OPEN COAST TIDAL ENERGY

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A D D E N D U M

LANCASHIRE SCHEME III (BLACKPOOL)

AND SCHEME II (TWO BASIN BLACKPOOL/RIBBLE)

COMPARISON WITH SCHEME MII

Morgan Horne

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INTRODUCTION

The main report concludes that scheme MII (Morecambe Bay) is without doubt the cheapest potential producer of energy of the schemes investigated, if potential non-energy contributions to the scheme costs are ignored.

As is pointed out in the conclusions to the report, the Blackpool Scheme (LANCS III) is likely to produce substantial non-energy benefits, and these will be significant in reducing energy costs in view of the relatively low capital cost of this scheme.

The comparative energy costs ignoring revenue other than tidal energy is given on page 23 of the report as:-

MII Morecambe 2 way generation 3.6p/KWh.

LANCS III Blackpool 2 way generation 4.9p/KWh.

The relative capital costs are £4681 million and £1939 million on the basis of the same amount of scheme refinement. To improve the finances of the Lancs III scheme to offer the same energy cost as the much larger and inherently more economic M2 scheme would require a reduction in capital cost from refinement of design, together with a credit for non-energy revenue equivalent to about £500 million in total.

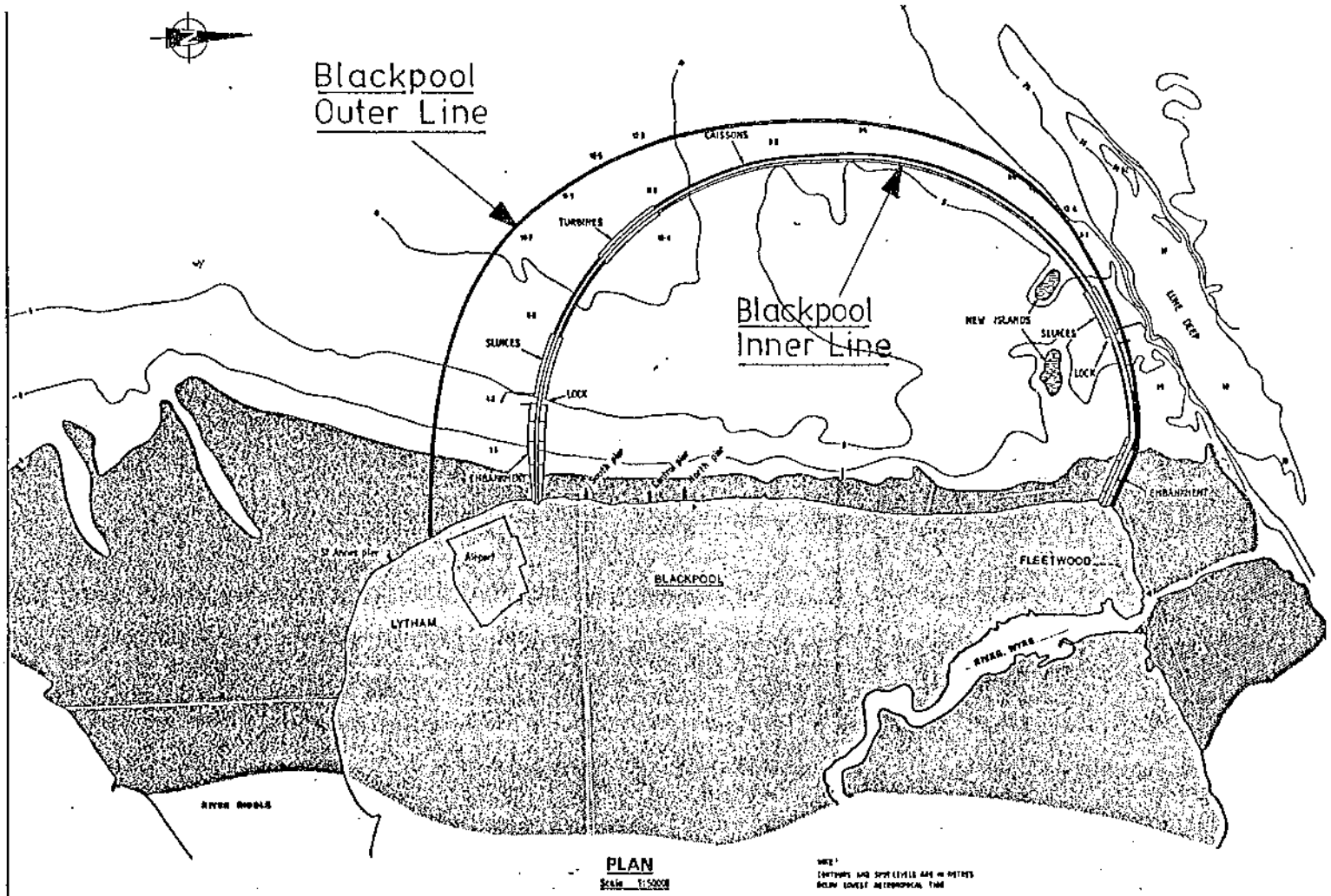
The object of this Addendum is to examine the extent to which such improvement is possible by:-

(a) Development of the scheme from the outline state evaluated for PART I of the report to bring it to the same degree of refinement as applies to scheme MII in PART II.

(b) Evaluate approximately the non-energy revenue potential.

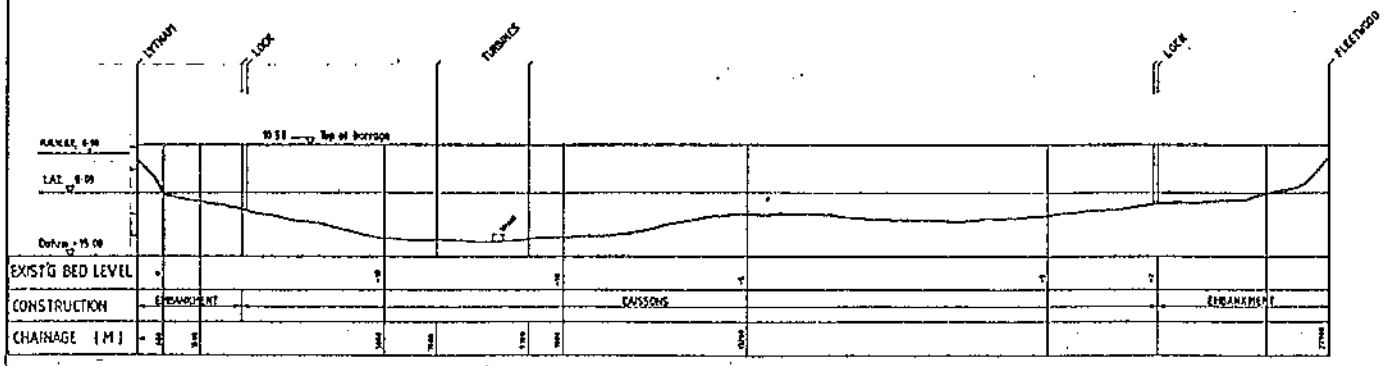
(c) To extend the work to comment briefly on the effects of expanding the Lancs III scheme to a two basin scheme involving the Ribble and Stockport coastline.

(d) To make further comparison with scheme M2.

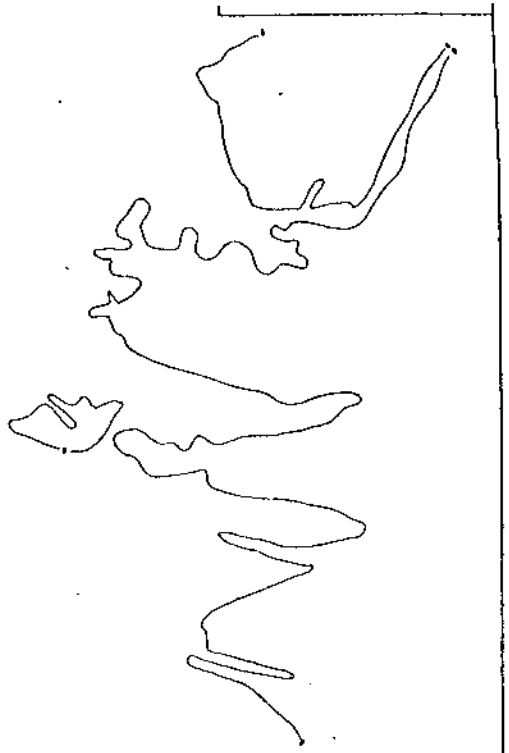


PLAN
Scale 1:50000

NOTE:
CONTOURS AND SPOT LEVELS ARE IN METRES
BELOW LOWEST ASTRONOMICAL TIDE



LONGITUDINAL SECTION
HORIZONTAL SCALE 1:50000
VERTICAL SCALE 1:500



No.	Date	Revision

TIDAL BARRAGE
BLACKPOOL
ALTERNATIVE LINE

Scale AS SHOWN	Date
Drawn A.P.H.	Checked
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LANCASHIRE SCHEME III

BLACKPOOL

ALIGNMENT

General

The alignment evaluated in PART I encloses on area of about 130Km^2. Further work has been done for this Addendum aimed at improving the area enclosed/barrage length ratio.

This involves moving the propose southern landfall nearer to Lytham as indicated on the enclosed map, to increase the basin size and to improve the Area/Length ratio, without increasing the length in deeper water disproportionately.

A landfall just south of Squires Gate airport should nnot be generally objectionable.

This revised Blackpool alignment encloses 157km^2.

Geology

Similar geology to that for the MII scheme exists (see PART II).

DESIGN BASIS

This would all be as for the MII scheme (see PART II) except that much smaller locks are needed.

COST ESTIMATES

The basis is all as for the MII scheme (see PART II) except for basic barrage cost and use of more turbines per km^2 of basin area.

For this Blackpool scheme the basic barrage cost is a much higher proportion of the total.

The barrage costs for scheme MII shown on page 40 of PART II are somewhat overestimated, on the grounds that doing so has a small effect on the economics of the MII scheme and leaves scope for later refinement.

For the Blackpool scheme such high figures give a misleadingly pessimistic forecast. The basic barrage cost for the larger Blackpool scheme has been estimated as follows:-

DEPTH BED BELOW CHART DATUM m	LENGTH Km	COST per Km (£ million)	COST (£ million)
0-2	6.5	20	130
2-5	3.6	22	78
5-7	14.2	26	370
7-10	2.1	31	65
10-12	5.7	36	204
			847

ENERGY OUTPUT

This has been estimated on the same principles as used in PART II for Morecambe Bay scheme except that the optimum turbine numbers per Km^2 of basin area are higher. The optimum to give least energy cost is about 126 Turbines per 100 Km^2 of basin area for 2 way generation. Ebb only generation has been seen from PART I to be uncompetitive for this scheme.

COST ESTIMATE

SUMMARY

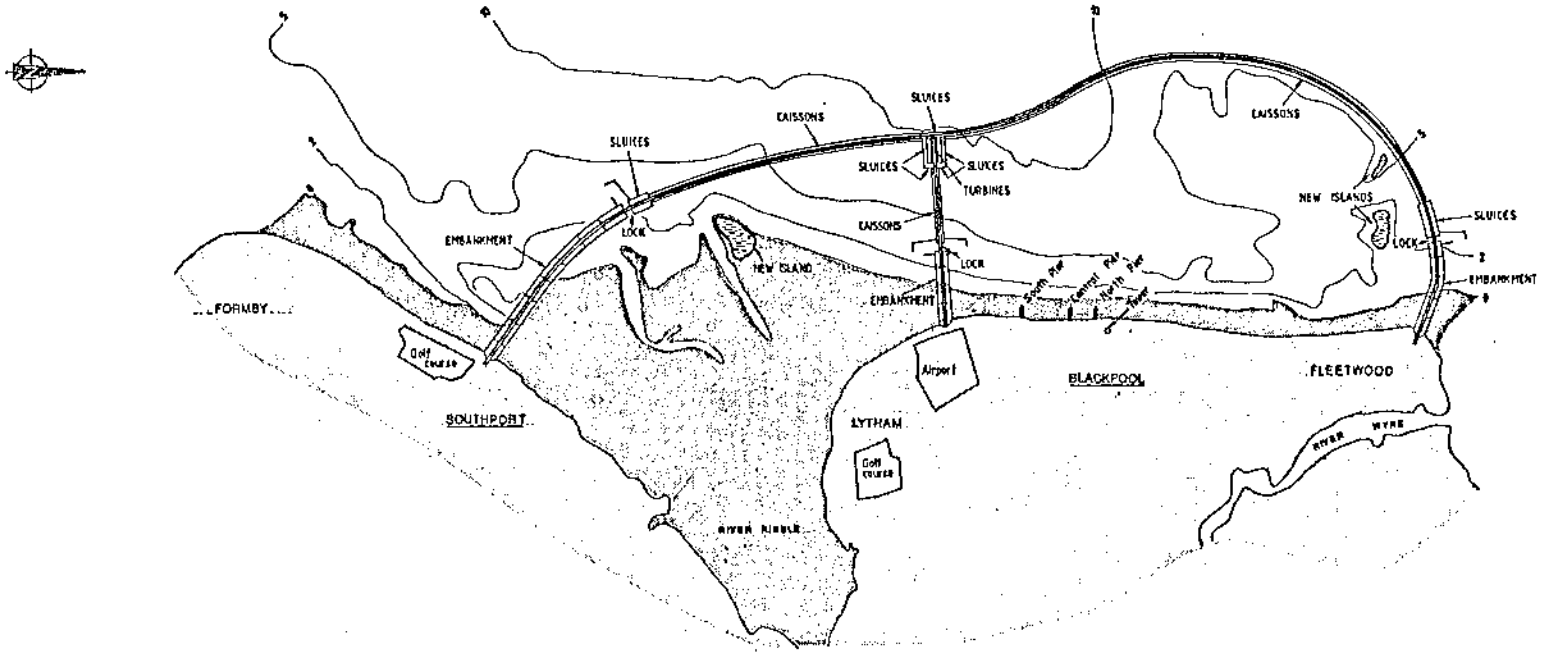
Enlarged Blackpool (Lancs III scheme)

enclosing 157 Km²

2 WAY GENERATION WITH TURBINE PONDS

CIVIL	**£ million**
Barrage	847
Draft Tubes (196 x 0.5)	98
Sluice Caissons (3Km @ £13m extra over plant caissons	39
Flap gate channels (3Km @ £21 million)	63
Locks	40
	1087
10% Design Contingency	108
	1195
MECH AND ELECTRICAL	
Turbine enclosures (196 @ 0.6)	118
Flap gates 43000m²	65
Vertical gates 21700m²	78
Turbines (196 @ £3.2 million	627
Lock gates	6
	894
Total Civil + M/E	2089
17½% construction contingency	366
	2455
4% Design, Management and Environ Study	98
	2553

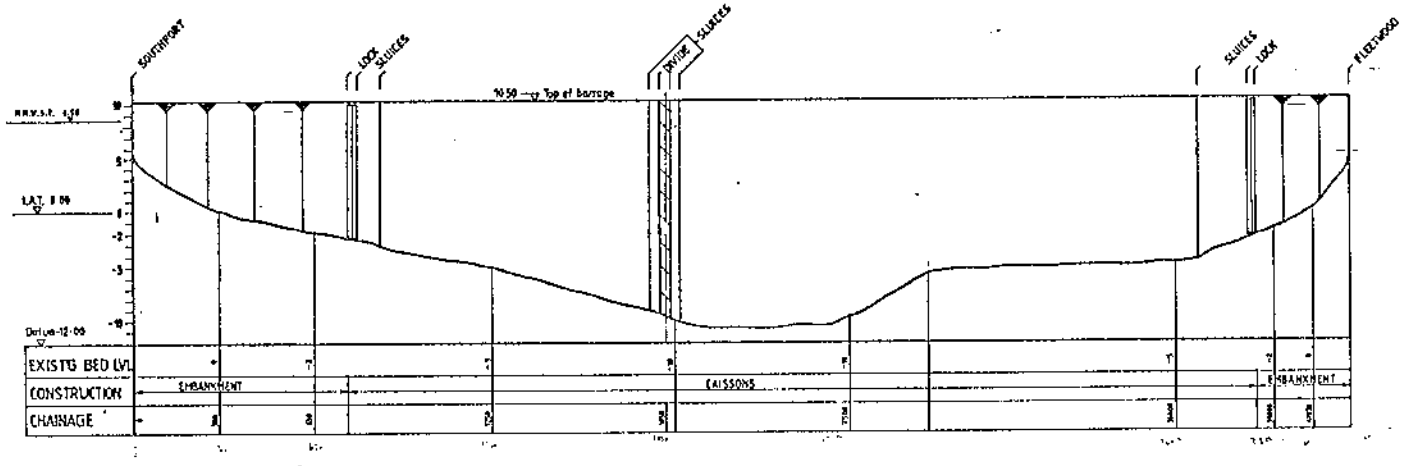
Estimate used in energy cost calculation
(excludes cost of connection to grid)



NOTE:
CONTOURS ARE IN METRES
BELOW LOWEST ASTRONOMICAL TIDE

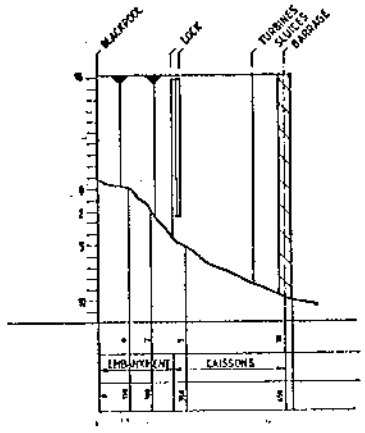
PLAN

SCALE - 1:75000



LONGITUDINAL SECTION - SOUTHPORT TO FLEETWOOD

HORIZONTAL SCALE - 1:75000
VERTICAL SCALE - 1:600



DIVIDING BARRAGE

No.	Date	Revision

TIDAL BARRAGE BLACKPOOL TO SOUTHPORT

Scale	AS SHOWN	Date	
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LANCASHIRE SCHEME II

TWO BASIN SCHEME BLACKPOOL/RIBBLE

This proposal would extend the Blackpool scheme to also enclose the Ribble.

A dividing barrage would form two basins, each of 130 Km^2 effective area.

A turbine pond at the junction of the main and the division barrage would allow the Blackpool basin to fill through the turbines, to generate on the flood tide, while the same turbines would allow the Ribble basin to discharge, thus generating on the ebb tide.

The turbines would be double used, as compared with a single basin, one-way generation scheme.

The Blackpool basin would be commissioned ahead of the Ribble basin construction, thus improving cash flow.

This method of using a turbine pond is the subject of a patent of Morgan Horne's, and is as far as each basin is concerned, a one-way only generation scheme.

It would be necessary to install more turbines than are required to minimise the energy costs, to ensure that the tidal range within the basins would be not too far from the natural regime.

Generation would be in four periods per day, each of $4\frac{1}{2}$ hours, which improves upon the output cycle of both single basin ebb-only or two-way generation.

The two basin scheme requires far fewer turbines than the Blackpool two way generation scheme, but has similar output. The Civil cost is, of course, higher.

The scheme is competitive and if it is decided to promote the Blackpool scheme, the advantages of extending to the two-basin scheme could be evaluated in more detail.

If, for example, it proves that producing sufficient turbines on time for a two-way generation scheme is impossible, the two basin scheme would gain favour.

However, it would involve answering the fear that the Ribble's habitat for birds would be effected detrimentally.

This would not be the case, but a good deal of public relations work would be necessary to convince doubters.

COST ESTIMATE

SUMMARY

Lancs II 2 basin scheme (Blackpool/Ribble)

enclosing 2 x 130 Km²

1 WAY GENERATION WITH TURBINE PONDS

CIVIL	**£ million**
Barrage	1210
Draft Tubes (96 x 0.5)	48
Sluice Caissons (1.5 @ £13m extra over plain caissons	20
Flap gate channels (1.5 @ £21 million)	30
Locks	60
	1368
10% Design Contingency	136
	1504
MECH AND ELECTRICAL	
Turbine enclosures (96 @ 0.6)	58
Flap gates 21000m²	31
Vertical gates 10000m²	35
Turbines (96 @ £3.2 million	307
Lock gates	9
	440
Total Civil + M/E	1944
17½% construction contingency	340
	2284
4% Design, Management and Environ Study	88
	2372

Estimate used in energy cost calculation
(excludes cost of connection to grid)

SUMMARY OF CAPITAL AND MAINTENANCE COSTS

	CAPITAL COST £ million	ENERGY OUTPUT TWh p.a.	MAINT. COST £ million p.a.	ENERGY COST 30 years 5% p/Kwh
BLACKPOOL (LANCS III) REVISED LINE 2-WAY GENERATION	2553	4.1	22	4.6
(Allowing for £90 million non-energy contribution)	2463	4.1	22	4.45
BLACKPOOL/RIBBLE 2 BASIN SCHEME	2376	3.9	20	4.5
MORECAMBE BAY (LANCS/CUMBRIA) SCHEME M2 (From Part II of Report) 2-WAY GENERATION	4544	9.2	41	3.65
MORECAMBE EBB ONLY - LEAST ENERGY COST SCHEME	3442	7.0	30	3.6
MORECAMBE EBB ONLY - COMPROMISE SCHEME	4279	7.8	38	4.1

NON - ENERGY CONTRIBUTION

TO BLACKPOOL SCHEME

COAST PROTECTION

The whole of the Blackpool and Fleetwood coast has heavy sea defences and although they may not be in need of reconstruction for many years, they will require replacement eventually.

Assuming defences to cost about £6 million per Km, and allowing for a 50% reduction on this cost due to the protection provided by the barrage, the capital contribution of the barrage to coastline protection could be valued at approximately £50 million.

MARINAS

The area would be very suitable for sailing. Protected day sailing would be available within the basin, with ready access to the open sea.

Marina berths are extremely expensive and in short supply, certainly in the favoured leisure boating areas, and the general contribution of this scheme to the prosperity of the area could create a ready demand for marinas.

Assuming 2000 marina places were provided, when leased or sold they could produce an equivalent capital contribution of as much as £40 million net.

Housing associated with the marinas

Housing developments associated with water sports facilities are known to be extremely profitable, and it is not hard to imagine an attractive development on reclaimed land, or wholly on piles, grouped round marinas and the lock harbours.

A contribution from a suitable development firm, perhaps one being a member of the barrage implementing or owning companies, could be very substantial.

Perhaps a reasonable contribution would be £20,000 per house and £10 million overall.

Leisure Islands

Artificial leisure islands could contain hotels, restaurants, holiday accommodation and the like, associated with small craft harbours.

Possible contributions from this source could be substantial and a first estimate could be a further £20 million.

Major maritime Theme Park

The nature of Blackpool and the protection offered by the barrage could provide a valuable opportunity for an imaginative large scale scheme.

It is impossible to place a value on its contribution to the tidal energy scheme, but it could be reasonable to equate the value to the purchase of several hundred hectares of land, less the extra infrastructure cost.

On that basis a contribution of about £20 million would be the least to be expected.

Offshore bird sanctuary

It would be possible to provide an artificial island for this purpose, from which birds could benefit from the protected waters and from the habitat provided by the barrage itself.

It would be placed in the hands of the RSPB or similar body, and would be a source of goodwill, but not revenue contribution.

Major City and associated part

The shallow and protected water of the basin would lend itself to a major development, associated with a deep water port and possibly an international offshore airport, all served by electricity from the barrage.

The scope is vast, but no attempt can be made to offset any such source of revenue against the energy cost at this stage.

SCHEME COMPARISON

The above estimate of non-energy revenue for the Blackpool scheme is not likely to be substantially improved upon. Even if it were doubled the cost of energy from a two-way generation scheme off Blackpool is not likely to be less than 4.3 p/KWh on the basis of 30 year write off and 5% discount rate.

There is no prospect of Blackpool scheme being as cheap on energy producer as the Morecambe scheme.

The choice of scheme to be promoted must weigh the prospect of a generally favourable reaction to a Blackpool scheme against the possibility of some (by no means unanswerable) opposition to the Morecambe scheme.

The other factor to consider is overall scheme cost and financing cost, which compare as follows:-

	Capital	Time to start of generation (years)	Approx Financing Cost at 8%	Total debt at start of generation
BLACKPOOL	2553	6	617	3170
MORECAMBE	4544	8	1816	6360

The effect of interest charges is to lessen the difference in energy cost in favour of the smaller scheme. The lower sum to be financed would only be an important consideration if the schemes were otherwise equally attractive financially, which they are not.

FURTHER COMPARISON WITH OTHER ENERGY SOURCES

Severn Barrage

The most up to date report from S.T.P.G. quotes capital cost at the equivalent of £10,240 million at late 1991 prices, and the output has been increased to 17 TWh/annum by re-evaluation of ebb-pumping and by increasing turbine numbers and turbine size.

This gives a comparative energy cost of 4.6p/KWh, as for the very much smaller Blackpool scheme, which compares with 3.6 pence/KWh for the Morecambe scheme.

Comparing finance charges gives:-

	CAPITAL	TOTAL DEBT £ million	DEBT/TWh of output
BLACKPOOL	2553	3,170	773
MORECAMBE	4544	6,360	691
SEVERN	10240	14,460	850

Hence both Blackpool and Morecambe seem much more likely to be financeable than the Severn Scheme, apart from their greater environmental appeal by use of 2-way generation.

Mersey Barrage

The cost of the Mersey scheme has varied little from that set out in the report, and it remains uncompetitive unless it is subsidised for social or other reasons.

Nuclear and Fossil Fuels

Comparison with existing stations is impossible, because of uncertainty regarding the extent to which capital has been written off and the difficulty of price rise adjustments for the older station building cost to bring them to anything like a reliable basis of comparison.

For stations of which the capital has been written off the energy cost has been quoted at less than 2 pence per KWh. For the tidal energy schemes, when of like age, the energy cost would be minute.

This comparison is really useless, because a tidal energy scheme would not be built unless the energy was saleable, which presupposes that older energy producers are to be abandoned.

The comparison can only be made on the basis of what would be the cheapest new method of energy production, and the financeability would be assessed in the light of enhanced rates for clean energy or penalties for CO_2 emissions.

The only reliable comparative cost for new stations were those quoted in PART I of the report from the evidence to the Sizewell enquiry. However the cost of nuclear energy has since been adjusted upward to allow for decommissioning, and of coal to allow for sulphur dioxide removal and other factors.

The figures quoted in PART I are the most reliable that have been obtainable to date. Even if they are somewhat inaccurate, it is clear that no source of energy would be as cheap as the Morecambe scheme, and none cheaper than the scheme off Blackpool. Both would be the cheapest producers of renewable energy.

OFFSHORE LAGOONS

Three areas have been examined. Each would provide a shallow barrage alignment, to enclose a sufficient area to give a basin area/barrage length ratio worth evaluation.

The alignments evaluated are shown on the enclosed chart extracts.

The advantage of the offshore lagoons is that they can be run to optimise generation value, without reference to the natural tide conditions at the shore line. Thus pumped storage could be used to a greater level of surcharge than is possible in open coastline or estuary schemes.

I. NORFOLK COAST

A large shallow area exists off the North Norfolk coast, which offers prospects for an offshore enclosed basin having acceptably low impact on this Heritage coastline. The tidal range is at the lower limit of interest for large scale tidal energy schemes.

II. BLACKPOOL

A relatively small area could be enclosd off Blackpool, but the tidal range is better than for the Norfolk scheme and environmental problems would not be great in this location. There could be non-energy benefits, as for the Blackpool scheme (Lancs III).

III. LES MANQUIERS

This area has huge tidal range and a shallow alignment could enclose a large area.

Environmental objections may arise; although access for leisure or fishing boats need not necessarily be denied.

This general area (between the channel islands and the Cotentin peninsula) has been studied before, but not we believe as a site for a wholly offshore scheme such as this.

BASIS OF COSTS

The Civil costs have all been arrived at by the same means as the coastline schemes, except that the basic barrage cost for Les Manquiers has been increased by 20% to allow for the extra caisson height and extra width required to cater for static overturning forces from the higher tide range.

For each of the three schemes a more elaborate pump/turbine has been estimated for.

The summary of costs are set out below.

ENERGY OUTPUT CALCULATIONS

The energy has been estimated from turbine numbers which have only been very approximately optimised for lowest energy cost, on the basis that the generation would be on ebb-only, with pumped surcharge, generating on every ebb tide.

It may prove better to run these wholly offshore schemes as base load generators during the summer, and for short term peak lopping during winter, but this aspect has not been investigated here.

COST ESTIMATE

SUMMARY

North Norfolk (offshore enclosed basin)

enclosing 246 Km²

EBB GENERATION WITH PUMPING

CIVIL	**£ million**
Barrage	1325
Draft Tubes (232 x 0.5)	116
Sluice Caissons (3Km @ £13m extra over plant caissons)	39
Locks	40
	1520
10% Design Contingency	152
	1672
MECH AND ELECTRICAL	
Turbine enclosures (232 @ 0.6)	140
Vertical gates 13000m²	47
Turbines (232 @ £3.6 million)	835
Lock gates	6
	928
Total Civil + M/E	2600
17½% construction contingency	455
	3055
4% Design, Management and Environ Study	122
	3177

Estimate used in energy cost calculation
(excludes cost of connection to grid)

COST ESTIMATE

SUMMARY

Blackpool (offshore enclosed basin)

enclosing 60 Km²

EBB GENERATION WITH PUMPING

CIVIL	**£ million**
Barrage	596
Draft Tubes (57 x 0.5)	28
Sluice Caissons (.6Km @ £13m extra over plant caissons)	10
Locks	20
	654
10% Design Contingency	65
	719
MECH AND ELECTRICAL	
Turbine enclosures (57 @ 0.6)	36
Vertical gates 2600m²	10
Turbines (57 @ £3.6 million)	205
Lock gates	4
	255
Total Civil + M/E	974
17½% construction contingency	170
	1144
4% Design, Management and Environ Study	44
	1188

Estimate used in energy cost calculation
(excludes cost of connection to grid)

COST ESTIMATE

SUMMARY

Les Manquiers (offshore enclosed basin)

enclosing 135 Km^2 Gross

127 Km^2 effective

EBB GENERATION WITH PUMPING

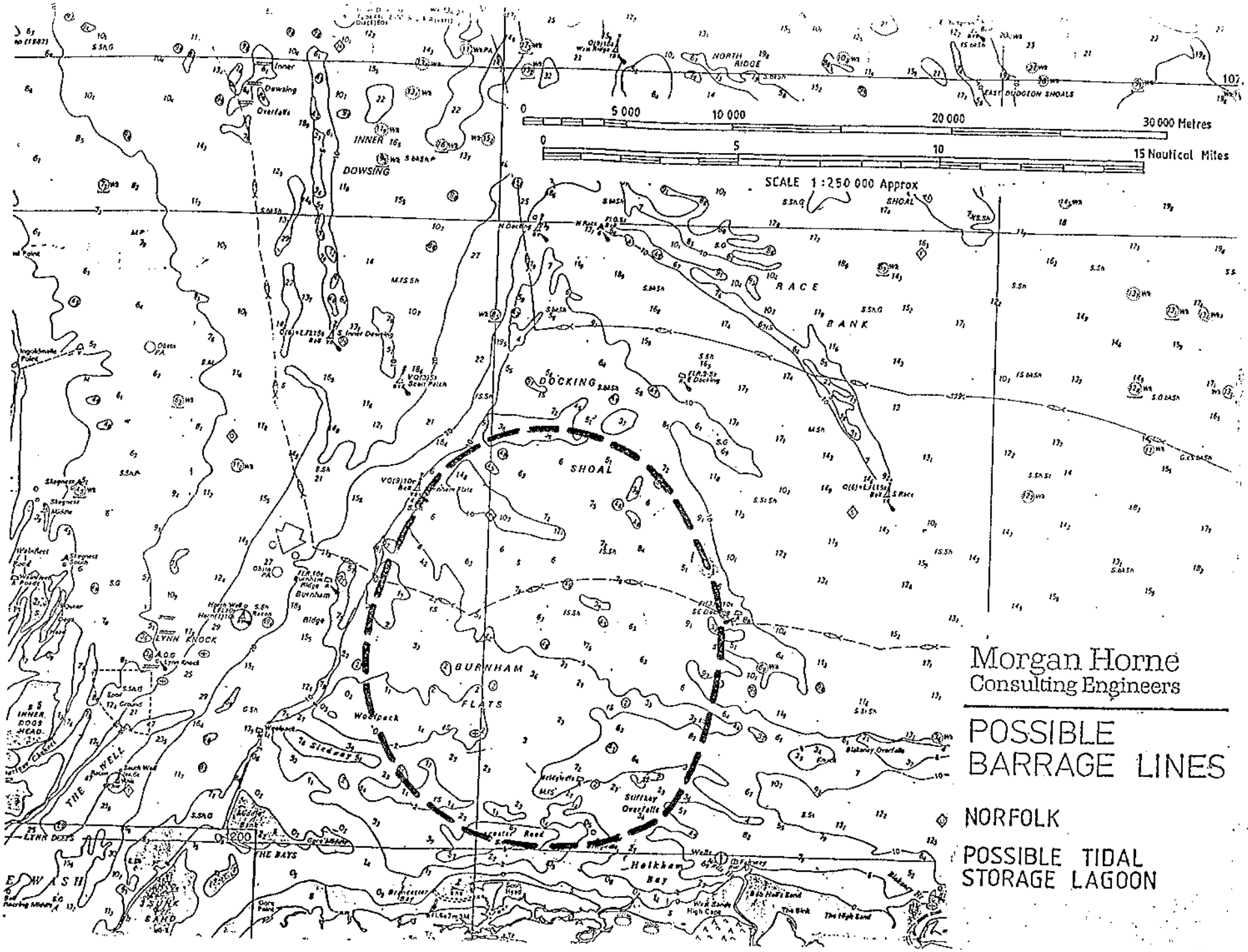
CIVIL	**£ million**
Barrage	1380
Draft Tubes (120 x 0.5)	60
Sluice Caissons (1.5Km @ £13m extra over plain caissons	20
Locks	30
	1490
10% Design Contingency	150
	1640
MECH AND ELECTRICAL	
Turbine enclosures (120 @ 0.6)	72
Vertical gates 6000m^2	22
Pump/Turbines (120 @ £3.6 million)	432
Lock gates	6
	532
Total Civil + M/E	2172
17½% construction contingency	380
	2552
4% Design, Management and Environ Study	102
	2654

Estimate used in energy cost calculation
(excludes cost of connection to grid)

SUMMARY OF CAPITAL AND MAINTENANCE COSTS OFFSHORE ENCLOSED BASINS

	CAPITAL COST £ million	ENERGY OUTPUT TWh. p.a.	MAINT. COST £ million p.a.	ENERGY COST 30 years 5% p/KWh
NORTH NORFOLK	3177	(2.3)* (2.7)*	29	10.0 8.6
BLACKPOOL	1188	1.2	11	7.2
MANQUIERS	2654	(3.0)* (4.8)*	24	6.6 4.2

* The tidal range is uncertain from information available. The energy outputs quoted are the upper and lower limits of reasonable predictions, as are the energy costs.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SCALE 1:250 000 Approx
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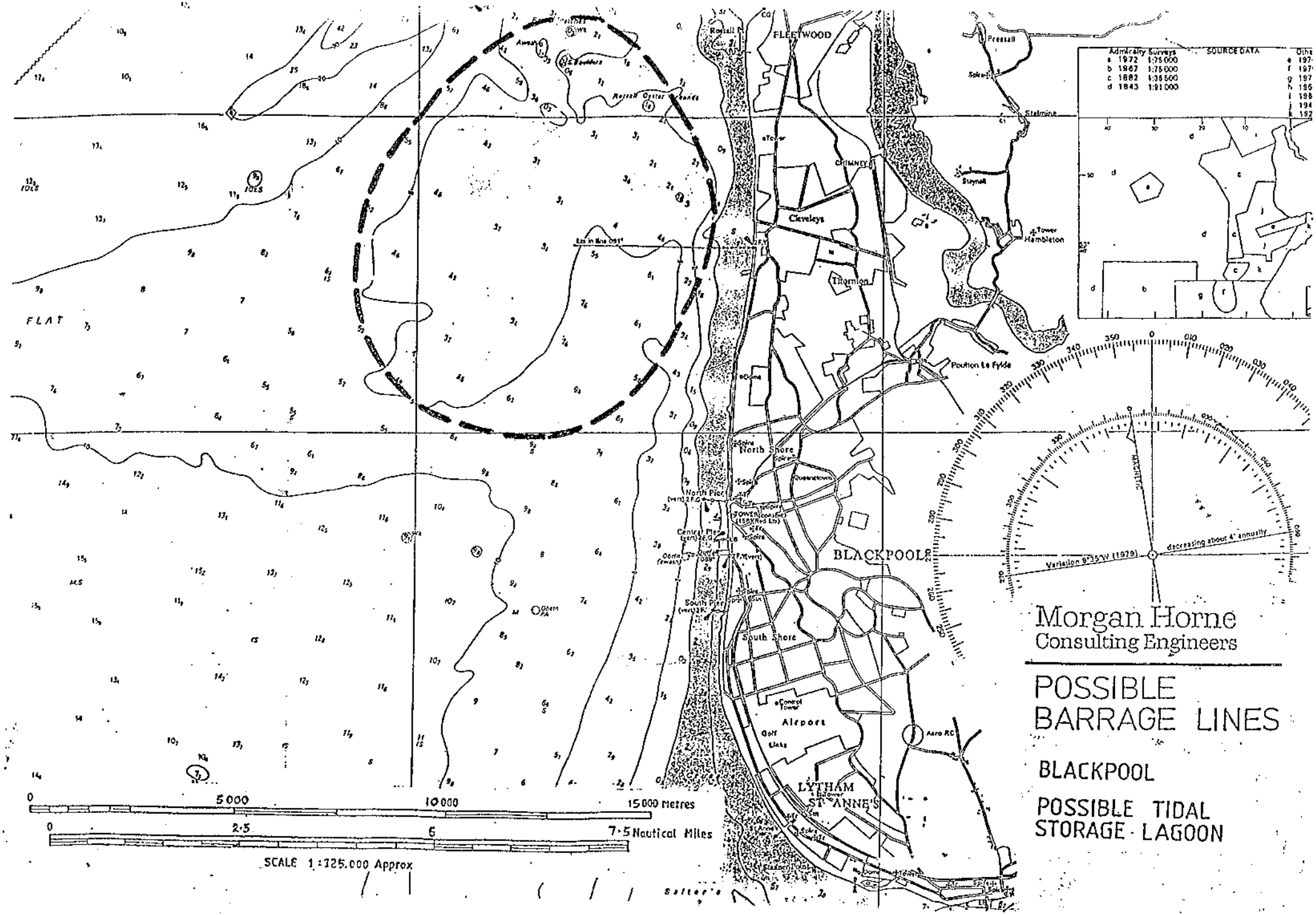
POSSIBLE BARRAGE LINES
NORFOLK
POSSIBLE TIDAL STORAGE LAGOON
DOWSING
INNER
NORTH RIDGE
RACE BANK
DOCKING SHOAL
BURNHAM FLATS
LYNN KNOCK
THE WELL
SUNK SAND
THE BAYS
Holkham Bay
EAST DUDGEON SHOALS



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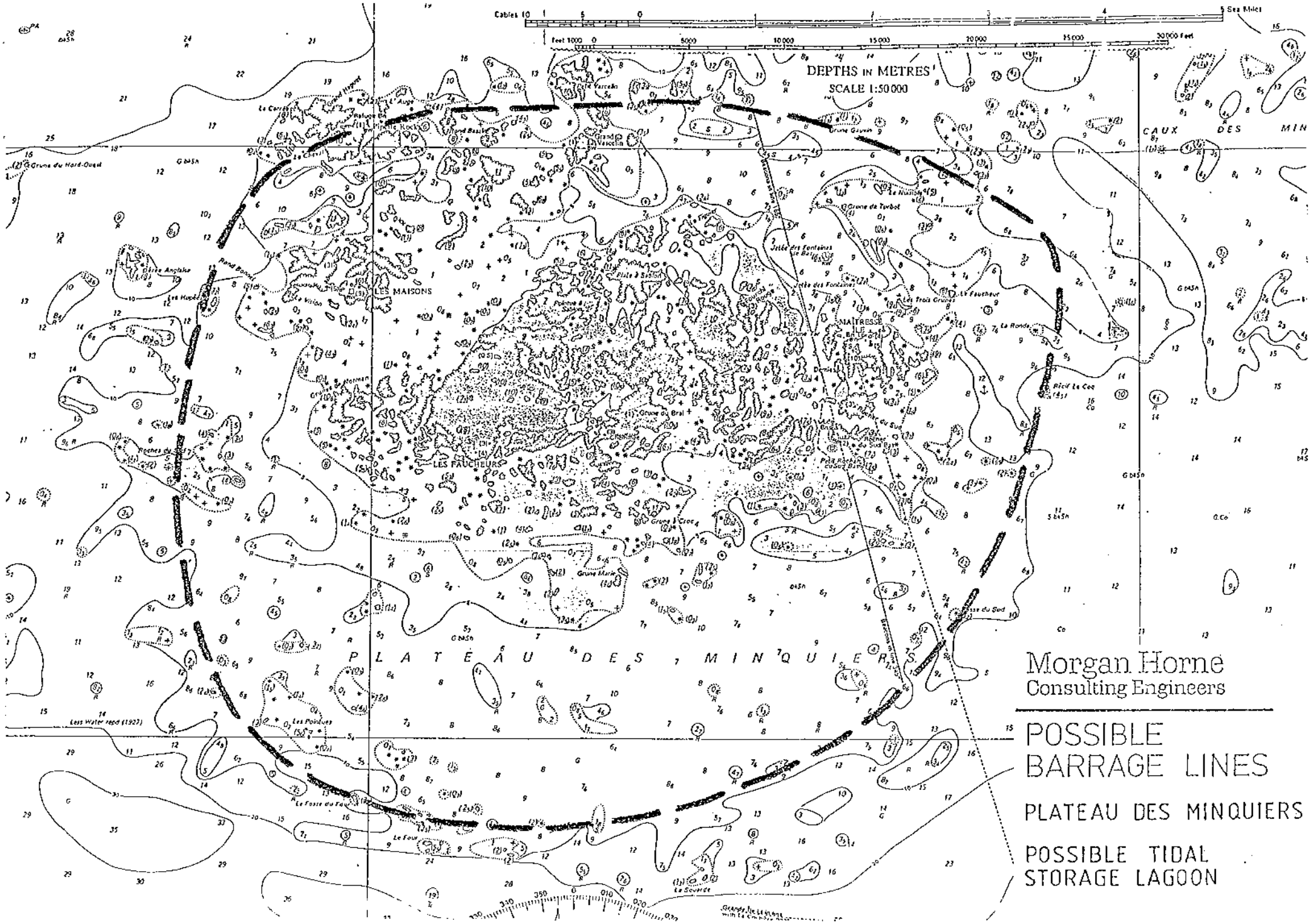
POSSIBLE BARRAGE LINES

BLACKPOOL

POSSIBLE TIDAL STORAGE - LAGOON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LES FAUCHEURS
MAITRESSE
CAUX DES MIN
PLATEAU DES MINQUIERS
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POSSIBLE
BARRAGE LINES
PLATEAU DES MINQUIERS
POSSIBLE TIDAL
STORAGE LAGOON