DEPARTMENT OF ARTS, HERITAGE GAELTACHT AND THE ISLANDS

STUDY OF DRAINAGE OPTIONS FOR LADY'S ISLAND LAKE AND TACUMSHIN LAKE

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Prepared by:
Malachy Walsh & Partners,
Boreenmanna Road,
Cork.

Client:
Department of Arts, Heritage,
Gaeltacht and the Islands
17/19 Lr. Hatch St.
Dublin 2

In association with:
Posford Duvivier,
Rightwell House,
Bretton,
Peterborough PE3 8DW,
UK.

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AND
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1.0 INTRODUCTION

1.1 General

Malachy Walsh & Partners were commissioned in February 1998 by the Department of Arts, Heritage, Gaeltacht and the Islands (DAHGI) to carry out a study of methods of draining Lady's Island and Tacumshin Lakes in Co. Wexford. The principal aims of the study were:-

- to develop a feasible and cost effective method of controlling water levels in Lady's Island Lake.

- to evaluate options for improving the existing method of controlling water levels in Tacumshin Lake.

In each case the conflicting needs of land drainage and environmental requirements are to be satisfied. In addition the potential impacts of drainage structures on coastal processes were to be assessed. Figures 1.1 and 1.2 show location plans for the two sites.

1.2 Background

1.2.1 Lady's Island Lake

Water levels in Lady's Island Lake are due to a combination of factors including: rainfall, overtopping of the beach by waves, seepage through the beach and evapotranspiration of rainfall. Periodically, when water levels in the lake are high, the lake is drained by forming a cut in the beach. The cut is initially narrow, but, eventually the water flowing from the lake lowers and widens the cut by an uncontrolled amount. A width of cut up to 263m has occurred in the past.

This method of draining the lake gives rise to a number of problems, which include the following:-

- lake levels have been so lowered as to threaten the lake's value as an area of environmental interest. In addition large areas of foul smelling lake bottom have been exposed and the appearance of the area changes considerably.

- the lake area can become tidal for a period following a "cut". This can result in an increase in the salinity of the lake water with potentially adverse environmental impacts. Usually the cut closes within a matter of weeks. However the cut has remained open for months in some instances.

- The barrier beach is vulnerable to overtopping by wave action. Overtopping caused an overnight increase in water level of 0.5m during December '89. The area of the cut is particularly vulnerable to overtopping.

- there is continuing conflicting pressures on the Lake Drainage Committee. On the one hand, from land and house owners in the vicinity for lower lake levels and from those representing environmental interests for higher lake levels.

1.2.2 Tacumshin Lake

Variations in water levels in Tacumshin Lake are caused by the same mechanisms as at Lady's Island. However, the lake waters drain through a pipeline buried in the beach.

There is a perception that the existing pipeline is insufficient to drain the lake. The existing pipeline, built in 1974, would appear to have extended further seawards. At times the seaward mouth of the pipe becomes filled with beach material impeding the flow of water in the pipe and reducing its ability to drain the lake.

There are conflicting pressures regarding the water level at Tacumshin. Environmentally the lake is of international importance and is, like Lady's Island, a proposed Special Area of Conservation (SAC). The habitat depends on the maintenance of water levels within the lake, whereas the drainage of the land surrounding the lake would be improved by lowering water levels.

1.3 Scope of Study

The study is to examine options for improving the drainage of both Lady's Island and Tacumshin Lakes. In both cases, particular emphasis is to be placed on the possible impacts options may have on coastal processes and vice versa.

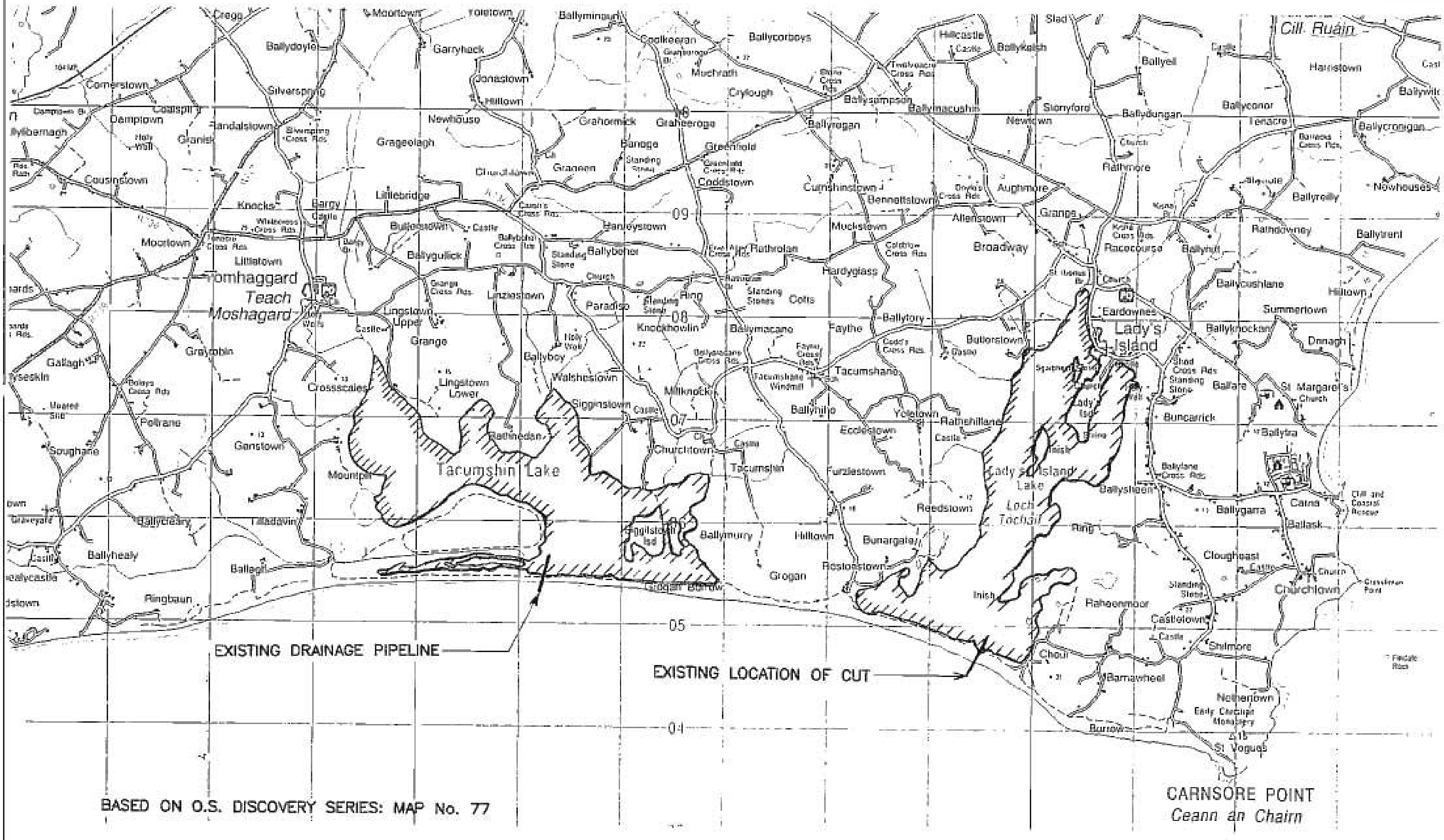
For Lady's Island Lake the study examines options for controlling the water level. Options using a pipeline through the beach and options based on limiting the size of the cut are evaluated in terms of their effectiveness in maintaining water levels between desirable limits, cost and impact on coastal processes.

For Tacumshin Lake an evaluation is made of options for improving the existing drainage. In the case of Tacumshin the evaluation concentrated on the use of some form of pipeline through the beach. Options are evaluated in terms of effectiveness, cost and impact on coastal processes.

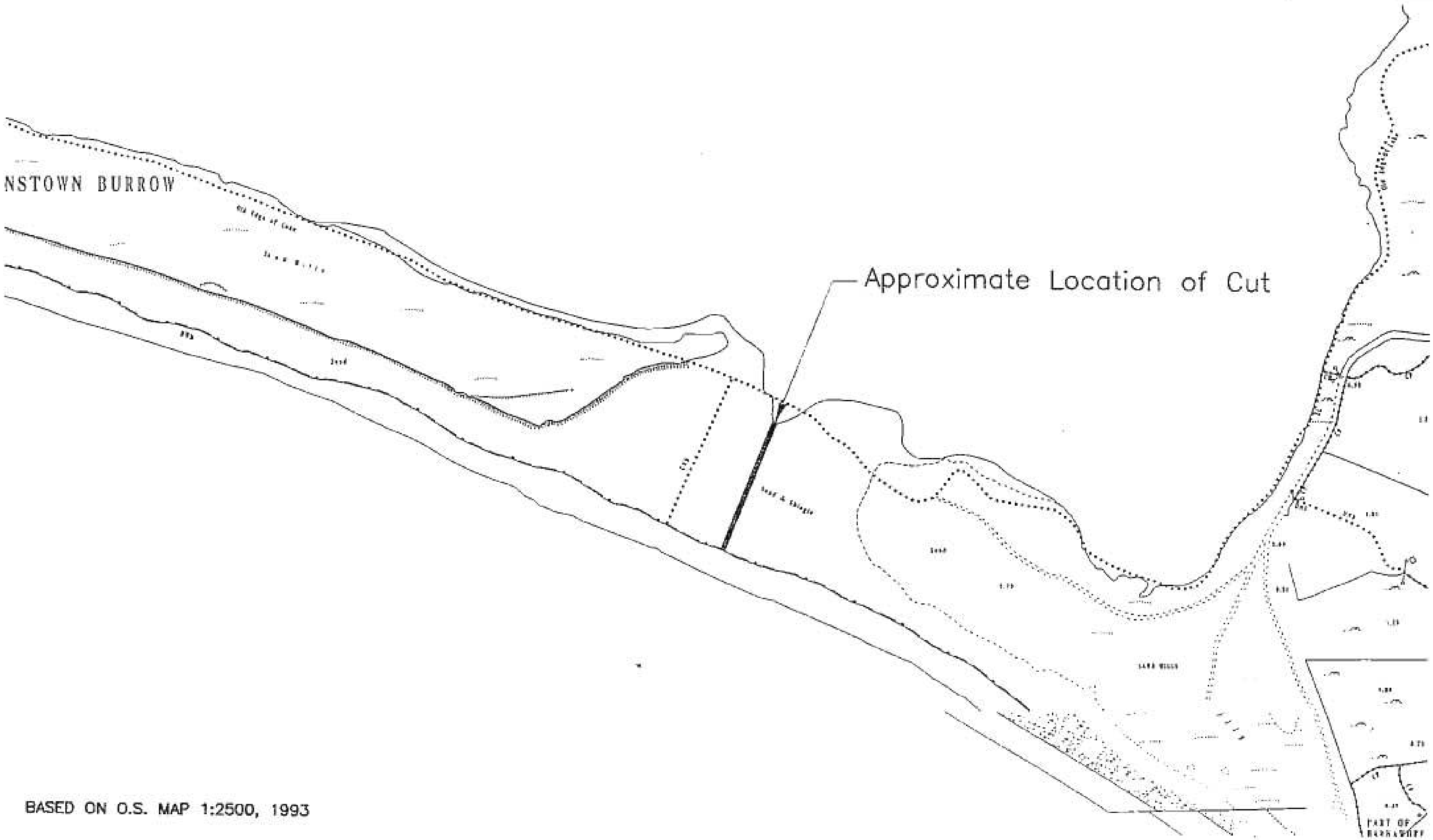
1.4 Acknowledgements

We would like to take this opportunity to acknowledge the assistance received on various aspects of the study from:

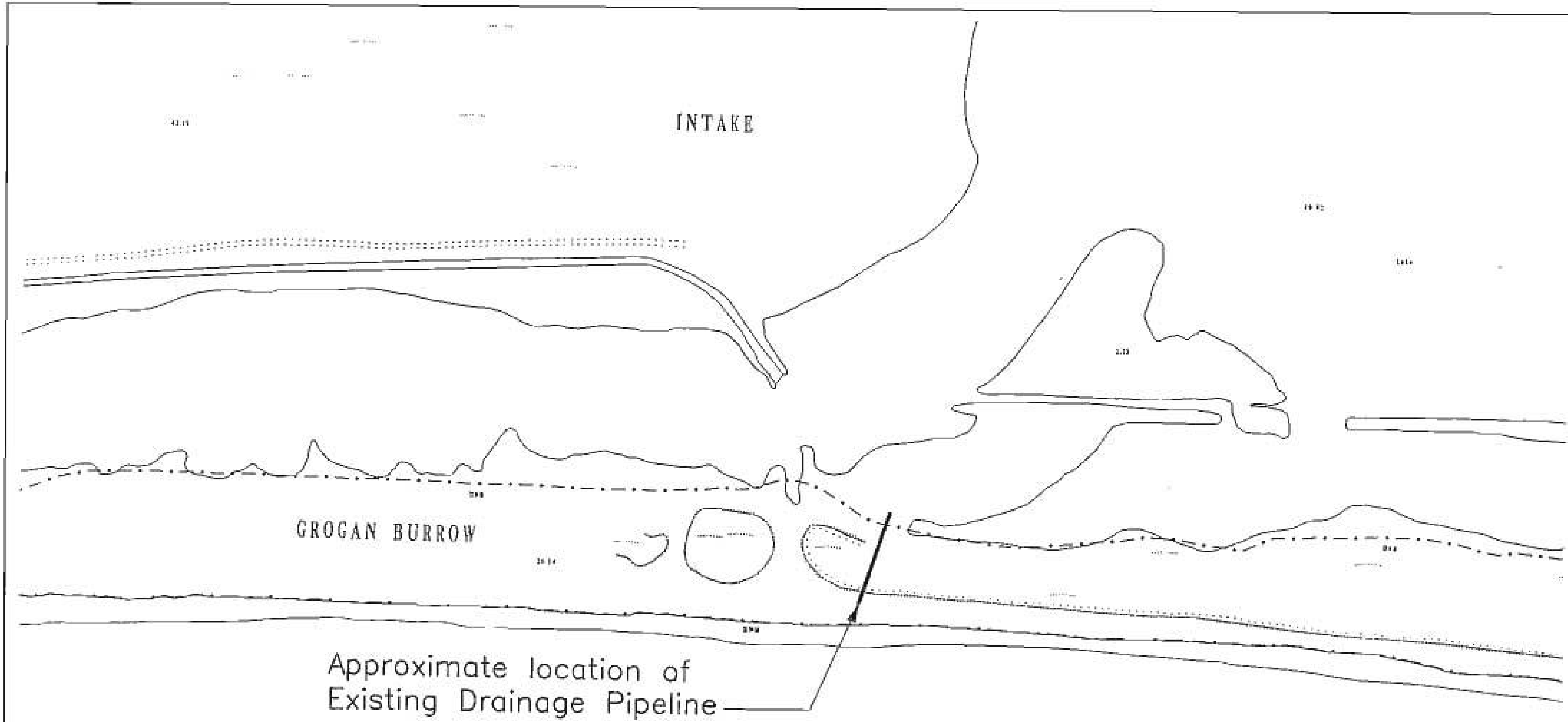
- Department of Arts, Heritage, Gaeltacht and the Islands (NPWS)
- Ordinance Survey
- SWC Promotions (Mr. Jim Hurley)
- Wexford County Council



Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	LOCATION PLAN	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98	1:50000
				[redacted] Figure 1.1	



Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	DrainageOptions Lady's Island Lake Tacumshin Lake	LOCATION PLAN LADY'S ISLAND LAKE	Malachy Walsh and Partners / POSFORD DUVIVIER	MAY '98	1:5000
				Drawn	Chkd.
				[redacted]	
				Figure 1.2(a)	



BASED ON O.S. MAP 1:2500, 1993

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	LOCATION PLAN TACUMSHIN LAKE	Malachy Walsh and Partners / POSFORD DUVIVIER	MAY '98	1:5000
				[redacted]	
				Figure 1.2(b)	

2.0 DESCRIPTION OF SITE

2.1 General

The topography of south Wexford is relatively low lying in the vicinity of Lady's Island and Tacumshin Lakes. The area consists of a veneer of boulder clay overlying rock (possibly granite). During the ice age, it is thought that the area of each lake was a spillway from an ice sheet to the north. Following the ice age it is thought that rising sea level drove gravel material northwards to form beaches trapping water in the areas of Tacumshin and Lady's Island Lakes.

The lakes are of similar size and in each case, the surrounding land drains into the lake and seawards through the barrier beach. The material of each barrier consists of a coarse sand to fine gravel . d_{50} values of 1 to 3mm were obtained for the four beach material samples analysed, see Appendix B for grain size curves.

Figures 2.1 and 2.2 show the profile of the barrier beach, in the vicinity of the cut at Lady's Island and the existing drainage pipeline at Tacumshin respectively.

2.2 Lady's Island Lake

The lake has a surface area of approximately 450ha and a catchment area of 18.9km^2. The lake level usually varies from 3.2m ODM (5.79 m ODD) to below 0.0m ODM (2.59m ODD). ODD is Ordinance Datum Dublin or Poolbeg and is 2.59m below ODM (Malin). ODM approximate to mean sea level (MSL).

The water from the lake is presently drained into the sea by forming a cut through the barrier beach, usually in late March of each year. A meeting of the Lake Drainage Committee is called, to discuss the "cutting of the lake" when water levels exceed 1.91m ODM, ie. 4.50mODD.

The barrier fronting the lake is approximately 1.5km long, varies in height up to 7.4mm ODM (10.0m ODD) and has a width of some 250m, between 0.0m ODM on the seaward side to the water level in the lake (1.24m ODM (3.83m ODD) following the cut of March '98).

The barrier consists of coarse sand/fine gravel. Trial pits dug in the vicinity of the cut indicated that there was little variation in material with depth through the barrier. Grain size analysis indicated that the material in the vicinity of the cut has a d_{50} grain size of 2 – 3mm. Ref 1 states that the barrier overlies peat which in turn overlies granite.

To each side of the cut the barrier beach is topped with sand dune type vegetation. In these areas, the material immediately under the vegetation is sand. In the area of the cut, the fine material has been removed from the crest of the beach.

2.3 Tacumshin Lake

Tacumshin Lake is fronted by a barrier beach of some 3.5km in length. The barrier is similar to that fronting Lady's Island Lake, but is not as wide. A distance of 130m was measured between mean sea level on the seaward side and a level of -0.45m ODM (2.14m ODD) on the lake side. The surface area of the lake varies considerably depending on the water level. It is however similar to that of Lady's Island Lake, approximately 450ha. The catchment area of Tacumshin Lake is some 40km^2. Figure 2.3 shows the approximate catchment area of Tacumshin Lake.

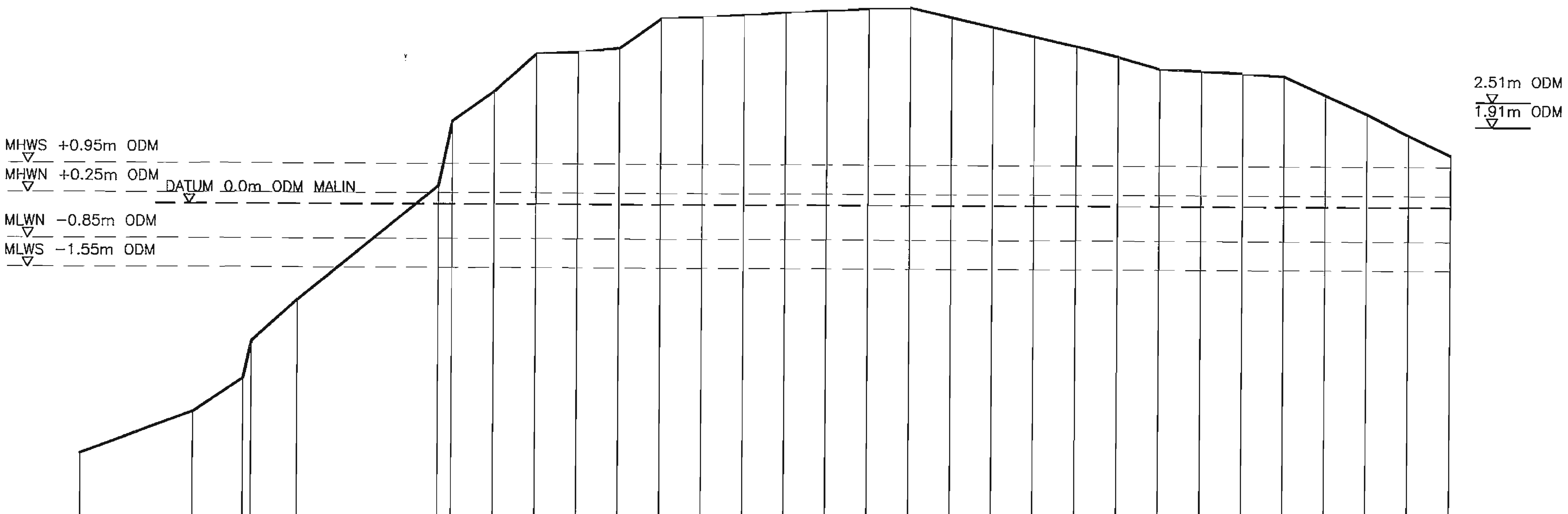
The barrier beach of Tacumshin has been breached at least twice in the past. In each case the breach moved west to the western extremity of the barrier where it remained open for about 30 years. As a consequence of these breaches, the crest elevation of the barrier is lower over the western part of the barrier than the eastern part.

A pipeline has been laid through the barrier approximately 1.6km from the western end. This pipeline has been constructed three times. In the 1860's a wooden culvert was built. A few years later an iron culvert was built and worked until 1910. The present pipeline was built in 1974, and uses the vent pipe and tidal flap of the iron culvert. The invert level of this pipeline is relatively low at approximately –1.75m ODM (0.84m ODD).

EXAGGERATED VERTICAL SCALE
0.0m OD MALIN = 2.59m ODM (POOLBEG)
ALL LEVELS TO OD MALIN

HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:100

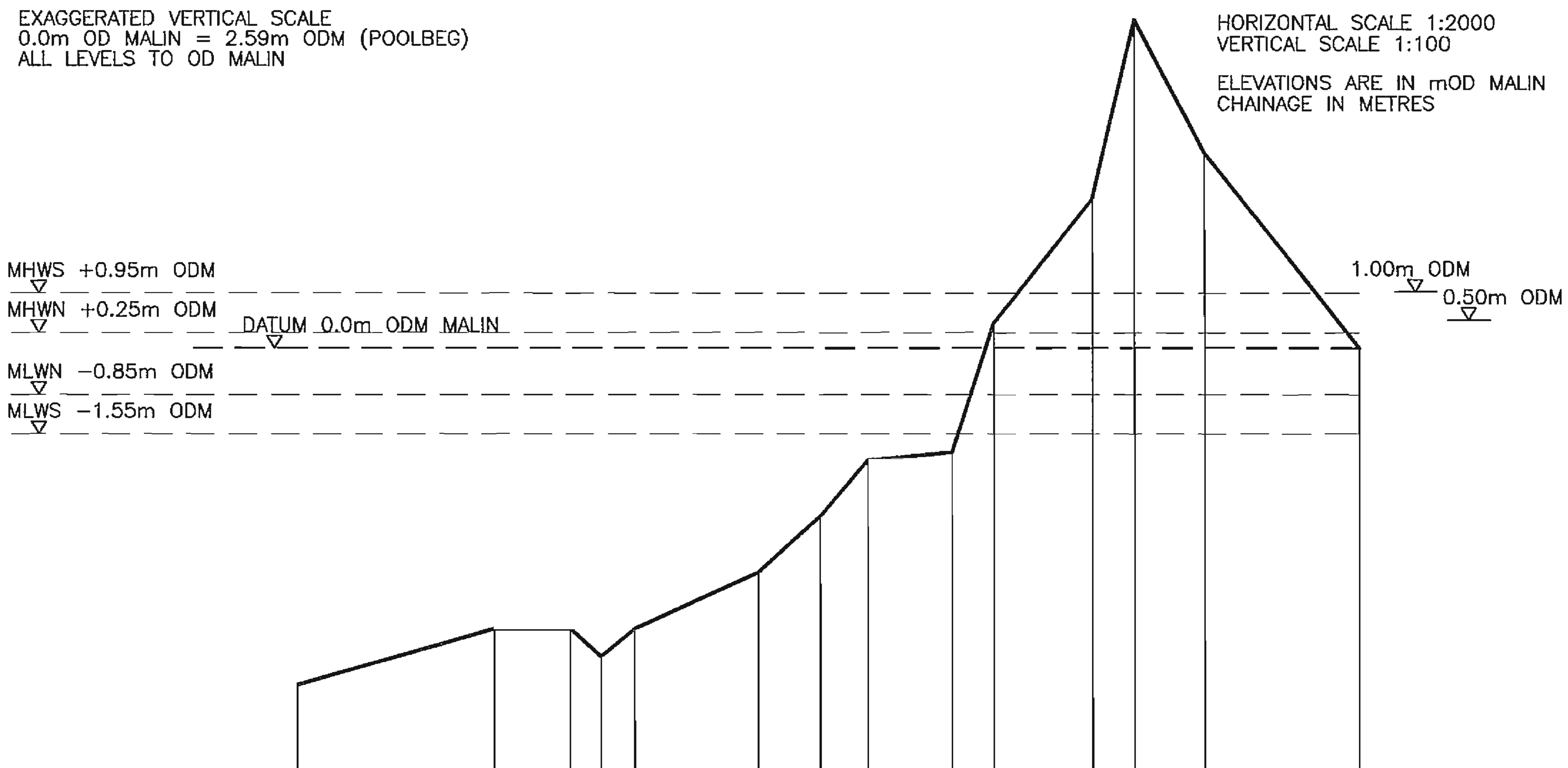
ELEVATIONS ARE IN mOD MALIN
CHAINAGE IN METRES



ELEVATION	−6.00	−5.00	−4.20	−3.30	−2.30	0.450	2.000	2.710	3.610	3.660	3.760	4.470	4.520	4.570	4.630
CHAINAGE	0	27	39	41	52	86	89.3	96	106	116	126	136	146	156	166

ELEVATION	4.680	4.730	4.760	4.530	4.300	4.070	3.840	3.590	3.300	3.260	3.210	3.140	2.680	2.230	1.720	1.240
CHAINAGE	176	186	196	206	216	226	236	246	256	266	276	286	296	306	316	326

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	LADY'S ISLAND LAKE BARRIER BEACH PROFILE	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98	AS SHOWN
				[redacted]	
				Figure 2.1	

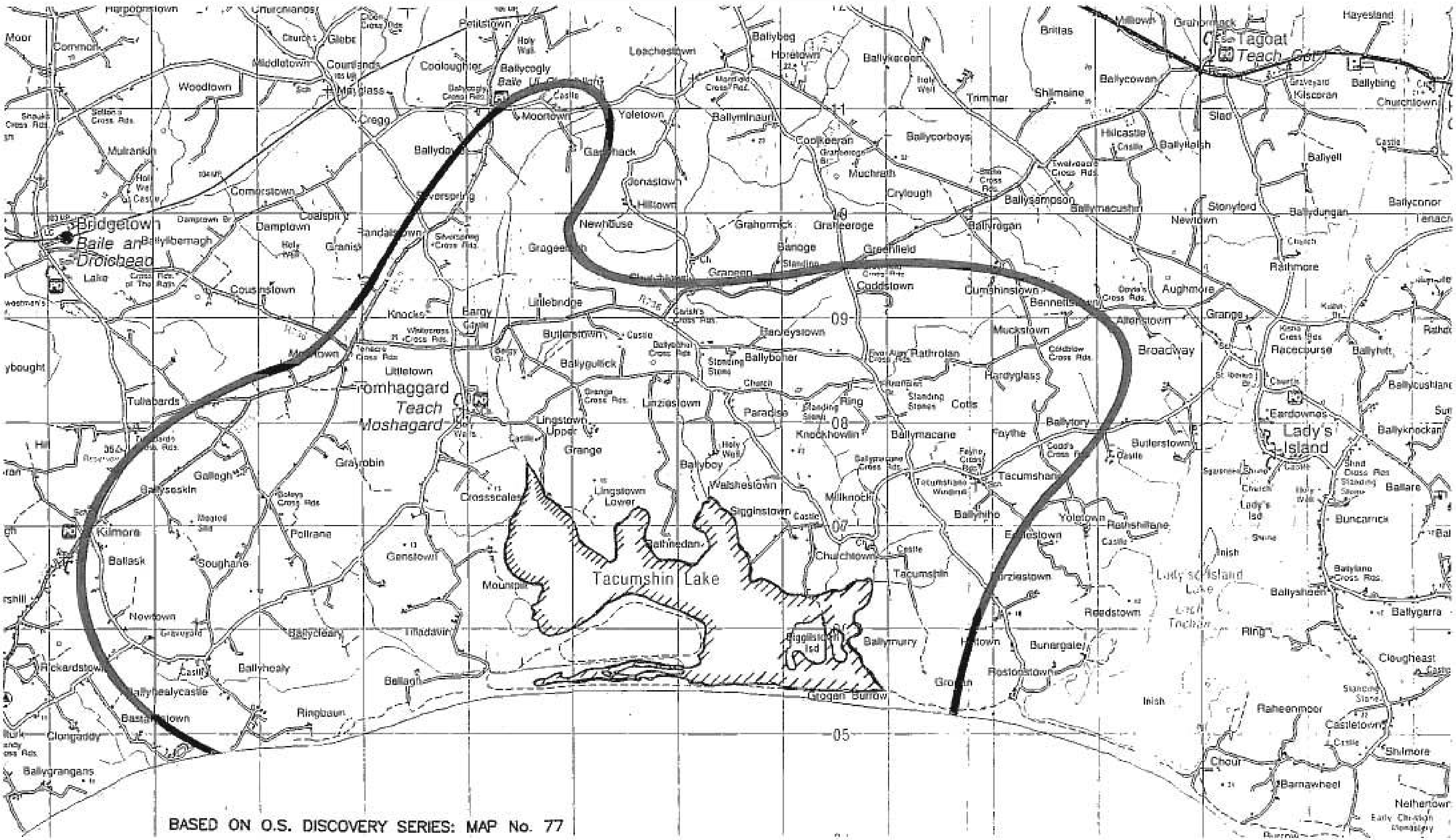


ELEVATION	−6.00	−5.00	−5.00	−5.50	−5.00	−4.00	−3.00	−2.00	−1.85	0.450	2.200	5.650	3.470	−0.40
CHAINAGE	0	70	97	108	120	164	186	203	233	248	283	298	323	378

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	TACUMSHIN LAKE BARRIER BEACH PROFILE	Malachy Walsh and Partners; POSFORD DUVIVIER	MAY '98	AS SHOWN

[redacted]

Figure 2.2



Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	DrainageOptions Lady's Island Lake Tacumshin Lake	TACUMSHIN LAKE APPROXIMATE CATCHMENT AREA	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98	1:50000
				[redacted]	
				Figure 2.3	

3.0 COASTAL PROCESSES

3.1 General

Water levels in the sea, changes in beach profile and the movement of seabed sediment are important coastal processes parameters when considering drainage options. An assessment of these coastal processes at Lady's Island and Tacumshin Lakes has been carried out as part of this study.

Prior to the assessment of coastal processes a survey of seabed levels was carried out and trial pits dug at both potential drainage locations. At each site a 200mm by 300m area of seabed was surveyed. During these surveys, grab samples were taken of seabed surface material and the grain size of the samples was visually assessed. The results of this survey are given in Appendix A. Beach material samples were taken at each trial pit. The pits indicate that the material of the barrier beach varies little with depth. However, the nature of the beach material and local water levels limited the depth of these trail pits to 1.5 to 2.0m. The lowest level within a trial pit was at –1.0m ODM (1.59m ODD).

The location of the sediment samples and the grain size distribution curves are given in Appendix B. Tables and figures detailing the results of the assessment of coastal processes are given in Appendix C. These tables and figures relate to:

- Normal and extreme tide levels.
- Normal and extreme offshore wave conditions.
- Longshore sediment transport rates both gross and nett.
- Plots of variation in longshore sediment transport rates with distance from the shore.
- Plots of changes in beach profile due to the 50 years offshore wave condition for a neap, spring and surge tide.

The findings of the assessment and how they impact on drainage options are described below.

3.2 Tide Levels

The discharge capacity of a pipeline through the barrier beach depends on the relative water levels in the sea and the lakes.

The Local Drainage Committee's preferred maximum, mean and minimum water levels of 2.51, 2.21, and 1.91m ODM (5.1, 4.8, 4.5 m ODD) respectively, are given in ref 1. These compare with MHWS (Mean High Water Springs) and MHWN (Mean High Water Neap) tide levels of 0.95 and 0.25m ODM (3.54 and 2.84 m ODD) respectively. These levels indicate that there is a reasonable amount of head available to drive discharge flows. However, it is also likely that in order to obtain sufficient head a pipeline option is likely to exit the seaward face of the beach within the tidal zone.

The existing pipe at Tacumshin is below mean sea level. Existing levels within Tacumshin are below MHWS. Tide levels are given in Table C1 of Appendix C.

Interpolation of Admiralty Tide Table data for Dunmore East and Rosslare using co-tidal chart no. 5058 gives a MHWS estimate of 0.95 ODM. Ref. 1 states that R.W.G. Carter recorded MHWS as 1.4m. ODM. Considerable change in tide levels takes place between Dunmore East and Rosslare. Most of this change would seem to take place east of Kilmore Quay. Before detailed design of drainage options can be undertaken, accurate tide levels should therefore be established for Lady's Island and Tacumshin Lakes. This would require the recording of sea water levels in the area for at least a one month period and analysing the results.

3.3 Wave Conditions

Extreme waves offshore of the south Wexford Coast can be very large. 50 year return period waves of 8 to 9m significant height (height of the highest one third waves) can occur offshore. (See tables C2 and C3, Appendix C). Such large waves would be reduced considerably, as they travel towards the shore, by breaking due to shallow water depths. The maximum significant wave height at the –5m ODM contour will be in the order of 3 to 4m. Maximum nearshore wave heights will occur during a surge tide combined with storm conditions from the southerly sector.

3 to 4m waves can occur at Lady's Island within 60m of 0.0m ODM, i.e. approximate mean sea level. Because of the seabed profile such waves will occur 120m seawards of the 0.0m ODM line at Tacumshin.

The actual design wave for a drainage outlet will depend on the outlet location. The further down the beach the outlet, the higher will be the design wave. Water levels 25m seawards of the 0m ODM line would limit waves to approximately 2.1m significant wave height at both Lady's Island and Tacumshin. The design wave height for pipeline outlets to both lakes is likely therefore to be in the range 2 to 2.5m, significant wave height.

3.4 Sediment Transport

The results of the assessment of long and cross shore sediment transport indicated that:

- the net longshore sediment transport rate is almost zero at Lady's Island and is towards the west at Tacumshin. However, gross transport at both locations is large and of similar magnitude. Gross rates of approximately 90,000 and 100,000 m^3/year were estimated for Lady's Island and Tacumshin respectively.

- maximum longshore transport takes place within 50m of the shore at both sites. While most of the the longshore transport takes place within 75m of the shore, the active transport zone at Tacumshin extends a considerable distance further seaward than at Lady's Island. It actually extends some 275m. This is due to differences in nearshore profile. At Tacumshin shallow depths extend further seaward than at Lady's Island.

- when the 50 year offshore wave condition was applied to the existing beach profiles at each site, considerable changes took place in the beach profile. In each case material was taken from the upper part of the beach profile and transferred to the lower part. Above –2m ODM (0.59m. ODD), the beach tended to retreat. Below -2.0m ODM the beach toe tends to move seaward. The volume of material moved is sensitive to sand grain size. For the Lady's Island profile, using a d_{50} of 3mm (as measured from the Lady's Island samples), the beach crest is estimated to retreat some 2 to 3m and the toe moves seawards some 10 to 15m. Using a d_{50} of 1mm the crest retreats some 20m and the toe advances by 75m. See Appendix C, figures C3 to C5.

- the existing profile at Tacumshin Lake does not appear to be as responsive to wave action, when using a d_{50} of 2mm (as measured from the Tacumshin sample, sample D). However, using a d_{50} of 1mm (see sample C), it is estimated that a 100m width of beach undergoes a profile change. See Appendix C, figures C6 to C8.

3.5 Retreat of Barrier Beach

In addition to longshore sediment transport and onshore/offshore movement of material during storms, there is a continuous movement of the beach landwards. This is caused by material on the seaward face being washed over the back of the crest of the beach. This is known as beach roll over. Various estimates of roll over have been made and are quoted in ref 1. Ref 1 states that estimates based on the age of the peat that is now in front of the barrier would indicate a roll over rate of 0.05m/year. A comparison of the “actual” barrier location in 1875 with that shown on the 1840 map is stated to give a roll over rate of 0.5m/year during this period. A comparison of maps from 1840 through 1895, 1922 and 1993 carried out as part of this study found that the roll over rate is likely to be between 0.05m/year and 0.5m/year.

A comparison between the tide marks indicated a retreat rate of 0.28m/year between 1922 and 1993 at Lady’s Island. However, a comparison of the location of the vegetation line indicated a retreat rate of approximately 0.2m/year to the west of the cut during the same period. However, the vegetation line to the east moved seawards during the same period. These rates relate to the barrier beach fronting Lady’s Island.

At Tacumshin Lake, there seems to have been some forward movement of tide marks between 1895 and 1922. However, there would appear to have been an overall retreat of some 0.2 to 0.3m/year in the tide marks since 1922. As with Lady’s Island, the vegetation line does not move as much as the tide mark, retreating at a rate of 0.2m/year. It is felt that, at both locations, retreat rates based on the vegetation line is likely to be a better indication of erosion and roll over than rates based on tide marks.

A design retreat rate of 0.2m/year would seem to suffice for both locations.

3.6 Conclusions

Drainage options therefore need to be considered in the light of the nearshore wave conditions, the volumes of longshore transport, the extent of the zone over which much of the longshore transport and beach profile changes take place, and the continual retreat of the barrier beach.

The coastal process assessment indicates that in order to minimise the risk of burying the pipeline outlet in beach material, the outlet should either be placed above the area of profile changes or extend seawards to at least the –6.0m ODM (-3.41m. ODD) contour. It would also be safer to hold an underwater pipe in an elevated position with respect to the seabed. The invert of the pipe would need to be held 1 to 1.5m above the existing bed level at the –6m contour in order to stay out of the range of beach profile changes. The –6m ODM contour is some 100m seawards of MSL at Lady’s island Lake, and some 200m seawards of MSL at Tacumshin Lake.

It would be best, of course, if it were possible that the outlet could discharge on the beach above any change in beach profile. However, levels in the lakes are such that this is unlikely in the case of Lady’s Island Lake and impossible in the case of Tacumshin Lake. However, it is still likely to be more cost effective to keep the outlet as far up the beach as possible, than to extend a pipeline to the –6m ODM contour.

Accurate tide levels need to be established for the study area. Such levels can only be established by recording water levels and analysing the results for tidal constants.

4.0 Drainage Parameters

4.1 General

With the exception of the existing methods of drainage, water levels in both Lady's Island Lake and Tacumshin Lake depend on the same combination of factors. The levels depend on: rainfall on the lake and on the lake catchment area ; water losses to the atmosphere due to evaporation and transpiration ; seepage through the barrier beach ; and overtopping of the barrier. For each lake these factors will have different effects on water levels, because of, amongst other things, lake size, catchment size, lake water level, barrier beach width, length, crest height and material. Lady's Island Lake levels are lowered periodically by forming a cut through the barrier beach. There is an existing drainage (1.05m diameter) pipeline through the barrier beach at Tacumshin Lake.

Increases in water level are due to rainfall, waves overtopping the barrier beach and seepage from the sea in to the lake. Lowering of water levels are due to existing drainage methods, evapotranspiration losses and seepage from the lake to the sea. Within the scope of this study, it is not possible to determine exactly the sensitivity of water levels to each individual factor. However, a wealth of information has been compiled in ref. 1 by Mr. Jim Hurley on variations in water levels in Lady's Island Lake.

This data can be used to estimate possible increases and decreases in water levels due to combinations of factors. Such estimates will be sufficient to evaluate drainage options.

The effects of the principal factors governing water levels in Lady's Island Lake are discussed below. While much less data exists for Tacumshin Lake an assessment will be made of discharge requirements based on Lady's Island Lake data and a comparison of lake size and catchment area between Lady's Island and Tacumshin Lakes.

4.2 Rainfall

Because of the effects of losses due to evapotranspiration, water being soaked up by dry ground, and water seeping seawards through the barrier it has not been possible to directly measure the effects of heavy rainfall on Lake levels. Average rainfall less losses due to evapotranspiration is equivalent to less than $0.3m^3/s$ entering Lady's Island Lake. However, over the 4 day period centred on the August '97 bank holiday weekend, when some 180mm of rain fell in South Wexford, the levels in Lady's Island Lake rose by 340mm. Assuming a lake surface area of 450ha, a rise in lake level of 340mm in 4 days is equivalent to an input of $4.43m^3/s$.

Therefore, while a relatively small pipeline would suffice to maintain yearly average water levels, a much larger pipeline would be required to maintain water levels over a shorter period.

While the 340mm rise in level would appear to be the fastest rise in water level due to rainfall alone during the period 1984 to 1997, it only represents approximately half the 180mm rainfall that fell on the catchment. The other half was lost due to soakage into the ground, evapotranspiration and seepage effects. 180mm of rainfall in a four day period over the $18.9km^2$ catchment area is equivalent to $9.8m^3/s$.

The volume of rainfall that falls on a catchment can be estimated from the size of the catchment area. The possible rise in lake level is then related, amongst other things, to the relative size of the lake with respect to the catchment area. Tacumshin Lake has an estimated surface area of 450ha and the catchment area of the lake is approximately 40 km^2. Similar rainfall events over

Tacumshin and Lady's Island could therefore give a water level rise and a drainage requirement for Tacumshin of up to two times the Lady's Island values.

4.3 Overtopping of the Barrier Beach

Ref. 1 details water level rises that have occurred in Lady's Island Lake due to water overtopping the barrier beach. The largest recorded overnight rise occurred during the storm of the 16/17 December '89. A combination of high tides, surge and large waves caused the lake level to rise by 0.5m due to overtopping of the barrier beach. Greater rises in water level have been recorded, but they have occurred over longer periods. The highest recorded daily rate of rise occurred during this December '89 storm.

A 0.5m rise in Lady's Island Lake is equivalent to an input of some 2.25 million m^3 of water. If this input is assumed to have occurred over a 12 hour period, it is equivalent to a barrier overtopping rate of some $52m^3/s$.

In some cases a considerable volume of water overtopped the barrier at the cut because the beach had insufficient time to rebuild. However, there was no "cut" in 1989. If this storm had occurred when the crest of the "breach plug" was low then a much greater volume of overtopping could have occurred.

Tacumshin Lake is fronted by some 3.5km of barrier beach compared to the 1.5km length of beach fronting Lady's Island. All other things being equal this would mean that over two times as much water could overtop the Tacumshin barrier beach than that which overtops the Lady's Island beach, i.e. over $100m^3/s$ during an event such as occurred on the night of the 16th December '89.

It has been estimated (Ref 1) that the wave conditions of the 16th December 1989 were equivalent to an 80 year event. The waves were combined with high tides and a surge. The return period of the combined event could therefore be greater than 80 years. However, nearshore wave conditions are depth limited which means that the higher the water levels, the greater will be the nearshore waves, provided the waves offshore are large enough. Therefore, similar overtopping could occur due to smaller offshore waves combined with higher water levels. The return period of the overtopping at Lady's Island due to the December '89 event is perhaps closer to that of sea water levels than that of offshore wave heights. Therefore, while the combination of events leading to the overtopping of the 16/17th December '89 may themselves be rare, the rapid rise in lake levels that resulted may not be as infrequent.

4.4 Seepage and Evapo/Transpiration Losses

Seepage from the sea into the lake can cause water levels to rise, but this is only likely to occur if water levels in the lake are relatively low. Seepage from the lakes combined with evapotranspiration losses is more likely to cause a problem of low water level in the lake than to raise water to flood levels.

During the years '86, '87 and '89 no cut was made in the barrier at Lady's Island. In 1986 monthly average water levels dropped 0.85m from a high in January to a low of 1.42m ODM (4.01m ODD) in September. In 1987 water levels dropped 0.79m from a high in April to a low of 1.87m ODM (4.46m ODD) in September. Lake levels dropped by 0.67m in 1989. During the hot dry summer of 1995, monthly average water levels remained at approximately 0.7m ODM (3.29m ODD) until September, following a "cut" in March.

During 1979, a cut during May caused water levels to drop to approximately 1.2m ODM (3.79m ODD). Subsequently lake levels rose by about 0.2m before dropping some 1.7m between July and October to –0.3 ODM (2.29m ODD). These observations would indicate that the average drop in lake levels due to seepage and evapotranspiration during the summer months is perhaps 0.8m, but that larger drops can occur.

4.5 Cutting the Lady's Island Barrier Beach

Cutting the barrier has in the past caused water levels to drop by over 2.5m. Usually, but not always the cut causes the water level to drop below the base level of the staff gauge (3.16m OD Dublin, 0.57m ODMalin). In 1990 the lake level remained below the base of the staff for 6 months. Sometimes the cut is closed by wave action before a satisfactory drop in water levels is achieved. In 1995 three cuts had to be formed.

Sometimes the cut remains open for a very long time. In 1983, it took 150 days for the cut to close. During this period it is assumed that the lake was tidal. The estimated final width of the breach reached 263m in 1983. It is thought that the large cut widths of the early 1980's were related to gravel extraction from the beach near Carnsore. In any event the breach widths have been smaller since the gravel extraction stopped. During the 1990s, breach widths greater than 100m occurred only once.

When the cut is initially formed, it is small. Usually there is little change in lake levels for a number of days. During this period the cut is gradually widening and deepening. At some time a threshold is past, presumably when the flow is such that water velocities can carry the gravel out of the cut to the sea in large quantities, the cut then deepens and widens quickly and there is a rapid drop in lake levels. Levels taken during the cut of 1990 show that for the first 3 days lake levels dropped by only 0.2m. Then on the fourth day the lake level dropped by over 2.2m in one day, i.e. at an average rate of over 100m^3/s. A detailed description of a cut is given in ref. 1. Velocities of 5 to 7m/s were measured by Malachy Walsh & Partners Staff in the 1998 cut during a site visit on the 18th February '98.

4.6 Water Level Variations in Lady's Island Lake

A combination of the factors discussed above give rise to water level variations in Lady's Island Lake. An attempt was made to assess the sensitivity of the water levels to the various factors.

It would appear that the most rapid rise in water levels occur due to overtopping of the barrier beach. An overnight rise of 0.5m having been recorded due to this mechanism. The second most important factor is heavy rainfall.

The rainfall of the August '97 bank holiday period caused a rise of 0.34m over four days. In the longer term, rainfall and overtopping tend to cause the water level to rise during the late autumn, winter and early spring. Figure 28 of ref 1 indicates that water levels rose by some 3.2m in the period October '79 to February '80. This is equivalent to a 1.4m^3/s rate of inflow to the lake over this period. Water level records since 1984 show smaller increases (than 3.2m) over the half of the year centred on December. During 1986, 1987 and 1989 when the cut was not made, water levels rose by 1.0 to 1.5m. These rises are equivalent to inflows of approximately 0.3 to 0.45m^3/s. The largest rise, occurring in 1989, being due in part (0.5m) to overtopping.

The largest monthly rise in the 1984 to 1997 period occurred from December 95 to January '96. This rise of 1.36m was due to a combination of a period of prolonged heavy rainfall and a storm surge with large waves on the 6th January '96. This monthly rise was equivalent to an inflow of

2.3m^3/s over the month.

4.7 Tacumshin Lake

There have been attempts in the past to drain Tacumshin Lake using a pipeline in the barrier beach. A wooden culvert was constructed in the 1860's , but failed to work. An iron culvert was built a few years later, but was sabotaged in 1910. Following the sabotage lake levels rose, and to relieve flooding, the barrier was breached. The breach gradually moved westwards until it reached Ballagh where it remained open until the late 1930's. The barrier was again breached in 1940. Again the breach moved west to Ballagh where it remained open until the early 70's. According to Ref. 1, the diameter of the existing pipeline is 42" i.e. 1.05m. During survey work carried out as part of this study, it was estimated that the pipe was laid at a slope of 0.2m in 145m i.e. 1 in 725. A pipe of this size, running full would have a discharge of approximately 1m^3/s. The actual flow through this pipe depends on the water level in the lake and the tide level. At low water and when the lake level is higher than the top of the pipe, the discharge rate would be higher. However, towards high water, there might not be any seaward flow through the pipe. The pipe has been set at a low level because of the low levels required within the lake.

The surface area of the lake varies depending on the water level in the lake. The 1:50,000 Discovery series map indicates that Tacumshin Lake has a similar surface area to that of Lady's Island Lake, ie. 450ha. If flowing at a rate of 1m^3/s it would take approximately 5 days to lower the lake level by 0.1m, assuming that during this time any inflows from rainfall are equal to evapotranspiration losses and seepage flows through the barrier.

As little data exists on water levels in Tacumshin Lake, monitoring of water levels are necessary in order that optimum levels can be established and controlled.

4.8 Preferred water levels in Lady's Island Lake

The Local Drainage Committee's preferred maximum, minimum and mean water levels are given for Lady's Island lake in reference 1. The levels are 2.51, 2.21 and 1.91m ODM, i.e. 5.10, 4.80, and 4.5m ODD. The design of drainage control measures should, if possible, be such that water levels in the lake are within the maximum and minimum range. The stated preferred mean level is just 0.3m above the preferred minimum. Recorded water level falls over the summer months of up to 0.8 to 0.85m due to seepage and evapotranspiration would make it impossible to ensure that lake levels do not go below the minimum value, if a mean value of 2.21m ODM (4.8m ODD) is maintained during the winter months. As it is not possible to control seepage and evapotranspiration losses during the summer it would better to try to achieve a water level close to the maximum in the early spring. It will be possible to design a drainage system so that average inputs can be discharged almost immediately. The larger the discharge capacity of the preferred drainage option, the closer the mean level can be allowed go to the preferred maximum level.

Earlier in the winter half of the year, the water levels of the lake can be drawn down in anticipation of the winter rainfall and overtopping. Towards the end of the winter period, water levels can be allowed rise so as to reduce the risk that evapotranspiration and seepage losses will cause the water levels to go below the preferred minimum. A form of flow control will therefore be necessary.

4.9 Discussion

The following conclusions can be drawn from the above regarding Lady's Island Lake:

- for the period 1984 to 1997 the most rapid rise in lake levels was due to waves overtopping the barrier beach during the storm of the 16th December 1989. A rise of 0.5m occurred overnight. This is equivalent to inflows of the order of $50m^3/s$.

- the most rapid recorded rise in lake levels due to rainfall was noted during the period 2nd to 7th August 1989. 180mm of rainfall in four days caused the lake to rise by 340mm. This is equivalent to an inflow of the order of $4.4m^3/s$.

- longer term rise and fall in water levels are due to a combination of factors. When the barrier was not cut falls of the order of 0.7 to 0.85m occurred from a water level of above 2m ODM (4.59m ODD). A fall of 1.7m occurred in 1979. In the dry summer of '95 however the lake level remained relatively static at 0.7m ODM (3.29m ODD).

- the largest recorded longer term rise in water levels occurred in the period October '79 to February '80 inclusive. The 3.2m rise was equivalent to an inflow of $1.4m^3/s$. When the lake was not cut average water levels were relatively high and the rise in level during the winter was in the order of 1 to 1.5m, equivalent to 0.3 to $0.45m^3/s$ over a 6 month period.

- the largest monthly rise during the period '84 to '97 was 1.36m, equivalent to an inflow of $2.3m^3/s$ over the month. This rise occurred between December '95 and January '96.

- while the design of a drainage system with a large discharge capacity could be used to ensure that the preferred maximum water level of ref. 1 is rarely exceeded it will not be possible to maintain a mean water level of 2.21m ODM (4.8m ODD) and simultaneously ensure that the level does not drop below 1.91m ODM (4.5m ODD). It would be better to allow the lake levels to vary so that it is near the maximum during the spring and near the minimum during autumn.

Water levels in Lady's Island lake will need to be automatically monitored in order that control of these levels can be optimised.

Monitoring of water levels in Tacumshin lake is necessary in order that optimum levels can be established and controlled.

5.0 EVALUATION OF OPTIONS.

5.1 General

This Section lists the options considered and evaluates them in terms of effectiveness in controlling lake levels, cost, and potential impact on coastal processes.

5.2 Lady's Island Lake

5.2.1 General

In the light of the findings of the assessment of coastal processes and drainage parameters a list of drainage options is drawn up that are likely to provide sufficient drainage capacity while attempting to keep costs low and to minimise any potential impact on coastal processes. The options have been divided into those that involve a pipeline and those that involve measures to restrict the depth and width of a "cut".

5.2.2 Options.

The options considered are:

Pipeline Options

a 1.2m internal diameter pipeline through the barrier beach and extending to 0.0m ODM. A second l.2m internal diameter pipeline parallel to this is also considered.

a 1.2m diameter pipeline through the barrier beach and extending seawards to the -6m ODM contour. The seawards end of the pipeline would be held above the seabed using piles. A second 1.2m pipeline parallel to this is also considered.

Pipeline options would have a control structure on the landward side of the beach. It is expected that within the barrier beach, the pipeline would be constructed of Class H concrete pipes. Towards the seawards end the pipeline is likely to be constructed of concrete lined ductile spun iron. The pipeline options would be supported on piles in the area of mobile beach face and where they extend below low water.

Non Pipeline Options.

a 2m deep 15m wide rock armour layer through the barrier beach and wrapped in geotextile to provide an area of high permeability.

continuation of the existing system of forming a cut, but modified so that the width and base level of the cut have fixed limits. The methods evaluated to achieve this includes:

- rock armour.
- sheet pile wall and rock armour.
- a proprietary concrete revetment mattress such as armourflex.

5.2.3 Evaluation of Options.

General

All options would use the area of the existing cut. Placing a pipeline or modified cut at any other location is unlikely to be a cheaper option. There is merit, however, in considering a pipeline location slightly to the west of the existing cut. It would be less vulnerable to wave overtopping and would be away from the protected plant, cottonweed (otanthus maritimes) just east of the existing cut. The lake bed levels are likely to be higher, however, and this could increase costs. Irrespective of where the drainage structure is placed, it should be sufficiently robust to withstand wave attack, beach profile changes and overtopping of the beach during storms.

The evaluation of options is summarised in Table 5.1. Costs and discharge capacities have been estimated for each option. For the pipeline options, average discharge has been estimated for lake water levels of 2.51 (5.1m ODD) and 1.91m ODM (4.5m ODD), the maximum and minimum water levels of Ref. 1 respectively. Discharge through a permeable layer have been assessed based on estimated velocities of 0.05 and 0.1m/s. Discharge through a modified cut have been estimated using a weir formula.

Pipeline Options

Table 5.1 shows that pipeline options that extend to 0.0m ODM (2.59m ODD) have greater discharge capacities than a pipeline that extends out beyond the area of maximum sediment transport, and half the cost. The lowest cost options would appear to be methods of limiting the size of the cut. However, such methods are limited in their capacity to drain the lake. This is discussed further below.

The examination of drainage parameters indicated that the largest recorded inflow to the lake was due to overtopping of the beach. On the storm of the 16/17 December of overtopping resulted in an equivalent inflow rate in the order of 50m³/s causing a 0.5m rise. Inflows due to rainfall of up to 4.4m³/s were also recorded, causing a 0.34m rise in early August, 1997.

However, in the long term, the greatest recorded net monthly inflow was equivalent to 2.3m³/s, while an average winter rise in lake level of 1m is equivalent to approximately 0.3m³/s. A 1.2m internal diameter pipeline has sufficient capacity to carry the longer term discharge demands, and could draw down a 0.5m rise in water levels in 7 to 10 days. The rise in lake levels of 0.34m that occurred in the period August 3-6, 1997 could be limited to 0.1m which could be drawn down in another two days by a 1.2m pipeline with a discharge capacity of 3.4m³/s when the lake water level is at 2.51m ODM (5.1m. ODD).

The use of two 1.2m pipelines doubles the capacity and halves the above draw down times, for a less than 50% increase in cost if both pipelines are laid at the same time.

The further the pipeline extends down the beach towards the low water mark, the greater is the potential head for driving flows through the pipeline. However, friction losses, due to increase in the length of the pipe tend to negate the extra head and the capacity will be lower. No further head will be gained by extending the pipeline below low water. Once extended below low water, the pipeline should extend to the -6.0m ODM (-3.41m ODD) contour and should be held above the bed at the seaward end in order to minimise the risk of blocking the pipeline outlet. Such an option is very costly.

From a discharge point of view the pipeline outlet should be as close to low water as possible. However, in order to reduce wave attack, it should be at as high a level as possible. Raising the outlet invert level to 0.5m from 0.0m ODM reduces the average discharge capacity to 2.9 and 2.16m³/s for lake water levels of 2.51 (5.1m. ODD) and 1.91m ODM (4.5m. ODD) respectively. Such discharge capacities are adequate for the longer term inflows into the lake.

The shorter pipeline is much less vulnerable to changes in beach profile and will have minimal impact on coastal processes. It will only influence the beach profile in its immediate vicinity. Because the outlet will be in an area of considerable wave action and profile change, it will be necessary to support the pipe outlet and may be necessary to replace the outer pipe length in, perhaps, twenty years.

Modified Cut Options

During the formation of the cut, it has been noted that it can take a number of days before the cut fully opens to let water out of the lake. The final lake draw down is at a rate of up to 100m³/s. Limiting the size of the cut has a number of disadvantages.

The maximum discharge from a drainage point of view will be low and it may therefore be necessary to form a cut much more regularly than at present. In estimating discharge capacities, it was assumed that the base level of the cut would be at the preferred minimum water level of 1.91m ODM (4.5m ODD) This results in a discharge of 16m³/s for a 20m wide weir. The cost estimates for Options 6 to 8 are based on a 20m wide weir.

The Option 6 weir could be widened to approximately 40m giving an apparent discharge capacity of $32m^3/s$ for a lake water level of 2.51m ODM (5.1m ODD). However, there are two aspects of the flow in the modified cut that could prevent it from working to its full potential. The initial discharge will be low and the water will flow into the beach instead of on top and is unlikely to carry gravel away from the weir in sufficient quantities.

Unless a very wide weir is constructed, the discharge will be considerably less than the maximum discharge of the present cutting operation. Therefore, to draw down the lake, the cut will have to be open for a greater proportion of the year than at present. Because water levels are to be controlled between a maximum and a minimum value, it may be necessary to make a number of cuts each year. Because the cuts are relatively small, there will be a greater danger of blockage due to wave action than at present. This increases the likelihood of the need for additional cuts.

At present, the lake is vulnerable to increase in water levels due to substantial volumes of water overtopping the beach at the area of the cut. Because the modified cut will now be smaller, less overtopping will occur. However, there remains a greater risk of overtopping in this area than using a pipeline option.

5.2.4 Conclusion.

It would appear that Lady's Island Lake can be adequately drained using a 250m long 1.2m internal diameter pipeline. Such a pipeline would have a control structure at its landward end, and would consist, for the most part, of concrete pipes except at the seaward end which would be constructed of ductile iron. The seaward outlet is likely to have an invert level in the range 0.0m ODM to 0.5m ODM, (i.e. 2.59 to 3.09m ODD). The higher level is preferred as it reduces wave action on the pipe. This Option is estimated to cost £170,000.

Recommendations in Section 4 regarding the control of water levels in Lady's Island Lake should also be considered.

Table 5.1
Evaluation of Options - Lady's Island Lake

No.	Option	Capital Cost	Discharge Capacity m^3/s		Comments
			2.51mODM (5.1m ODD)	**1.91mODM (4.5m ODD)**	
1	1.2m internal diameter pipeline extending from control structure to MSL	£170,000	3.0	2.5	Sufficient capacity to maintain lake levels in normal conditions. Seaward outlet could be vulnerable to beach movement and wave attack.
2	Option 1 plus additional 1.2m pipe	£245,000	6.0	5.0	Doubling of discharge capacity for some 40% increase in cost over 1. The extra discharge capacity may not be considered necessary.
3	1.2m internal diameter pipeline extending from control structure to -6m ODM	£335,000	3.2	2.85	Sufficient capacity to maintain lake levels in normal conditions. Will have a greater impact on coastal processes than 1. Will be difficult to clear seaward end of blockages. Expensive
4	Option 3 plus additional 1.2m pipe	£500,000	6.4	5.7	Doubling of discharge capacity for 50% increase in cost over 4
5	Rock armour buried within beach to improve permeability	£225,000	less than 1.5 - 3	less than 1.5 - 3	Costly, considering relatively low discharge capacity. Danger of blocking.
6	Rock armour buried within beach to limit extent of cut	£115,000	16	0	Invert of weir would need to be placed at minimum lake level - restricts discharge capacity as lake level drops.

Table 5.1 cont'd

7	Sheet piling driven into beach to limit extent of cut	£142,000	16	0	Barrier beach will be vulnerable to overtopping. Cut may not open sufficient to achieve maximum discharge.
8	Proprietary mattress to limit extent of cut	£80,000	16	0	Discharge capacity is low given that cut will only operate for a short period each year.

Discharge capacities have been estimated using the formula $Q = \mu A(2gH)^{0.5}$ where A is the area of the pipe, H is the head difference along the pipe.
$\mu = 1/(\lambda L/d+E)^{0.5}$, where $\lambda=8g/C^2$, L is length of the pipe, d is the diameter of pipe, and E is the sum of the coefficients for energy loses in the pipe.
$C = R^{1/16}/n$ where R is the hydraulic radius and n is the manning coefficient. A manning coefficient of 0.0125 was used.

5.3 Tacumshin Lake.

5.3.1 General.

In view of the findings of the evaluation of options at Lady's Island Lake, only a limited number of pipeline options are considered at Tacumshin Lake. The main differences between the two lakes are; the lake level at Tacumshin is generally lower; the catchment area of Tacumshin is bigger; and there is an existing drainage pipeline through the beach. Options are evaluated as before, in terms of effectiveness, cost and minimal impact on coastal processes.

5.3.2 Options.

The options considered are:

- replace the seawards 25m of pipe with a ductile iron pipe and extend seawards by 5m.

- replace the seawards 25m of pipe with a ductile iron pipe and extend seawards by 200m.

- construct a new 1.2m internal diameter pipeline extending from a new control structure on the lake side of the barrier beach to approximately 5m seawards of the existing outlet.

- construct a new 1.2m internal diameter pipeline extending from a new control structure on the lake side of the barrier beach to approximately 200m seawards of the existing outlet.

As for Lady's Island, all new pipelines would have a control structure on the landward side of the beach. Within the barrier , the pipeline would be constructed of Class H concrete pipes except towards the seaward end where it is likely to be constructed of ductile iron. Pipeline options would be supported on piles where they are expected to extend above the beach face or seabed.

5.3.3 Evaluation of Options.

The evaluation of options is summarised in Table 5.2.

The existing concrete pipeline has been damaged by storms and is now shorter than its original length. The outlet is on the beach in an area of changing beach profile and is likely to block. There is a danger that the pipeline will be damaged further and that the frequency of blockage will increase. In order to prevent this, an option was considered whereby approximately 25m of the seawards end of the concrete pipe is replaced with ductile iron and extended seawards perhaps 5m. The seawards end of the pipeline would be supported in such a way as to minimise the risk of blockage and damage due to beach profile changes.

A fully operational existing pipeline would be able to handle most of the longer term inflows due to rainfall. If it were necessary to ensure that lake levels are lowered quicker than at present, following periods of heavy rainfall or overtopping, then a second pipeline is likely to be the optimum solution. A second pipe could be placed at a higher invert level than the existing pipe. The optimum level depends on costs and desired lake levels.

Extending the existing or an additional pipeline seawards of the zone of maximum sediment transport adds significantly to the cost without any improvement in drainage capacity. Such an extended pipeline will also interfere with coastal processes much more than a pipeline that discharges onto a beach, and, will be more difficult to clear of any sand that may enter the outlet.

A pipeline discharging onto the beach face within the tidal zone will need to be designed to be robust enough to withstand wave attack and changes in beach profile. It may be necessary to replace the outer length of pipe, perhaps, every twenty years.

5.3.4 Conclusions.

In order to ensure that the existing pipeline continues to work, it is recommended that the seawards 25m be replaced with a ductile iron pipe and extended seawards by approximately 5m. The pipe outlet should be supported.

The control structure for any additional pipeline should be such that the lake levels will not be drawn down lower than they can be at present.

Table 5.2
Evaluation of Options - Tacumshin Lake

No.	Option	Discharge Capacity m³/s		Cost	Comments
		1.0m ODM 3.59m ODD	**0.5mODM 3.09m ODD**		
1	Replace seawards 25m of pipe with ductile iron pipe and extend seawards by 5m	1.9	1.5	£40,000	This will prevent further degradation of the existing situation. It is unlikely to improve the existing discharge capacity by a significant amount.
2	Replace seawards 25m with ductile iron pipe and extend seawards by 200m	1.5	1.1	£350,000	While this option moves the outlet seawards of the sediment transport zone, the extra cost over Option 1 is unlikely to be justifiable. It will have a greater impact on coastal processes.
3	Option 1 plus additional 1.2m diameter pipeline extending from new control structure to 5m seawards of existing outlet	4.6	3.5	£195,000	This will more than double the drainage capacity of the existing pipeline.

Table 5.2 cont'd

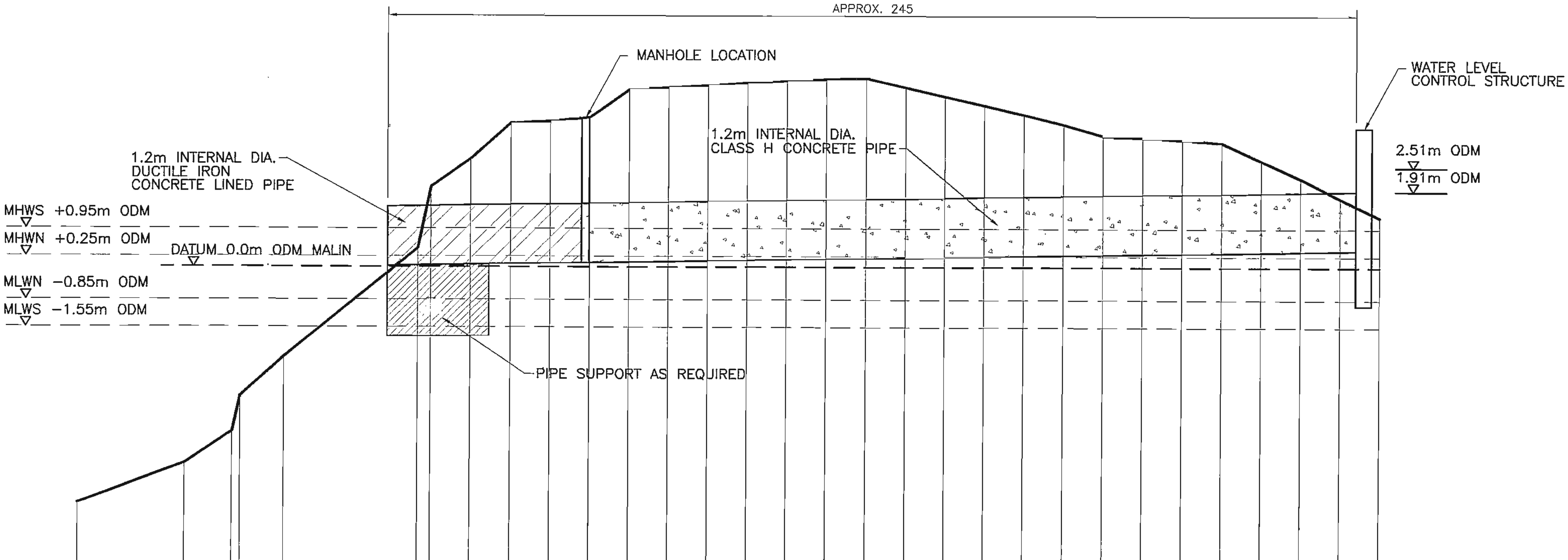
4	Option 2 plus additional 1.2 diameter pipeline extending from new control structure to 200m seawards of existing outfall.	3.6	2.7	£845,000	As for option 2, this option moves the outlet seawards of the sediment transport zone. However, the extra cost is unlikely to be justifiable. It will also have a greater impact on coastal processes.

Discharge capacities have been estimated using the same formulae as Table 5.1.

EXAGGERATED VERTICAL SCALE
0.0m OD MALIN = 2.59m ODM (POOLBEG)
ALL LEVELS TO OD MALIN

HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:100

ELEVATIONS ARE IN mOD MALIN
CHAINAGE IN METRES



ELEVATION	−6.00	−5.00	−4.20	−3.30	−2.30	0.450	2.000	2.710	3.610	3.660	3.760
CHAINAGE	0	27	39	41	52	86	89.3	96	106	116	126

ELEVATION	4.470	4.520	4.570	4.630	4.680	4.730	4.760	4.530	4.300	4.070
CHAINAGE	136	146	156	166	176	186	196	206	216	226

ELEVATION	3.840	3.590	3.300	3.260	3.210	3.140	2.680	2.230	1.720	1.240
CHAINAGE	236	246	256	266	276	286	296	306	316	326

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	LADY'S ISLAND LAKE OPTION 1: 1.2m DIA. PIPELINE TO 0.0m ODM	Malachy Walsh and Partners / POSFORD DUVIVIER	MAY '98	AS SHOWN

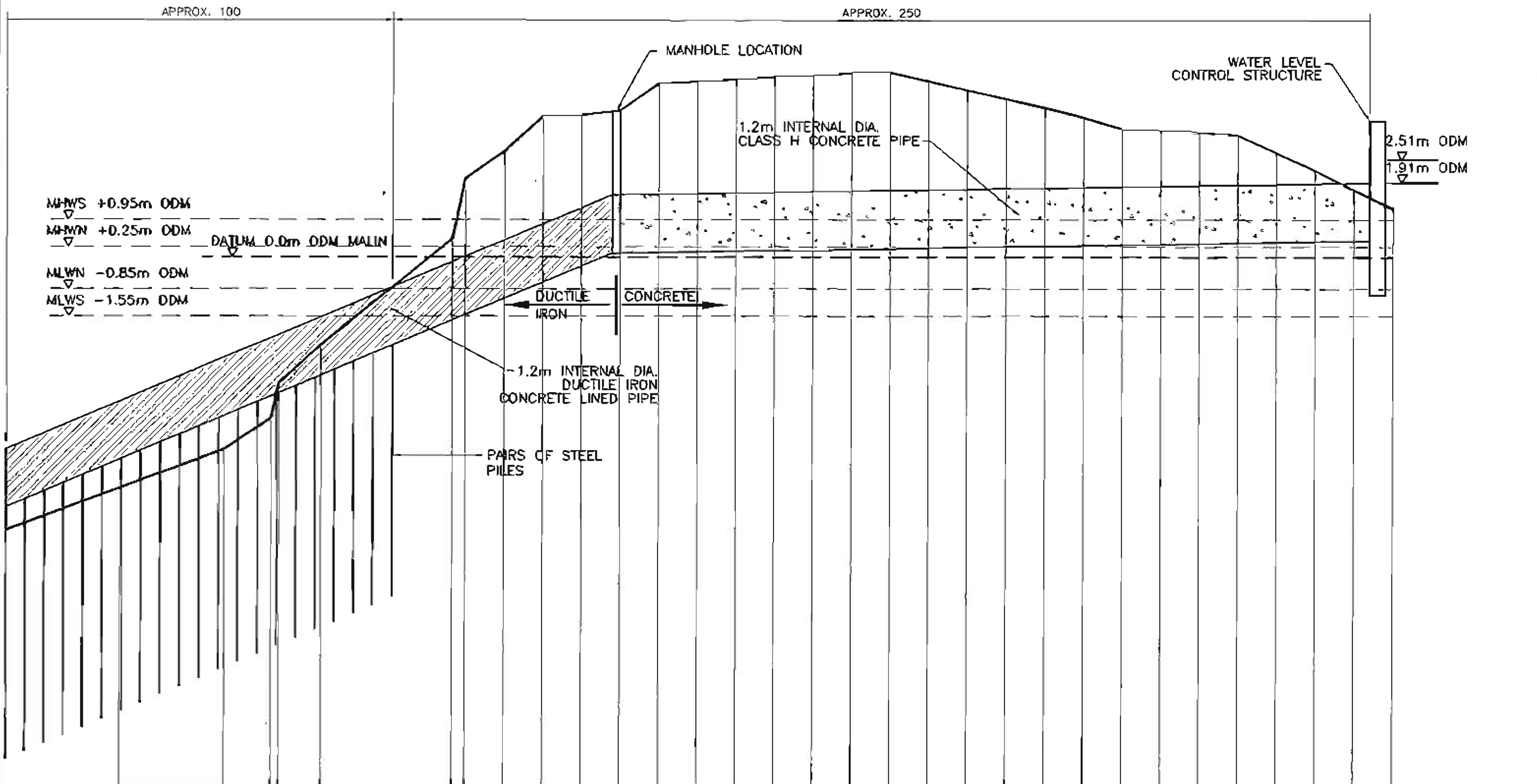
[redacted]

Figure 5.1

EXAGGERATED VERTICAL SCALE
0.0m OD MALIN = 2.59m ODM (POOLBEG)
ALL LEVELS TO OD MALIN

HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:100

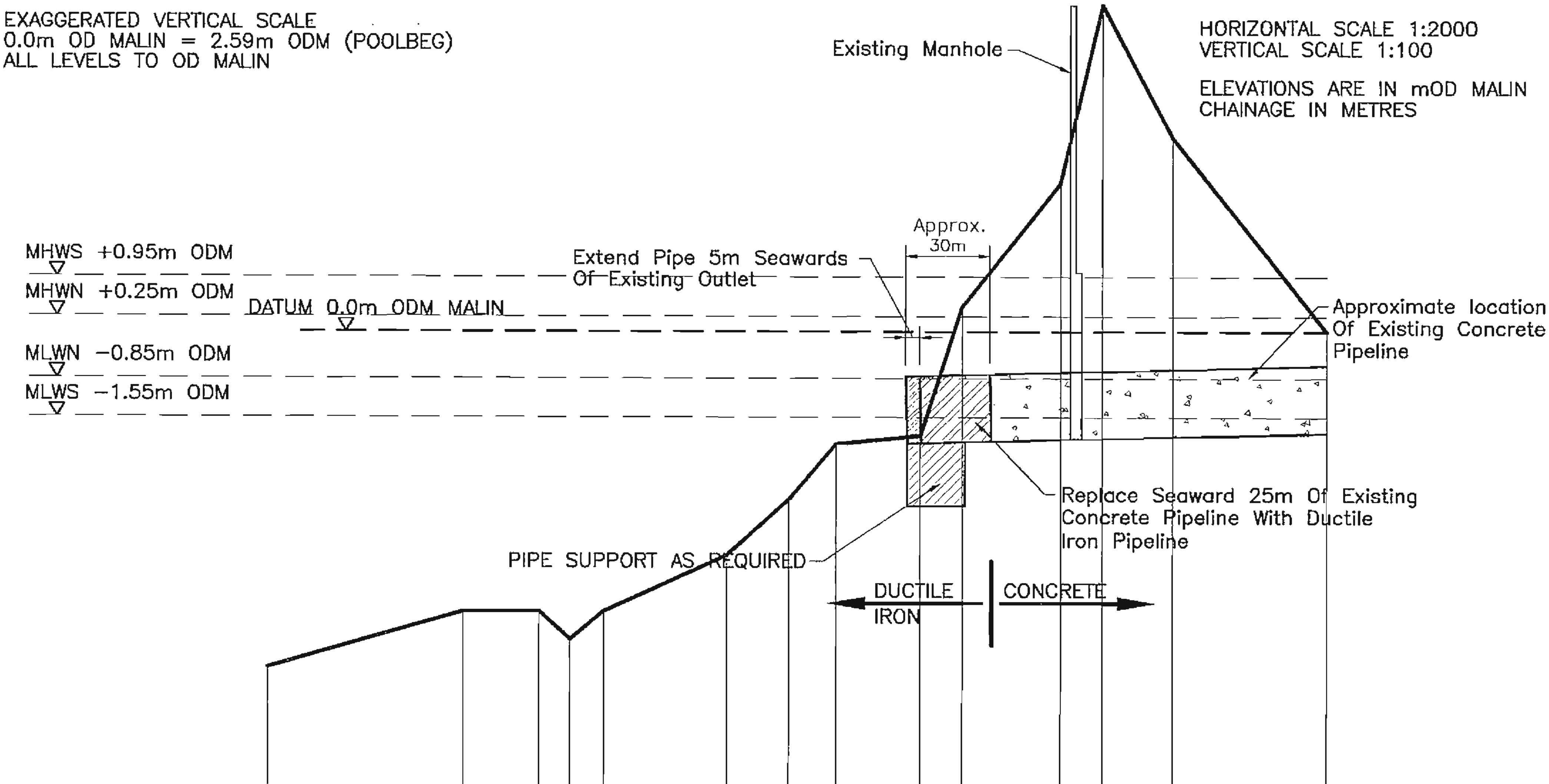
ELEVATIONS ARE IN mOD MALIN
CHAINAGE IN METRES



ELEVATION	-6.00	-5.00	-4.20	-3.30	-2.30	0.450	2.000	2.710	3.610	3.660	3.760	4.470	4.520	4.570	4.630	4.680
CHAINAGE	0	27	39	41	52	86	89.3	96	106	116	126	136	146	156	166	176

ELEVATION	4.730	4.760	4.530	4.300	4.070	3.840	3.590	3.300	3.260	3.210	3.140	2.680	2.230	1.720	1.240
CHAINAGE	186	196	206	216	226	236	246	256	266	276	286	296	306	316	326

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	LADY'S ISLAND LAKE OPTION 2: 1.2m DIA. PIPELINE TO -6.0M ODM CONTOUR	Malachy Walsh and Partners / POSFORD DUVIVIER	MAY '98	AS SHOWN
				[redacted]	
				Figure 5.2	



ELEVATION	−6.00	−5.00	−5.00	−5.50	−5.00	−4.00	−3.00	−2.00	−1.85	0.450	2.200	5.650	3.470	−0.04
CHAINAGE	0	70	97	108	120	164	186	203	233	248	283	298	323	378

Client	Project	Title
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	TACUMSHIN LAKE OPTION 1: EXTEND EXISTING PIPE

Malachy Walsh and Partners

POSFORD DUVIVIER

Date: MAY '98

Scale: AS SHOWN

[redacted]

Figure 5.3

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions.

The study concludes that;

- the most cost effective means of draining Lady's Island Lake is by use of a pipeline, buried in the barrier beach, with a control structure at the lake end and discharging directly onto the beach at a level between 0.0m ODM (2.59m ODD) and 0.5m ODM (3.09m ODD). Abrasion may mean that the outer length of pipe may need to be replaced in, perhaps, twenty years.

- a modified cut mechanism, whereby, for example, rock armour is used to limit the size of the cut is unlikely to be able to generate sufficient discharge to open the cut to its limits. Such a cut will also be more vulnerable to closure by wave action than the existing cut.

- in order than the existing pipeline at Tacumshin does not become semi permanently blocked, it will be necessary to replace 25m of the seaward end of the pipeline with a ductile iron pipe supported at the outlet. Abrasion may mean that the outer length of pipe may need to be replaced in, perhaps, twenty years.

- a control structure will be required at the lake end of the Lady's Island drainage pipeline to control the discharge through the pipeline.

- the coastal process regime at each site is such that a pipeline extending seawards of the zone of maximum sediment transport is very costly. Approximately £335,000 and £350,000 at Lady's Island and Tacumshin respectively for a 1.2m pipeline.

- very little data exists on water levels in Tacumshin Lake.

6.6 Recommendations

The study recommends that;

- water levels in Lady's Island Lake be controlled using a 1.2m diameter pipeline discharging onto the beach face. The cost of such a pipeline, a control structure, and support at the outlet is estimated to be £170,000.

- water levels in Lady's Island Lake be managed so that they are close to the minimum preferred level in late autumn and to the maximum preferred level in late spring. This will allow a buffer against excessive inflow during winter and against losses during summer. Such management is required because of the relative closeness of the preferred maximum and minimum lake levels of 2.51m ODM (5.1m ODD) and 1.91m ODM (4.5m ODD) respectively.

- the existing pipeline at Tacumshin be improved by replacing the seawards 25m with a ductile iron pipeline and extending the pipeline seawards by 5m. This is estimated to cost £40,000.

- prior to detailed design of drainage options, establish accurate estimates of tide levels in the vicinity of Lady's Island and Tacumshin Lakes. This requires recording of sea levels in the area for at least one month, and the analysis of this data.

- levels in Tacumshin and Lady's Island lakes should be automatically monitored

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APPENDIX A
BATHYMETRIC SURVEY

HYDROGRAPHIC SURVEYS LTD.
Telephone (021) 831184 Fax (021) 831193

THE COBBLES
CROSSHAVEN
CO. CORK

Malachy Walsh & Partners,
Consulting Engineers,
Floraville Rd.,
Boreenmana Road,
Cork.

19th March, 1998

Attn: Mr. [redacted]

Re: Hydrographic Survey at Tacumshin & Ladys' Island

Dear Sir,

I enclose the results of the above survey, H.S. 29/98 refers. The survey areas are based on information provided by the Dept. of Arts, Heritage, Galetacht and the Islands, via Rosanna Nolan.

Datum points, in O.D. Malin, were provided by Ms. Nolan at each site.

The survey was carried out on 13th inst. in very good sea and weather conditions. Baselines were established at each site, parallel to the beach, and lines of soundings were run normal to the baseline. Control for the survey was provided by line of sight and laser ranger, output to 0.1m. Depths are in metres and decimetres reduced to O.D. Malin from tides measured (by level) on site.

Results of the bathymetry indicate a relatively clean seabed with a short steep slope just below the low water line (LWL), seawards of the LWL the seabed is quite flat.

Sand on the beach, at each site, is of a coarse nature. Three samples were obtained at various locations along the proposed centreline at each site. The sample obtained was quite small, in each case, and consisted of fine sand. It is possible that some of the fines may have run out of the grab. Alternatively, there may be a shallow layer of fine sand overlying a harder material.

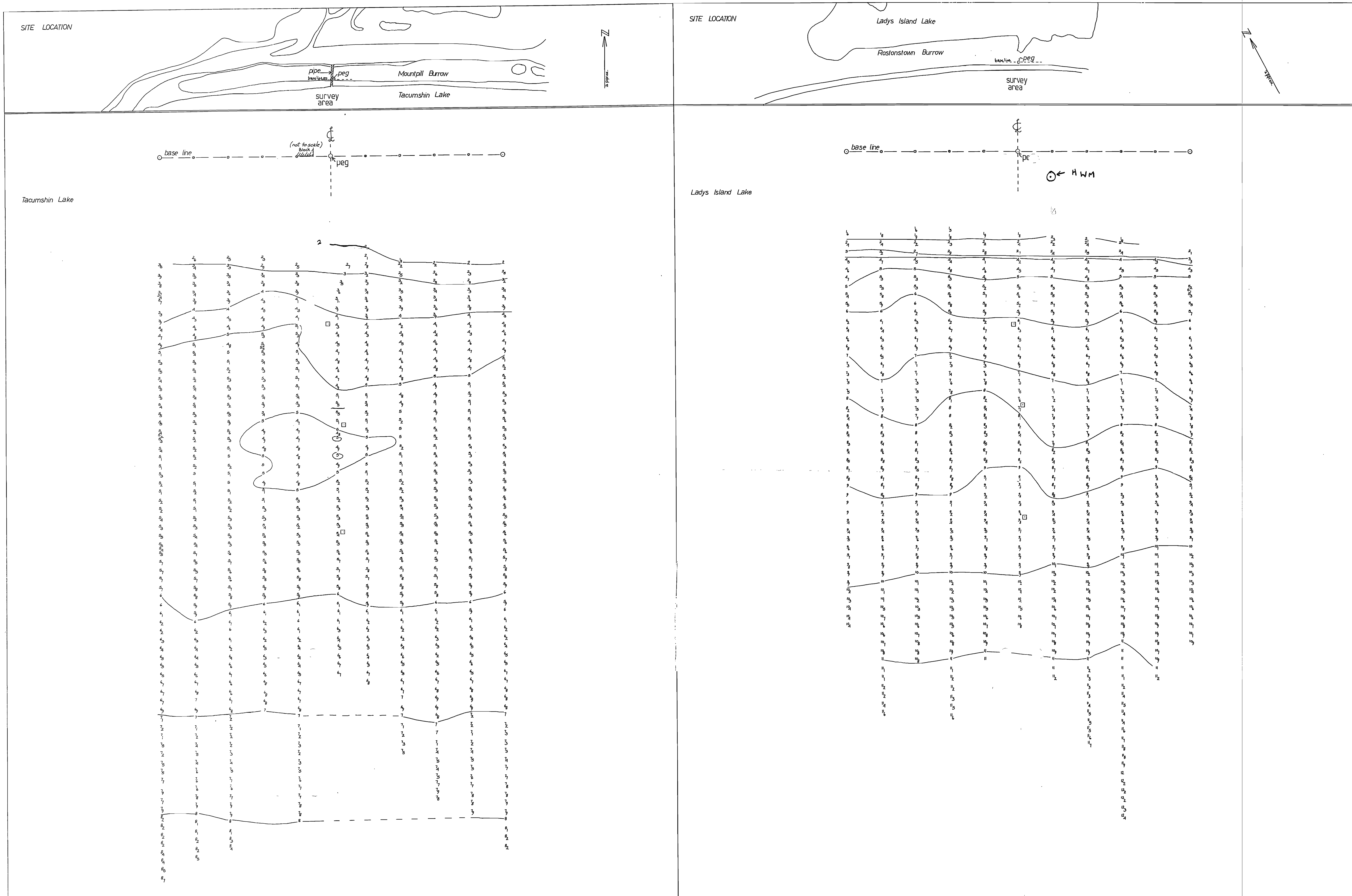
Locations of the samples obtained are indicated on the drawing.

If you have any queries please revert to the undersigned.

Yours sincerely,

[redacted]

[redacted]

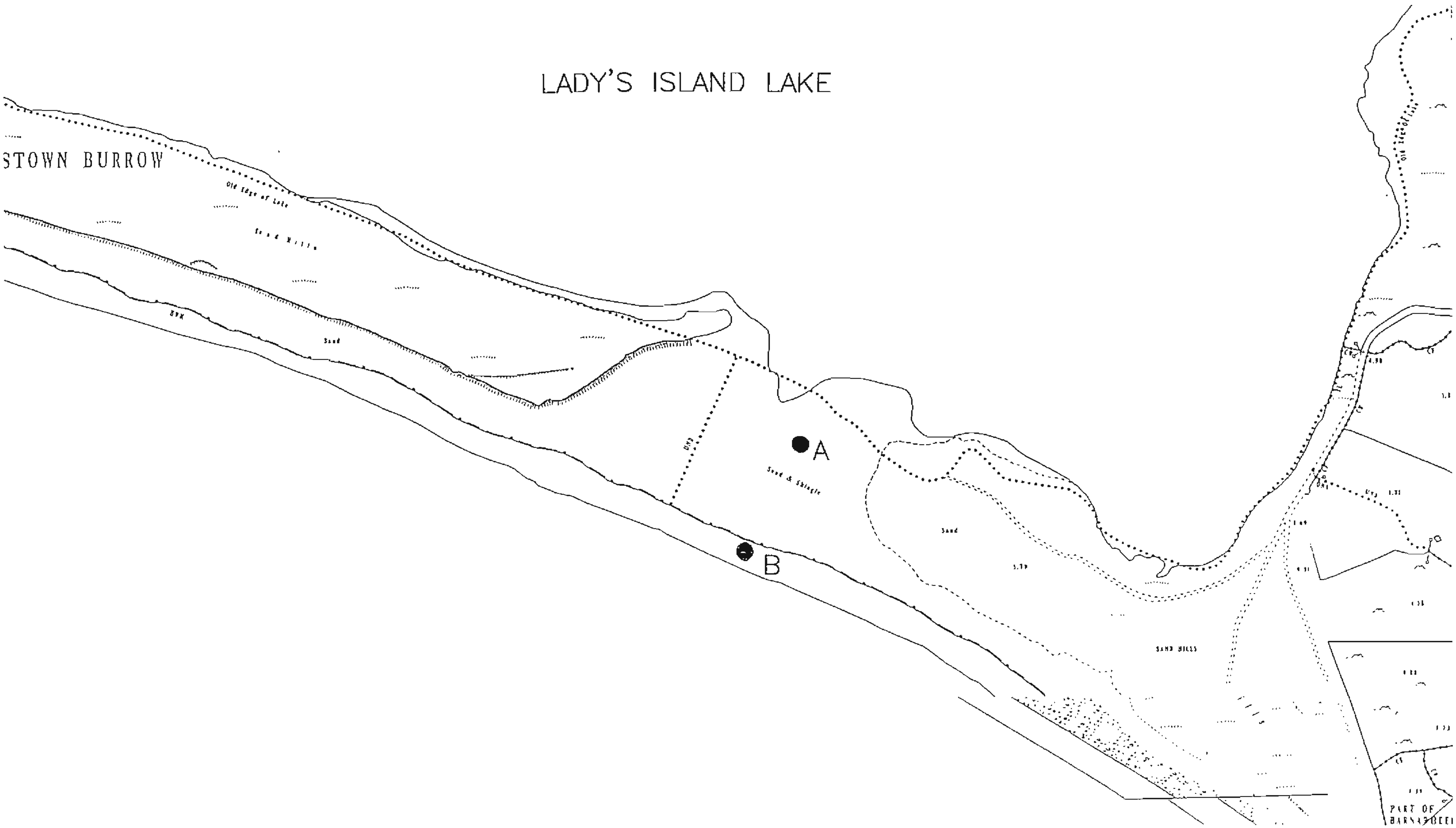


TITLE LADYS ISLAND LAKE & TACUMSHIN LAKE BATHYMETRIC SURVEY	Drwg No. HS 29/98 Date 13/03/98 Scale 1:1000	CLIENT *Duchas The Heritage Service.* *Dept. of Arts, Heritage, Gaeltacht & the Islands.* *SURVEYED BY HYDROGRAPHIC SURVEYS LTD.* *THE COBBLES, CROSSHAVEN, CO.CORK. TEL. 353-21-831184.*	Memoir 1. Soundings in metres and decimetres reduced to O.D.(Malin). 2. Horizontal control by laser. □ sample location	0 5 10 20 30 40 50 60 70 80 90 100m

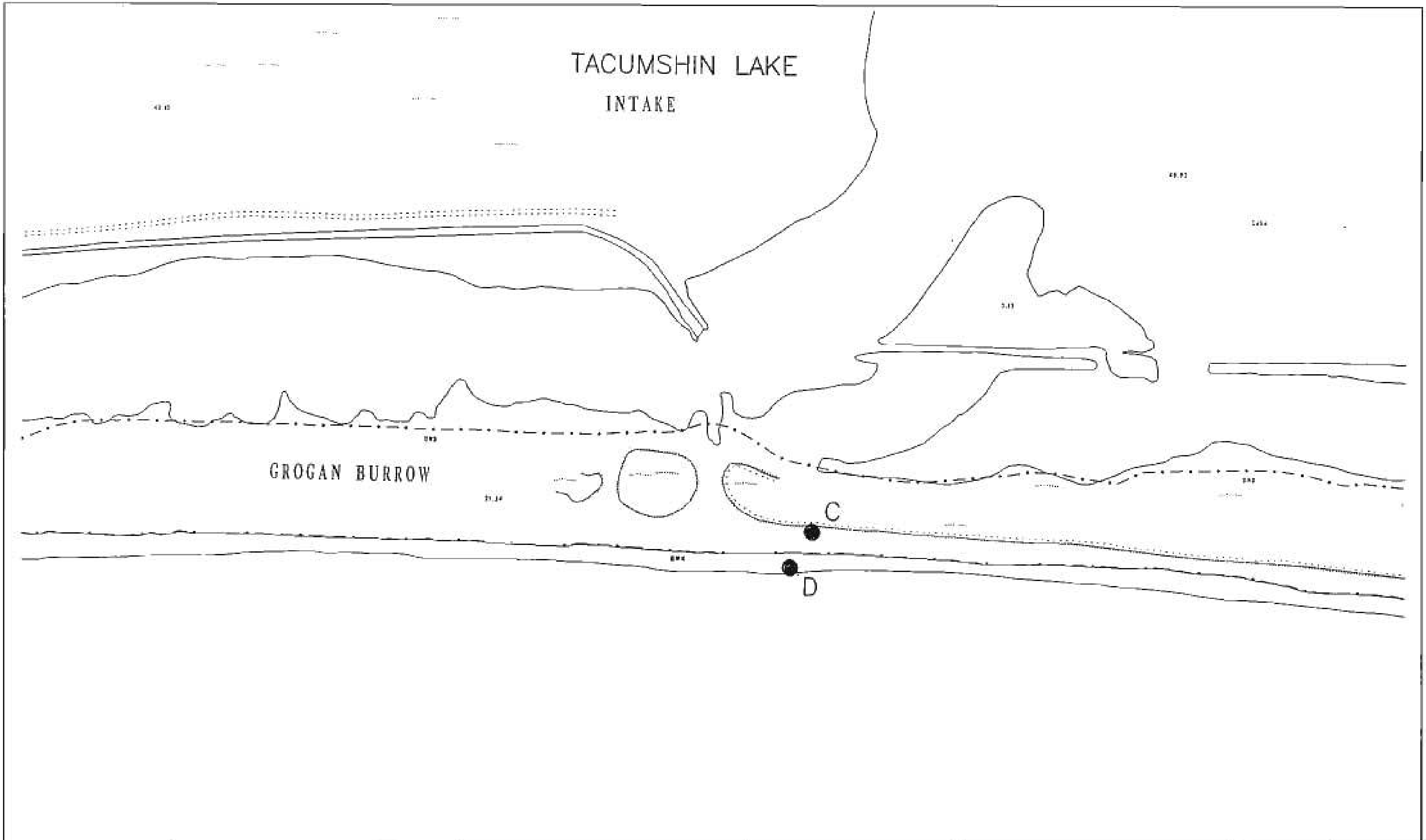
Drawn by	G.C.
Checked by	TBT
Approved by	m.d.

Produced by HYDROGRAPHIC SURVEYS LTD.

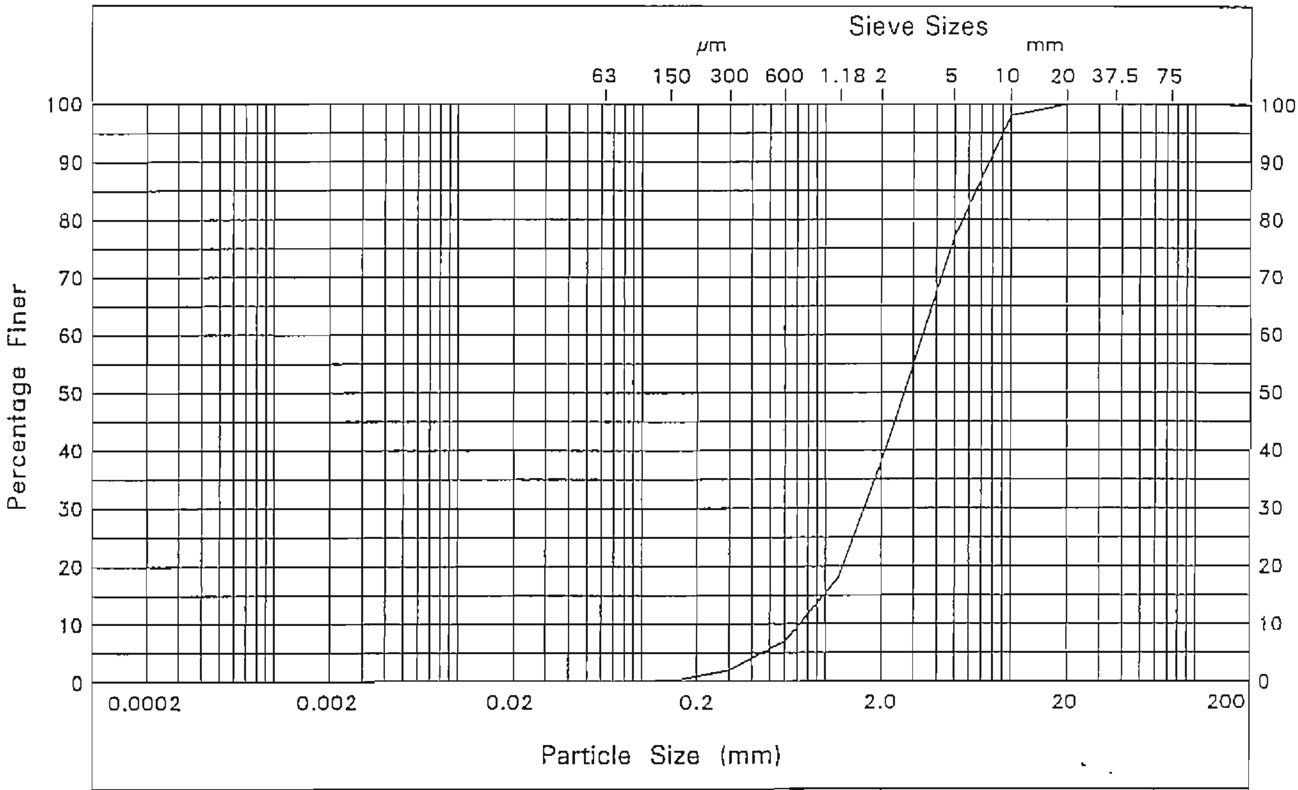
APPENDIX B
BEACH SAMPLE
GRAIN SIZE ANALYSIS



Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	LOCATION PLAN BEACH SAMPLES GRAIN SIZE ANALYSIS	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98	1:5000
				[redacted] Figure B1(a)	



Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	LOCATION PLAN BEACH SAMPLES GRAIN SIZE ANALYSIS	Malachy Walsh and Partners / POSFORD DUVIVIER	MAY '98	1:5000
				[redacted]	
				Figure B1(b)	



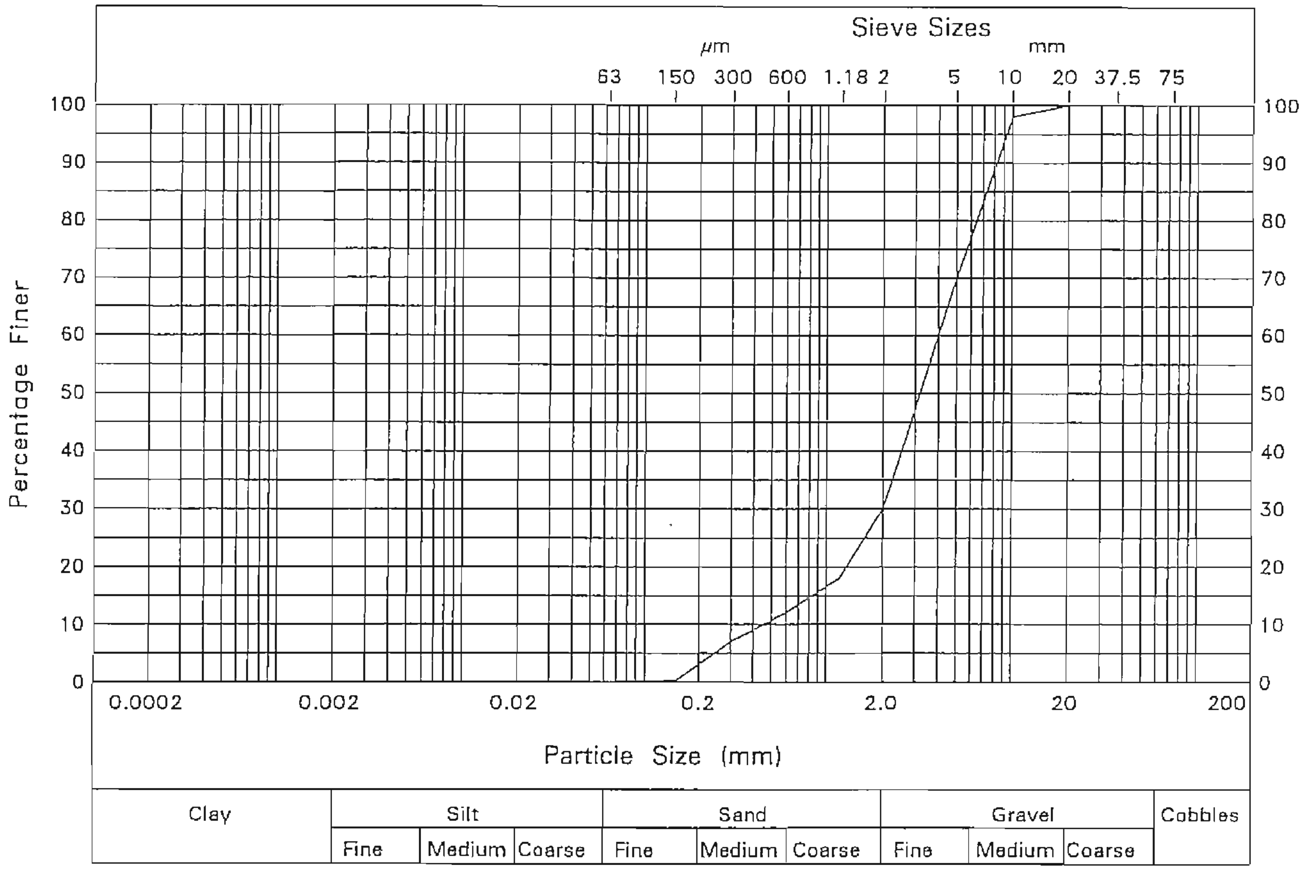
Clay	Silt			Sand			Gravel			Cobbles
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	

Particle Size	% Passing	Particle Size	% Passing
75 mm	100	1.18 mm	18
37.5 mm	100	600 µm	7
20 mm	100	300 µm	2
10 mm	98	150 µm	0
5 mm	77	63 µm	0
2 mm	38		

Hole TP A	Test Performed:
Depth 0.00	Sample Description Coarse SAND and fine to medium GRAVEL
Type A	

Form 25/3

Laboratory - Particle Size Plot	**Project** MALACHY WALSH & PARTNERS LADY'S ISLAND LAKE	**Contract** 178047
GEOTECH Specialists Ltd		**Sheet** Figure B2

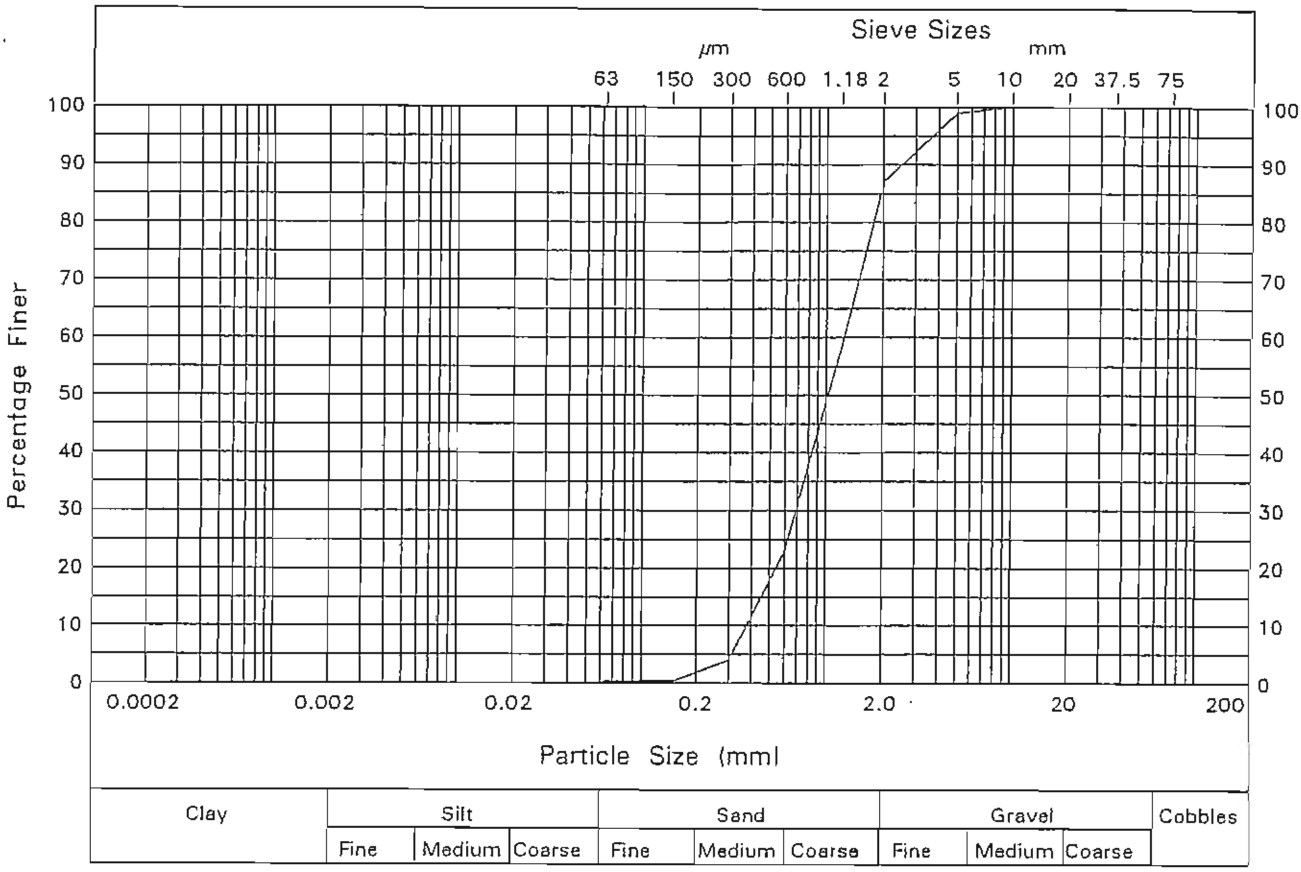


Particle Size	% Passing	Particle Size	% Passing
75 mm	100	1.18 mm	18
37.5 mm	100	600 µm	12
20 mm	100	300 µm	7
10 mm	98	150 µm	0
5 mm	70	63 µm	0
2 mm	30		

Hole TP B	Test Performed:
Depth 0.00	Sample Description Sandy fine to medium GRAVEL
Type B	

Form 25/3

Laboratory - Particle Size Plot	**Project** MALACHY WALSH & PARTNERS LADY'S ISLAND LAKE	**Contract** 178047
GEOTECH Specialists Ltd		**Sheet** Figure B3

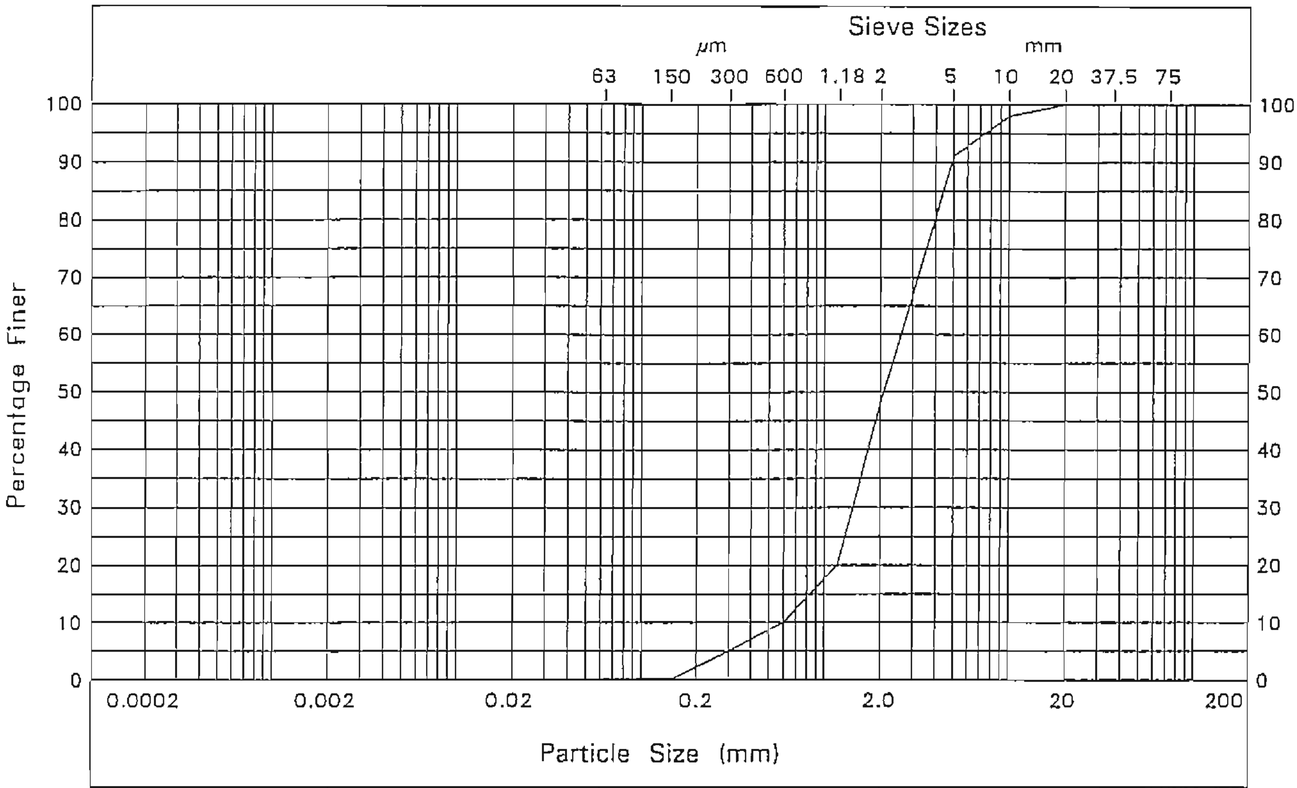


Particle Size	% Passing	Particle Size	% Passing
75 mm	100	1.18 mm	57
37.5 mm	100	600 μm	23
20 mm	100	300 μm	4
10 mm	100	150 μm	1
5 mm	99	63 μm	0
2 mm	87		

Hole C	Test Performed:
Depth 0.00	Sample Description Multi-coloured, medium and coarse SAND with some fine gravel
Type B	

Form 25/3

Laboratory - Particle Size Plot	**Project** MALACHY WALSH & PARTNERS TACUMSHIN LAKE	**Contract** 178067
GEOTECH Specialists Ltd		**Sheet** Figure B4



Clay	Silt			Sand			Gravel			Cobbles
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	

Particle Size	% Passing	Particle Size	% Passing
75 mm	100	1.18 mm	20
37.5 mm	100	600 µm	10
20 mm	100	300 µm	5
10 mm	98	150 µm	0
5 mm	91	63 µm	0
2 mm	48		

Hole A	Test Performed:
Depth 0.00	Sample Description Multi-coloured, coarse SAND and fine GRAVEL
Type B	

Form 25/3

Laboratory - Particle Size Plot	Project	Contract 178067
GEOTECH Specialists Ltd	MALACHY WALSH & PARTNERS TACUMSHIN LAKE	Sheet Figure B5

APPENDIX C
COASTAL PROCESSES

APPENDIX B

BEACH SAMPLES : GRAIN SIZE SAMPLES

<u>CONTENTS</u>

APPENDIX C

COASTAL PROCESSES

CONTENTS

Table C1
Lady's Island and Tacumshin
Coastal Processes
Water Levels

Description	Level mODM	Level mODM
Nominal 50 Year	4.54	1.95
MHWS	3.54	0.95
MHWN	2.84	0.25
MLWN	1.74	-0.85
MLWS	1.04	-1.55

1. Estimates of tide levels have been based on interpolations between Admiralty Tide Table Data for Dunmore East and Rosslare. The interpolation was carried out using co-tidal chart No. 5058.

2. The nominal 50 year extreme water level was estimated by adding 1m to the MHWS level. During studies at Rosscarbery, Tramore and Dungarvan, it was found that the 50 year water level is approximately 1m above MHWS at these locations.

Table C2
Lady's Island and Tacumshin
Coastal Processes
Offshore Wave Climate [1]

WAVE [2]	**DIRECTION (degrees North)**									
HEIGHT (m)	**MEAN (m)**	**050/070**	**080/100**	**110/130**	**140/160**	**170/190**	**200/220**	**230/250**	**260/280**	**290/310**
Calm	*	24	41	26	26	45	36	72	118	31
0.5 – 1m	0.75m	212	294	189	200	489	453	753	882	362
1.5 - 2.0m	1.75m	70	114	79	98	273	307	530	587	184
2.5 - 3.0m	2.75m	33	44	30	47	95	142	241	268	69
3.5 - 4.0m	3.75m	10	9	16	13	35	45	107	126	18
4.5 - 5.0m	4.75m.	1	7	7	1	11	17	25	47	13
5.5 - 6.0m	5.75m	0	1	2	0	2	5	13	20	8
6.5 - 7.0m	6.75m	0	0	2	0	0	2	5	14	1
7.5 - 8.0m	7.75m	0	0	0	1	2	1	6	1	0
8.5 - 9.0m	8.75m	0	0	0	0	0	0	3	1	0
9.5 – 10.0m	9.75m	0	0	0	0	0	0	2	1	0
TOTAL[3]	*****	**350**	**510**	**351**	**386**	**952**	**1008**	**1757**	**2065**	**686**
TOTAL[4]	*****	**3.5**	**5.09**	**3.5**	**3.85**	**9.5**	**10.06**	**17.54**	**20.61**	**6.85**

[1] Number of occurrences from Met Eireann database of visually observed wave heights, for the period 1960 - 1994.

[2] Number of occurrences for the sea area latitude: 51:0 to 52.2^{o}N longitude : 5.5 to 8.0^{o}W.

[3] Total number of occurrences from each direction.

[4] Total percentage frequency from each direction.

Table C3
Lady's Island and Tacumshin
Extreme Offshore Waves [1]

RETURN PERIOD	120 DEGREES	150 DEGREES	180 DEGREES	210 DEGREES	240 DEGREES
YEARS	Hs (m)	Hs (m)	Hs (m)	Hs (m)	Hs (m)
1	5.25	4.53	5.39	6.05	8.01
5	6.81	5.83	6.69	7.5	9.86
10	7.48	6.38	7.24	8.12	10.66
50	**9.04**	**7.68**	**8.55**	**9.57**	**12.52**
100	9.71	8.24	9.11	10.2	13.31
150	10.1	8.56	9.43	10.56	13.78
200	10.38	8.79	9.67	10.82	14.11
250	10.6	8.97	9.85	11.02	14.37

[1] These estimates of extreme significant wave height have been made by fitting a gumbel distribution to the data of Table 1. The method of least squares was used to fit the data to the distribution. Extreme estimates have been made based on a constant sea state for a 3 hour period.

Table C4
Lady's Island and Tacumshin
Coastal Processes
Longshore Sediment Transport[1] : Yearly Average

LOCATION	OFFSHORE WAVE DIRECTION	SEDIMENT TRANSPORT RATE[3]	EQUILIBRIUM ANGLE[4]
		[2]Van Rijn (m^3/yr)	Degrees
LADY'S ISLAND	120 degrees	0	-0.3
	150 degrees	-8,484	-0.3
	180 degrees	-31,816	-0.3
	210 degrees	-4,242	-0.3
	240 degrees	44,543	-0.3
Net	-	**0**	-
Gross	-	**89,085**	-
TACUMSHIN	120 degrees	-42,422	- 30
	150 degrees	-33,938	- 30
	180 degrees	-2,121	-30
	210 degrees	10,606	-30
	240 degrees	8,484	-30
Net	-	**-59,391**	-
Gross	-	**97,571**	-

[1] Calculated over ?? from High Water Level
[2] Author of Transport formulae used
[3] Negative indicates Westward movement; positive indicates Eastward movement.
[4] Positive indicates clockwise movement of the shoreline to achieve equilibrium. Negative indicates anti-clockwise movement of the shoreline to achieve equilibrium.

Table C5
Lady's Island and Tacumshin
Coastal Processes
Longshore Sediment Transport : Extreme Values

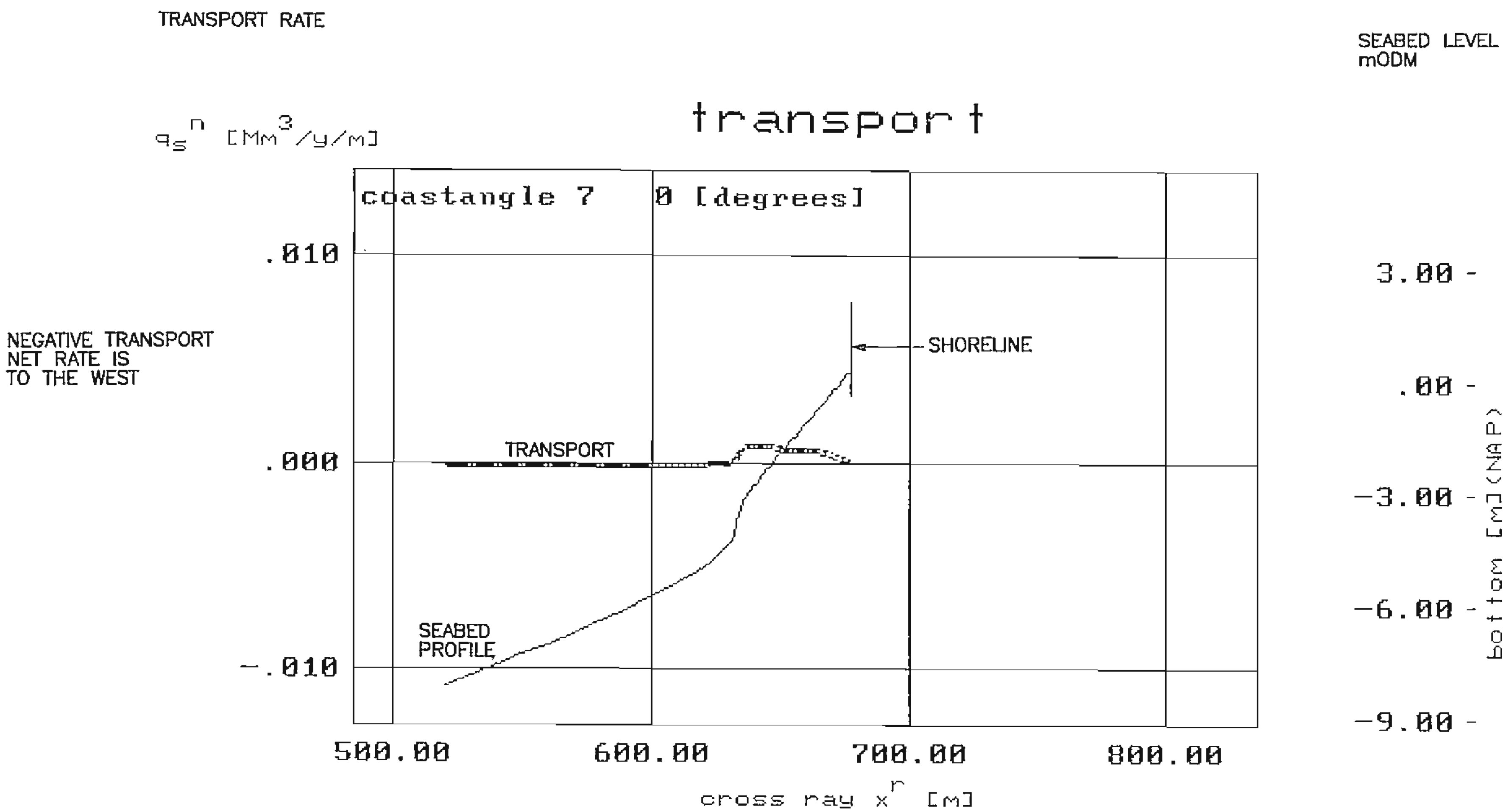
WATER LEVEL	**LOCATION**	**OFFSHORE WAVE DIRECTION**	**SEDIMENT TRANSPORT RATE[1]** [2]**Van Rijn (m^3/6hours)**		
			2m WAVES	**4m WAVES**	**8m WAVES**
MHWS + 1m	**LADY'S ISLAND**	120 degrees	-	-	-68
		150 degrees	-7	-68	-404
		180 degrees	-14	-110	-459
		210 degrees	-	-14	-212
		240 degrees	-	41	-
MHWS		120 degrees	-	-	-82
		150 degrees	-14	-82	-377
		180 degrees	-21	-116	-390
		210 degrees	-	-201	-185
		240 degrees	-	41	-

1 Negative indicates Westward transport; positive indicates Eastward movement

2 Author of transport formula used.

Table C5 cont'd

WATER LEVEL	LOCATION	OFFSHORE WAVE DIRECTION	SEDIMENT TRANSPORT RATE[1] [2]Van Rijn (m^3/6hours)		
			2m WAVES	**4m WAVES**	**8m WAVES**
MHWS + 1m	**TACUMSHIN**	120 degrees	-14	-82	-260
		150 degrees	-21	-103	-233
		180 degrees	0	-7	-41
		210 degrees	21	96	151
		240 degrees	0	55	192
MHWS		120 degrees	-14	-75	-212
		150 degrees	-21	-96	-185
		180 degrees	0	-7	-34
		210 degrees	21	82	123
		240 degrees	0	55	158



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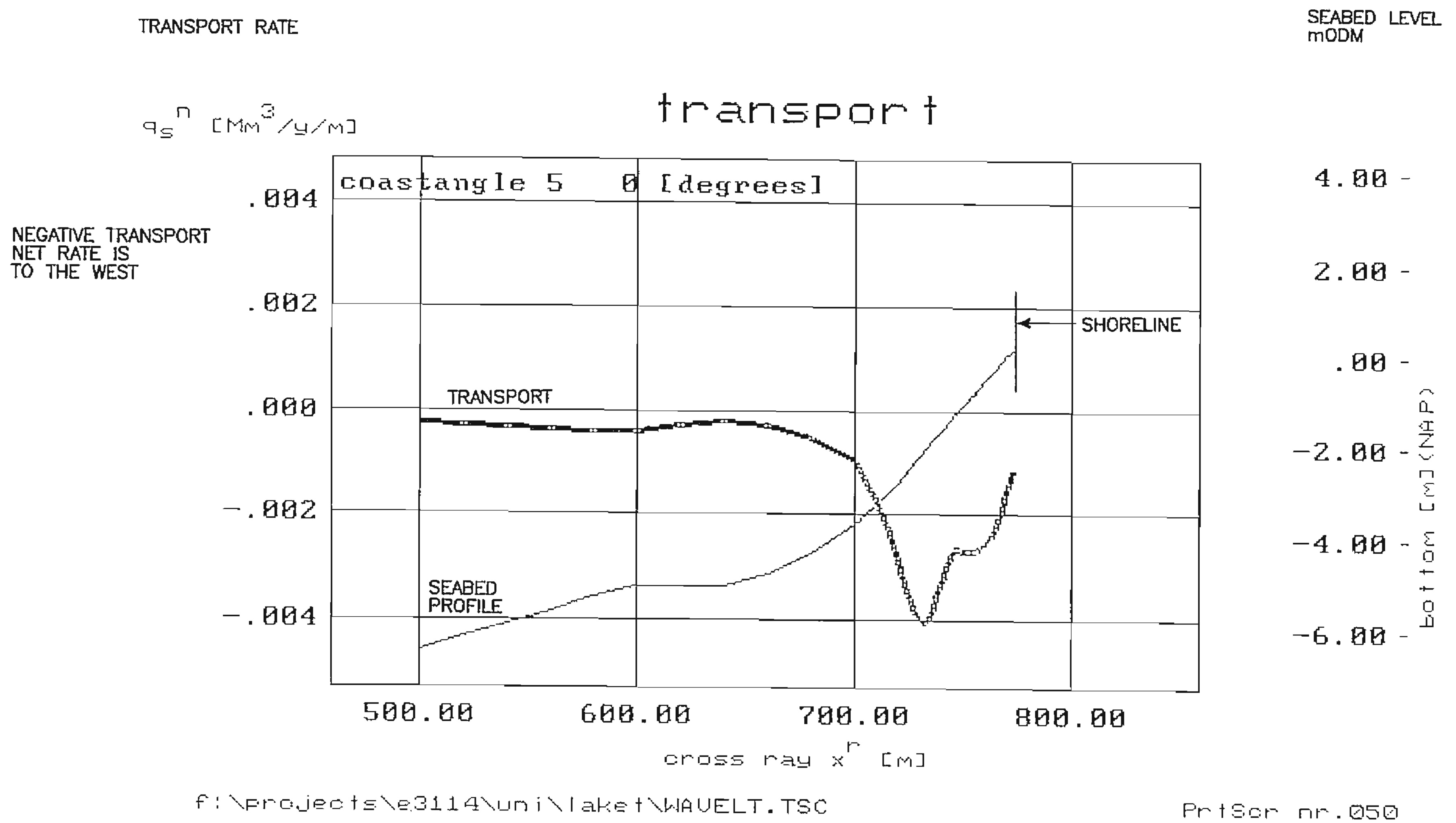
PrtScr nr.032

SHOWTS 1.13

delft hydraulics (c)

VARIATION IN LONGSHORE SEDIMENT TRANSPORT WITH DISTANCE FROM SHORE

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	LADY'S ISLAND LAKE NET LONGSHORE SEDIMENT TRANSPORT	Malachy Walsh and Partners / POSFORD DUVIVIER	MAY '98 [redacted] Figure C1	



SHOWTS 1.13 delft hydraulics (c)

VARIATION IN LONGSHORE SEDIMENT TRANSPORT WITH DISTANCE FROM SHORE

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	TACUMSHIN LAKE NET LONGSHORE SEDIMENT TRANSPORT	Malachy Walsh and Partners; POSFORD DUVIVIER	MAY '98	[redacted] Figure C2

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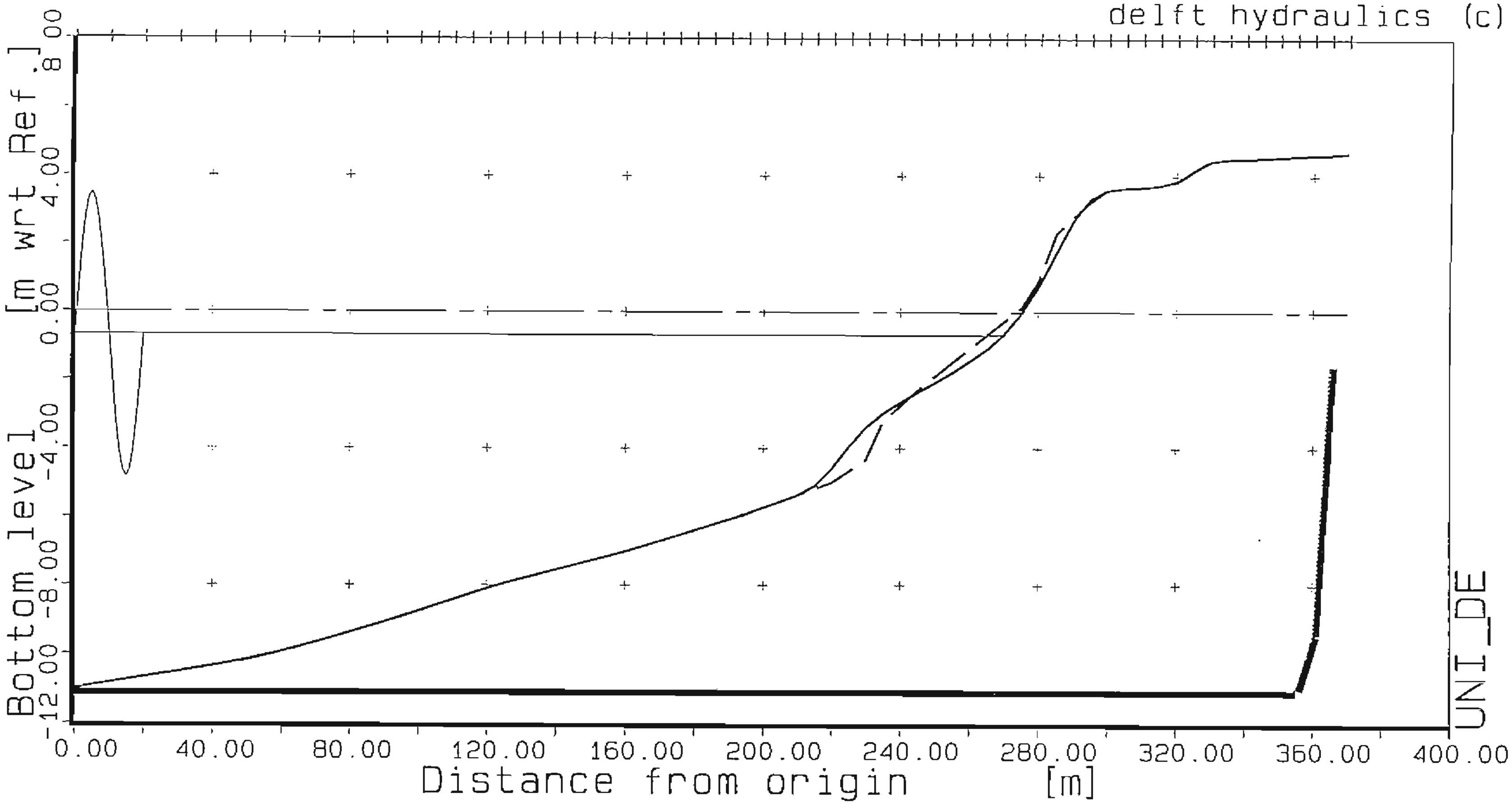
delft hydraulics (c)



E3114/01/001

Lady's Island Lake

Surge tide Hs=8.34

D50=3mm note no on shore movement

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	SURGE TIDE d_{50}=3mm LADY'S ISLAND LAKE PROFILE CHANGE	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98	
				[redacted]	

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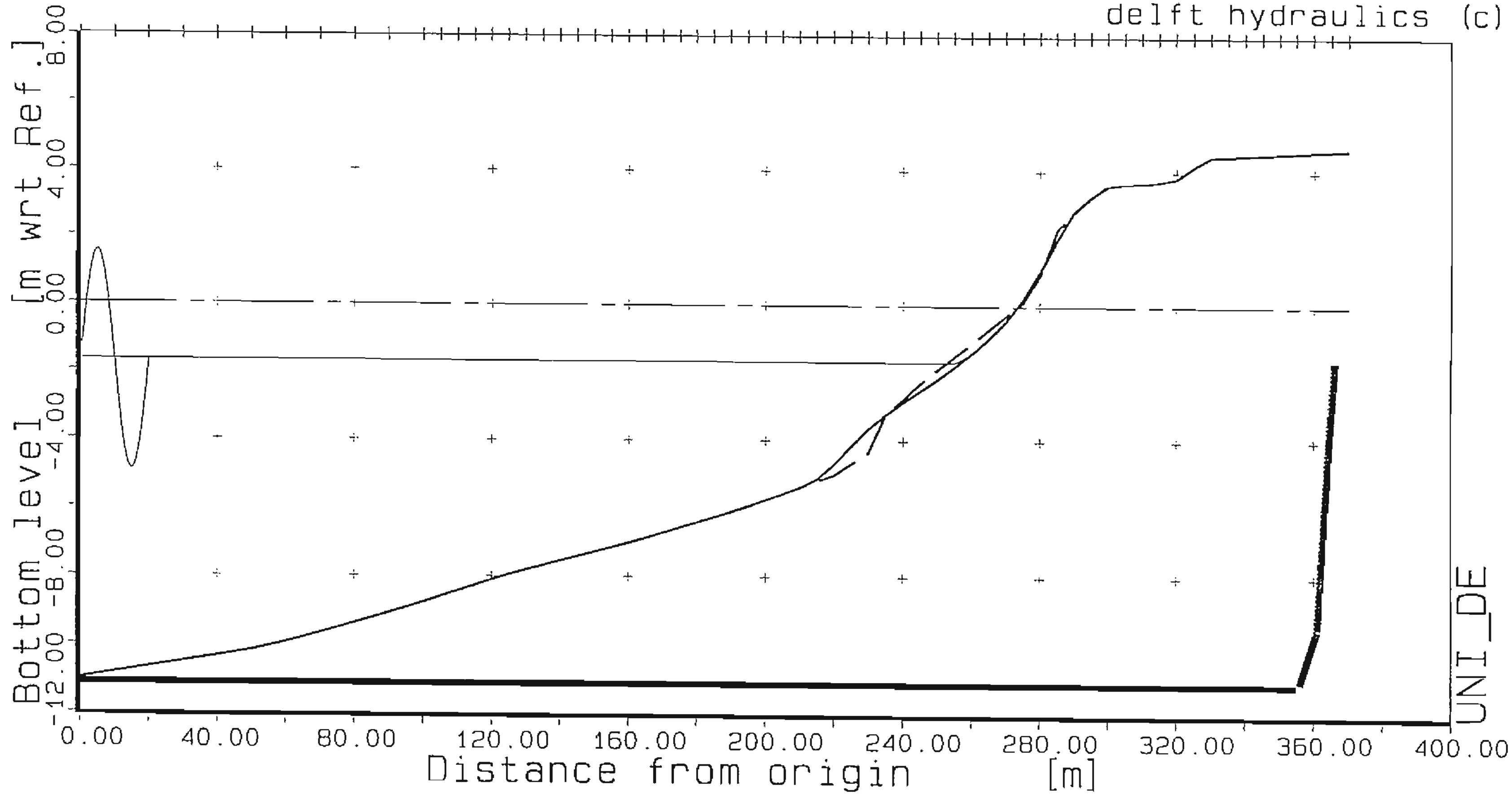

E3114/01/001

Lady's Island lake

Spring tide Hs=6.5m

D50=3mm

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	SPRING TIDE d_{50}=3mm LADY'S ISLAND LAKE PROFILE CHANGE	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98	
				[redacted]	
				Figure C4(a)	

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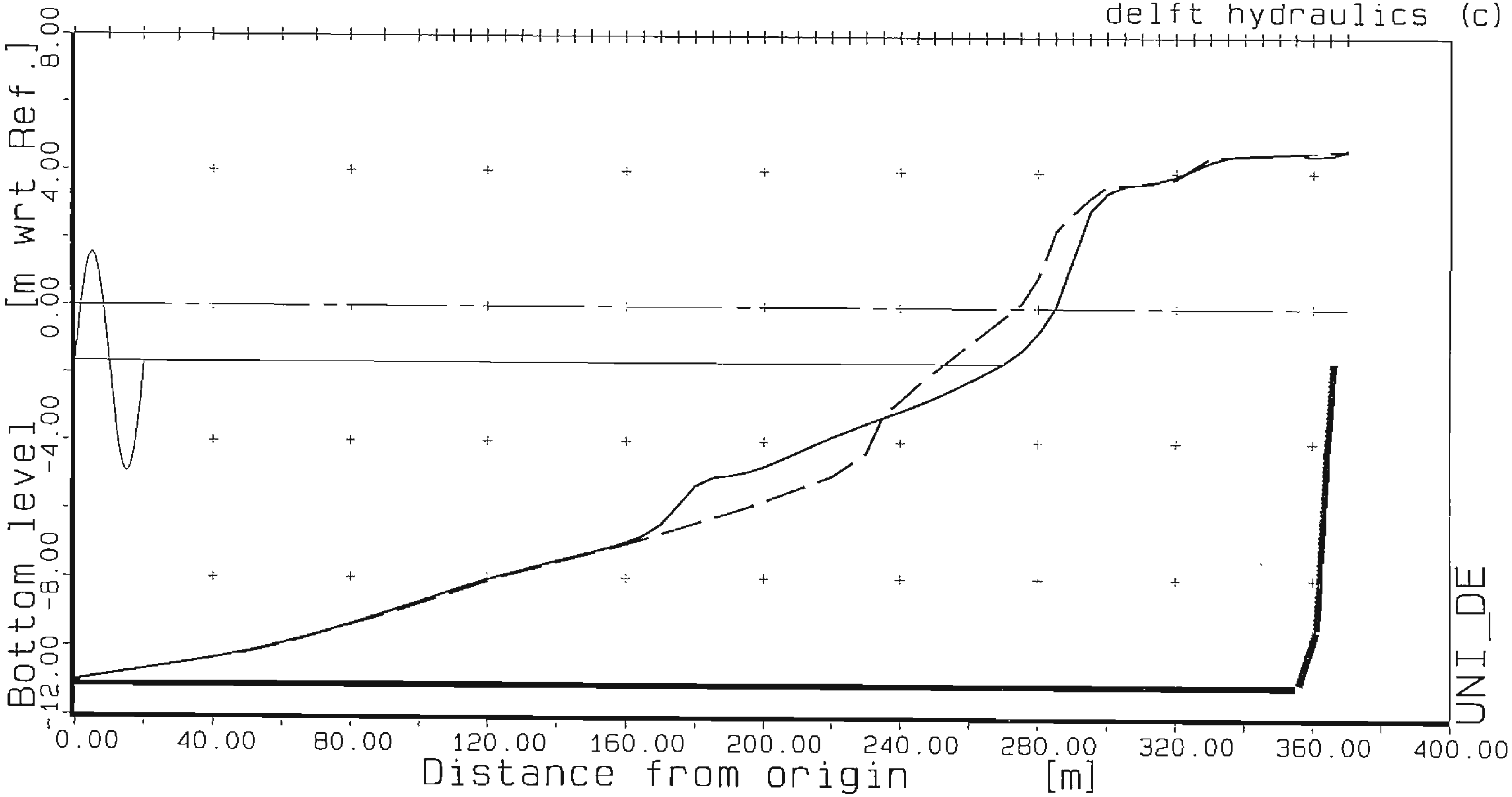
delft hydraulics (c)



E3114/01/001

Lady's Island lake

Spring tide Hs=6.5m

D50=1mm

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	SPRING TIDE d_{50}=1mm LADY'S ISLAND LAKE PROFILE CHANGE	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98 [redacted] Figure C4(b)	

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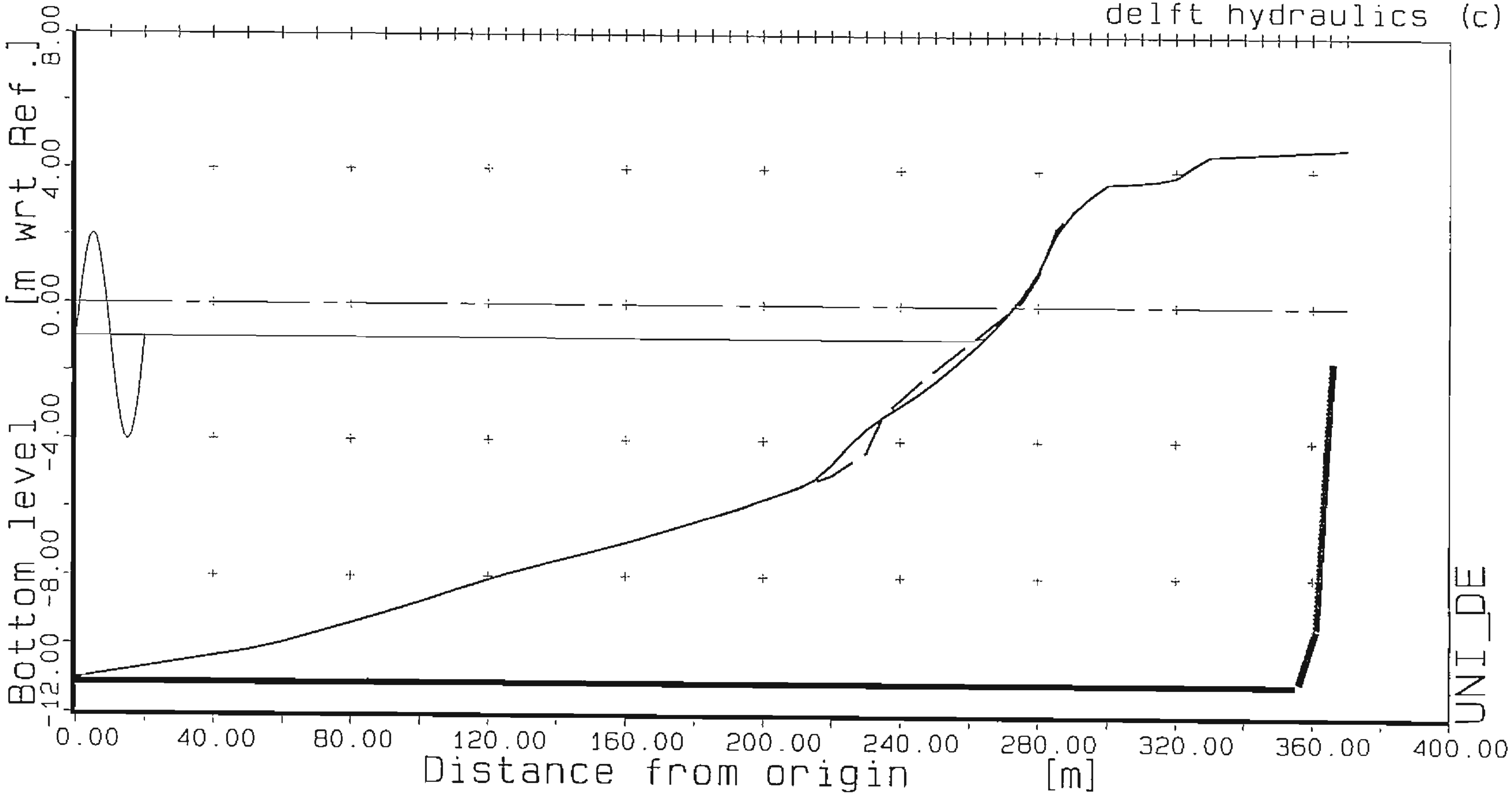
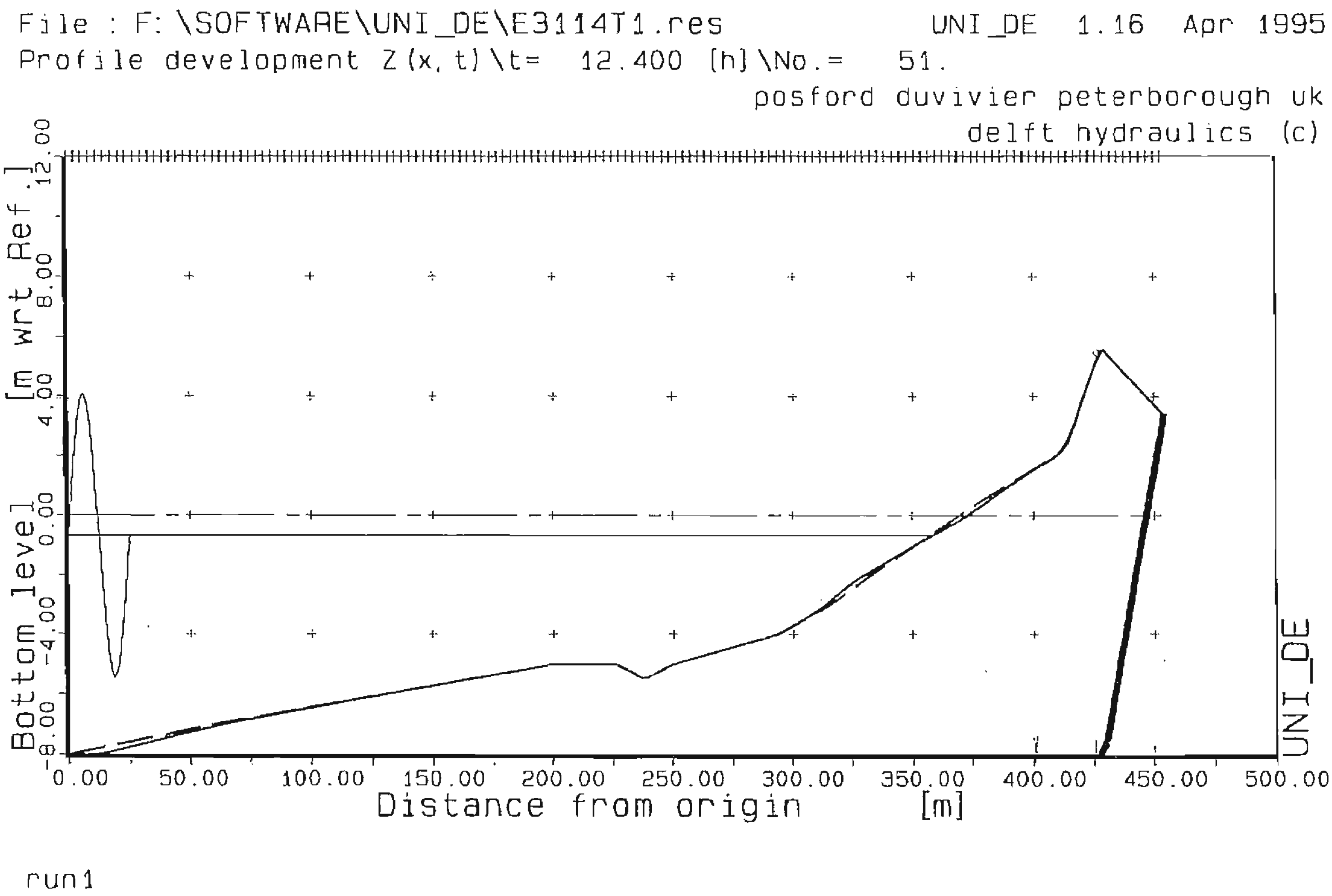
posford duvivier peterborough uk
delft hydraulics (c)



E3114/01/001
Lady's Island Lake
Neap tide Hs=6.1m
D50=3mm

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	NEAP TIDE d_{50}=3mm LADY'S ISLAND LAKE PROFILE CHANGE	Malachy Walsh and Partners / POSFORD DUVIVIER	MAY '98 [redacted] Figure C5	



Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	SURGE TIDE d_{80}=2mm TACUMSHIN LAKE PROFILE CHANGE	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98 [redacted]	

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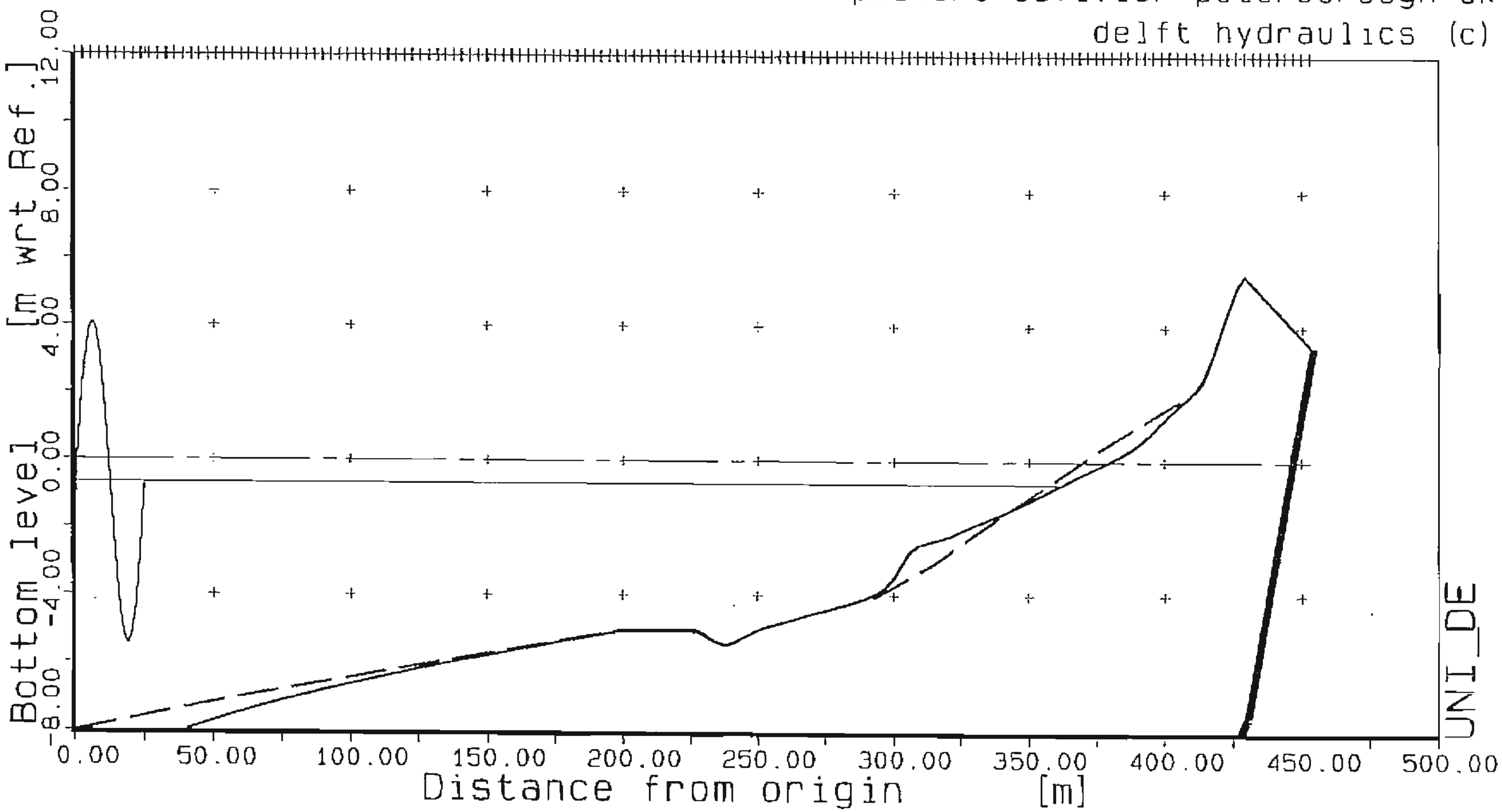
delft hydraulics (c)



E3114/01/001

Tacumshin Lake

Surge Tide Hs=9.55m

D50=1mm

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	SURGE TIDE d_{50}=1mm TACUMSHIN LAKE PROFILE CHANGE	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98 [redacted]	Figure C6(b)

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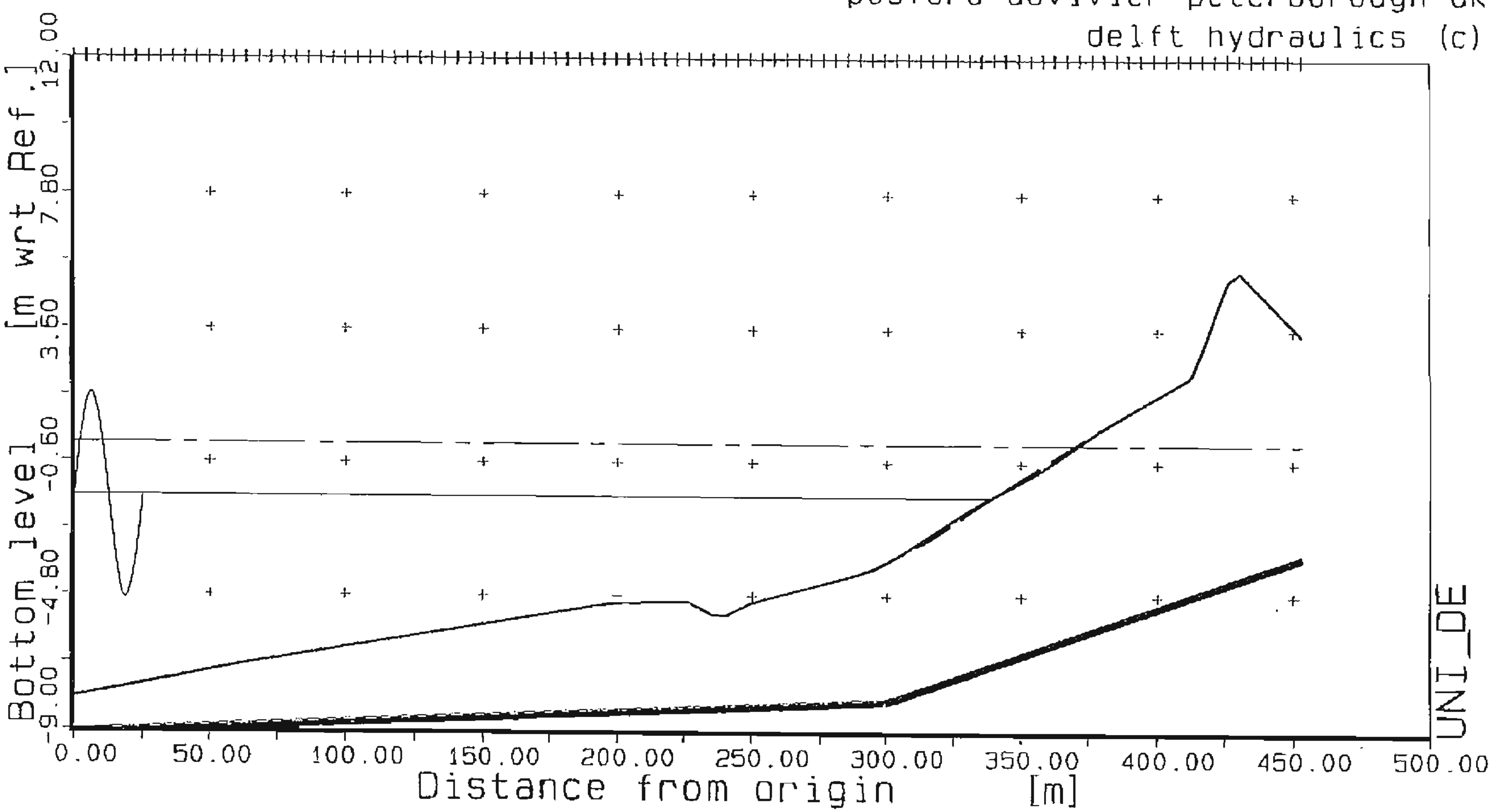
delft hydraulics (c)



e3114/01/001

Tacumshin

spring tide

d50=2mm

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	SPRING TIDE d_{50}=2mm LADY'S ISLAND LAKE PROFILE CHANGE	Malachy Walsh and Partners POSFORD DUVIVIER	MAY '98 [redacted] Figure C7	

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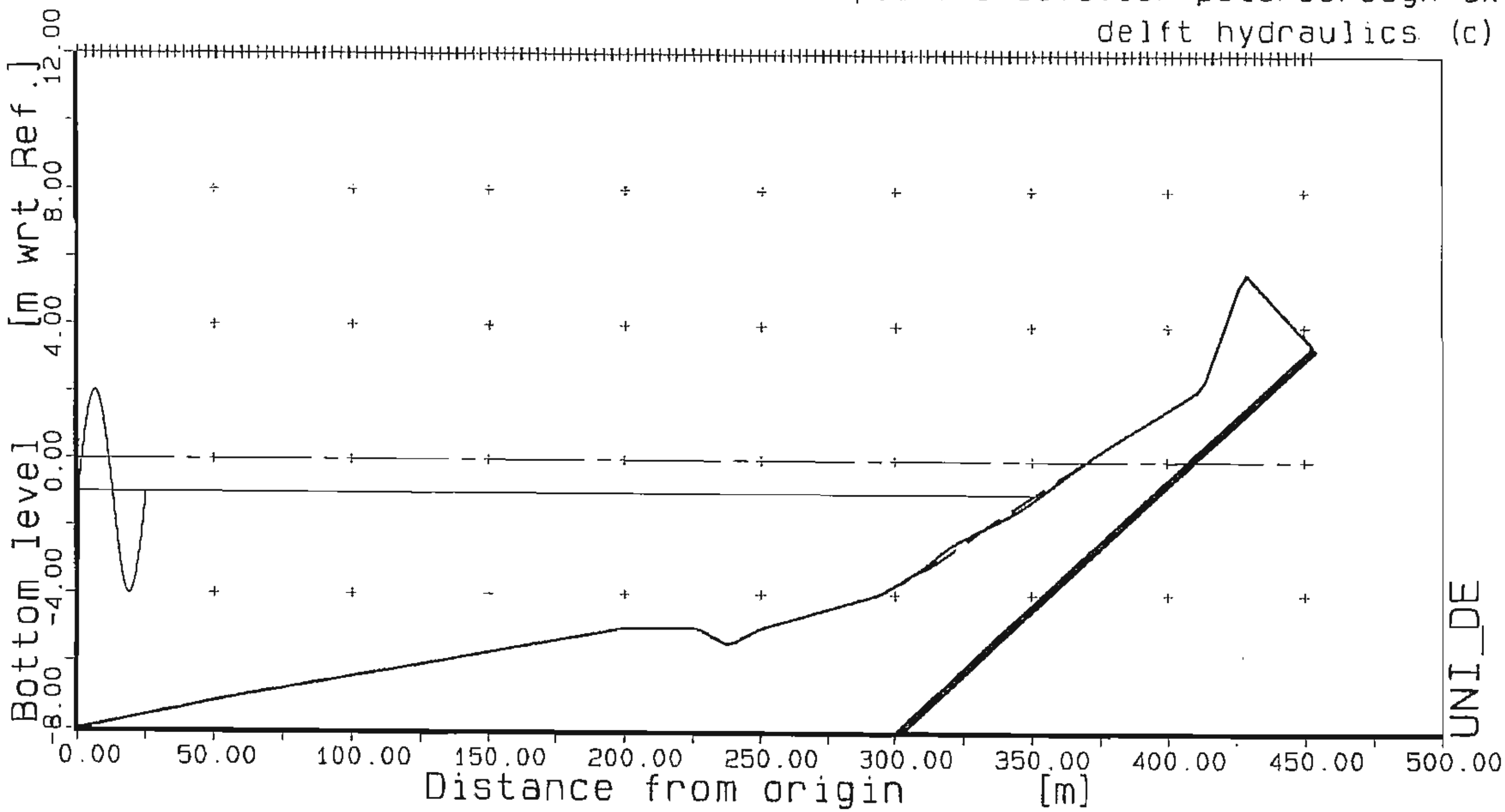
posford duvivier peterborough uk
delft hydraulics (c)



E3114/01/001

Tacumshin

Neap tide Hs=6.1m

D50=2mm

Client	Project	Title		Date	Scale
Department of Arts, Heritage, Gaeltacht And The Islands	Drainage Options Lady's Island Lake Tacumshin Lake	NEAP TIDE d_{50}=2mm TACUMSHIN LAKE PROFILE CHANGE	Malachy Walsh and Partners / POSFORD DUVIVIER	MAY '98	
				[redacted]	
				Figure C8	