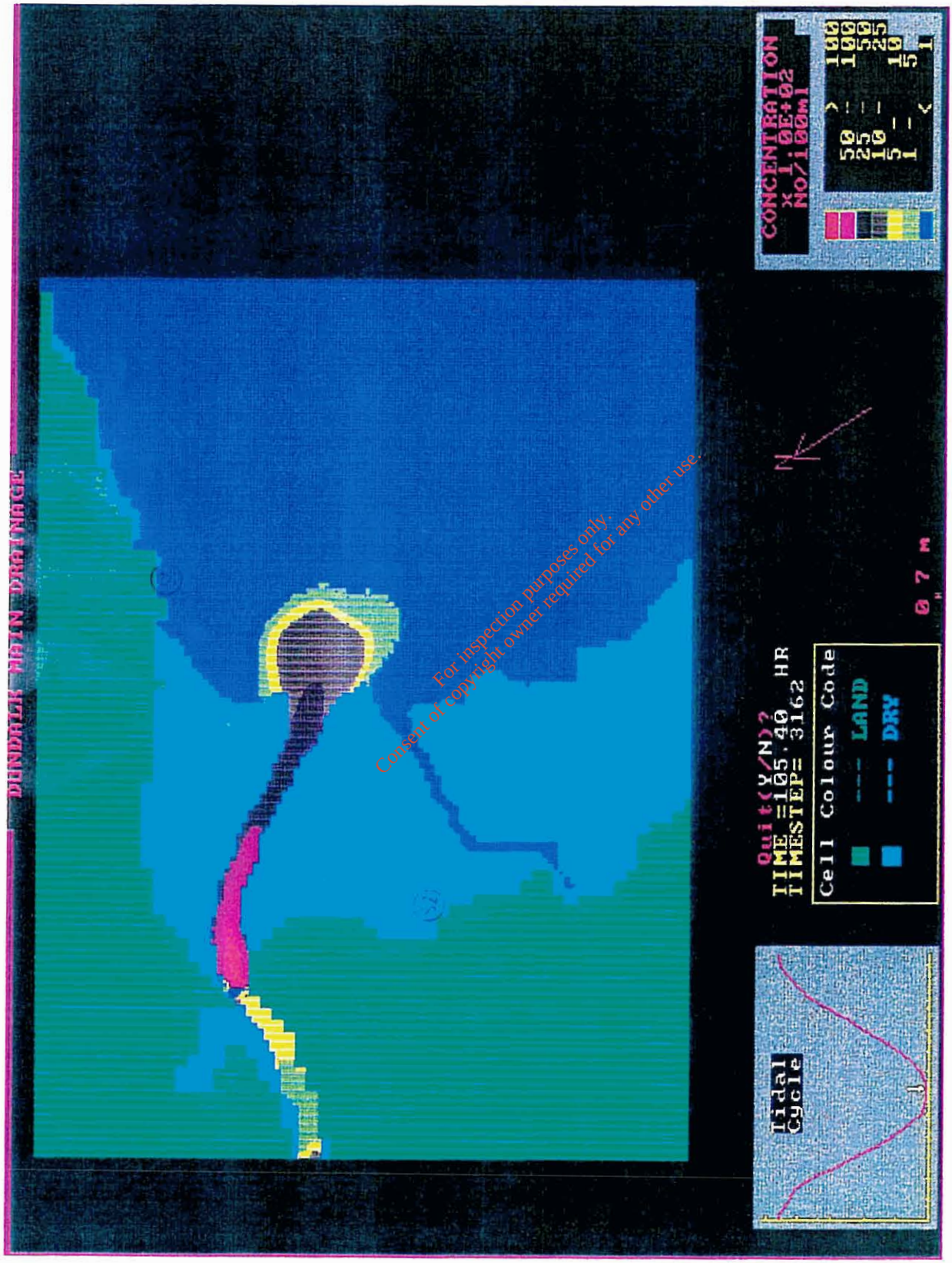

Figure 27 **Analysis 3 FCL Dispersal at Low Water.**

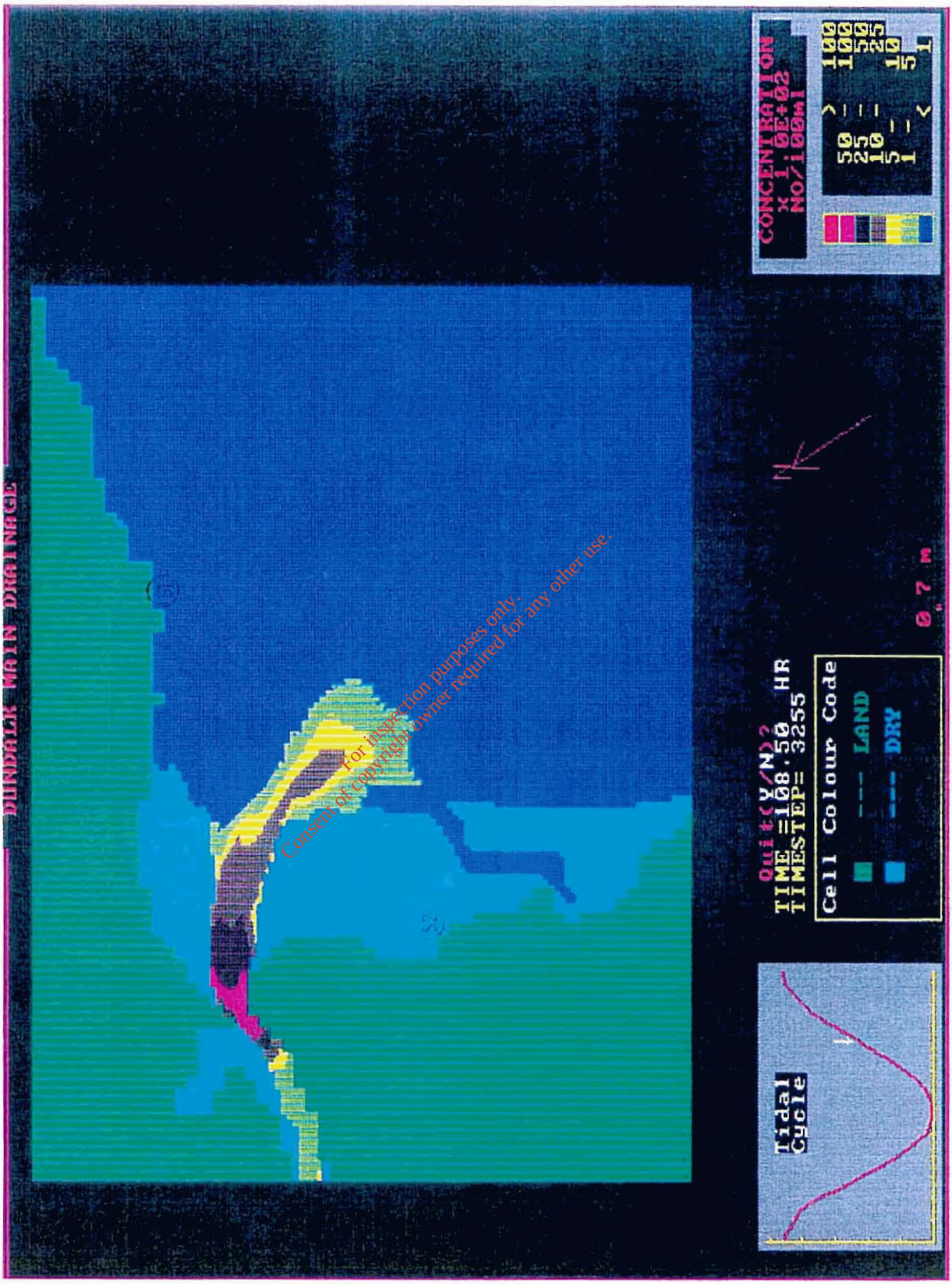

Figure 28 Analysis 3 FCL Dispersal at Mid Flood.