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Supplementary Environmental Information

Assessment of Maintenance Dredging Requirements

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Able Marine Energy Park

Assessment of maintenance dredging requirements

Technical Note DDR4808-04

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Contents

1. Introduction

1.1 BACKGROUND

Able UK proposes to construct Able Marine Energy Park (AMEP) near Immingham on the southern shore of the Humber Estuary. AMEP will be a facility for the construction of offshore wind turbines and other activities associated with sources of renewable marine energy. AMEP will consist of a large reclamation approximately 1,300 m in length along the shore and extending 300 – 400 m out into the estuary from the existing flood defence.

Impacts of AMEP on the hydrodynamic and sediment regime were assessed and reported in HR Wallingford (2011). Sediment transport modelling resulted in predictions of significant accumulations of sediment on the intertidal and shallow subtidal areas upstream and downstream of the reclamation, and into the berthing pocket and AMEP dock. The operational areas of AMEP will require maintenance dredging. Additionally the development is predicted to have a wider effect on sediment transport in the region resulting in some changes to siltation rates at adjacent facilities.

The sedimentation northwest of the development is likely to lead to burial of the E.ON outfall and has a high risk of burying the Centrica outfall, which is further to the north. It is assumed for the purposes of this report that both of these outfalls will be re-routed so that there will not be a requirement to undertake any type of maintenance dredging in the vicinity of the outfalls.

1.2 OBJECTIVE OF THIS TECHNICAL NOTE

This Technical Note reviews available information on maintenance dredging in the Humber Estuary to gain further understanding of the variability in maintenance requirements that may be expected. Using this information together with the modelling results provided in (HR Wallingford, 2011), estimates are provided for maximum annual and maximum three-year maintenance dredging requirements at AMEP.

2. Data review

The following sources were considered in the preparation of this Technical Note:

- Humber Maintenance Dredging Baseline Document (ABP Humber Estuary Services, 2008).
- ABP Harbour Master's Report for the Humber Harbour Area, 2011.
- ABP Harbour Master's Report for the Humber Harbour Area, 2010.
- Available Annual OSPAR reports on Dumping of Wastes or Other Matter at Sea (1999 to 2009).
- HR Wallingford (2011), Assessment of the effects of a proposed development on the south bank of the Humber Estuary on fine sediments.
- Information on South Killingholme Dredging activities supplied by Able UK to HR Wallingford.

3. Model predicted sedimentation rates in ES

The summary predicted changes to annual maintenance dredging requirements were provided in the Environmental Statement. They are included here in Table 1 below (from HR Wallingford, 2011). These were modelled for the final layout of AMEP as shown in

Figure 1. At two locations the model predictions can be compared against reported maintenance dredging requirements (See Section 5). At these locations the predicted infill was 2-3 times higher than the reported values. This difference was used as the basis for providing a range of upper and lower estimates in Table 1.

It was emphasised in the modelling study (HR Wallingford, 2011) that the numbers below provide a likely range of potential future maintenance dredging requirements. In reality the actual figures will be dependent on many factors, meteorological, operational, and other, and so these ranges remained estimates with considerable uncertainty and potential for variation from year to year and also within any year.

Table 1 Annual Infill Estimates (Dry Tonnes/Year, Existing Case)

	Lower Estimate	**Upper Estimate**
Humber Sea Terminal	215,000	537,000
AMEP Berthing Pocket	0	0
AMEP Dock	0	0
Region inshore of Centrica and E.ON Intake/Outfall Lines	0	0
South Killingholme Oil Jetty	56,000	139,000
Immingham Gas Terminal	34,000	85,000
Humber International Terminal	305,000	763,000
Immingham Bulk Terminal	539,000	1,348,000

Table 2 Annual Infill Estimates (Dry Tonnes/Year, Post-Development)

	Lower Estimate	**Upper Estimate**
Humber Sea Terminal	204,000	511,000
AMEP Berthing Pocket	234,000	585,000
AMEP Dock	17,000	42,000
Region inshore of Centrica and E.ON Intake/Outfall Lines	94,000	234,000
South Killingholme Oil Jetty	31,000	77,000
Immingham Gas Terminal	31,000	77,000
Humber International Terminal	279,000	697,000
Immingham Bulk Terminal	510,000	1,274,000

Table 3 Predicted changes to Annual Infill Estimates (Dry Tonnes/Year)

	Lower Estimate	**Upper Estimate**
Humber Sea Terminal	-10,000	-25,000
AMEP Berthing Pocket	234,000	585,000
AMEP Dock	17,000	42,000
Region inshore of Centrica and E.ON Intake/Outfall Lines	94,000	234,000
South Killingholme Oil Jetty	-18,000	-46,000
Immingham Gas Terminal	-2,000	-4,000
Humber International Terminal	-19,000	-48,000
Immingham Bulk Terminal	-30,000	-74,000

Modelled annual infill into the Immingham Outer Harbour Basin was 1,946,000 dry tonnes, giving a lower estimate of 780,000 dry tonnes per year (baseline). Inclusion of AMEP led to a reduction in modelled IOH infill by approximately 5% (with-scheme lower and upper estimates of 740,000 to 1,846,000 dry tonnes per year respectively).

4. Present-day maintenance dredging and disposal in the Humber Estuary

4.1 OSPAR ANNUAL REPORTS

Table 4 below shows the disposal quantities reported in OSPAR (1999-2009) for licensed disposal sites in the Humber Estuary. Figure 2 shows the approximate locations of these sites. The annual OSPAR reports quote disposal quantities in dry tonnes. It is noted that the UK generally quotes wet tonnes and that some conversion will have been required.

Note that quantities in red italics in Table 4 represent disposal from both capital and maintenance dredging and so include construction of HIT and IOH. All other figures relate to disposal from maintenance dredging operations. Figure 2 shows the disposal plotted against time. From these figures it is possible to make four main observations:

1. From 2000 to 2004, the largest annual disposal was to HU080
2. From 2005 to 2009, the largest annual disposal was to HU060, close to Immingham (although 2005 and 2006 values included some material from capital dredging)
3. Disposal to HU060 increased substantially in 2007, predominantly as a result of the maintenance requirement for IOH.
4. Total disposal of maintenance dredging to these disposal sites for the last three years on record (OSPAR) is about 4.3, 4.5 and 3.4 million dry tonnes per year respectively.

4.2 ABP PUBLISHED MAINTENANCE DREDGING FIGURES

ABP publish maintenance dredging figures in wet tonnes. These were converted to dry tonnes by assuming wet density of 1,300 kg/m^3 and dry density of 500 kg/m^3.

While the OSPAR disposal quantities are presently only readily available for the period from 1999 to 2009, Table 5 provides ABP dredge disposal figures extending further back in time (derived from a graphic in ABPHES, 2008) and converted to dry tonnes (also shown in Figure 4).

Table 6 provides a detailed summary of maintenance dredging figures mostly taken from the ABP Harbour Master's Reports for the Humber Harbour Area, 2010 & 2011. These figures show:

1. For 2007, the two sets of figures (OSPAR disposal quantities and ABP maintenance dredging quantities re-interpreted as dry tonnes) predict an annual maintenance requirement of around 4,000,000 dry tonnes. The difference in the quantities from the two datasets is possibly attributable to small differences in assumptions as to dry density used when converting from wet tonnes to dry tonnes.
2. For 2010 and 2011, total maintenance dredging was approximately 2,300,000 dry tonnes per year.
3. Reported maintenance dredge quantities in 2010 and 2011 appear to represent the lowest figures for maintenance dredging since 1993 (based on comparing against the longer term record of annual disposal quantities shown in Figure 4 and reproduced from ABP, 2011).

Table 4 Annual disposal figures (dry tonnes) from OSPAR annual dumping reports

Site	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HU020	*93,655*	*131,903*	*106,946*	80,991	69,023	128,816	95,896	83,942	60,550	44,269	44,223
HU030	799,651	728,926	533,209	653,368	750,200	715,788	795,164	617,343	627,409	628,695	235,234
HU060	*1,698,487*	*1,046,841*	*1,145,136*	*1,813,426*	*1,596,513*	*2,068,278*	*1,943,594*	*2,029,737*	3,263,668	3,700,435	2,862,328
HU080	1,395,476	1,878,174	1,742,202	2,062,147	3,552,949	2,122,956	1,393,833	*192,832*	0	0	0
HU090	324,373	256,472	306,129	315,080	171,003	325,772	294,885	264,395	389,680	273,255	210,356
HU112								13,706	0		

Table 5 Approximate historical disposal quantities (dry tonnes) – from ABPHES (2008)

Year	Hull	Immingham	SDC	Grimsby	total
1985	1,346,000	1,150,000	961,000	307,000	3,769,000
1986	961,000	1,226,000	1,115,000	269,000	3,576,000
1987	1,384,000	1,303,000	1,153,000	307,000	4,153,000
1988	846,000	803,000	2,038,000	192,000	3,884,000
1989	1,153,000	611,000	2,576,000	269,000	4,615,000
1990	1,230,000	496,000	2,807,000	192,000	4,730,000
1991	846,000	650,000	2,730,000	192,000	4,423,000
1992	1,153,000	611,000	1,307,000	307,000	3,384,000
1993	730,000	457,000	653,000	153,000	2,000,000
1994	1,346,000	919,000	2,153,000	269,000	4,692,000
1995	1,365,000	823,000	2,923,000	250,000	5,365,000
1996	1,807,000	1,226,000	3,153,000	384,000	6,576,000
1997	769,000	688,000	3,423,000	153,000	5,038,000
1998	884,000	919,000	2,807,000	230,000	4,846,000
1999	846,000	1,457,000	1,384,000	269,000	3,961,000
2000	807,000	919,000	1,923,000	192,000	3,846,000
2001	692,000	842,000	1,615,000	307,000	3,461,000
2002	692,000	1,226,000	1,653,000	269,000	3,846,000
2003	730,000	996,000	2,884,000	115,000	4,730,000
2004	730,000	1,534,000	1,615,000	230,000	4,115,000
2005	730,000	1,534,000	1,000,000	269,000	3,538,000
2006	750,000	1,630,000	153,000	269,000	2,807,000
2007	730,000	2,765,000	0	346,000	3,846,000

Table 6 ABP detailed maintenance dredging quantities for 2010 and 2011

Location	Wet Tonnes 2010	Wet Tonnes 2011	Dry Tonnes 2010	Dry Tonnes 2011
Albert Entrance	25,324	15,895	9,740	6,113
Albert Dock	12,684	51,242	4,878	19,708
Alex Entrance	110,215	10,326	42,390	3,971
Alex Dock	61,575	11,449	23,683	4,403
Ro-Ro Terminal	2,230	0	858	0
Queen Elizabeth Dock	0	0	0	0
KG Dock	110,622	149,127	42,547	57,357
KG Entrance	286,377	143,451	110,145	55,173
RT1	96,546	71,356	37,133	27,445
Saltend	230,170	214,355	88,527	82,444
Hull	1,598	141,746	615	54,518
Goole	5,575	12,265	2,144	4,717
Grimsby Alex	33,138	17,577	12,745	6,761
Grimsby Royal Basin	1,230	17,506	473	6,733
Grimsby Royal Dock	95,641	96,679	36,785	37,184
Grimsby Entrances	240,300	182,537	92,423	70,207
Grimsby Fish Dock	16,021	6,798	6,162	2,615
Grimsby Marina	0	0	0	0
Immingham Bellmouth	239,721	301,717	92,200	116,045
Immingham Dock	189,842	308,289	73,016	118,573
Immingham Gas Terminal	41,679	46,690	16,030	17,958
Immingham West Jetty Ext	81,914	64,585	31,505	24,840
Humber International Terminal	370,370	312,370	142,450	120,142
Immingham Bulk Terminal	395,484	533,950	152,109	205,365
Immingham Outer Harbour	2,532,553	2,671,303	974,059	1,027,424
Sunk Dredged Channel	0	34,503	0	13,271
Subtotal	**5,180,809**	**5,415,715**	**1,992,619**	**2,082,967**
South Killingholme Oil Jetty	*13,410*	*2,688*	*5,158*	*1,034*
Humber Sea Terminal	*500,000*	*500,000*	*192,308*	*192,308*
Grimsby Fish Docks	*104,000*	*104,000*	*40,000*	*40,000*
Totals	**10,979,028**	**11,438,117**	**2,230,084**	**2,316,309**

5. AMEP maintenance dredging requirements

5.1 MODEL PREDICTED SEDIMENTATION AND OBSERVED MAINTENANCE DREDGING QUANTITIES

As mentioned in Section 3, HR Wallingford (2011) used a factor of approximately 2.5 to determine the lower estimate of deposition into berths. This was based on two locations from which observed siltation rates were provided as shown in Table 7 below.

Table 7 Comparison of annual predicted and observed deposition into adjacent berths (tonnes dry solids) reported in HR Wallingford (2011)

	Modelled	Observed
Humber Sea Terminal	537,000	192,000
South Killingholme Oil Jetty	139,000	
Immingham Gas Terminal	85,000	
Humber International Terminal	763,000	
Immingham Bulk Terminal	1,348,000	492,000

Given the level of uncertainty in modelled infill predictions, the predicted future changes to maintenance dredging requirements are presented as a range. It should be noted that this is good practice in sediment transport modelling and that a model predicted infill rate within a factor of 2-5 of the observed figures is not unreasonable.

Table 8 below expands on this assumed relationship by considering further data made available for this review. With the exception of the reported dredging for South Killingholme Oil Jetty (for which the 2010 and 2011 quantities are much lower than modelled), the berths for which data are given in Table 8 show model predicted baseline sedimentation rates are 2-9 times greater than observations for 2010 and 2011.

As stated in HR Wallingford (2011), reasons for this difference will include (amongst others) deficiencies in a simple linear scaling of the spring-neap cycle simulated, the absence of extreme (storm) tide conditions and wave effects, the motion of ships into and out of the berths and berth occupancy, assumptions on densities, frequency (and precise locations) of maintenance dredging, and natural variability in suspended sediment concentrations in the Humber Estuary. Considering only the last item reveals year on year differences in maintenance dredging requirements of a similar order to that seen above.

Table 8 Predicted range of maintenance requirements versus observed

	Lower Estimate	Upper Estimate	2007	2010	2011
Humber Sea Terminal	215,000	537,000	192,000		
South Killingholme Oil Jetty	56,000	139,000		5,158	1,034
Immingham Gas Terminal	34,000	85,000		16,030	17,958
Humber International Terminal	305,000	763,000		142,450	120,142
Immingham Bulk Terminal	539,000	1,348,000	492,000	152,109	205,365
Immingham Outer Harbour	778,000	1,946,000		974,059	1,027,424

From these few additional data sets, one can see that the observed dredging quantities are all closer to the lower estimate provided in the HR Wallingford, 2011. The figures for Immingham Outer Harbour are within the range predicted by the modelling. Note that the numerical modelling previously undertaken for IOH led to an under-prediction of the initial maintenance requirements incurred in 2007 and 2008 (ABPHES, 2008).

5.2 ESTIMATING A MEAN, MAXIMUM AND MINIMUM MAINTENANCE DREDGING REQUIREMENT FOR AMEP

1. Using the additional information in Table 8 to improve the judgement used in HR Wallingford (2011) would suggest that using a mean factor of 1/4.7 (derived from Table 8, not including SKOJ factors) and minimum and maximum factors of 1/8.9 and 1/1.9, again based on these few observations in 2007, 2010 and 2011, would lead to mean, minimum and maximum maintenance requirements.

2. Further extracting a signal attributable to variability (from year to year) in background suspended sediment concentrations is more difficult, because the data on maintenance and disposal quantities are affected by a range of commercial and natural drivers. Examining the variability about the mean trend in Figure 4, for Immingham, Grimsby and Hull suggests a year on year variability of about 30%.

3. Other major uncertainties in deriving a maximum maintenance dredging quantity for AMEP include, in no particular order: disposal activities up and down river and in particular to the neighbouring HU060; maintenance and capital activities at neighbouring terminals; berth occupancy; actual requirements at the AMEP berths; future evolution of channels and banks e.g. Foul Holme Spit; actual density and time between dredges.

The total predicted annual infill into the AMEP berth pocket and dock was 251,000 to 627,000 dry tonnes per year. Table 9 below shows the derivation of a lower and upper estimate for maintenance dredging derived from following steps 1 and 2 above.

Table 9 Lower and upper estimates of AMEP annual maintenance requirement

	Dry tonnes/year	
	Lower Estimate	Upper Estimate
Estimated maintenance requirement (Step 1)	70,000 (+/- 30%)	330,000 (+/- 30%)
Estimated maintenance requirement including observed variability (Step 2).	49,000	429,000

Based upon these predictions, estimated maximum annual and maximum three-yearly maintenance dredge figures are 429,000 dry tonnes and 1,287,000 dry tonnes respectively. Assuming the dry density of 500 kg/m3 and a wet density of 1,300 kg/m3, this equates to upper annual and three-yearly estimates of 1.1 and 3.3 million wet tonnes per annum.

Allowing for some uncertainty around actual densities of deposited sediments (e.g. assuming the dry density could be 400kg/m^3 – 500kg/m^3), this leads to maximum annual and 3-yearly estimates of 1.5 and 4.0 million wet tonnes respectively.

The upper estimate of annual maintenance dredge requirement is less than that reported in the ES.

Although a localised patch of sediment (34,300 dry tonnes annual equivalent) was predicted by the modelling to deposit against one flank of the turning area/approach channel shown by the dotted line in Figure 1, this was attributed to slope stabilisation and not a need for maintenance. Apart from at this location, there is no predicted requirement for dredging the turning area and approach channel as contained within the dotted line in Figure 1.

5.3 MAINTENANCE REQUIREMENTS AT COMPARABLE FACILITIES

Maintenance requirements along a similar length of berth pockets fronting HIT should provide a reasonable source of information for future expected requirements at AMEP. Summing reported maintenance requirements for Immingham Gas Terminal, Immingham Bulk Terminal (IBT) and Humber International Terminal gives a similar scale in terms of berth length and width. However, the maintained berth pocket depths at IBT and HIT (-14.4m and -14.0m CD) are greater than proposed at AMEP (-11m CD).

Summing the maintenance dredging requirements for these three terminals, using the information provided in (ABPHES, 2010 and ABPHES, 2011), leads to total maintenance dredging of 310,600 and 343,500 dry tonnes in 2010 and 2011 respectively. As these figures come within the range estimated in Table 9 (approximately 20% below the upper estimate), this appears to lend some confidence to this estimate.

6. *Maintenance dredging operations*

The volume of the in-situ material being dredged to create the berth pocket is 627,000 m^3(Able UK, 2011) with an additional ~160,000m^3 dredged to create the dock. Annual maintenance dredging requirement of 429,000 dry tonnes per year equates to approximately 858,000m^3 or a worst case unmaintained scenario of filling the berth pocket and dock area to the present day bed levels once per year with a low density mud. The above figures quoted in Section 5.3 suggest the rate of infilling may typically be somewhat lower but still requiring significant maintenance dredging. This is likely to require dredging on a relatively frequent basis.

Approximately 880,000 m^3 of in-situ material will be dredged for the turning area/approach channel (Able UK, 2011). There is no predicted requirement for maintenance dredging the turning area and approach channel as contained within the dotted line in Figure 1.

7. *Conclusions*

Previously published predictions of sedimentation at AMEP have been considered alongside available information on reported maintenance dredging quantities at adjacent facilitates to provide a basis for estimating a maximum annual and a maximum three–yearly maintenance dredge figure.

The estimated upper annual and upper three-yearly maintenance dredge figures are 429,000 dry tonnes and 1,287,000 dry tonnes respectively. Converting to figures in wet tonnes provides estimated maximum values of 1.5 million and 4.0 million wet tonnes respectively.

The maintenance dredging is expected to be required in the berth pockets. With the turning area and approach channel predicted to be largely maintenance free.

8. References

ABP Humber Estuary Services, 2008. Humber Maintenance Dredging Baseline Document

ABP Harbour Master's Report for the Humber Harbour Area, 2011.

ABP Harbour Master's Report for the Humber Harbour Area, 2010.

Able Marine Energy Park Dredging Strategy (Annex 7.6). Able UK, 2011.

Available Annual OSPAR reports on Dumping of Wastes or Other Matter at Sea (1999 to 2009).

HR Wallingford (2011), Assessment of the effects of a proposed development on the south bank of the Humber Estuary on fine sediments. EX Report EX6603.

Figures

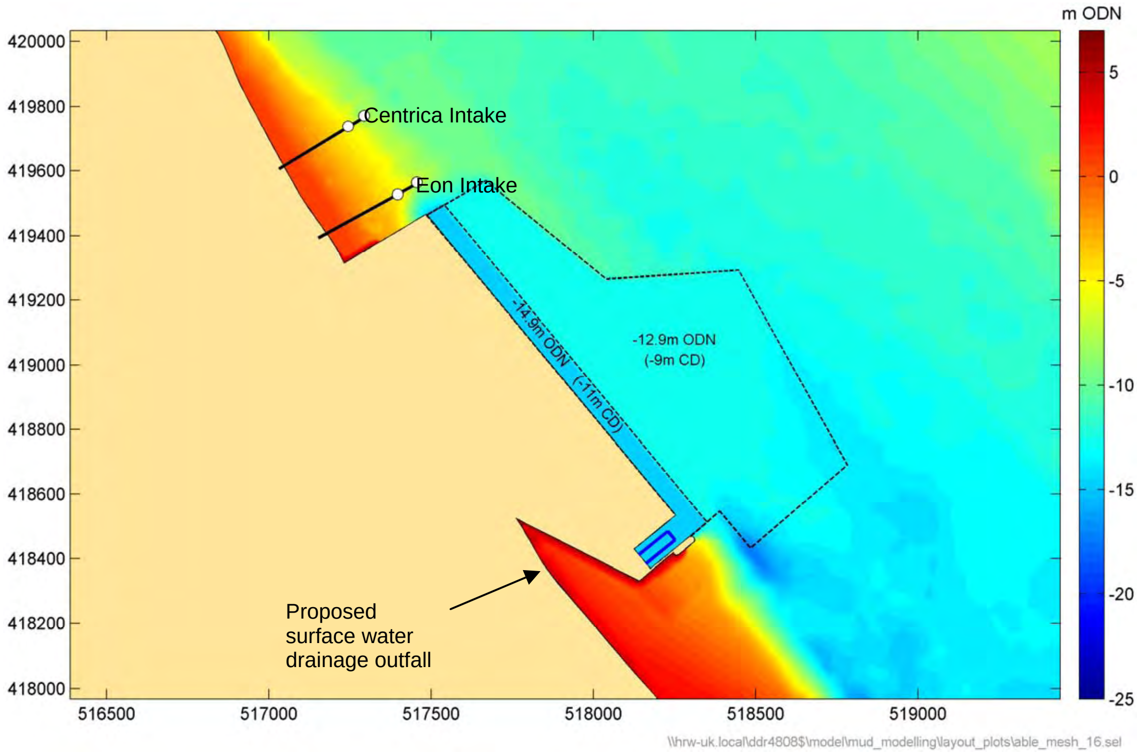

Figure 1 Model layout and bathymetry (with AMEP scheme) also showing locations of E.ON and Centrica intakes and outfalls

Figure 2 Map showing approximate locations of dredge disposal sites in the Humber Estuary

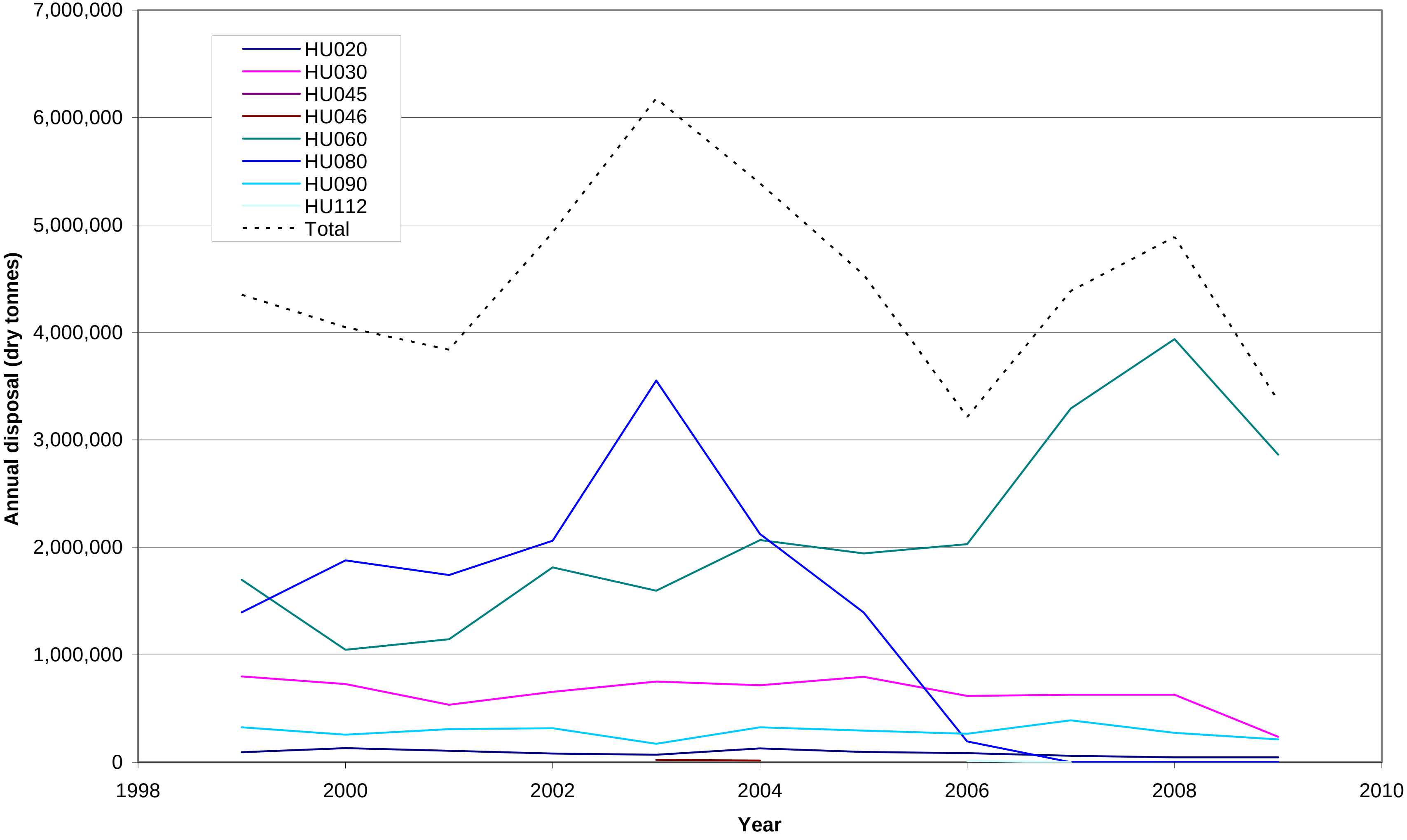

Figure 3 Humber annual disposal figures (from OSPAR)

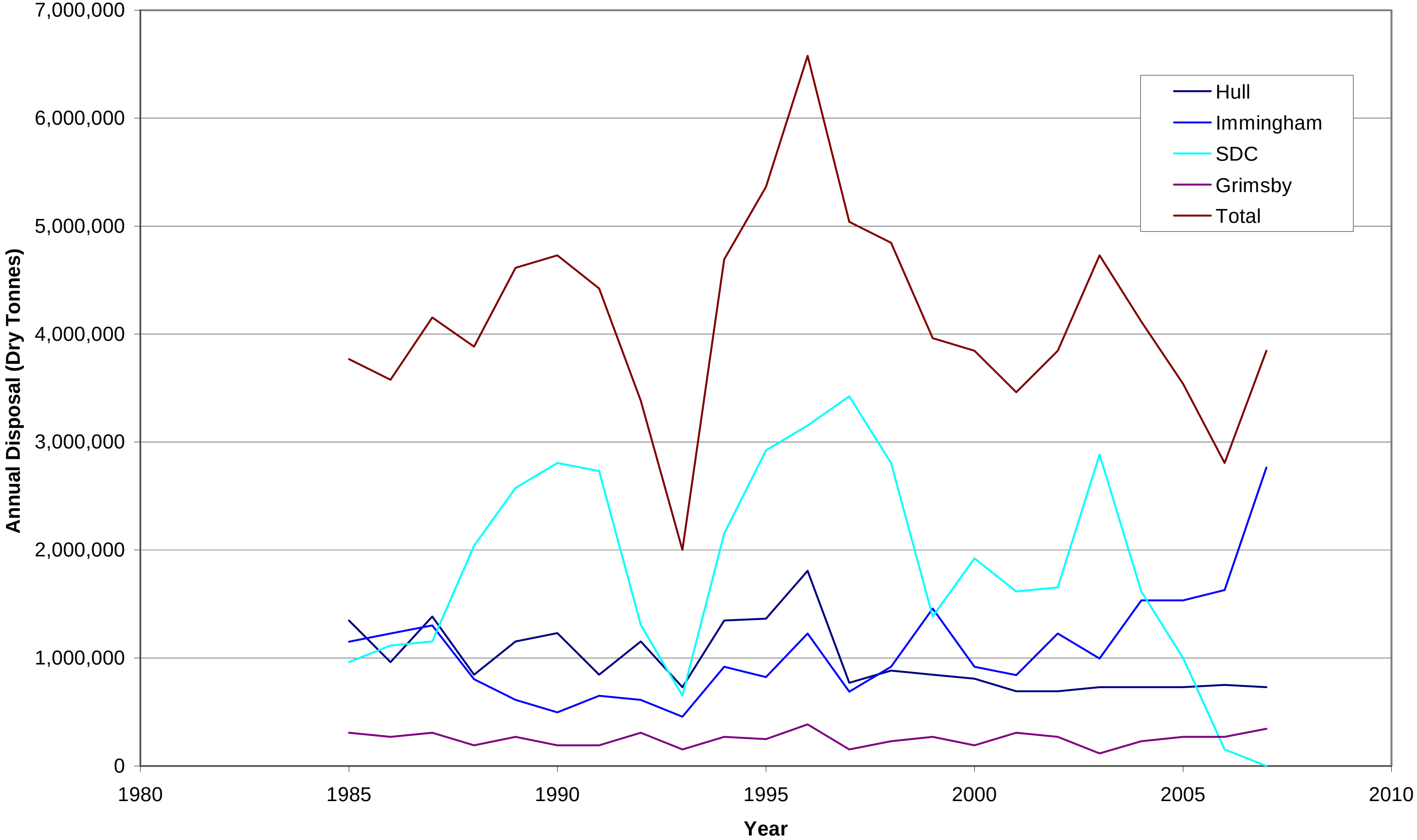

Figure 4 Approximate Historical Humber Annual Disposal Quantities (taken from ABP Graphic)