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(ACE Paper 17/98)
for advice

Treatment levels for discharges of sewage to the north western water control zone

Introduction

On 20 October 1997 ACE considered the recommendations of the EIA for the Outlying Islands Sewerage Master Plan implementation. With respect to the Siu Ho Wan Sewage Treatment Plant, the Council advised that design for upgrading to chemically-enhanced primary treatment should proceed, but that the treatment level should be reviewed (to determine whether UV disinfection should also be provided) when the outcome of other relevant studies became known in early 1998.

2. Since October, consultants undertaking the EIA for the Strategic Sewage Disposal Scheme have completed a review of the threats posed to marine mammals by discharges of undisinfecting sewage. Similarly, consultants carrying out a review of the Yuen Long/Kam Tin SMP have completed an assessment of the impact of different levels of treatment of the Yuen Long/Kam Tin sewage prior to discharge to Urmston Road (NWNT outfall). This paper summarises the outcome of these studies, and makes recommendations regarding the level of treatment to be applied to these sewage flows in the future.

Yuen Long/Kam Tin SMP review

3. This review was prompted by the need to cater for an unexpectedly rapid population increase at Tin Shui Wai, which would result in the discharge of 280% more sewage at Urmston Road, via the North West New Territories Trunk Sewer, than originally envisaged. As well as assessing the basic infrastructure provision, the review also addressed, through computer modelling, the likely impact of an increased discharge volume. In making this assessment, due consideration was given to discharges from the other two main outfalls in the area namely the Pillar Point outfall and the Siu Ho Wan outfall. The assessment was run on the basis of projected maximum volumes as given in the following table. Existing flows are also given for comparative purposes.

	Present flow (m ³ /day)	Maximum flow (m ³ /day)
NWNT	40,000	588,000
Pillar Point	110,000	287,000
Siu Ho Wan	4,900	194,752

4. The locations of the discharges are shown in Figure 1.

5. In projecting the impact of the discharges in question on water quality, for those determinands most likely to affect marine life directly (that is, dissolved oxygen and ammonia) the consultants have modelled the worst case conditions. For both dissolved oxygen and ammonia these are observed in the wet season when the water column is stratified and the effluent plumes are trapped beneath the surface. The approach has been extended also to *E.coli* to aid visualisation of the possible impacts of the outfalls on water quality.

6. On this basis, the effects of different levels of treatment on the key parameters may be summarised as follows

Parameter	Base condition (no local loads)	Preliminary treatment	Chemically-enhanced primary treatment	Secondary treatment	WQO (mg/L) (annual average)
Near bed DO (mg/L) (wet season)	3-5	3-5	3-5	3-5	2
Depth-averaged DO (mg/L) (wet season)	4-5.5	4-5.5	4-5.5	4-5.5	4
tidally-averaged unionised ammonia; max. in water column (mg/L) (wet season)	<0.004	<0.008	<0.008	<0.006	<0.021
total inorganic nitrogen (mg/L) depth-averaged (annual average)	0.25-0.4	0.25-0.45	0.25-0.45	0.25-0.45	0.5

Parameter	Base Condition (no local loads)	Discharge without disinfection	Discharge with disinfection*	WQO(mg/L) (annual average)
<i>E.coli</i> (counts/100ml) max. in water column (wet season)	0	5-10 ⁵	5-150	n.a.

* represent 99.9% removal of *E.coli* with CEPT + UV Disinfection

7. The results demonstrate that neither dissolved oxygen nor total inorganic nitrogen are materially affected by treatment level. The only parameters that are obviously affected by the discharges are ammonia (marginally) and *E.coli*. Plots showing the *E.coli* and ammonia distributions are presented in Figures 2 to 6. From these, two key points are evident namely:

- (i) for ammonia, the impact of the NWNT outfall is evident, but Siu Ho Wan and Pillar Point are not visible; however even in the immediate vicinity of the outfalls the WQO is met;
- (ii) for bacteria all three outfalls have an obvious effect on water quality; the highest levels of *E.coli* at the Sha Chau and Lung Kwu Chau Marine Park, in the trapped layer, are projected to be upto 5,000/100ml. (This figure would of course, be significantly lower if averaged over the whole water column.)

Impact of sewage on marine mammals

8. The SSDS EIA consultants have reviewed over 100 academic papers and reports to try to determine whether marine mammals are at risk from microbes in sewage. They have also reviewed the circumstances in which disinfection is provided to major coastal sewerage schemes to determine the rationale for adopting or failing to adopt disinfection. Their findings may be summarised as follows:

- (i) marine mammals in captivity are susceptible to infections by microbes commonly found in human sewage;
- (ii) notwithstanding (i), there is no evidence of a link between sewage discharges and disease in marine mammals in the wild;
- (iii) where there have been large scale mortalities amongst marine mammals in the wild, these have usually been associated with bacteria or viruses normally found in the natural environment;
- (iv) no authority has established a water quality objective for the protection of marine mammals;
- (v) by and large, sewage discharges to coastal waters are not disinfected; where disinfection is provided, it is for discharges in areas where humans may come into close contact with significantly contaminated receiving water (for example, where the discharge is to a bay and there are bathing beaches or other water-based recreational activities nearby); only one authority has chosen to disinfect sewage in order to provide additional protection for marine mammals; in this case the species in question was given the status of "honorary human being".

Conclusions

9. On the basis of the modelling results, there is no evidence that a degree of treatment higher than preliminary needs to be provided for the purposes of achieving established water quality objectives. Evidence that undisinfected sewage discharges may have an impact on marine mammal populations in the wild is also very thin. Certainly there is no basis on which a microbial water quality

objective for the purpose of protecting marine mammals might be established. On their own, the modelling results and the evidence in the scientific literature do not justify disinfection.

10. Nevertheless, since the outfalls were planned there has been a very material change in the area, in that a marine park, the Sha Chau and Lung Kwu Chau Marine Park has been established (in 1996). The main emphasis of the marine park is to protect and conserve the general ecology of the seabed and to protect the Chinese White Dolphin which are commonly found within it. The park is considered to be a "sensitive receiver" and as such merits special consideration when new coastal infrastructure projects, or new or revised sewerage provision are being planned. It is clear from the model outputs that at full load the NWNT and Pillar Point outfalls will interact to bring about a decline in the microbiological water quality in the marine park. This can be dealt with by disinfecting the sewage to remove 99.9% of bacteria. This in turn can only be done on an effluent which is relatively low in suspended solids. Given the status of the marine park as a sensitive receiver, it is therefore proposed to raise the level of treatment for both these discharges to chemically enhanced primary, and to disinfect the treated effluent using UV disinfection.

11. The case for disinfection of the Siu Ho Wan discharge is less strong. The undisinfected effluent is unlikely to impact on water quality in the marine park. Nevertheless the following considerations are relevant

- (i) the normal distribution of the dolphins extends well beyond the marine park, with sightings recorded in much of the waters north of Lantau (Figure 7);
- (ii) the dolphins tend to show a preference for estuarine waters, extending more into Hong Kong waters in the wet season and retreating up the Pearl River in the dry; increased quantities of relatively fresh water discharging from sewage outfalls may help to retain more dolphins in north west waters for longer periods each year;
- (iii) there is strong evidence that dolphins will aggregate wherever fish are found in significant quantities; since sewage outfalls are known to attract fish, there is a possibility that in future the dolphins will spend more time in the vicinity of the Siu Ho Wan outfall.

Taking these factors into consideration, and in particular the fact that designation of the Sha Chau and Lung Kwu Chau Marine Park cannot of itself provide comprehensive protection for the dolphins, we propose to disinfect also the discharge from Siu Ho Wan.

12. Taking into account the size of the discharges, and their relative proximities to the Sha Chau and Lung Kwu Chau Marine Park, the priorities for upgrading are (1) Pillar Point discharge (2) NWNT discharge (3) Siu Ho Wan discharge.

13. On the basis of the projected flows in 2011, a rough indication of the relative cost and land implications of the different treatment levels is as follows

		Capital Cost (\$million)	Recurrent Cost (\$million/year)	Land Requirement (ha)
Pillar Point	Preliminary	190	3.4	2.7
	CEPT	520	40	5.8
	CEPT + UV disinfection	670	55	5.9
	Biological + UV disinfection	1,920	110	15
NWNT (San Wai)	Preliminary	180	3	2.5
	CEPT	490	38	5.1
	CEPT + UV disinfection	630	50	5.2
	Biological + UV disinfection	1,700	100	13
Siu Ho Wan	CEPT	330	25	3.7
	CEPT + UV disinfection	430	34	3.8
	Biological + UV disinfection	1,200	71	9

(Figures are cumulative, not incremental)

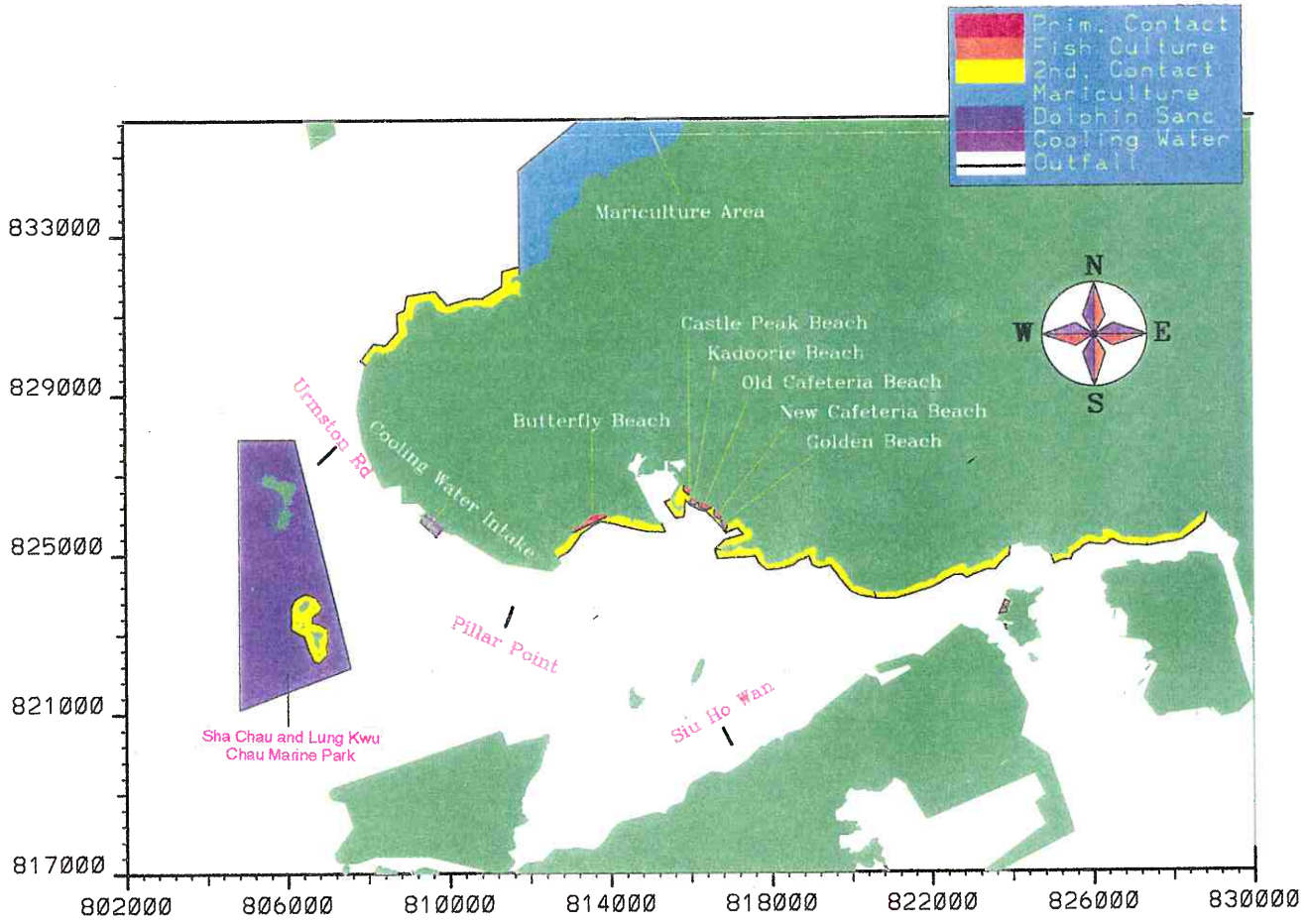
Advice Sought

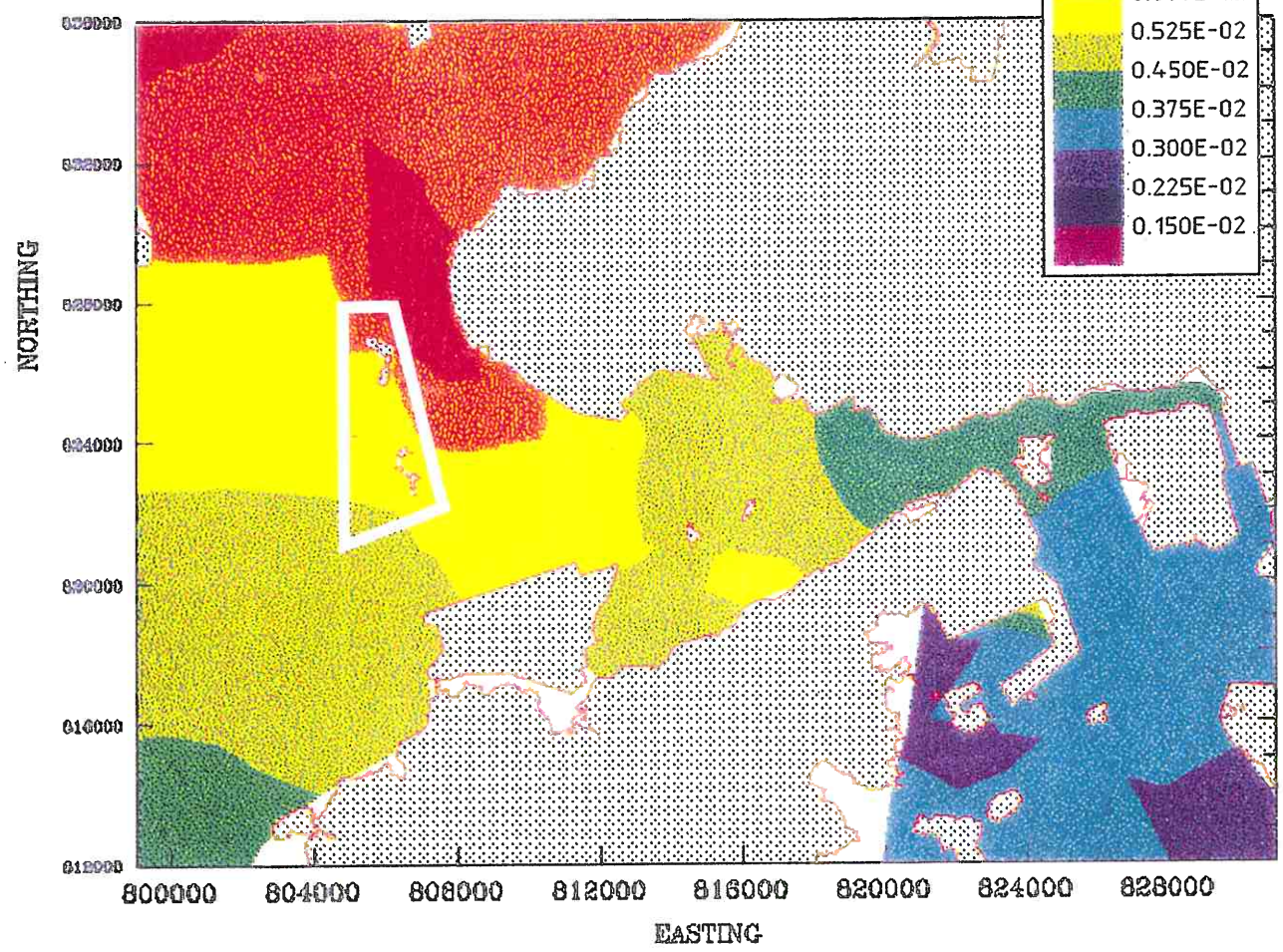
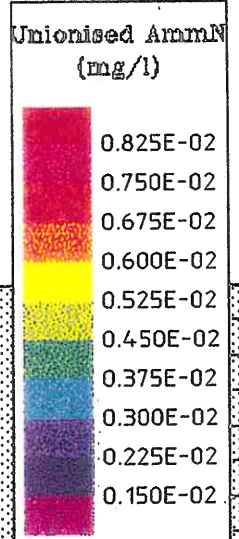
14. Members are invited to endorse the following recommendations :
- (a) that the discharges from the NWNT trunk sewer and Pillar Point should be subjected to chemically enhanced primary treatment and disinfected to remove 99.9% of bacteria; and
 - (b) that the discharge from Siu Ho Wan should be disinfected to remove 99.9% of bacteria.

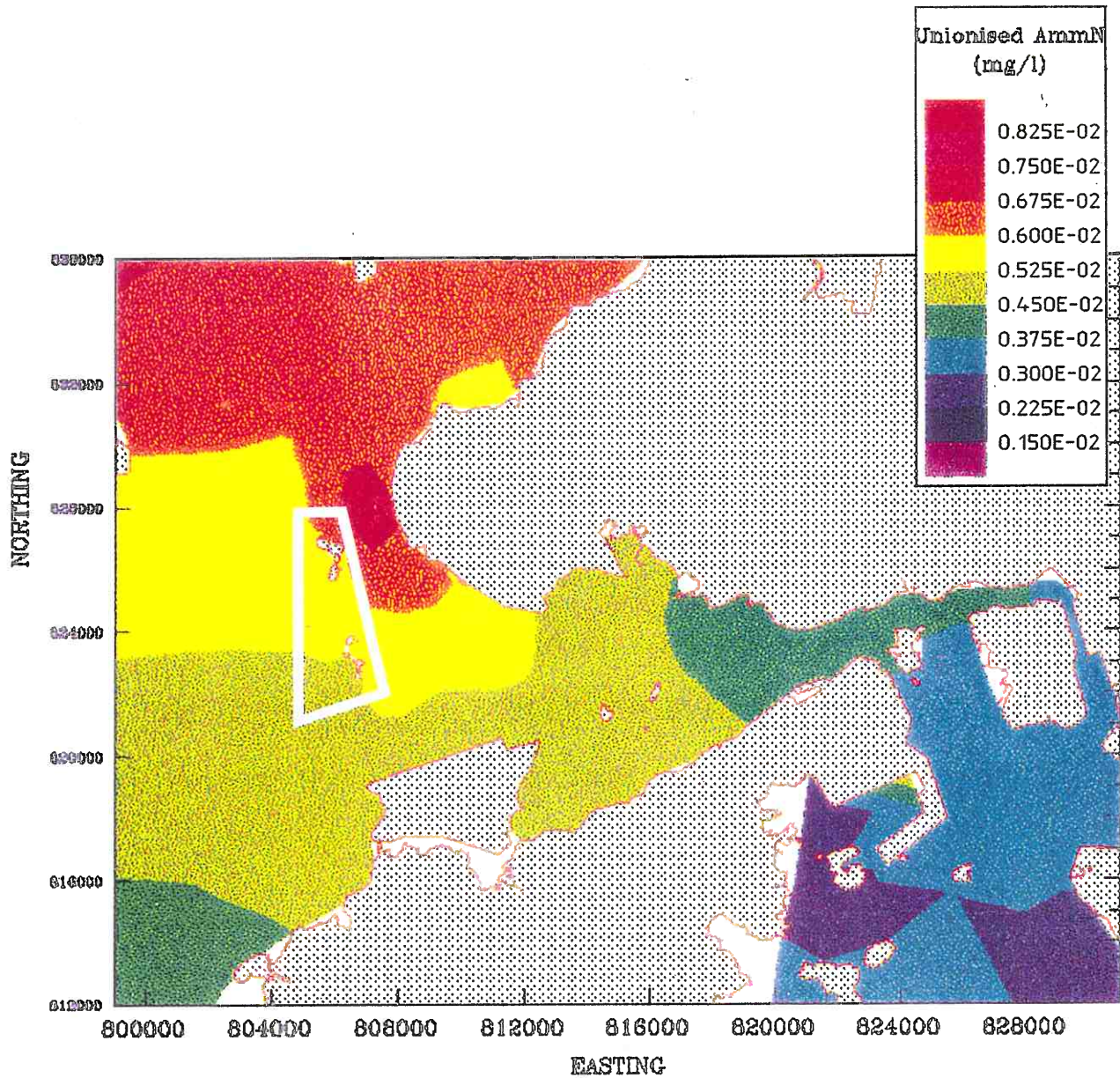
The Way Forward

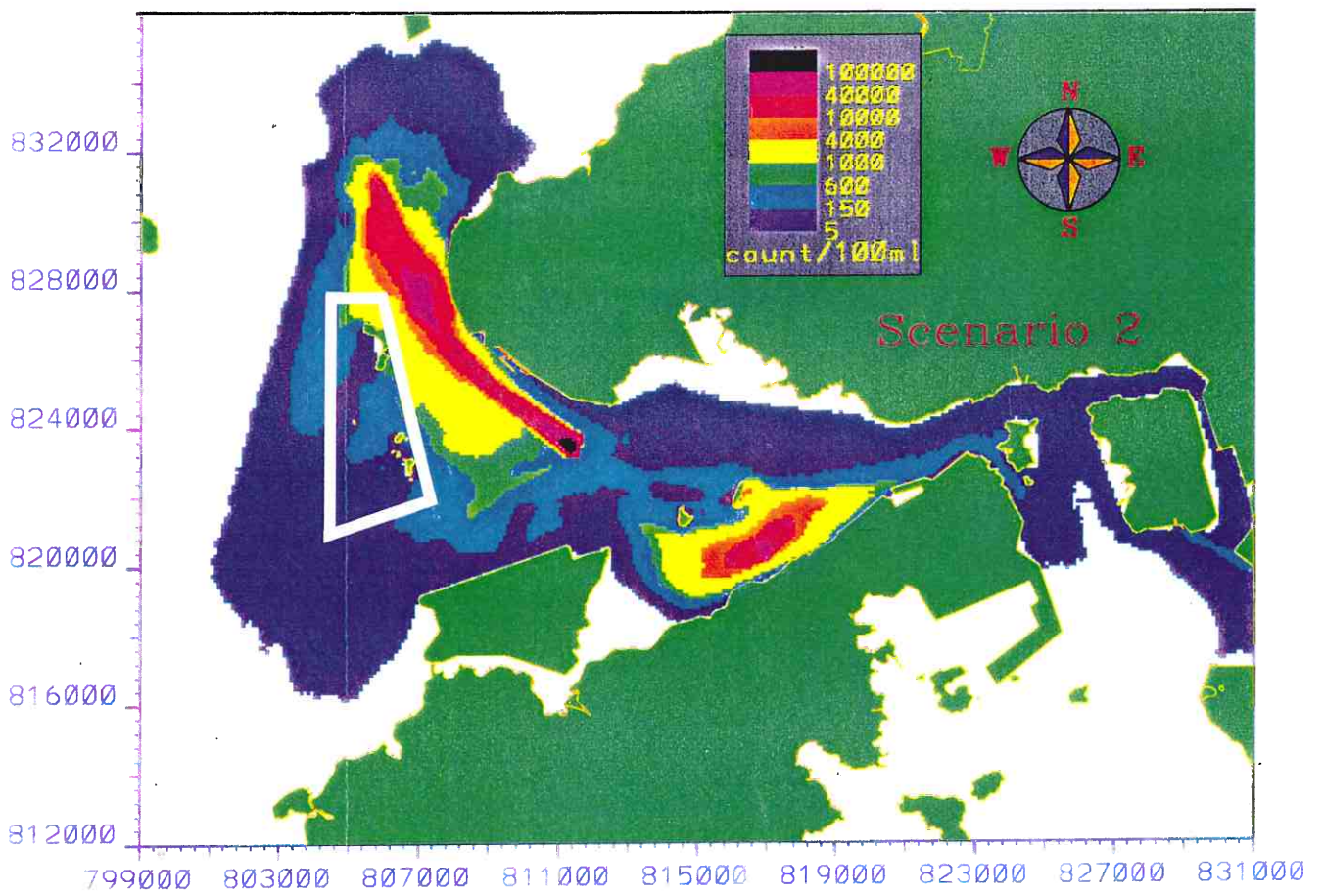
15. Subject to Members' endorsement of the recommendations, steps will be taken to implement the recommendations.

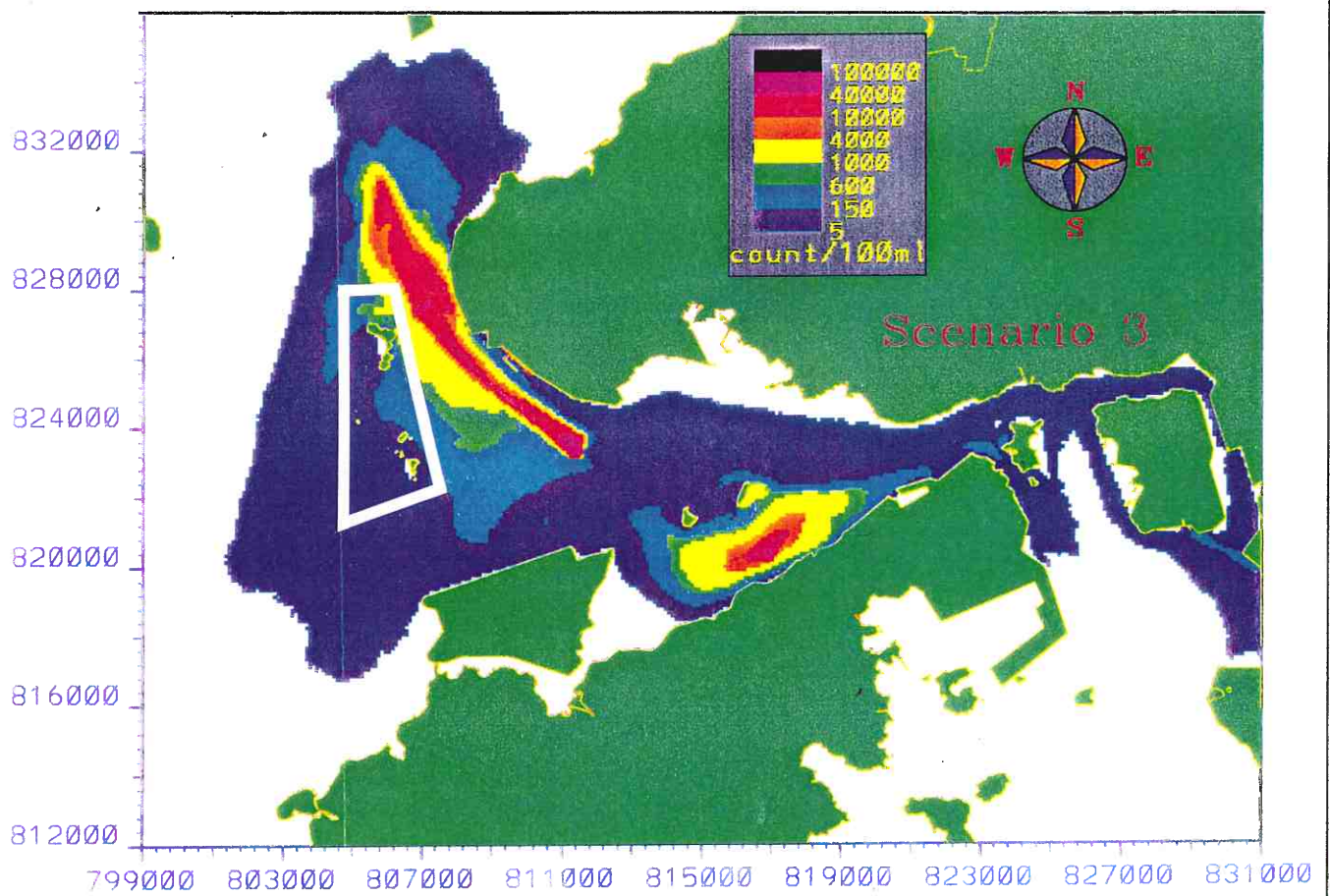
Environmental Protection Department
April 1998









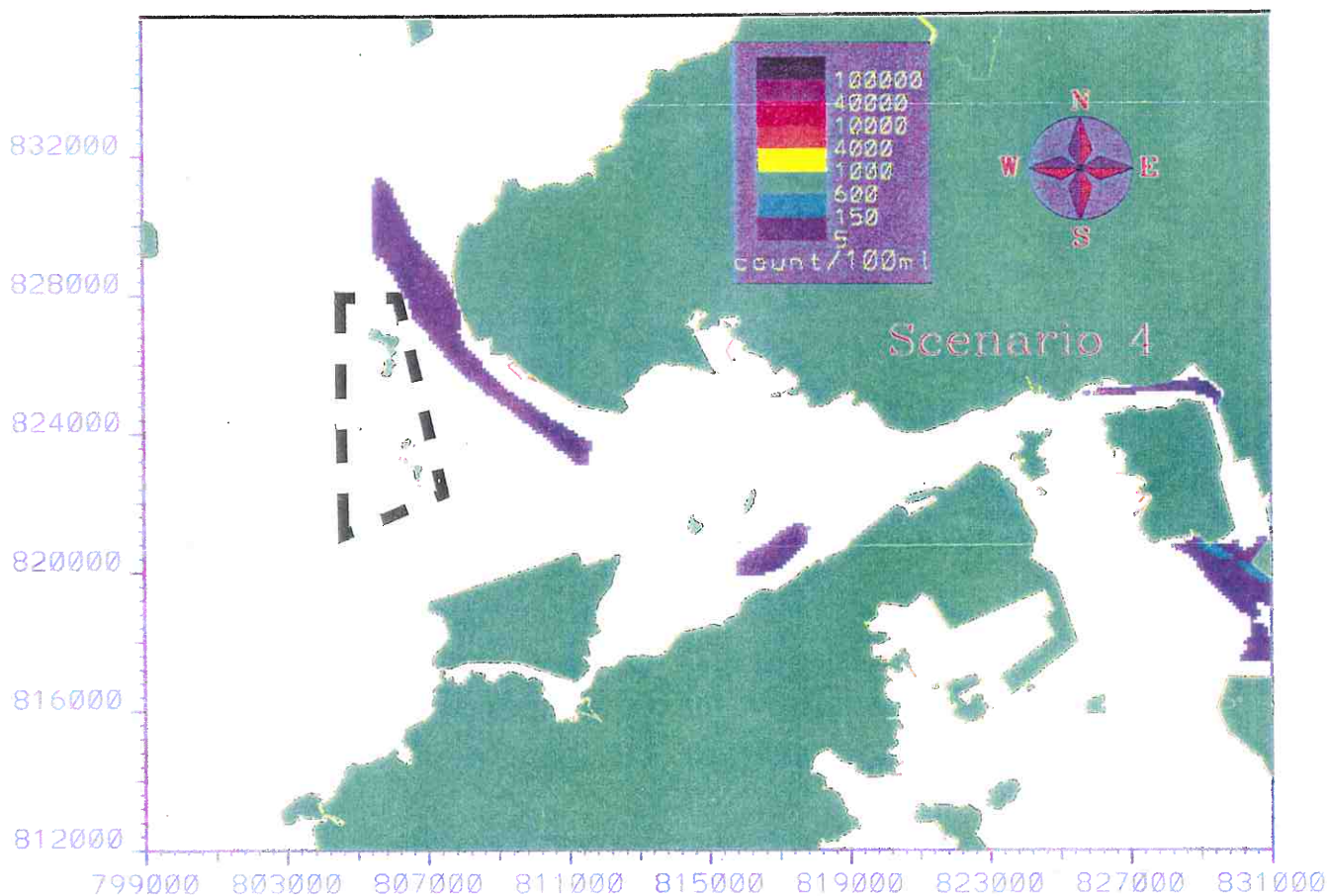


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E.coli Distribution with CEPT
at All STWs Maximum Concentration
in Water Column for Wet Season

Figure
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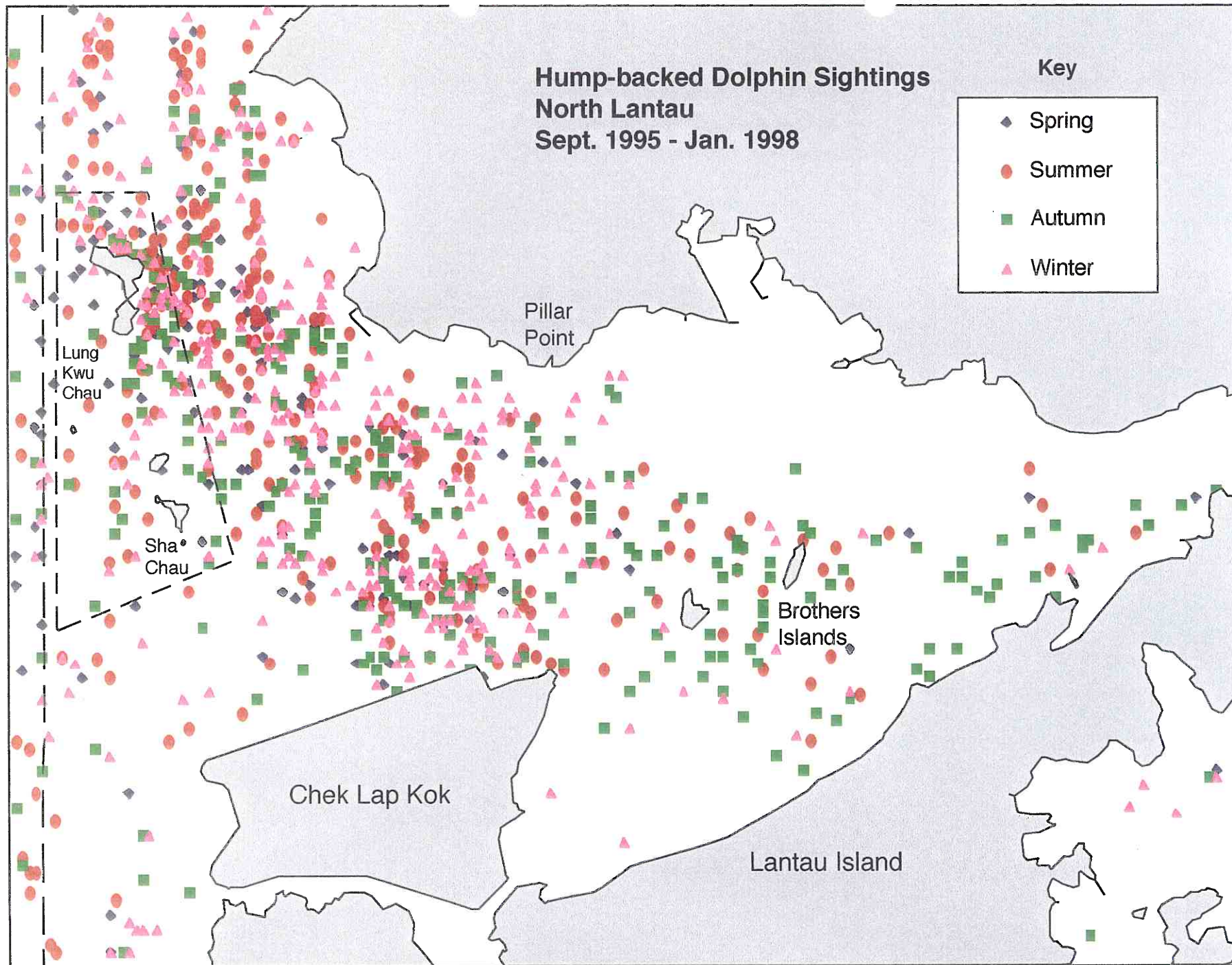


Figure 7 Hump-backed Dolphin Sightings at North Lantau