5

Marine Impacts

5. MARINE IMPACTS

5.1 INTRODUCTION

5.1.1 The hydrodynamics and water quality of Hebe Haven could potentially be affected by the proposed dredging and reclamation by changing the shoreline and bathymetry of the Haven. The small scale nature of the works is, however likely to limit such impacts to the immediate vicinity of the proposed works. Water quality impacts are likely to be restricted to the construction phase of the project, and in particular the dredging phase of the works, when sediment released during dredging works could potentially impact on local water quality. Direct water quality impacts could occur through the release of suspended solids, while indirect impacts might occur due to the subsequent release of nutrients, oxygen demanding substances, or TBT from the bed sediments into the water column.

5.1.2 Both hydrodynamic and water quality impacts have been investigated using detailed numerical models of Hebe Haven, and these are reported later in this chapter. First however, the loss rates of sediment during the proposed dredging are described as these will control any water quality impacts.

5.2 SEDIMENT RELEASE RATES

5.2.1 The area to be dredged is small and lies in shallow water at the proposed site. The materials to be dredged are believed to comprise fine marine sediment but no details are available concerning the particle size distribution of the mud. In view of the sheltered nature of the area, it seems likely that the sediment will be relatively fine and contain about 10% sand in contrast to the 20-25% which is typical of Hong Kong marine muds. However, for the purposes of the modelling to be described below, a worse case assumption of 100% fine sediment has been made. The general characteristics of the site, in combination with the small volume of material to be dredged and the desirability of ensuring low rates of sediment release, indicate that the use of small grab dredgers would be preferred. These will have a low rate of production (and thus low rates of sediment release) and minimise the amount of over dredging which will be necessary in order to ensure that the required depths are achieved.

5.2.2 The estimated rates of production for small grabs of 1-3 m^3 capacity are given in Table 5.1.

Table 5.1 Estimated Dredging Rates of Production

Dredger	Production, m^3	
	Per working hour	Per 72-hour week
1 m^3 grab	63	4,536
2 m^3 grab	99	7,128
3 m^3 grab	123	8,856

5.2.3 Grab dredgers may release sediment into suspension by the following mechanisms:

- impact of the grab on the bed as it is lowered;
- disturbance of the bed as the closed grab is removed, which may be exacerbated by the release of gas from the disturbed sediments;
- sediment washes off the outside of the grab as it is raised through the water column and when it is lowered again after being emptied;
- leakage of water from the grab as it is hauled above the water surface;
- spillage of sediment from over-full grabs;
- loss from grabs which cannot be fully closed due to the presence of debris.

5.2.4 Sediment release rates during mud dredging operations have been measured and reported in literature, but the wide range of methods used to make these measurements make it difficult to derive a set of rules which can be applied in a predictive manner. A detailed review of the available published data was undertaken during the Contaminated Spoil Management Study (Mott MacDonald, 1991) which subsequently led to the development of the comparative loss estimates, per cubic metre dredged, presented in Table 5.2 (Kirby and Land 1991; Environment Canada, 1994).

Table 5.2 Comparative sediment losses, per cubic metre dredged at grab dredging

Dredger	Approximate Dredger Capacity		
	Large	Medium	Small
	Sediment loss, kg m^{-3} dredged		
Grab (open)	12	17	25
Grab (closed)	11	14	20

5.2.5 The grabs likely to be used for this project fall into the category medium to small. The loss estimates in Table 5.2 should be treated with considerable caution as they are intended mainly to illustrate the variation of losses, when working in muddy sediment in harbour areas and in 'average' water depths (of the order of 10 metres), according to the type and size of dredger used. Site-specific factors such as water depth, current speed and the detailed nature of the soils will influence the magnitude of the losses. In addition, Table 5.2 was based on a largely intuitive assessment of published data which was often incomplete with respect to details of dredger operation and site characteristics.

5.2.6 The relatively small difference between the release rates of open and closed grabs is due to the fact that closed grabs tend to cause greater disturbance of the bed as they are lowered because of the pressure wave which forms ahead of the grab. The advantage of using closed grabs is that most of the sediment losses occur close to the bed, rather than throughout the water column as is the case with open grabs. The sediment released close to the bed is thus more likely to settle on the bed within, or very close, to the dredging site. However, in this case, the water is so shallow that there is likely to be no discernible advantage to using closed grabs and, in fact, losses might even be greater than those resulting from the use of open grabs.

5.2.7 Data contained in the Environment Canada Review (1994) which was not included in the Contaminated Spoil Management Study review, tend to support the general order of magnitude of the estimates given above. Tavolaro (1984) estimated, on the basis of a mass balance study, that 1.22% of the material dredged by a grab dredger is lost to suspension (excluding losses incurred if barges are allowed to overflow). This percentage loss can be converted into an indicative loss expressed as kg per m^3 dredged by assuming a particle specific gravity of 2.65, a bulk density of 1.5 t/m^3 and a seawater density of 1.025 t/m^3. Using these assumed values, a dry density of 775 kg/m^3 is obtained and the 1.22% loss equates to a loss of 9.45 kg m^{-3} dredged which is similar to the losses given in Table 5.2 for large grabs. However, this estimate should be treated with caution as full details of the dredger and of the site and soil characteristics are not available.

5.2.8 Table 5.3 shows the release rates which would be derived from combining the rates of production given in Table 5.1 and a sediment loss of 25 kg per cubic metre dredged (Table 5.2, small dredger with open grab).

Table 5.3 Estimated release rates based on Table 5.1 and Table 5.2

Grab Volume, m^3	Hourly production, m^3	Estimated sediment release rate, kg sec^{-1}
1	63	0.438
2	99	0.688
3	123	0.854

5.2.9 Most recently, as part of a research project being undertaken for the Federation of Dutch Dredging Contractors, Dredging Research Ltd. were provided with full details of Dutch measurements around grab dredgers. This data, in combination with analyses of source strengths at three sites in the USA (Collins, 1991), suggest that the loss rates based on the releases given in Table 5.2 may be somewhat conservative. The data are summarised in Table 5.4 below.

Table 5.4 Sediment release rates for grab dredgers based on USA and Dutch observations

Grab	Location	Sediment release		Comments
volume, m^3		kg m^{-3} dredged	kg sec^{-1}	
1.1	Netherlands	3	0.075*	
1.3	Netherlands	11	0.269*	Grab leakage due to coarse debris
2.5	Netherlands	11	0.318*	Grab leakage due to coarse debris
3	Netherlands	9	0.210*	
3	Netherlands	3	0.085*	
3	Netherlands	19	0.875*	Measurements influenced by sediment resuspension due to nearby shipping movements
7.65	USA	Not reported	0.243	Sweeping used
7.65	USA	Not reported	0.445	
9.2	USA	Not reported	1.684	Sweeping used
Unknown	Netherlands	13	0.437*	

Sources: Collins (1991), Pennekamp et al. (1996), Waterloopkundig Laboratorium (1989 & 1990).

** indicates derived value.*

5.2.10 The estimated loss rates given in Table 5.3 are higher than the trends revealed by the data summarised in Table 5.4, particularly bearing in mind that no coarse debris is to be expected in the Hebe Haven sediments. It will be noted that only two sets of observations yielded a release rate in excess of 0.5 kg sec^{-1}. One of these was from an operation involving a 'medium' grab dredger (9.2 m^3) during which 'sweeping' was undertaken, i.e. the grab bucket was dragged over the dredged surface to smooth out irregularities. The other was derived from an operation adjacent to a busy shipping channel in which it was almost impossible to distinguish clearly between sediment released from the dredging operation and that put into suspension by shipping movements.

5.2.11 The particle size distribution of the sediment which is released during dredging will be the same as that of the original in situ soil. To give a worst case scenario, this is assumed to be 100% in this study.

5.2.12 Based on the above, it is considered that a loss rate of 0.5 kg sec^{-1} is a suitable, probably upper-bound, release rate to be used for the assessment of the effects of the works at Hebe Haven subject to the provision that dredging is undertaken using a grab with a capacity of no greater than **6 m^3** or less and that 'sweeping practices' are not used.

5.3 IMPACT OF TRIBUTYL TIN

Background

5.3.1 Since TBT has previously been found in sediments in Hebe Haven, and recent sampling work undertaken for the purposes of this EIA indicate its presence, it is likely to be present in the dredged sediment. The following sections provide background information which has been used to assist in the assessment and interpretation of modelling results.

The Nature of TBT

5.3.2 TBT is a highly effective anti-foulant used on the hulls of ships to provide long term protection from the growth of marine organisms. The paints are designed to slowly release TBT and can last for up to 7 years (*New South Wales Environmental Protection Agency, 1990*). However, the released TBT is, by necessity, in a biologically available form while in the water column and therefore has the potential to affect non-target marine organisms. TBT does, however, have a relatively short half life in the water column and either degrades into less harmful breakdown products such as DBT or MBT or is adsorbed onto particulate material and subsequently settles on the seabed where it may degrade at a slower rate.

5.3.3 The persistence of TBTs in the sediment has not been investigated in detail in Hong Kong. However, the literature quotes a half life of between one and three years (*New South Wales Environmental Protection Agency, 1990*). It is thought that photolysis (breakdown by sunlight) is an important mode of abiotic degradation of TBT to its less harmful breakdown products DBT and MBT (1986).

Effects of TBT in the Marine Environment

5.3.4 The adverse effect of TBTs on marine organisms has been studied widely in order to determine safe limits. Organisms such as fish, bivalves, gastropods and crustaceans exposed to low levels of TBTs show abnormal symptoms such as: the distortion of sensitive epithelial tissues, organ and tissue changes, decreased growth, reduction in reproductive capacity, decreased growth, poor-ordination, loss of mobility, shell deformations and inhibition of development of newly laid eggs. Sub-lethal effects of TBT have been recorded at concentrations as low as 20ng TBT/l (i.e. 20 parts per trillion)

Table 5.5 Concentration of TBT in the water column which is toxic to marine organisms

Marine Organism	TBT Concentration (ngTBT/l)
Fish	≥ 200
Bivalves	≥ 50
Gastropods	≥ 2
Crustaceans	≥ 250

Source: New South Wales Environmental Protection Agency, 1990.

5.3.5 In the UK, a safe level for ambient TBT concentrations in marine water has been set at an order of magnitude below the level known to affect gastropods (most sensitive to TBT) i.e. 2ηg TBT/l (Goldberg, 1986). In Hong Kong there are currently no water quality objectives for TBT. As such, the UK safe level has been considered during this assessment. The assessment was based on the results produced by water quality modelling which is described below.

5.3.6 The environmental impact of TBTs in Hong Kong has not been widely investigated, therefore a safe level of TBT in marine sediments has not been established, although this is under investigation following a study undertaken for the Fill Management Committee on dredged material classification (*EVS Consultants, 1996*).

5.4 HYDRODYNAMIC MODEL

Model Set-Up

5.4.1 The reclamation and dredging works proposed under this project will change the coastline configuration and seabed contours and therefore have the potential to affect the tidal flow in the vicinity of the Club. Any changes in hydrodynamics could affect flushing times and could therefore impact upon water quality.

5.4.2 To assess the impacts of the reclamation and dredging on tidal flow, a numerical hydrodynamic model of Hebe Haven and Port Shelter has been constructed using the HR TELEMAC 3D software. The small scale of the reclamation and dredging (Figure E1, Appendix E), dictates that a fine scale model is required in order to properly resolve the changes in coastline and bathymetry. The full model grid used in the study is shown in Figure E2. The model configuration prior to development is shown in Figure E3, and post development in E4, while model bathymetries pre- and post development are shown in Figures E5 and E6 respectively.

5.4.3 The TELEMAC model applied in this study is fully 3D with 5 layers in the vertical. Boundary conditions were supplied from a calibrated large scale model covering the whole of Hong Kong and adjacent waters. The calibration of the larger scale model is described in HR (1998), and the model has been applied in the Green Island Study to assess the impact of the Green Island reclamation.

5.4.4 In the present study, boundary conditions for a single tide type (dry season intermediate tide) have been extracted from the larger scale model and applied at the seaward boundary of the fine scale model (Figure E2). The imposed tidal elevation at the boundary is shown in Figure E7.

Impacts on Tidal Flow

5.4.5 The hydrodynamic model has been run for the same tidal forcing with the pre and post development configurations and the tidal flows have been compared for the two scenarios. The currents across Hebe Haven at high water, peak ebb, low water and peak flood are shown in Figures E8, E8.1, E8.2 and E8.3 for the pre-development scenario, and Figures E9, E9.1, E9.2 and E9.3 for the post development scenario. Comparisons of the figures indicates that maximum current speeds are small in the area of the Hebe Haven Yacht Club (a maximum of 0.03m/s). The figures also indicate that tidal currents are little affected by the proposed reclamation and dredging. This conclusion is further reinforced by comparing Figures E10 and E11, which show time histories of tidal currents at the six locations shown in Figure E1. The figures clearly demonstrate that tidal currents are affected only within the dredged areas (locations 1 and 2) but not at other locations in the vicinity of the proposed development.

5.4.6 The conclusion that the proposed works have little impact on tidal currents also implies that tidal flushing and hence water quality will be little affected by the development following its completion. There is, however, the question of water quality impacts during construction, and this is discussed in detail below.

5.5 WATER QUALITY IMPACTS DURING CONSTRUCTION

5.5.1 Methodology

5.5.2 Water quality impacts during construction could potentially result from dredging activities, during which fine sediment is released into the water column. Increased suspended sediment loads can arise, as well as impacts related to the release of nutrients or potentially toxic substances from the bed sediments. Dissolved oxygen levels can also be impacted due to the oxygen demand within the sediments. Each of these impacts have been simulated using the SEDPLUME model.

Particle Tracking model SEDPLUME

5.5.3 The plumes of sediment arising from dredging were simulated using the HR SEDPLUME model. The model uses the hydrodynamic output from the TELEMAC-3D flow model to track the 3-dimensional movement of sediment particles. Dispersal in the direction of flow is provided by the shear action of differential speeds through the water column while turbulent dispersion is modelled using a random walk technique. The deposition and resuspension of particles are modelled by establishing critical shear stresses for erosion and deposition. Resuspension occurs when the bed shear stress exceeds the critical shear stress for erosion, while deposition occurs when the bed shear stress falls below the critical shear stress for deposition.

Input conditions and parameters used in plume dispersion simulations

5.5.4 The dispersion simulation was carried out over a single 25 hour tide with the release of material timed to experience the fastest current speeds. Release occurred at a single point, positioned on the edge of the dredging areas (Figure 5.1) so that the current speeds experienced by the plume would be as large as possible and the dispersion maximised. Release continued for 12 hours (simulating a 12 hour working day) with a loss rate of 0.5kg/s. Prior to running the flow model sufficient warm up time was allowed to provide a realistic representation of the flow pattern.

5.5.5 It was considered that the shallow depths (of approximately 3.5m) at the release point would not allow the plume to disperse significantly during the first moments of release when material descends rapidly towards the bed under the action of momentum and negative buoyancy. For this reason, the initial spreading radius of material was assumed to be 5m. Although a considerable proportion of the material released will descend towards the bed and will not be entrained into the water column, there is considerable uncertainty about this process and therefore a worst case scenario has been adopted whereby all of the sediment released (0.5kg/s) is assumed to be entrained into the water column.

5.5.6 The following sediment properties, representative of fine sediments, were used in the plume dispersion simulations:

Critical bed shear stress for erosion	$t=0.3N/m^2$
Critical bed shear stress for deposition	$t=0.1N/m^2$
Settling velocity	W=1mm/s
Erosion constant	M=0.0005ms
Lateral diffusion	$D=0.2m^2/s$

Plume dispersion simulation results

5.5.7 The results of the plume dispersion simulation are shown in Figures 5.4 and 5.5. These show the peak and mean suspended sediment increases during the 12 hours of dredging work for intermediate tide conditions. It should be noted that immediately after work has stopped, concentrations fall rapidly back to background levels. The figures show that material released into the water column falls to the bed without any significant advective movement. This is because of the very slow current speeds in the vicinity of the dredging (peak depth-averaged speeds less than 2cm/s).

5.5.8 The peak increase in suspended sediment concentrations is 175mg/l at the point of dredging itself. The highest mean suspended sediment concentration increase over the course of the 12 hour dredging period is 140mg/l, again at the point of dredging.

5.5.9 Using the results of Figure 5.5, and by considering the areas to be dredged over the 3 month operation, it is possible to derive the "envelope" of peak concentration increases over the whole dredging operation. This is shown in Figure 5.6.

Five potentially sensitive locations have been established in the vicinity of the proposed works (Figure 5.1),

1. Mangal communities at the mouth of the stream located to the north of the dredging area.
2. Mangroves at the rocky tip of the outcrop south of Ta Ho Tun Ha Wai.
3. Rocky shore habitat with interspersed mangrove, just east of Sha Tsui.
4. Rocky shore habitat with interspersed mangrove, just south of Tsiu Hang Hau.
5. Gazetted bathing beach and Fish Culture Zone south east of Sha Tsui.

5.5.10 Even considering peak concentrations and the maximum envelope of impact shown in Figure 5.6, there is no suspended sediment increase at any SRs. Increases in suspended sediment concentrations are restricted to the area within and immediately adjacent to the areas to be dredged, and impacts in the surrounding waters are predicted to be minimal. Exceedance of the suspended sediment WQO (i.e. an elevation of 3.5mg/l, Section 4) is predicted to be restricted to an area within approximately 100m of the dredging point.

5.6 IMPACTS ON TBT CONCENTRATIONS

5.6.1 As described in section 4.4, sediment TBT concentrations were determined from 3 samples taken from the vicinity of the proposed dredging (see Figure 5.1). These measured concentrations of TBT in sediment varied from 2µg Sn/kg to 998 µgSn/kg at a point immediately adjacent to the coastline. These values were very variable and it was therefore necessary to consider a range of possible TBT sediment concentrations within upper and lower limits in the modelling.

5.6.2 Increases in TBT concentration in the water column can be in the form of particulate or soluble TBT. TBT may therefore be adsorbed onto particles or due to disturbance, desorbed into the water column. The model assumed that the dissolved TBT was able to travel further than the adsorbed TBT which descends to the bed almost immediately. The division of TBT into sediment and water is given by the following equation:

$$\mathrm{TBT}_w = \frac{\mathrm{TBT}_{sed}}{\mathrm{K}}$$

where TBT_W *is the concentration of TBT in water (mg/kg water)*

TBT_{sed} *is the concentration of TBT in sediment (mg/kg sediment)*

K is the partition coefficient.

At present the scientific community give figures for the partition coefficient, K, for the division of TBT between water and sediment from 0.6 to 55000. The higher values tend to relate to muddy sediments of high organic content in saline conditions where less of the TBT desorbs into the water column, and the lower values tend to relate to sand and clear water conditions where there is more desorbtion. The higher values of partition coefficients effectively mean that there is no significant desorbtion. Although the range of partition coefficients is large (Waldock *et al.*(1987)), most of the measurements are of the order of 10^3 and so this has been taken as a best estimate. Using this value of the partition, both the dissolved and adsorbed TBT fractions were investigated.

Adsorbed TBT concentrations

5.6.3 The adsorbed TBT concentrations in the water column were calculated from the SEDPLUME model results using the following formula:

$$TBT\ concentration\ (\eta g/l) = C^{*}TBT_{sed}$$

where C = increase in tidal average suspended sediment concentration above background (kg/m^3)

TBT$_{sed}$ = TBT content of sediment (mg/kg sediment)

5.6.4 The measured concentrations of TBT in sediment varied from 2 μg/kg to 998 μg/kg. Using this range in the model a range of possible values for adsorbed TBT concentration in the water column was generated. Using the upper value (998 μg/kg) the concentrations varied from 108ηg/l at the dredging point to 0.1ηg/l at a distance of 100-150m away. Using the lower value (2 μg/kg) the concentrations vary from 0.22ηg/l at the dredging point to 2x10^{-4} ηg/l at a distance of 100-150m away from the works. These results are shown in Figure 5.2. For comparison, the UK designated safe limit for TBT concentrations in the water column is 2ηg/l. This result confines any potential exceedance of the 2ηg/l guideline to within 100m of dredging, with no exceedance attributable to adsorbed TBT released by the works at any of the SRs.

5.6.5 Throughout the course of the simulated 3 month dredging period the largest TBT concentrations were predicted for SR.2 (see Figure 5.1) when dredging takes place at the north eastern extremity of the dredging area, some 200m away from location SR.2. By considering the TBT concentrations predicted in the simulation for a distance of 200m from the dredging point it is possible to estimate concentrations (averaged over a 12 hour dredging period) experienced at location 2 for this worst case. Even assuming an upper limit of 998 μg/kg in the dredged sediment, very low concentrations of the order of 0.1 ηg/l are predicted even at the worst affected SR.2. Such concentrations are well below the safe level for ambient TBT concentrations adopted in the UK (2 ηg/l), and significantly lower than reported sub-lethal levels.

Desorbed (dissolved) TBT concentrations

5.6.6 The dissolved or desorbed TBT concentration was predicted using a second run of the SEDPLUME particle tracking model. In essence, the simulation described in Section 5.5 was rerun with the critical bed shear stress parameters changed to ensure no deposition or erosion of desorbed TBT particles and the settling velocity set to zero. In this way, TBT particles released at the point of dredging were advected and dispersed with the current movements. It was assumed that the TBT fully and instantaneously desorbed from the sediment at the point of release and dissolved into the water column and did not re-adsorb back onto sediment - i.e. a worst case prediction. In reality, a proportion of the TBT desorbed from sediment would re-adsorb back onto sediment; the TBT takes a finite time to desorb to the equilibrium levels described by the partition coefficient and therefore it is likely that the contaminant would not be fully desorbed; and the dissolved TBT would begin to break down into its less harmful degradation products DBT and MBT.

5.6.7 Figure 5.3 shows the results of the desorbed (dissolved) TBT dispersion simulation. The amount of TBT desorbed was calculated by taking the partition coefficient for TBT to be 10^3 and the concentration of TBT in sediment to the mean of the three measured values, 340mg/kg sediment. These values gave an average TBT concentration over a 12 hour dredging cycle at the dredging point itself of 0.05 ηg/l and an average dissolved TBT concentration at a distance of approximately 300m from the dredging point of 0.001ηg/l. These values represent a "best estimate" of the increases in dissolved TBT concentration. The uncertainty in the possible values of partition coefficients and of sediment concentrations of TBT means these values could potentially decrease/increase by 1 or 2 orders of magnitude although for "muddy" sediments in saline conditions the concentration of TBT in the water column would tend to be at the lower end of this range. Even allowing for the possible variation in the partition coefficient and of the concentration of TBT in sediment, at this distance from the dredging, the upper limit of possible desorbed TBT concentrations would not exceed the 2ηg/l level.

5.6.8 The model simulations therefore indicate that there will be no significant contamination with respect to TBT to any of the potential SRs. Even at SR.2, which is most likely to be effected by the dredging, the TBT concentration is not expected to exceed 2×10^{-2} ηg/l. The increases in TBT are therefore predicted to be very localised and of short duration, due to the limited period of dredging for the proposed development and the nature of TBT.

5.7 DISSOLVED OXYGEN CONCENTRATIONS

5.7.1 The potential for reductions in dissolved oxygen concentrations during dredging was calculated using the formula:

$$\text{DO Reduction (mg/l)} = C*SOD*K*0.001$$

where C = increase in tidal average suspended sediment concentration above background (kg/m^3) predicted by the SEDPLUME model
SOD = sediment oxygen demand in mgO/kg sediment
K = daily oxygen uptake factor

0.001 is a factor used to make the units consistent.

5.7.2 No local measurements of sediment oxygen demand were available so a value of 15,000 mg/kg sediment was used, which was the value used in the previous East Sha Chau Study (ERM, 1996). This value is representative of highly organically enriched sediment and is likely to represent an upper limit for sediment oxygen demand in Hebe Haven. The (dimensionless) value of K was taken as 0.23, a typical value for daily oxygen uptake.

5.7.3 The reductions in dissolved oxygen concentrations over the simulation due to dredging are shown in Figure 5.7. The maximum value experienced is 0.37mg/l at the dredging point itself. Within 100-150m of the dredging point the DO depletion drops by a factor of 1000, indicating an insignificant impact. The small reductions in DO due to dredging indicate that dissolved oxygen WQOs will not be exceeded, even in the very near vicinity of the dredging operation. This conclusion is reinforced by the result that DO depletion at each of the SRs is zero.

5.8 NUTRIENT CONCENTRATIONS

5.8.1 The increase in nutrient concentration within the water column due to dredging was calculated using the formula :

$$\text{Nutrient concentration (mg/l)} = C*NU_{sed}*0.001$$

where NU_{sed} = nutrient content of sediment

No local measurements of nutrient concentration were made available so a relatively high value for nitrogen in the bed sediments of 860 mgN/kg sediment was used. This came from a previous Hong Kong study at East Sha Chau (ERM, 1996) and is a high value compared to EPD sediment monitoring data in Hebe Haven.

5.8.2 The nitrogen concentration within the water column over the simulation is shown in Figure 5.8. The maximum value experienced is 0.10mg/l at the dredging point itself. Within 100-150m of the dredging point the DO depletion drops by a factor of 1000. The increases in nutrient concentration at each of the SRs is zero. The modelling therefore clearly shows that the dredging impacts on nutrient concentrations will not be significant and exceedance of the inorganic nitrogen WQO will be limited to an area within a few tens of metres of the dredging operation.

5.9 CONCLUSIONS

5.9.1 Model simulations have been undertaken to assess the potential impacts of the proposed dredging and reclamation at the Club on the waters of Hebe Haven, including:

- the change in tidal flows and tidal flushing following completion of the proposed works; and
- the impact on water quality, including suspended solids, TBT, dissolved oxygen and nutrients, during dredging operations.

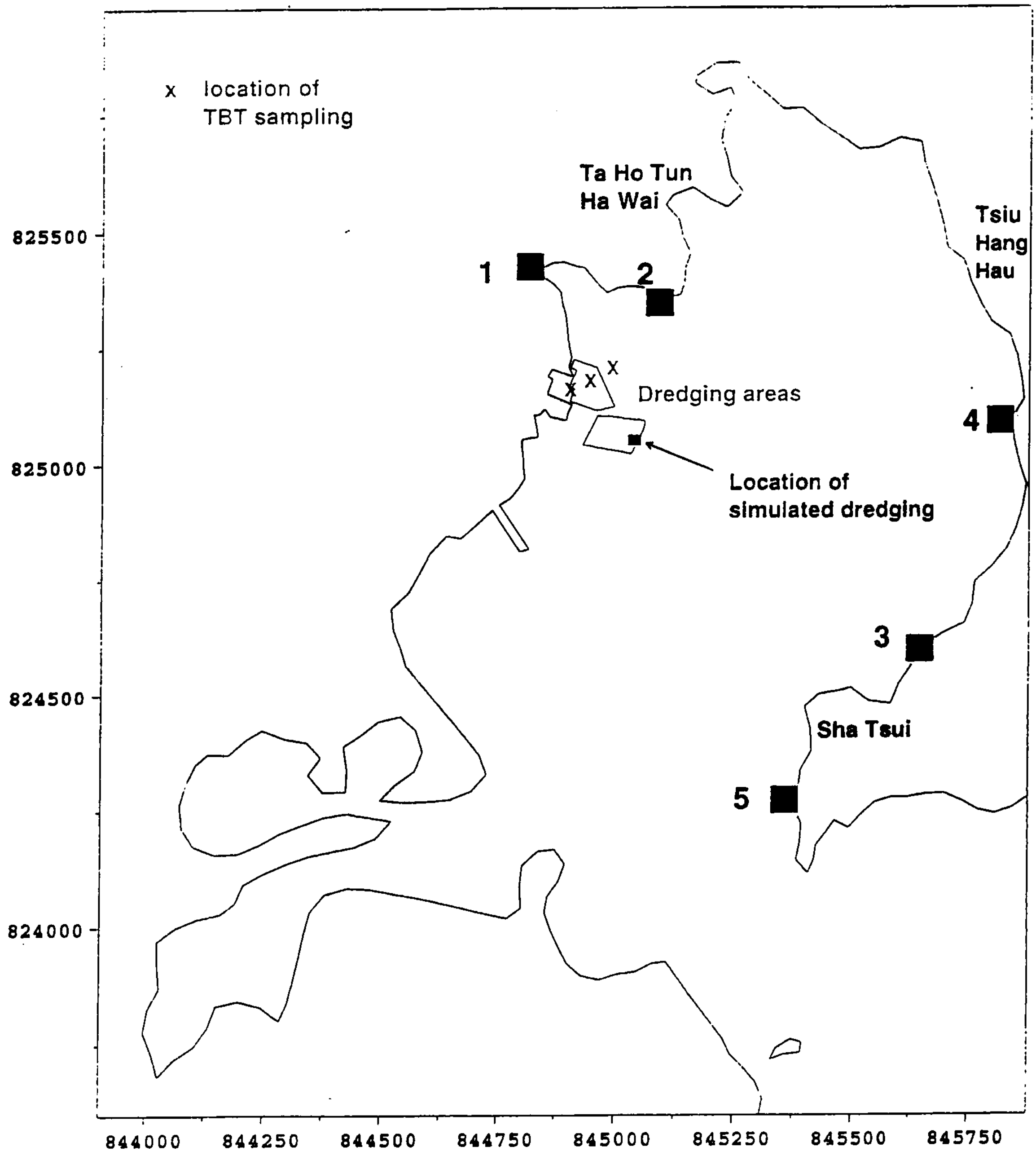
5.9.2 The hydrodynamic simulation indicates that tidal flow is low and is modified by the proposed works only in the immediate vicinity of the dredged areas, and not over any other part of Hebe Haven. The limited area of impact on tidal flows would indicate that tidal flushing and water quality would not be adversely impacted post-development. Indeed, the tidal flows in the dredged areas are predicted to increase, which may improve tidal flushing.

5.9.3 Impacts on water quality during dredging operations are also predicted to be minimal for all parameters simulated. The dredging period itself is short approximately three months and the daily dredging duration would be restricted to normal working hours. In such a dredging scenario the cumulative depletion of dissolved oxygen is predicted to be negligible. The model results support this by showing that dissolved oxygen depletion drops by a factor of 100 at only 100m from source. Hence, due to the low tidal currents and associated small tidal excursion in Hebe Haven, water quality impacts are predicted to occur only in the immediate area surrounding the dredging. Impacts on SRs are predicted to be zero for all parameters simulated except TBT. Non- zero TBT concentrations occur only at SRs 1 and 2 (Figure 5.1), though concentrations due to dredging are predicted to be very low and insignificant.

5.9.4 The water quality modelling results for the dredging period are based on a sediment loss rate of 0.5 kg/s, which implies use of a single small - medium grab dredger throughout the dredging operation. Use of such a dredger would not only minimise water quality impacts, but also limit the possibility of over-dredging.

5.9.5 The use of an open grab is appropriate for the proposed works in the shallow coastal waters of Hebe Haven. Closed grabs are designed to reduce the loss of sediment from the exposed mud contained in the grab as it is hauled to the surface. The benefits of using such grabs thus increase as the water depth increases. However, when using closed grabs, the losses at the bed are greater than those incurred with open grabs because of the effects of the pressure wave which is generated ahead of the grab as it is lowered to the bed. In shallow water, this increased sediment release may offset, or may be even greater than, the reduced loss during the recovery of the full grab. Thus, in very shallow waters of Hebe Haven, it is most unlikely that the use of closed grabs will result in a significant reduction of sediment release and may, in fact, actually increase losses.

5.9.6 Silt curtains are often used to limit the impact of dredging, but are also likely to be ineffective in the present case. When used in shallow water, silt curtains can agitate the sea bed, resulting in possible increases in suspended solids.



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Hebe Haven Yacht Club Development - Phase 2 EIA

Figure 5.1 **Hebe Haven, proposed dredging areas and potentially sensitive locations**

Job No. EA00501

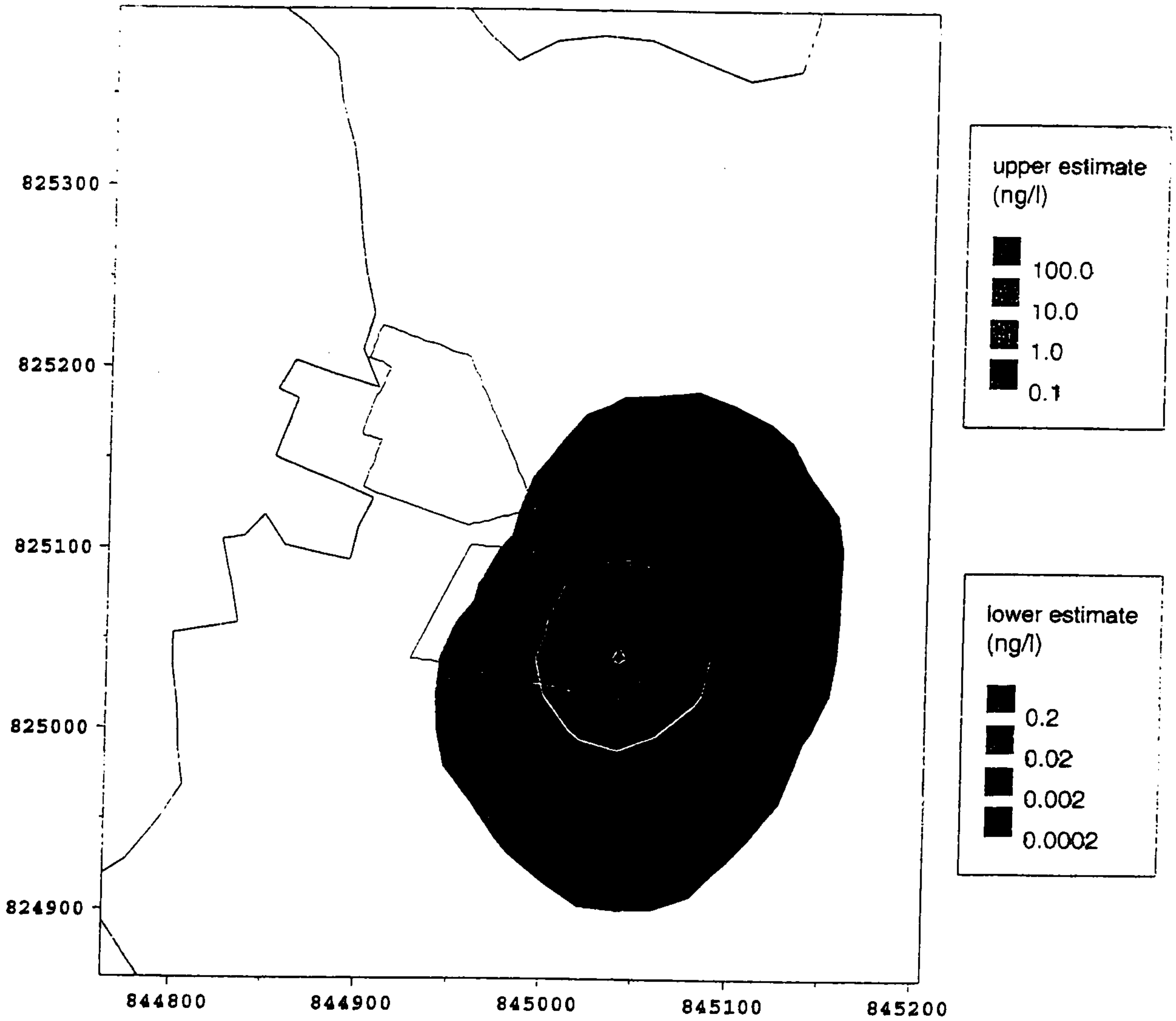

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Figure 5.2 **Upper and lower estimates for adsorbed TBT concentrations over 12 hour dredging cycle**

Job No. EA00501

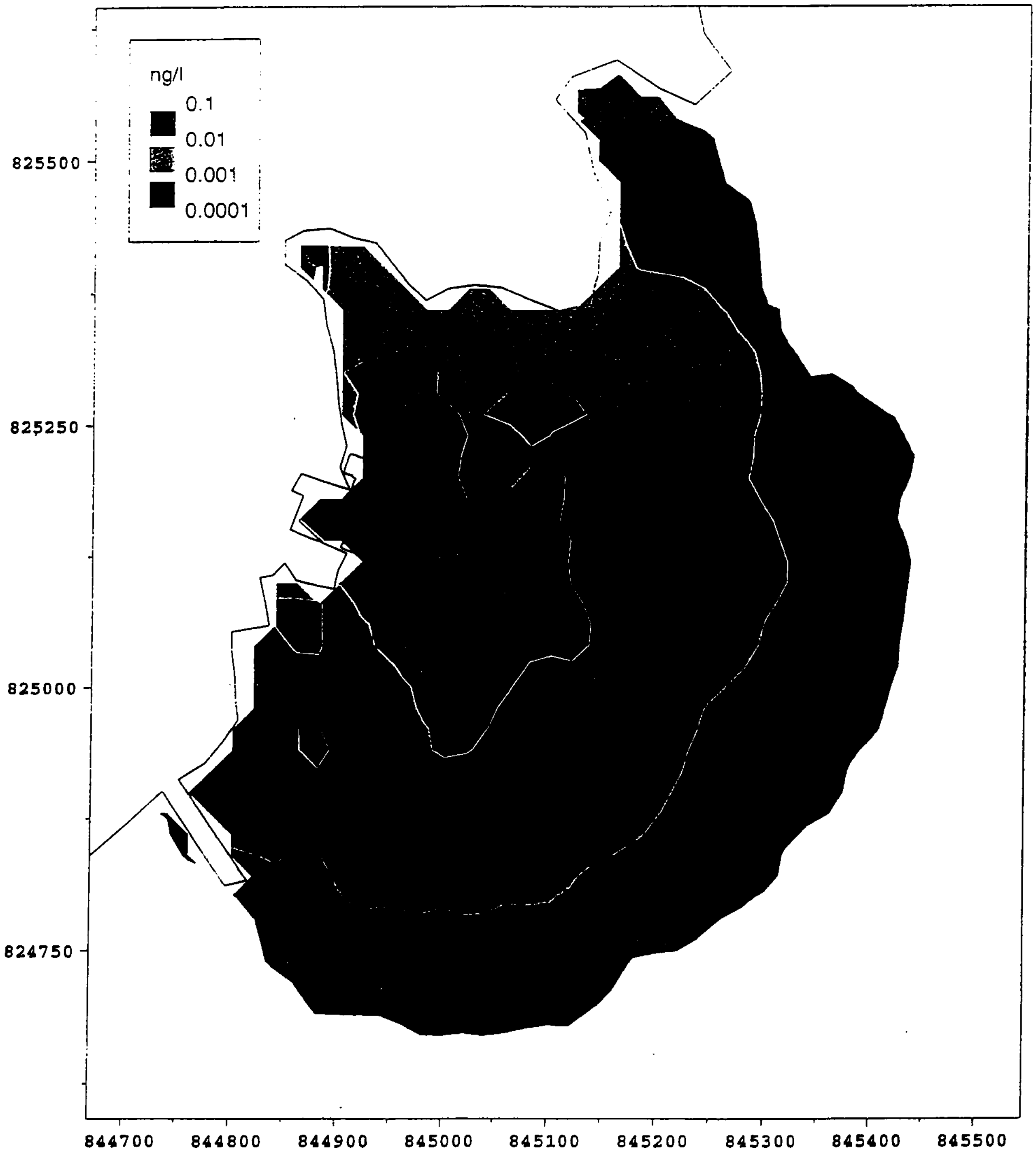

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Figure 5.3 **Average TBT desorbed concentration over 12 hour dredging cycle using representative TBT parameters**

Job No. EA00501

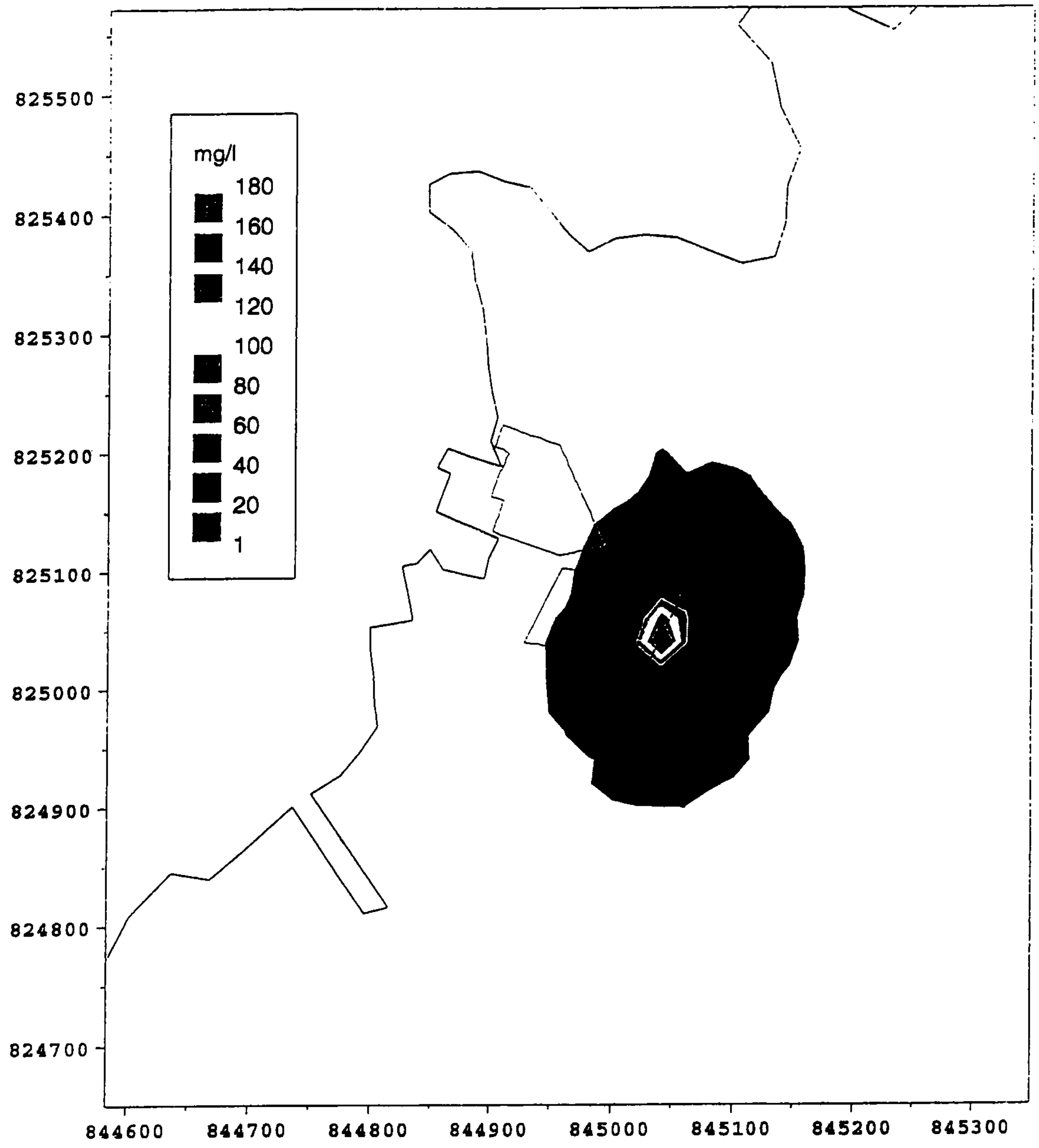

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Figure 5.4 **Peak concentrations experienced over 12 hour dredging period**

Job No. EA00501

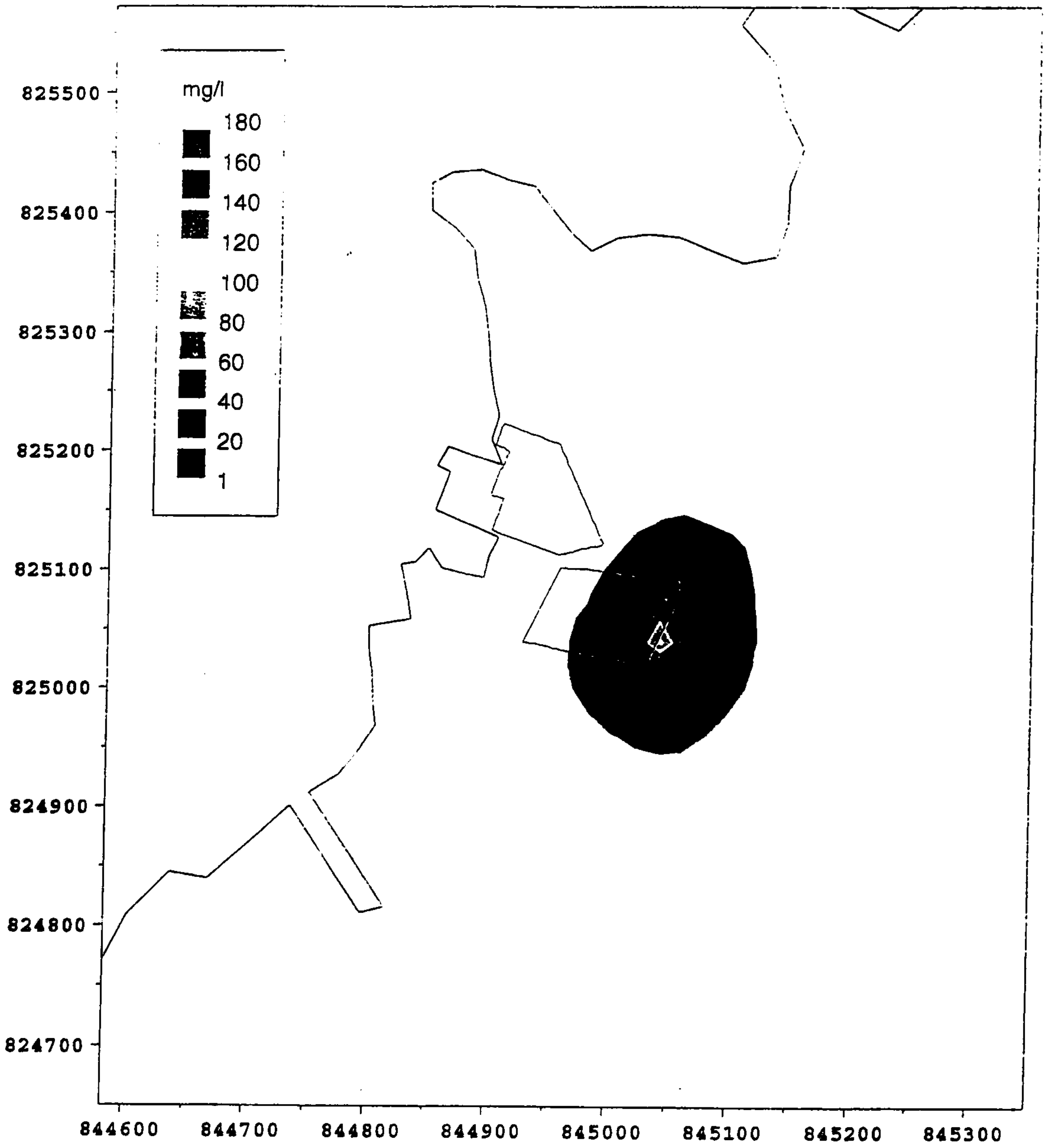

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Figure 5.5 **Mean concentrations experienced over 12 hour dredging period**

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Figure 5.6 **Envelope of peak suspended sediment concentrations experienced over 3 month dredging period**

Job No. EA00501

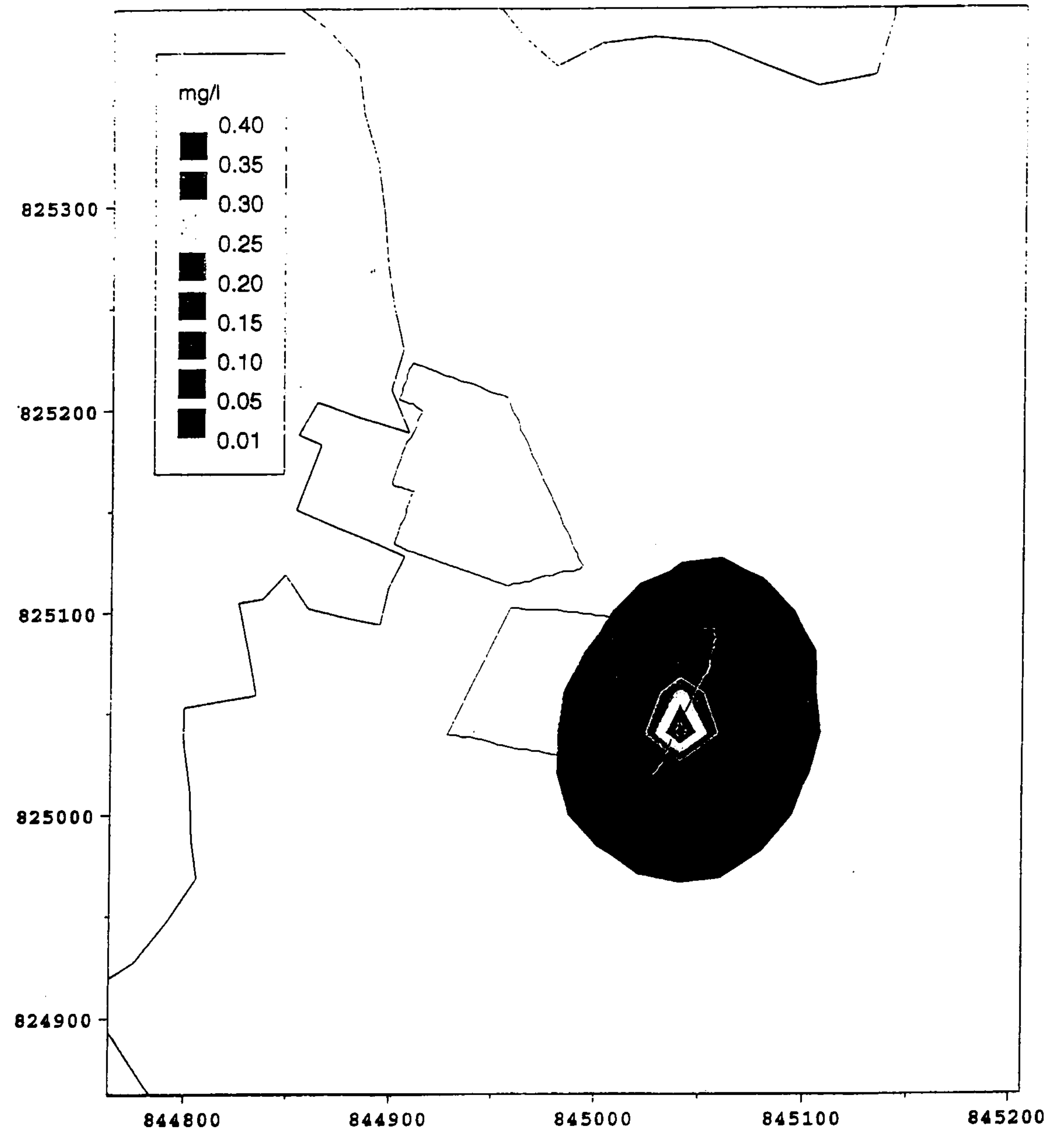

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Figure 5.7 **DO depletion over 12 hour dredging cycle**

Job No. EA00501

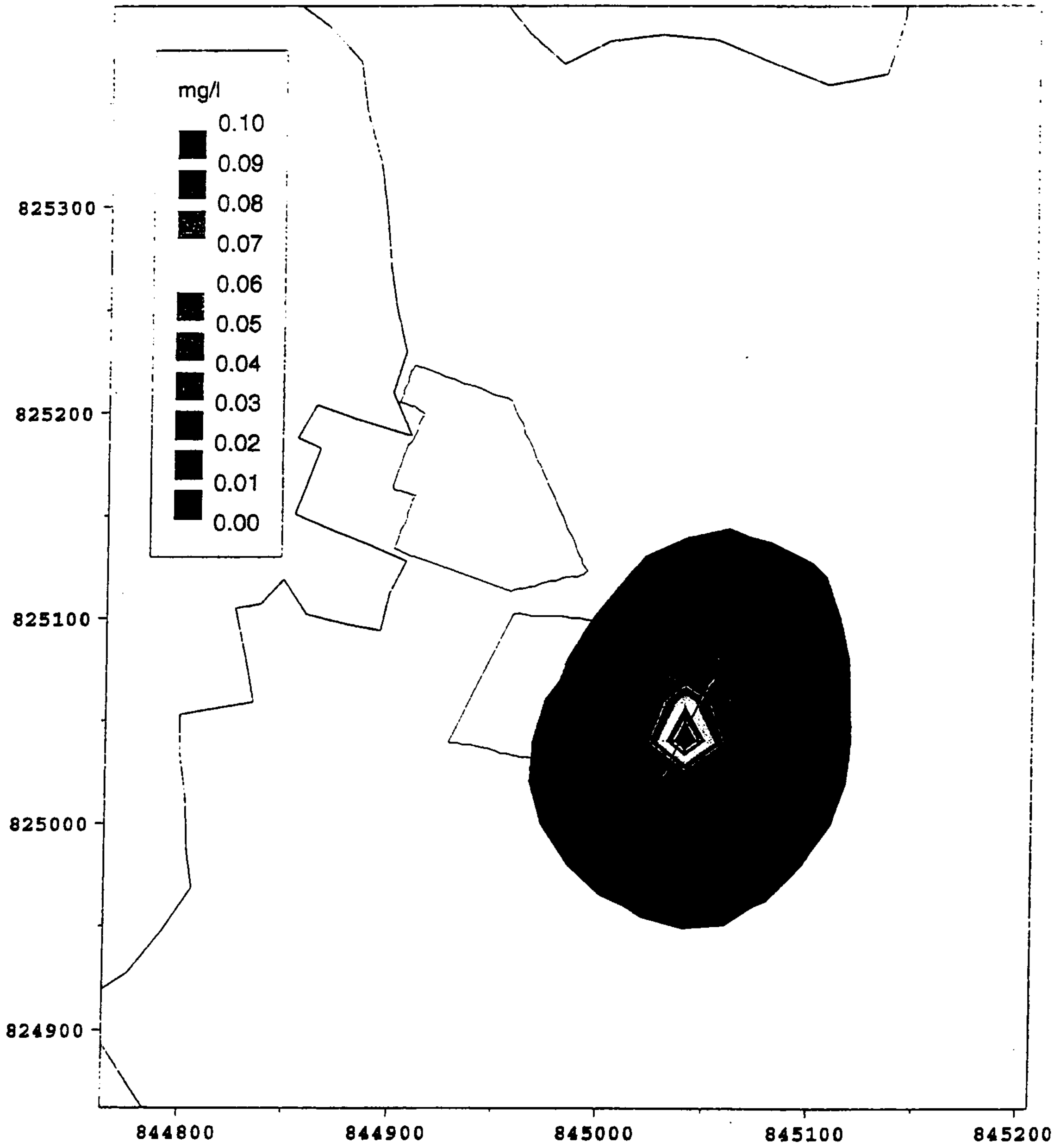

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Figure 5.8 **Nutrient concentration over 12 hour dredging cycle**

Job No. EA00501