MARINA PROJECTS

Pwllheli Harbour
Pwllheli, Gwynedd

Gwynedd Council

Commercial in Confidence

DRAFT
Dredging Strategy

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1. EXECUTIVE SUMMARY

To be completed following client feedback

2. INTRODUCTION

2.1 BACKGROUND

Pwllheli harbour was developed into its current form as a function of the development of the Pwllheli Marina over the period 1989-1991. The changing form and shape of the harbour and consequent increase in leisure berthing provision brought with it a requirement to maintain areas of water at depths suitable for berthing and navigation.

Over the period 1992-2007 there has been a programme of maintenance dredging undertaken in varying forms in different areas of the Harbour. The dredging activity is generally dictated by the nature of the material deposited and its location. For example the material within the Harbour Entrance is largely created by the coastal processes of longshore drift and this requires different treatment to the material deposited within the marina basin.

The vast majority of the maintenance dredging has been undertaken by the Local Authority and this report has been commissioned to prepare a dredging strategy that pulls together the historic situation, lessons learned to date and set the scene for the future dredging of Pwllheli Harbour.

2.2 STUDY BRIEF

The study brief is set out within the Cyngor Gwynedd Council Briefing document reference CPF 1191 April 2008 and it refers to Drawing No CPF/1191/Spec – this drawing (Rev B) is provided within Appendix 7 of this report. The brief requires that this study addresses the following points:

1. To prepare a dredging strategy that addresses all the different aspects of maintaining the approach channel and berthing basin. It has been agreed that the strategy should consider a 10-15year life span.

2. Produce a time series summary of the historic dredging activities undertaken in the harbour since the capital dredging for the marina in 1989. The summary to include details where possible of methods of dredging and disposal; design dredge depths and actual depths achieved including initial over-dredge.

3. Comment on the design dredge and advertised depths of the approach channel and marina basin.

4. Comment on the proposed maintained dredged width of 25m for the approach channel.

5. Comment on the suitability of bed levelling/ploughing as an ad hoc maintenance dredging approach.

6. Comment on the need for a sustainable recycling strategy for the material in the stilling lagoon.

7. Comment on the current recycling strategy for the Harbour Entrance dredging.

8. Comment on the licence and consent requirements and the extent to which these might influence the dredging/disposal strategy. Identify associated risks and key constraints such as environmental designations.

9. Conduct an appropriate consultation with statutory consultees.

10. Are the funding options detailed in the Appendix 2 programme (of the brief) sufficient to be able to prosecute a robust strategy?

11. Identify appropriate contractors/plant capable of prosecuting the proposed strategy.

12. When preparing the strategy consider the implications of climate change on the volume of sedimentation being deposited within the harbour from marine and fluvial sources. The information contained in the Supplementary Note to Operating Authorities-Climate Change Impacts, October 2006 issued by Defra to be used to make the assessment.

2.3 METHODOLOGY

A key element of the strategy is a review of the extensive data and reports held by Gwynedd Council and to this end an extensive review session was conducted as the first stage of the process. A day was spent at the Council offices in Dolgellau identifying and reviewing key reports and documents and a significant amount of time has been

spent gathering extensive background information. Extracts of relevant reports were copied and the data subsequently reviewed. This report does not make extensive reference to the wealth of reports with only the key findings being identified.

The conclusion of the first stage of work saw site visits conducted to fully appreciate the constraints affecting the location. This first stage has been important in fully establishing the background and baseline position.

The detailed survey information has been reviewed in further detail to establish the quantity and nature of the material that accretes in the main areas of the Harbour to identify the scale of the likely dredging operation and frequency.

Review of the harbour activities has also been undertaken to establish the key issues that impact on the requirements for maintenance dredging.

Development of the strategy has relied upon Marina Projects experience of the licensing regime for maintenance dredging and general knowledge of the dredging market place, contractors methods etc. Consultation has been conducted with Countryside Council for Wales (CCW), the Environment Agency and the Harbour Consultative Committee and where relevant appropriate details have been included within the relevant section. The study work has also benefited from our recently developed knowledge of the area consequent of our involvement in the development of concept proposal for a Welsh National Sailing Academy and Event Centre in Pwllheli.

Review of the site and dredging history has identified three distinct areas of the Harbour and the report is therefore broken down into the structure outlined below:

Section 3 provides details of the site and the dredging history. Three key areas are identified, The Harbour Entrance, Access Channel and the Marina Basin and a more detailed description of these zones is provided in the following sections (Section 4-6) and Section 7 describes the stilling lagoon area.

Section 8 identifies the various types of dredging, disposal and the licensing and consenting regime that is linked to the dredging method/activity.

Each section where relevant includes a summary of the key issues identified within the section. Within Section 9 the key issues are brought together to develop a series of

recommendations with appropriate discussion of other pertinent issues that have informed the basis for the strategy.

3. SITE & DREDGING HISTORY

3.1 LOCATION & DESCRIPTION

The following section provides a summary description of the relevant prevailing conditions within the Harbour.

Pwllheli Harbour is a relatively small body of water with the main area of the Harbour being some 600m x 600m and this is accessed via a tidally restricted Harbour Entrance which is currently in the order of 30m wide and approximately 1km long at a design depth of 0.56m below Chart datum (-3.0m OD). The harbour area has two rivers flowing into it; The Afon Erch enters in the North East corner and the Afon Rhyd-hir from the North West corner.

The harbour hosts a range of moorings from swinging moorings and piled pontoon moorings to a fully serviced 400 berth marina as shown on the plan at Appendix 1. The marina basin covers an area of approximately 5Hectares and has a design dredge depth of 3.06m below Chart Datum (-5.5m OD).

3.2 PHYSICAL PROCESSES

As is typical of sheltered environments like this the dominant sediment type in the inner harbour is mud and silts. The foreshore in the Harbour is inter-tidal mudflat and is the subject of environmental designation as discussed in Section 3.7. The supply of sediment to the Harbour is primarily derived from the local coastal processes with a small amount of fluvial input from the two rivers.

As noted it is the local coastal processes which result in a littoral drift of aggregate along the beach towards the Harbour Entrance which result in a significant volume of sands and gravels being transported into the Harbour Entrance and deposited within the Harbour. The greatest volume of material is deposited in the entrance with the proportion of material reducing further into the Harbour. These processes and the effect on the harbour are discussed further in Sections 4, 5 and 6 below.

3.3 TIDAL CONDITIONS

The tide conditions within the Harbour are detailed in Table 3.1 below:

Tide	Ordnance Datum	Chart Datum
Highest Astronomical Tide	3.26m	5.7m
Mean High Water Springs (MHWS)	2.56m	5.0m
Mean High Water Neaps (MHWN)	0.96m	3.4m
Mean Low Water Neaps (MLWN)	-0.74m	1.7m
Mean Low Water Springs (MLWS)	-1.94m	0.5m
Lowest Astronomic Tide (LAT)	-2.44m	0.0m

Table 3.1 – Tide details for Pwllheli Harbour

3.4 SITE HISTORY & DEVELOPMENT

Following a lengthy period with no development and against the background of limited use of Pwllheli Harbour in the late 1980's and then in the early 1990's the then local Authority Cyngor Dosbarth Dwyfor commenced the development of the harbour to include a 400 berth marina. Separate contracts were let for the development which was undertaken in three main phases as follows:

1989 – Phase 1 – Civils work, dredging, land reclamation and demolition
1990 – Phase 1a – Design, construction and installation of pontoons
1991 – Phase 1b – Land based facilities.

Review of the 1989 contract documents confirms the following key points:

- The work was undertaken by a cutter suction dredger and the plant was of a size that dictated that a significant over dredge of both the channel and marina basin was conducted (at no cost to the contract) in order to provide adequate access.
- In addition to the intended over-dredge there was a further over-dredge in the marina basin and Access Channel.
- The material to be dredged was generally sands and gravels overlying stiff clays – the clays generally were below the design dredge depth.
- Dredge arisings were used to reclaim the Glan Don Peninsula
- The Access Channel was designed at 80m width (Posford Duvivier Drg No. 5513/7 – Oct 1998).
- Review of the navigation marks suggests that the channel is a maximum identified width of 60m.

As noted above there was a significant over dredge of the marina basin and Access Channel and these issues and post construction issues are described in more detail in the relevant section below.

3.5 REPORTS AND STUDIES

As noted in Section 2.3 a review was undertaken of the extensive reports held by Gwynedd Council. A wealth of information is available, not all of which is directly relevant to the study. In order to clarify the issues this report aims to identify only the fundamental points that have a material bearing on the current situation and the future dredging strategy. The key documents that have influenced this study and development of the strategy are:

3.5.1 **Pwllheli Harbour Development - Draft Status Report on Phases 1a & 1b(ii)** – by by Posford Duvivier – September 1992

This report provides an update on issues arising following the capital dredging contract. The report notes that the Access Channel and marina basin were the subject of over dredging. Indeed there is reference to dredging in the channel of up to 2.5m beyond the design dredge depth. The report also notes the benefits arising from the over-dredge in the channel in the form of a greater tidal access window and the creation of a sump to take-up the early year siltation.

3.5.2 **Pwllheli Harbour Development Monitoring of Bed Levels Report** – by Posford Duvivier – September 1993

The report notes the following key points:

- Accretion of material at the Harbour Entrance – which it reports is set at 60m width with other areas of the channel set at 80m width.
- Deposition of material to the north of the marina basin, gravels, sands and silts. Maintenance dredging was recommended to address this.
- General silting of 350mm across the marina basin but depths still below the design depth over 95% of the basin.
- Silting in the channel of 200mm but still well below the design level – a problem is noted that some high spots, that were removed to the design

level, are perceived to create a problem because of the general extra depth in the channel

- Additional finger berths were introduced to the marina beyond the limit of the design depth, the siltation has created tidal restrictions to these "opportunist" berths.
- Assessment of siltation rates in the basin are estimated at 7,000m^3 per annum.
- Suggestion that maintenance of the Harbour Entrance will be required on a regular basis (early estimates of an annual removal of 16,000 – 20,000m^3).

3.5.3 **Pwllheli Harbour Navigation Maintenance Plan** – by Shoreline Management Partnership – December 1997.

This report was commissioned by Gwynedd Council following Local Government Reorganisation as a consequence of which the Authority had responsibility for maintenance dredging.

The report quantified the dredging requirements, identified that a local approach to disposal of dredgings was required and confirmed a link between the Harbour Entrance dredging and coastal replenishment works. In order to finalise the development of a dredging plan, the report made a recommendation to undertake a number of additional studies:

- Siltation review study
- Beach management study
- Dredging techniques appraisal

3.5.4 **Pwllheli Harbour Navigation Maintenance Plan** – Report EX 3898 – by HR Wallingford – July 1998

The key finding of this study that influences the development of this dredging strategy is the identification of the processes that create deposition within the Harbour. In essence the ebb tide flows are insufficient in strength to re-suspend material deposited on the flood tide. The sediment regime in Pwllheli Harbour is such that the vast majority of sediment deposited in the Harbour is marine in origin, even in the marina basin. The marina basin also suffers a level of accretion from the re-worked sediments contained to the North of the marina basin and is impacted

by fluvial flows. Assessments are made of predicted accretion rates in the main areas of the Harbour and these are reported in the relevant sections below.

3.5.5 **Review of the Pwllheli Harbour Navigation Maintenance Plan & Factual Sedimentation Report** (hereafter referred to as the Factual Sedimentation Report) – by Civil Engineering Solutions – Feb 2007.

This report was commissioned to review the dredge volumes and accretion rates within the various harbour zones to inform the development of the dredging strategy; as such this report provides a key input to the development of this strategy. Great efforts were made to gather all of the hydrographic survey data gathered since the dredging of the marina in 1989/90. The report pulled together the extensive available survey data to culminate in a detailed assessment of the dredged volumes and sedimentation rates within the harbour.

The data collated enabled realistic assessments of sedimentation rates to be made based upon measurements from robust survey data; rather than relying on modelling data.

3.5.6 **Pwllheli, Traeth Crugan Coastal Defence Options Study Report -** by Faber Maunsell – Sept 2008.

This report reviews the coastal defence options for the frontage to the west of Pwllheli Harbour that receives the recycled material from the Harbour Entrance. The report confirms that beach nourishment is beneficial and will continue largely as present in the immediate future. It is clear that the dredging strategy and the nourishment strategies have a symbiotic relationship.

In the medium to longer term it will be necessary to review the nourishment strategy where the aspiration is to return the beach to a state of equilibrium.

Other relevant information from these reports is highlighted in the relevant sections of this report.

3.6 DREDGING ACTIVITY

Gwynedd Council's Coast Protection Unit (CPU) has been responsible for maintaining navigation within Pwllheli Harbour since 1997[1]. This has involved dredging operations to maintain navigation at the Harbour Entrance ensuring depth of water is sufficient for navigation, and separate operations within the marina to ensure adequate water depth for moored vessels to stay afloat.

As is noted above there are two distinct dredging operations within the Harbour and three distinct and separate zones; The Harbour Entrance; Access Channel; and the Marina Basin. In order to clearly identify the issues associated with the different areas sections 4-6 below describe separately each area in greater detail. The three zones are identified on Drawing No. MP115a-P-100 at Appendix 1.

Historically Gwynedd Council has been responsible for and has undertaken the majority of the dredging works within the Harbour. In order to establish the dredging requirement and monitor levels of accretion within the Harbour area, Gwynedd Council undertakes an annual hydrographic survey generally in September/October. This establishes the condition of the harbour and precedes all dredging campaigns which is confirmed by discussion with Gwynedd's Maritime Officer that establishes the areas within the harbour to be dredged.

Periodic hydrographic surveys are undertaken during the dredging campaigns to inform the dredging management contractor and the council of progress. Post dredge hydrographic surveys are undertaken for the dredge areas at the end of each campaign.

These surveys provide a wealth of valuable information which is explored further in the relevant sections below:

3.7 ENVIRONMENTAL DESIGNATIONS & ASSESSMENT

Within Pwllheli harbour itself the mudflat is designated as Biodiversity Action Plan (BAP) Priority Habitat. Other relevant designations are in close proximity to the harbour and these are listed below:

- Llyn Peninsula and the Sarnau: Special Area of Conservation (SAC)

[1] Review of the Pwllheli Harbour Navigation Maintenance Management plan & Factual Sedimentation Report CPF/1671 Feb 2001 Civil Engineering Solutions Ltd

- Morfa Abererch: Site of Special Scientific Interest (SSSI)
- Mynydd Tir y Cwmwd a'r Glannau at Garreg yr Imbill: Site of Special Scientific Interest (SSSI)
- Lon Cob Bach: Local Nature Reserve (LNR)

There are two elements to the dredging proposal in terms of potential impacts upon the environmentally sensitive sites. The first is the dredging activity and associated works proposed within the harbour which may directly and indirectly impact the Special Area of Conservation (SAC), and two Sites of Special Scientific Interest (SSSI). The second element of beach nourishment works may also have an impact upon the SAC and SSSI both directly and indirectly. In addition to the national and international sites, as noted above, there is also a Local Nature Reserve and many habitats rich in biodiversity in close proximity.

The above designations are listed in more detail in Appendix 2 with a brief description of the reason for each designation, potential impacts by the proposals.

Of particular consideration is the SAC Action Plan, of which Gwynedd Council is a key member of the Relevant Authorities Group. The Policies and actions of the Plan should therefore be considered by the Council in establishing its Dredging strategy. The following section assesses the potential impacts of any proposal on the designations and the resulting issues for the study work and resulting strategy.

Whilst all areas are designated for important ecological features, it should be noted that policies and legislation for internationally designated areas (i.e. SACs, SPAs) are more stringent than for nationally important areas (i.e. SSSIs) and generally have precedence.

Both the dredging activity and the beach nourishment works will have potential for direct and indirect impacts upon the SAC and SSSI sites. Previous assessments have considered the impacts and found them to be manageable, with monitoring work proposed to ensure projections were accurate and data gaps were filled. So long as the timings, volumes and methods employed do not change then the assessed impacts will remain as previously established.

In the area of the bunded disposal site and potentially impacted by any works within the Harbour is the Lon Cob Bach Local Nature Reserve and the Council should ensure that impacts, direct or indirect, to the Lon Cob Bach LNR are avoided.

In discussions regarding the proposals for the Events Centre and Sailing Academy CCW stated that they are not comfortable with a loss of BAP habitat. There is the potential that some of the area impacted by the dredge activity proposed within the Pwllheli Harbour Dredge strategy could influence BAP habitat. The CCW's priority is the SAC and whilst CCW will defer to the other authorities tasked with consideration of BAP implementation, CCW will likely advise these authorities of their opposition to loss of BAP habitat. Previous maintenance dredging activity has not impacted the current extent of mudflat in the Harbour, and the Council should ensure that if an alternative approach is proposed consideration of the potential impact on BAP habitat is reviewed.

To ensure that the Council fulfil their duty it would be prudent to re-visit the information upon which the assessments were made to ensure there have been no significant changes which could alter the conclusion of previous assessments. It is felt that a complete re-assessment is not required (or unlikely) as long as the Council can demonstrate that the impacts as a result of any changes remain negligible or manageable.

3.7.1 Appropriate Assessment (AA)

An AA has already been carried out. It is recommended that GC liaise with CCW to ensure that the AA remains fit for purpose

3.7.2 Environmental Impact Assessment (EIA)

As an EIA has already been carried out for the beach nourishment works it is felt dialogue with the Marine & Fisheries Agency (MFA) should be established to ascertain if the EIA Regulations will be triggered again, or if the pervious EIA will suffice.

Before completing the consultation with the relevant Authorities it would be advisable to ensure that the survey work mentioned in the previous AA/EIA has been completed, or reasons why not established.

3.8 SUMMARY OF DREDGING HISTORY

Review of the available data confirms that when the marina basin and Access Channel were formed in 1989/90 there was a significant over dredge of both areas. It is the case that accretion of material over the period up until 1999 had no great operational effect because of the additional depth created by this over dredge. Only relatively limited activities were required at the north of the Marina Basin and at the Harbour Entrance.

Within the marina basin continued accretion reduced the available depth for vessels and recognising the need to take action Gwynedd Council commissioned various studies over the period 1997-98 which culminated in the Council purchasing their own dredger in 1999. This dredger "The Nessie" was operated under a management contract to conduct dredging campaigns over the period 1999-2006. The material was pumped into a bunded area within the Harbour and to date no action has been taken to remove material from this bunded area. Generally the dredging in the marina basin has by and large kept pace with the deposition of sediments from 2002-2006.

The Access Channel has had no dredging work undertaken since it was formed. The accretion that has occurred since it was formed has taken up the over-dredge and has also narrowed the channel, to a relatively natural form with the deeper water generally being found on the outside of the bend. The shallowest depths in the channel as identified in the latest survey of May 2008 are at the design dredge level.

The Harbour Entrance suffers from a constant supply of littoral drift material requiring relatively regular dredging activity. Initially ad hoc work was undertaken to maintain the channel. In recent years this has been replaced by a major dredge every 4/5 years with the material extracted from dredging being transported along the beach some 5km for beach nourishment works on Traeth Crugan, excess material is stockpiled locally and used as required for further beach nourishment. Early evidence suggests that this process and the timescales are sustainable, with the channel becoming narrower towards the end of the 4-5yeard period but the depth in the channel remaining relatively constant. A further review of the Coastal Defence Options Study and input to the Shoreline Management Plan from CCW suggests that this recycling approach is the most appropriate approach for the short to medium term.

The following Sections 4, 5 and 6, deal in greater detail with the three distinct zones of the harbour separately.

3.9 KEY ISSUES

1. ***The marina basin and channels were subject to a significant over-dredge when originally formed.***
2. ***Extensive study work has been conducted into dredging methods and previous reports have confirmed that a local disposal option is required to address the maintenance dredging requirement within the Harbour.***
3. ***There are a number of environmental designations of note but most importantly any dredging which creates a direct input to the designated SAC will be of most concern to CCW.***
4. ***Once the dredging strategy is confirmed, review the basis of existing Appropriate Assessment and Environmental Impact Assessments to ensure they remain fit for purpose and to ensure impacts as a result of any changes to dredging and disposal methods are noted. Assuming these changes remain negligible or manageable the assessments should be updated accordingly.***

4. HARBOUR ENTRANCE

4.1 DESCRIPTION

The design depth for the Harbour Entrance when constructed in 1989/90 was -3.0m OD (-0.56m CD). The Harbour Entrance was formed by a cutter suction dredger cutting its way into the harbour to create the marina basin in 1989/90. The local coastal processes are such that the net littoral drift regime is from west to east which means that material being moved along the foreshore between Carreg y Defaid and Carreg yr Imbill spills out and accumulates at the entrance to Pwllheli Harbour.

The implications of this coastal process were identified during the design of the plans for development of the Harbour and a 500m long rock armour training wall was constructed to the north of the Harbour Entrance with the intention of creating a self maintaining Access Channel. A short bull-head rail crib groyne was also constructed to the south of the Entrance to try and control the littoral drift material, the aim being to mitigate the effects of the littoral material by deflecting the drift of material. The training arm and bull-head rail crib groyne are detailed on the Location Plan at Appendix 1.

The design has been partially successful but despite the training arm and short groyne, sand and gravel material still accumulates at the Harbour Entrance. Over time the build-up of material creates a source of material that is washed into the harbour and is deposited in the Access Channel and marina basin. The condition of the crib groyne is such that an amount of maintenance work is required and consideration should be given to supplementing the groyne with the addition of some large rock armour in front of the groyne to provide both additional protection and reduce overtopping by material that can then be washed into the Harbour.

Whether the crib groyne provides the optimum solution is a matter for debate and one that can only be resolved by additional specialist study work to establish whether a solution is possible that avoids the accumulation of material in the Harbour Entrance.

The design for the harbour provided for an 80m wide entrance and the channel at this point was to be dredged to -3.0m OD (-0.56m CD). It is clear that full tidal access was not envisaged by the design. For example at MLWS tides (+0.5m CD) there will be approximately 1m of water in the Entrance. For vessels of a greater draft or when wind and tide conditions create a lower tidal level, access for vessels will be restricted.

When the marina was originally formed there was a significant over dredge in the main Access Channel to create access for the dredger. This created a perception of an enhanced tidal access window by leisure vessels using the harbour and berthed in the marina. However it must be noted that bed levels outside of the Harbour Entrance are shallower than the marina basin design dredge depth over a distance of some 300-350m. Indeed it is some 100m from the Entrance to the -4.0m OD contour (-1.56m CD).

As a consequence of the design dredge depths and the accretion that occurs Pwllheli Harbour has a level of tidal restriction within the Entrance which particularly impacts upon deep draft vessels.

It is also notable that the Report on Monitoring of Bed levels 1993 notes that within 12 months of formation, dredging of the Harbour Entrance was necessary to maintain the navigable channel which was set at 60m opposite the sewer outfall and retained at 80m elsewhere.

4.2 CURRENT DREDGING METHODS

The accumulated material within the Harbour Entrance was removed in an ad-hoc manner as part of larger dredging campaigns or as discrete efforts to resolve particular issues. Dredging activity was undertaken in 1992, 1994, 1996, 1997, 1998 and 2001. The dredged material was generally stockpiled on the Garreg yr Imbill peninsula and reused along the coast as required.

In February 2002 a new strategy was implemented to maintain the Harbour Entrance to avoid the ad hoc nature of previous campaigns. The strategy is still current and it is the intention of the strategy to carry out a major dredge of the Harbour Entrance at intervals of every 4/5 years. It is envisaged that each major campaign would typically remove some 100,000 tonnes of material from the Harbour Entrance.

Against the background of the littoral drift referred to previously, the dredged material is transported 5km west by dumptruck to nourish Traeth Crugan thereby immediately recycling the dredged material. The nourishment material is placed on the upper beach, above the mean high water spring tide contour, so that it is winnowed out naturally during storm events and returned into the littoral drift system.

The balance of material that cannot be accommodated at Traeth Crugan is maintained in a stockpile at Garreg yr Imbill. If the winnowed material is used at Traeth Crugan the stockpile material is available for replenishment, such additional transfer of material currently requires additional permission from CCW. Gwynedd Council report that in 2002, 100,000tonnes of material was dredged from the Harbour Entrance and 70,000 tonnes of material was recycled to nourish Traeth Crugan beach with the balance of 30,000tonnes being stockpiled on Garreg yr Imbill peninsula. As anticipated the material was gradually winnowed out of the nourished area and by 2006 virtually all the material had been returned into the littoral drift system.

It was necessary to repeat the nourishment exercise in February 2007 suggesting that a 4/5 year cycle was appropriate. This created a balance between ensuring that the nourishment area was ready to receive a significant volume of material for replenishment and the Harbour Entrance had not been reduced to such an extent that access was unduly impacted.

The time scales between dredges are dependent upon weather conditions with storm events creating increased call on the winnow material and also a greater rate of deposition at the Harbour Entrance. Some flexibility will need to be designed into the future strategy and it will also be necessary to monitor the levels of material in both locations to allow for forward planning of resources. As noted previously the report in September 2008 by Faber Maunsell into the Coastal Defences Options for Traeth Crugan confirmed that “continuation of the recent practice of beach recycling from the harbour area will be required to sustain conditions in the future”. Furthermore it is noted that the local nourishment and dredging strategies are symbiotic.

The strategy is currently economically viable because a grant of 85% is received towards the cost of transporting the material to Traeth Crugan. The grant is received from the Welsh Assembly Government under the Land Drainage Act 1991. This strategy will need to provide guidance on the frequency of dredging in the Harbour Entrance.

4.3 ACCRETION RATES & MATERIAL TYPE

The material in the Harbour Entrance is almost entirely sands and gravels and experience confirms that it is ideally suited for re-use as beach nourishment.

The Factual Sedimentation Report identifies the quantity of material dredged in the Entrance from 1992-2002, in total as some 101,500m^3. Allowing for the dredging undertaken in 2007 when a further 100,000 tonnes (51,250m^3) was removed the total volume removed amounts to 152,750m^3.

In simple terms it is possible to assess the average dredging requirement as 152,750m^3 divided over the period 1992-2007 (15 years) and this suggests an annual dredging requirement of some 10,200m^3/annum. Interestingly the 100,000 tonnes reported removed in 2002 lasted for 5 years and this equates to 10,250m^3/annum.

The various studies conducted in 1997, 1998 and 2007 made assessments of the sedimentation in various zones of the harbour by comparison of survey data. The zones were largely the same but importantly the zone for the Harbour Entrance did not reflect the zone which can be dredged by shore based plant and therefore the comparison between the calculated sedimentation volume and the actual volume removed by dredging does not compare the same plan areas. Nonetheless it is interesting to compare the assessments of the various studies, and it should be noted that the later studies are based on a more extensive and reliable data set:

1. The 1997 Maintenance Plan at Appendix VIII reports average annual deposition over the period 1991-1997 of 7,600m^3 it is perhaps more useful to consider the rate of deposition which is calculated at an annual rate of 164mm. The assessment allows for the material dredged from the Entrance during the period. The comparison survey (Drg No. PE/01/07M/208G/20) does show that significant deposition on the south side of the channel is in part limited by erosion on the north side of the channel adjacent to the training wall.

2. The Navigation Maintenance Plan 1998 suggests observation of deposition at 6,900m^3/annum and also makes an assessment of the simulated deposition, unfortunately in the Entrance zone the simulated value is dismissed as being of little value because the nature of material is not adequately reflected by the model.

3. The Factual Sedimentation Report assesses sedimentation over the period Oct 2000-March 2006. Within the Harbour Entrance it reports a total difference in volume of 18,200m^3 over the period. During this period some 52,500m^3 of

material was removed (albeit some was almost certainly removed from further up the beach and outside of the zone boundary) suggesting a maximum deposition of 70,700m^3. Over the intervening 65month period this equates to approximate annual deposition of 13,052m^3.

4. It is noteworthy that review of the Oct 2002 survey does not indicate evidence of the reported Feb 2002 dredge works.

Review of the May 2008 Hydrographic survey indicates that the channel is currently at full design depth over a width of only 20m-25m, generally soundings are between -3.0m OD and – 4.0m OD. Some accretion against the training arm is reducing the width which if removed would increase the width to a minimum of 30m. This survey is only some 15months after the 2007 dredge of the Entrance. The results of this survey may bring into question the viability of an extensive dredging regime at the Harbour Entrance. A lower key solution might be more appropriate i.e. smaller quantities on a more frequent basis.

Civil Engineering Solutions have undertaken an assessment of the volume of material that would need to be removed from the Harbour Entrance to achieve the design channel width and depths proposed on Drg No CPF/1191/Spec/B. The calculation uses the May 2008 survey and assesses the volume to be removed as 1,400m^3. It is useful to compare the May 2008 position with the September 2003 survey which was a similar period after the 2002 dredge of the Harbour Entrance. The September 2003 survey of the same area shows the channel at full design depth over at least 40m and the depths are all generally -4.0m OD or deeper.

The Review of the Pwllheli Harbour Navigation Maintenance Management Plan report suggests that whilst the Harbour Entrance closes up due to deposition on the south side of the channel, depths within the channel remain relatively constant. However there is evidence to suggest that immediately after extensive dredging the Harbour Entrance channel has rapidly reduced in width and depth, for example following construction and also following the 2007 dredge. The rapid loss of width and depth following dredging operations can be explained by a reduction in water velocity and concomitant reduction in energy to move littoral material arriving at the Harbour Entrance. It is worth considering the effect that extensive dredging in the Harbour Entrance might have on deposition rates elsewhere within the harbour and this might influence the extent and frequency of future dredging.

Particular attention will be required to the Harbour Entrance area in the next survey to establish the extent of dredging that will be required sooner than the currently anticipated 4 year cycle.

4.4 DESIGN DREDGE DEPTHS AND WIDTHS

The design depth in the Entrance will be dictated by the design of the Access Channel and sea bed level in the areas immediately outside of the harbour.

With respect to depth the fact that it is some 100m from the Entrance to the -4.0m contour and 350m to the -5.5m OD contour (marina design depth) suggests that opportunities to reduce the depth significantly will be limited by the ability to maintain the bed levels in the resultant Access Channel. Review of the May 2008 survey confirms that depths outside the Entrance all exceed -3.5m OD and therefore a reasonable ***future*** aspiration might be to review the potential to increase the depth in the Entrance to -3.5m OD. Such an aspiration only to be pursued once there is certainty that a dredging strategy can first maintain the current design depth. This extra 0.5m will increase the tidal access window for virtually all craft in the Harbour.

The design of channel width needs to consider the throughput of vessels and the viability of maintaining an increased channel width both at the Entrance and in the Harbour. The recent experience (from the 2002 Harbour Entrance dredge) suggests that a 25m channel width is reasonably self maintaining due to the increased velocity of the water passing through the channel. Further detail on the design of channel width is provided in Section 5.4, in respect of the Access Channel, and is not repeated here.

4.5 DREDGE METHODS

The existing method of dredging and recycling the material appears to be well suited to the site's requirements and adequately addresses the adjacent coastal defence issues. Furthermore the process is relatively efficient and cost effective and in this sense it can be considered a sustainable solution to the problem.

Provided that the grant from WAG is maintained and the requirement for nearby beach nourishment works exist there appears to be little reason to change the currently adopted method. Consideration might be given to the following areas:

1. Improving the monitoring of the nourishment site and post dredge survey works in the Entrance to establish the optimum frequency of works and provide for forward planning of resources.
2. Consideration to packaging the Harbour Entrance dredge with other harbour dredging works into a term contract that might provide better cost control and reduced risks to Gwynedd Council.
3. Increasing the frequency of the dredging so that a narrower channel is maintained – recent experience suggests that a 25m channel is reasonably self maintaining.

In the event that there is a requirement to increase the volume of dredge material in the Entrance and/or place it an alternative beach recharge location the dredging might be better undertaken by floating plant that will more efficiently transport and place the material. For example a small Trailing Suction Hopper Dredger will be able to dredge the material, transport it along the coast and pump the material ashore for placement by locally deployed plant. The costs associated with mobilising the required plant and availability of such plant will likely make this a more expensive process than the existing regime.

Alternatively if there is an excess of material there maybe a financial advantage in selling the material to the construction industry. It should be remembered that the material may well belong to the Crown Estate and royalties would need to be paid in such an event.

4.6 KEY ISSUES

1. ***There is evidence to suggest that extensive dredging in the Harbour Entrance causes an increase in the rate of accretion both within the Harbour Entrance and elsewhere within the Harbour. Accordingly the width of the Harbour Entrance needs to be optimised to ensure that additional width does not lead to reduced flows with a resultant increase in accretion rates both within the Harbour Entrance and elsewhere within the Harbour.***

2. ***The current method of dredging and disposal appear to be the most appropriate for the circumstances as does the proposed design. A focus***

of the strategy must be to ensure that the optimum Harbour Entrance alignment, width and depth is maintained and in this regard the key question to resolve is the frequency of dredging.

3. ***As a long term aspiration there may be future potential for a marginal increase in the depth of the channel in the Harbour Entrance and Approach Channel but this must only be considered once a sustainable dredging strategy for the Harbour is assured.***

5. ACCESS CHANNEL

5.1 DESCRIPTION

The design depth of the Access Channel when constructed was -3.0m OD (-0.56m C D). The Channel was designed to be 80m wide although review of the navigation marks suggests that the identified width is nearer 60m.

As noted previously the Access Channel was over dredged significantly when constructed. There was an intention to dredge at least 1m beyond the design depth to create access for the plant and in many places this additional 1m depth was exceed, by as much as a further 1.5m. Indeed in contract correspondence the Method Statement confirms that in order to accommodate the size of the dredger the channel would need to be dredged to a level of approximately -4.6m OD[2] over a 20m width. This over dredge was to be maintained as the dredger effectively worked its way out of the harbour. Review of the post dredge survey[3] suggests that this depth was achieved over a greater width than 20m. Indeed the 1997 hydrographic survey indicates depths in excess of -4.0m OD over areas of some 50-60m width.

5.2 CURRENT DREDGING METHODS

The effect of the over dredge is that over the period since establishment of the marina it has not been necessary to undertake any maintenance dredging within the Access Channel.

Current works are underway in the channel to remove some localised high spots by “ploughing”. A plough is normally utilised to remove high spots into deeper areas of water or “low-spots”. It is understood that CCW have expressed concerns with respect to the potential for smothering that might occur within the adjacent SAC if the ploughed material is deposited outside of the Harbour. However consent has been granted and this is no doubt in part due to the limited nature of the work. The opinion of CCW is however a clear indication of their reaction if a major dredge were proposed that resulted in significant distribution of fine material outside the Harbour.

[2] Harbour & General letter to Posford Duvivier dated 23 June 1989
[3] Drg No CES/A1/037/01

When considering whether ploughing will be effective in the channel it is important to consider the material type – refer below. Ploughing is most effective in silts and very fine material and usually it is used in conjunction with other dredging works which remove material from the deposition site. It may be that the nature of the material in the Access Channel is not particularly suited to ploughing and the results of the current works will need to be monitored.

Given the difficulty in mobilising dredging plant to site it is recommended that the option to undertake ploughing works is retained within the long-term dredging strategy at least as a method for dealing with local problems.

5.3 ACCRETION RATES & MATERIAL TYPE

5.3.1 Channel Width

The lack of dredging noted above is not an indication of a lack of accretion in the channel. It is the case that since its development the Access Channel has suffered accretion but to date it has not adversely affected the depths in relation to the design depth. The accretion that has occurred has taken up the original over-dredge and has also narrowed the channel, to a relatively natural form with the deeper water generally being found on the outside of the bend, especially opposite the Harbour Masters Office. The latest May 2008 survey indicated that the Access Channel is at or below the proposed design depth over the whole of length as detailed on Drawing No. CES/A1/95/1 - the shallowest depths in the channel are close to the design dredge level.

It is however the case that the width of the channel has reduced significantly from the original design and the following table compares the width in 1997 with the width in 2008. The assessment has measured the width of the channel that is at or below the design depth every 100m (starting from the interface with the Harbour Entrance zone (Chainage 0m). The measurement has ignored the position of moorings which are present and which impact on the width of the channel available for navigation.

Chainage	Channel width at design depth (m)		Lost width (m)	Comment
	1997	2008		
0	47	20	27	At interface with Entrance
100	62	44	18	

200	70	43	27	
300	90	68	22	Navigation reduced by moorings
400	77	44	33	Navigation reduced by moorings
500	84	60	24	Navigation reduced by moorings
600	98	74	24	
700	95	64	31	At interface with marina

Figure 5.1 – comparison of channel widths

The impact of this loss of width and water depth is that the channel has tended to follow the outside of the bend i.e. the deeper water is where the flow is naturally faster.

As noted above a number of moorings are present (in the area opposite the Harbour Masters Office - between chainages 300m and 600m) and these are on the outside of the bend and in the naturally deep water. Assessment of the available water for navigation on the May 2008 survey identifies that at chainage 400m a pinch point is present which restricts the channel width to approximately 16m. This is the area of the current ploughing operations.

A significant issue for vessels navigating the channel is both understanding the depth but perhaps as importantly the position of the Access Channel. The current situation is clearly very different from the original design and as a consequence of the existing narrower channel the navigation marks placed as part of the original contract works do not adequately identify the position of the clear water channel. The dredging strategy will need to consider the placement of these marks once a decision on the depth and width of channel is confirmed.

5.3.2 Accretion Rates

As in Section 4.3 a comparison can be made between the various studies conducted in 1997, 1998 and 2007 of the assessments made of the sedimentation in various zones of the harbour by comparison of survey data. The Access Channel zone was generally the same in each survey. It should be remembered that for the purpose of this study the Access Channel zone (as identified in Appendix 1) has been extended towards the Harbour Entrance to reflect the fact that dredging in the Entrance with land based plant can only extend some 200m into the harbour.

1. The 1997 Maintenance Plan at Appendix VIII reports average annual deposition over the period 1991-1997 of approximately 3,500m^3 at an annual rate of deposition assessed at 58mm.

2. The Navigation Maintenance Plan 1998 suggests observation of deposition at 3,200m^3/annum and also makes an assessment of the simulated deposition, which compares favourably at 3,800m^3.

3. The Factual Sedimentation Report assesses sedimentation over the period Oct 2000-March 2006. Within the Access Channel it reports a total difference in volume of 32,271m^3 over the period. With no dredging in the Channel since construction, the total volume divided by the period suggests average annual deposition of 90mm.

   More detailed analysis of the accretion rates highlights that significant accretion occurred between September 2001 and October 2002 (approx. 15,500m^3) and there is no explanation for this accretion provided. However this might be a further indication of the adverse impact that a deeper and wider Entrance, with resultant slower flow rates, has on accretion in the rest of the harbour.

   Beyond this period the annual rate of deposition slowed each year from 2002-2006 such that the average over the period equates to around 32mm. The annual deposition from 2002-2006 amounts to an average of less than 2,200m^3. Ignoring the results from 2001/02 the average annual deposition amounts to 3,800m^3, comparing favourably with items 1 and 2 above.

4. Additional volume analysis for the Access Channel has been conducted by CES comparing the May 2008 survey with the design incorporated on Drawing No. CPF/1191/Spec B at Appendix 7. The assessed quantity for removal amounts to some 7,500m^3 although it must be noted that this volume calculation makes no account of the recent ploughing works.

5.3.3 Material Type

Review of the information gathered during site investigation works in May 2008 confirms that the material in the Access Channel varies from gravely sand (nearest the Entrance) to sandy silt with the material profile becoming less dense the further into the

harbour the sample location. The sample nearest the marina has the greatest concentration of silt material this being 83% sand and 17% silt material (i.e. material less than 0.002mm in size).

5.4 DESIGN DREDGE DEPTHS & WIDTH

5.4.1 Design Depth

Consideration of the design depth in this location will need to consider the following points:

- The cost and viability of maintaining the Harbour Entrance
- The sea-bed levels outside of the harbour

The design dredge depth for Access Channel shown at Appendix 7 reflects the original design depth of -3.0m OD. Given the significant volume of material that needs to be removed to maintain the Harbour Entrance and the fact that bed levels immediately outside the Entrance in Cardigan Bay are generally at the same level as the Access Channel the design depth appears to be appropriate.

Certainly before any decision could be made to increase the depth there would need to be studies undertaken to confirm that a deeper channel could be maintained and that the necessary extended access to deeper water could be achieved and maintained. It should also be remembered that deepening of the channel and extending it would constitute capital dredging and that element outside the Harbour Entrance is within a designated European site. Furthermore as noted previously any decision to increase the depth or width of the channel should only be made once a viable and sustainable strategy is confirmed.

5.4.2 Design Width

With respect to width the proposed design drawing refers to a number of appropriate design codes, including The Yacht Harbour Association (TYHA) Code of practice for the design of marinas and Institution of Civil Engineers Dredging Design and Practice Guide. The ICE guide is perhaps better suited to commercial ports and harbours and the TYHA guide is far from extensive.

In designing the channel width the practical considerations are:

- Exposure to wind, wave and tidal currents that will affect manoeuvrability of approaching vessels, note that yachts are more susceptible to tidal influences than power boats.
- The number of vessels in the harbour and likely levels of usage
- Type and size of vessels, note that generally power boats are more manoeuvrable
- The extent of navigation aids in use
- The channel alignment and approaches – a straight channel with good visibility being preferable.
- The length of the Access Channel

A more extensive design guide is provided by the Australian Design Code AS3962[4] and this is used more extensively in worldwide marina design. This states that the preferred width of a marina entrance is 30m or 6 times the beam of the widest vessel in the harbour. The code confirms that the minimum marina entrance is the greatest of 20m; the length of the longest vessel in the marina plus 2m; or 5 times the beam of the longest boat in the marina.

It needs to be borne in mind that the TYHA code and the Australian code are for the design of marinas and the Harbour Entrance and Access Channel is not only serving the 400 berth marina but numerous harbour moorings and public and commercial slipways that introduce significant levels of vessel activity into and out of the harbour at peak times.

In the case of Pwllheli and considering all of the factors outlined it would be preferable to provide for the widest channel that can be reasonably maintained – and within the Access Channel zone the aspiration should be to maintain a channel of at least 30m and preferably 35m or even 40m wide. However these aspirations can only be addressed once it can be demonstrated that a 25m channel as currently proposed can be maintained.

A further and significantly more important consideration might be the position of the Access Channel. It is clear that the channel is deeper to the outside of the bends and it may be appropriate to consider relocating existing piled moorings to allow the channel

[4] AS 3962 Guidelines for design of marinas

to follow the naturally deeper water. This will serve to minimise the dredging burden from this zone of the harbour.

A positive benefit of the reduction in channel width (from circa 80m to 30m) will be a resultant increase in inter-tidal areas within the Harbour area. This additional 50m of width over some 900m will not only create an additional 4.5Ha of inter-tidal mud flats it will also provide for zones where birds are less liable to disturbance from passing vessel activity.

5.5 ANNUAL DREDGING BURDEN

Based on the various assessments outlined above it would appear that a reduced Access Channel of 25m width, would suffer accretion rates in the range 30mm - 60mm/annum. Based upon an area of channel of say 28,000m^2 (700m length by 40m width, allowing for side slopes) the annual dredging burden might be assessed as being in the range 840-1,700m^3.

5.6 DREDGING METHODS

The relatively limited dredging burden, nature of the material and proximity to the marina basin suggests that provided the method employed within the marina can be utilised within the approach channel, this will provide for the most cost effective solution. Given the relative proximity of the two zones, dredging of the Access Channel would also be most cost effectively undertaken at the same time as dredging of the marina basin, thus avoiding further mobilisation costs. The dredging strategy should therefore seek to plan operations to ensure that the dredging of the Access Channel is undertaken in conjunction with the dredging of the Marina Basin.

5.7 KEY ISSUES

1. ***There has never been any maintenance dredging within the Access Channel, only very recent and limited ploughing works. Since its construction the accretion that has occurred has largely accounted for take-up of the over dredge and latterly has reduced the channel to a more realistic width.***

2. ***Initially the strategy should be to adopt the design width and depth outlined on Drg No CPF/1191/Spec B at Appendix 7.***

3. ***The position of the channel is not reflected by the navigation marks.***

4. ***The dredging strategy should consider the position of the Access Channel. It is clear that the channel is deeper to the outside of the bends and it may be appropriate to consider relocating existing piled moorings such that the channel can follow the naturally deeper water. The position of the Access Channel and particularly whether to relocate the existing mooring piles and allow the channel to follow the natural deep water will need to consider the financial and operational implications of the relocation of the moorings.***

6. MARINA BASIN

6.1 DESCRIPTION

The post dredge survey of the original capital dredge that formed the marina basin is recreated on drawing No.CES/A1/037/01 within the Factual Sedimentation Report. Review of this drawing highlights the extent to which the marina basin was dredged below the design depth of -5.5m OD, generally it can be seen that depths are between 500mm and 1m deeper than specified.

Shortly after completion of the marina an area of deposition to the north of the marina basin created some operational problems. This was documented in the Pwllheli Harbour Development Monitoring of Bed Levels Report 1993. The report notes heavy deposition of sands, gravels and silts to the north of the marina basin and north western corner and a dredge of this area was recommended.. The report suggests that the source of the material has primarily been erosion caused by the Afon Erch and Rhyd-hir cutting new channels and re-working previously deposited material, however given the nature of the reported material and what is now generally understood about the processes at work in the Harbour it may be that the sand and gravel element of the deposition is simply related to the wider coastal processes.

Additionally the report noted that following completion the marina was extended from 250 to 400 berths to take advantage of the deeper and larger basin area. This included a number of finger pontoon berths being added to the north of the marina and these berths extended over the dredge slope, the siltation noted above created a difficulty for vessels accessing berths in this area.

As a result of the above report Seascot Shipmanagement Ltd was employed to carry out dredging work. Maintenance dredging was carried out in the two northern most bays of the existing marina to restore the design dredge levels and capital dredging was undertaken to the north of the existing marina basin to provide additional capacity to receive river channel erosion material from the Afon Erch. The contract commenced in November 1994 and was completed in August 1995 and the assessment of volume is estimated at 9,250m^3 in the Maintenance plan review of 1997.

It is the case that due to the additional depth created when the basin was formed no general maintenance dredging of the basin was required for a significant period – until the winter of 1999/2000.

6.2 DREDGING METHODS

The marina basin was formed by use of a cutter suction dredger (capital dredge) with the dredged arisings pumped ashore for general reclamation on Glan y Don peninsula and between the Island and Ffordd y Cob. Material from the Seascot dredging campaign was used to reclaim land adjacent to Morfa'r Garreg.

The 1997 Navigation Maintenance Plan identified the requirement for maintenance dredging within the marina basin and a subsequent study into dredging techniques identified a proposed regime whereby the dredged material would be pumped into a bunded area within the Harbour. Gwynedd Council then undertook the following steps:

- Purchase of the Nessie N8DX portable cutter suction dredger.
- Formation of a bunded stilling lagoon adjacent to Morfa'r Garreg
- Letting of a dredger operation and maintenance contract

The stilling lagoon is 225m long with an overflow at the southern end and has an operational capacity of 22,000m^3. The Lagoon is discussed further in Section 7.0 below.

The first operating contract for the dredger was awarded to Holyhead Towing Company Ltd and they operated the dredger for one campaign but did not take up the option to extend their contract. The contract was re-tendered and was won by Wyre Waste Management of Fleetwood who completed five dredging campaigns despite the vessel being sunk in Fleetwood Dock in September 2001 during a marketing visit.

A total of six consecutive maintenance dredging campaigns were undertaken from 1999/2000 to 2005/06. All the campaigns concentrated on the marina basin but some dredging was also undertaken around the craning dock and refuelling pontoon area. Historically operations have been carried out between October and March, and generally last approximately 3 months. Dredging plant is always removed from the Harbour by Easter due to the increased demands in recreational marine activity.

The dredging works always sought to reinstate the original design depth and with the exception of a limited amount of material removed for engineering works to the bund the rest of the dredged arisings remain in situ in the stilling lagoon.

It is reported (within the GC Brief) that the volume of material being deposited in the stilling lagoon did not reflect the improvements indicated by the analysis of pre and post hydrographic surveys. This anomaly is attributed to the difference in volume between the saturated material on the seabed and the dry material in the lagoon. The shrinkage factor, as determined by independent materials laboratory tests, is over 2 (Celtest - Feb 2008, Moisture Content = 150% by dry mass, Test Report Ref STR 131019). On the basis of the 150% moisture content this will account for at least 23,000m^3 of saturated material being dredged from the Marina Basin and deposited in the bund.

Analysis of the surveys between 2002 and 2006 within the Factual Sedimentation Report – 2007, suggests that only a modest increase occurred in the level of material deposited and that the annual dredging programme over the same period (more or less) kept pace with the accretion.

There has been no dredging in the basin since 2006, in part due to a lack of capacity within the stilling lagoon.

6.3 ACCRETION RATES & MATERIAL TYPE

As in Section 4.3 and 5.3a comparison has been made between the various previous assessments of the sedimentation in various zones of the harbour by comparison of survey data. The marina basin zone has varied between assessments but the scale of the zone and the extent of changes allows for a reasonable comparison between surveys, with the most important benchmark being the rate of accretion.

1. The 1997 Maintenance Plan at Appendix VIII reports average annual deposition in the basin over the period 1991-1994 of 12,000m^3 at an annual rate of accretion of 112mm. From 1994-97 the deposition amounted to an annual volume in the basin of 8,200m^3 at an annual rate of 73mm. The zone area varied between the surveys in the range 108,000-111,000m^2. These assessments are adjusted to reflect dredged volume of material removed from the basin.

2. Using the same zones from the 1997 plan annual accretion rates reported in the Navigation Maintenance Plan are estimated at 5,800m^3 against the observations of 8,200m^3. A correction was applied to the estimated volume which accounted for material theoretically deposited to the North of the basin but ultimately ending up within the marina basin. In summary the 8,200m3 per annum at a rate of 73mm was verified by the study.

3. The Factual Sedimentation Report assesses sedimentation over the period Oct 2000-March 2006. The siltation calculation relates to a much smaller area than the 1997 study at just 70,160m^2 with no adjustment for dredged material removed from the basin. In total the assessment of accretion amounts to some 25,456m^3 over the 6 year period. The averaged deposition rate excluding dredging was 67mm per year. Of real note the surveys confirm that the difference between 2002 and 2006 amounts to just 2,500m^3 suggesting that the maintenance dredging process undertaken during this period were more or less keeping pace with the accretion.

4. However it is again interesting to note that as in the Access Channel the results for 2002 show a rapid increase in the rate of accretion between 2001 to 2002 – the difference in volume increasing by nearly 17,000m^3 from 5,400m^3 to 23,100m^3.

5. Volume analysis by CES compares the September 2007 Survey with the design profile indicating a volume of material to be removed of 53,600m^3.

6. Additional volume analysis for the Marina Basin has been conducted by CES comparing the May 2008 survey with the original design profile, it is reported that some 59,450m^3 of material would need to be removed to achieve the original design dredge profile. Comparison with the similar calculation that is based on the September 2007 Survey indicates an increase in 9months of some 5,850m^3.

6.3.1 Material Type

Review of the information gathered during the sediment sampling survey in May 2008 confirms that the material in the marina basin is a relatively consistent sandy

silt mix. The survey results confirm that the material has a silt content (material less than 0.002mm in size) ranging from 52%-62% with the balance being sand.

6.4 DESIGN DREDGE DEPTHS

6.4.1 Design Depth

The difficulty and cost of dredging in Pwllheli harbour demands that the dredging burden is minimised to maximise the efficiency of the dredging activity. The marina basin is the deepest and most extensive operational area and will be a focus for accretion of material.

Consideration of the design depth within the marina basin should consider the following points:

- The vessel mix, typical draft and maximum draft
- The design depths of the Access Channel and Harbour Entrance
- The practicalities of maintaining excessive water depth.

The design dredge depth for marina basin proposed on Drg No CPF/1191/Spec B reflects the original design depth of -5.5m OD. Reinstatement of this depth over the entire basin will provide approximately 3.5m of water at MLWS and 3m of water at LAT.
Given the typical berth mix and high ratio of motor vessels this proposed water depth appears excessive and it should be possible to allow certain areas of the marina basin to be dredged to shallower depths thus allowing a more cost efficient management of the dredging programme.

Accordingly a review of the current vessel mix has been undertaken and set against the berth layout to establish the most appropriate design dredge depths. Introduction of different dredged zones within the basin will require a more pro-active management of berth allocation such that deeper drafted yachts are allocated berths in deep water with motor vessels berthed in-shore in the shallower zones. Allowance will also be required to accommodate visitor activity and also for future growth in vessel size and changes to trends in usage.

In preparing a more efficient dredge profile for Pwllheli marina the following factors have been taken into account:

- Existing dredge levels
- Base line tidal data
- Existing berth mix within the Marina
- Past and future trends with regards to the berth mix
- Gap analysis of variances in berth mix drafts against historic dredge depths
- Analysis of maximum vessel drafts for differing types and sizes of vessels
- Operational constraints in generating and maintaining dredge levels
- Operational activity of vessels that enter and egress the marina – consideration of levels in the Access Channel
- Visiting vessel activity

6.4.2 Berth mix and associated vessel drafts

The historic berth mix within Pwllheli marina demonstrates a continued trend towards an increasing ratio of motorboats to that of sailing boats. Since 2001 the percentage of resident motor boats has risen from 37% to 43% in 2008. Linked directly to this trend is the reduced dredge depth requirement for such vessels.

Whilst this study does not result in a design profile based on an increasing level of motorboats and associated reduced water level requirement, it is a point worthy of noting within the study that future dredge profiles should consider and review such changing market trends on a periodic basis.

In considering the drafts of specific vessels we have utilised industry and archive data of over 900 vessels within the length band applicable to Pwllheli marina (motor and sailing vessels from 6m to 20m in length) to arrive at maximum draft/depth requirements specific to boat and associated berth lengths. Analysis of this data has enabled us to arrive at optimum dredge depth requirements for the range of berth lengths available within the marina. This data has been utilised to create dredge zones appropriate for the number of berths within the marina. Where motor and sail boats of a similar length are berthed within the same zone, the maximum draft of the deepest hull configuration (sailing vessel) has been taken as the minimum requirement for the zone. This in turn enables the local management flexibility within

the berthing allocation of same length vessels. It would be possible to take this a step further and differentiate between motor vessels and sailing vessels but this would greatly reduce operational flexibility. An alternative approach would be to review the mix of vessels in each zone when deciding on the priority of dredging.

6.4.3 Application of design depths

Drawing MP115a-P-102 at Appendix 3 demonstrates a direct application of the dredge depth profile for Pwllheli marina. This multi zone model clearly demonstrates the varying level of water required throughout the marina configuration in direct relation to boat lengths and drafts. Eight zones, each specific to berth length and the associated maximum draft vessel that may be berthed in the location is depicted in this drawing.

The design depths noted are at lowest astronomical tide (-2.44m Ordnance datum; 0.0m Chart Datum).

The design of the dredge levels and zones has been arrived at through consideration of existing vessel depth requirements and associated pontoon length. The zones created have a maximum vessel occupancy which is noted in table 6.1 below. This represents the total number of vessels (of a length and associated depth) that may be berthed within the zone. In all circumstances the model facilitates the existing berth mix; however future increases in certain vessel bands may result in the marina operator being unable to facilitate such rising vessel numbers.

For example an increase in sailing vessels between 8m to 10m (from 90 No.) would result in the operator either being unable to accommodate the vessel or having to allocate the vessel to a deeper and therefore longer pontoon berth. This would in turn result in an in efficiency on financial returns for the berth.

Whilst the theoretically design depths illustrated would cater for the existing berth mix as noted above, clearly to apply this model within a practical dredge programme is un-realistic in terms of the number of zones created, restrictions for the marina operator on vessel allocation within the zones and the physical nature of the dredging which would include intricate level variances.

Table 2b below outlines the dredge zones, depths applied and the configuration and number of vessels that may be allocated to each area. The table also demonstrates the restrictions on the growth of vessel numbers in each zone. The same table also appears on Drawing MP115a-P-102.

Zone	Equivalent design depth @ L.A.T.	Vessel configuration	Total berths in zone	Occupancy as at '08
A	**-1.15**	Sail upto 6 & Power 6 & 6 to 7m	52	42
B	**-1.2**	Power 8 to 10 m	70	70
C	**-1.7**	Sail 6 to 7 & 8 to 10m (Inc H/H 6 x 12 to 15m)	90	90
D	**-1.3**	Power 10 to 12m	24	23
E	**-1.9**	Sail 8 to 10 & 10 to 12m (Inc H/H 5 x 15+)	89	88
F	**-2.6**	Sail 15+	14	14
G	**-2.4**	Sail 10 to 12 & 12 to 15m (Inc H/H 10 X 15+)	58	58
H	**-1.3**	Power 12 to 15m & 7x 10m Power	32	26
		Total	**429**	**411**

Table 6.1 – Theoretical Dredge zone data

In order that a more practical dredge profile is created with improved operational parameters within the differing berth length areas, a three zone dredge model has been created. This has the following advantages:

- Simple three level application of water depths required for berth length bands relative to the existing marina pontoon configuration
- Practical solution that is readily achievable and deliverable by the dredging contractor
- Significant overall reduction in dredge volumes and associated costs
- Sustainable dredge depths relative to physical marina layout i.e. quay wall, and Access Channel depths
- Continued ability to manage berthing allocation with flexibility in market trends
- There is no immediate requirement to re-allocate existing berth holders
- No reduction in accessibility of berths
- The reduced area of deep water will likely reduce the extent of accretion in the basin.
- May facilitate an opportunity to introduce differing pricing structure for deeper berths.

Drawing MP115a-P-103 at Appendix 4 illustrates the proposed design dredge depth for Pwllheli marina. The resultant reduction in dredge volume that arises if the profile is

adopted, when compared to that of a blanket -3.0m Chart Datum dredge is some 53,500 m^3. The assessment from CES suggested 59,450m^3 to reinstate the original depth profile and comparison of the two volumes suggests that only around 6,000m^3 of material needs to be removed to achieve the design profile detailed on Drg No. MP115a-P-103.

The resultant water depths achieved in each location consider both existing and future market trends in regards to annual berthing contracts and visiting vessel activity. Ultimately water depths are relative to that of the berth length and the maximum depth vessel that may be accommodated on each berth.

Table 6.2 below details the design dredge depths for the three zones. The reduction in zone numbers and associated increase in zone areas highlights the increased flexibility in berthing allocation and simplification for the dredge contractor in attaining water depths.
The dredge areas and volumes are also noted in table 6.2, demonstrating the overall reduction in dredge material to be removed as a result of adopting this dredge profile. The same table also appears on Drawing MP115a-P-103.

Zone	Equivalent design depth	Practical dredge depth	Dredge zone area (m^2)	Design dredge volume saving (variance from -3.0m C.D. m^3)
A	-1.15	-1.5	22,744	34,116
B	-1.2	-1.5		
D	-1.3	-1.5		
H	-1.3	-1.5		
C	-1.7	-2.0	19,526	19,526
E	-1.9	-2.0		
F	-2.6	-3.0	9,618	0
G	-2.4	-3.0		
		Total design dredge volume saving		53,642

Table 6.2 – Practical dredge zone detail

6.5 ANNUAL DREDGING BURDEN

The Basin area calculated by the Factual Sedimentation Report amounts to some 70,160m^2. Assessing the dredging burden for the marina basin area appears more complex because of the variation in results so it is perhaps more useful to consider the range of assessments:

1. The Navigation Maintenance Plan gives a dredging burden between an estimate of 5,800m^3 and observations at 8,200m^3 and this equates to rates of between 83 and 117mm per annum.
2. The Factual Sedimentation Report suggests the rate of accretion over the period 2000-2006 amounted to a total of some 25,000m^3 at an average of 67mm per year. However this excluded the volume of material dredged from the basin over the same period. Evidence suggests that the total volume of dredged material estimated to have been pumped into the stilling lagoon is 15,350m^3. Once allowance is made for the consolidation of this material (Moisture Content 150% by dry mass) the equivalent volume equates to 23,000m^3 which would have the effect of doubling the accretion rate to 135mm per annum.
3. Based on an area of basin of some 70,160m^2 and allowing for the range of results noted above, the average annual dredging burden for the marina can be assessed as being in the range 5,800m^3- 9,500m^3 per annum. It is likely that the overall annual burden will be to the lower end of this range if a narrower largely self maintaining Harbour Entrance can be delivered.

6.6 KEY ISSUES

1. ***Historically dredging works within the basin have sought to reinstate the original design depths. The methods employed have proven to provide a practical cost effective solution to the dredging requirement for the marina basin.***

2. ***The marina basin sits some 2.5m deeper than the Access Channel and Harbour Entrance and therefore the additional depth only needs to provide "sufficient water" to accommodate the berthed vessels.***

3. ***There is evidence that an annual campaign of dredging into the stilling lagoon can keep pace with the accretion. Estimates of the annual dredging burden suggest a requirement to dredge in the order of 6,000m^3 – 8,000m^3. (This will equate to a consolidated volume of material in the lagoon of 4,000-6,000m^3).***

4. ***The design depth of -5.5m O.D over the entire basin provides for an over supply of depth particularly to the smaller berths. A proposed alternative***

dredge profile is recommended that will greatly reduce the volume of material to be removed.

7. STILLING LAGOON

7.1 DESCRIPTION

As noted in Section 6.2 in 1999 a stilling lagoon was formed adjacent to the Morfa'r Garreg basin to receive dredged material pumped directly from the marina. The stilling lagoon is 225m long and 40m wide with an overflow in the north east corner, nearest the marina basin. The base of the lagoon is at approximately 0m O.D. which provides for a depth of material approaching 4.4m when filled to the upper bund level of 4.4m above O.D. (refer photos at Appendix 5).

The lagoon acts as a large settling tank as it receives pumped material in the north–west corner, with the discharge water passing to the overflow in the north east corner of the lagoon. The heavier gravel and sand material settles out quickly with the lighter sands and silts carried towards the overflow. On-site review of the material contained within the lagoon confirms that a significant proportion of material is sand and gravel and could be readily extracted to provide immediate capacity. Further on-site investigation of the material contained within the lagoon will be required to establish the exact make-up of material.

7.2 CAPACITY

The lagoon has a theoretical capacity of some 25,000m^3 if filled to 4.4m OD however the maximum operational level has been set at 3.92m OD and this reduces the capacity to 22,000m^3.

The latest assessment of material within the lagoon confirms that 15,350m^3 of material is in-situ leaving a residual capacity of 6,650m^3. This spare capacity will not be sufficient to deal with the immediate requirement and early action will be required to free-up capacity within the lagoon.

7.3 MATERIAL TYPE

The material within the lagoon is a mixture of gravels, sands and silts and this reflects the nature of the material that has been deposited within the marina basin. The treatment of this material will depend on the nature and various proportions of the material.

Initial analysis suggests that up to 50% may be sands and gravels which could be readily re-used as beach recharge material, or alternatively following screening it could be used within the construction industry.

Chemical analysis of the material within the stilling lagoon and also of the potential source material i.e. from the marina basin and Access Channel confirms that the material appears to fall into a non hazardous classification. However in order for the material to be approved for disposal, further analysis is likely to be required: -

1. If the material is to go to landfill then Total Petroleum Hydrocarbon (TPH) analysis may be required – TPH is used to refer to a range of crude oil based products.
2. If the material is to be disposed to sea then Cefas are likely to require their own analysis in any case – there is nothing within the current test results to suggest likelihood of a problem in this respect.

It may be necessary in either case to demonstrate to Cefas the validity of the existing test results, including the accreditation of the testing laboratory.

7.4 FUTURE OF THE LAGOON

To date the lagoon has received all of the material from the 6 marina dredging campaigns carried out over consecutive winters from 1999/2000 to 2005/06. No material of any consequence has been removed from the lagoon and a strategy is required to address this recycling and release additional capacity for future dredging campaigns. This strategy should consider the varying nature of the material.

The significant role of the lagoon in the future of maintenance dredging in Pwllheli Harbour **should not be understated.** Without the lagoon the options for dealing with the dredged arisings are extremely limited. The strategy for the lagoon must address not only the recycling of the material but the following aspects:

1. Maintenance of security and signage
2. Inspection and maintenance of the bund structure

3. Need for investigation into the grading of the material, contamination and salinity.
4. Potential to increase the capacity of the bund
5. Ensuring the long term future of the bund and its status as a fundamental part of the marina and harbour infrastructure is recognised within local planning framework to avoid threats from development.

Interest has been shown by a locally based party, with access to a screening machine and a fully licensed landfill site, to address the material within the bund and an offer has been made to conduct a free trial on site to review the grading and nature of the material across the bund. A trial along the following lines has been proposed.

1. GC supply a suitable excavator on site for 1 day
2. Samples are taken from 6-7 separate locations across the lagoon – each sample being a full 20tonne load of an articulated tipper
3. The material is transported to the landfill site (within 10miles) and screened
4. Review of the results of the process will identify the approximate proportions of gravels, sands and silts across the bund.
5. A budget proposal can be provided to address the material within the bund.

7.5 LICENSING

In April 2008 The Environment Agency brought into force the Environmental Permitting (EP) Regulations. These new regulations combine Pollution Prevention and Control regulations and Waste Management Licensing regulations.

The activity of placing dredged arisings in the stilling lagoon, allowing the material to drain and settle out and then moving the graded material to its final site is classed as waste treatment and will require permit under the Environmental Permitting Regulations. This is regardless of whether the material ultimately ends up being re-used. The conditions within the license will be specific to the detail of how the material is handled and ultimately disposed (or re-used), therefore once the strategy is confirmed detailed discussion with the EA should be undertaken to establish an appropriate Environmental Permit.

In addition the stilling lagoon itself will also require consent as a waste holding area. This is a consent that should be put in place directly by the local Authority. It is also

noteworthy that technically the stock pile at Garreg yr Imbill might also be considered a waste holding area and GC should consider licensing the site in a similar fashion to avoid any conflict with the EA.

Due to the complex and strict regulation surrounding waste disposal and handling, and given Gwynedd Councils role as a planning authority and a competent authority under the Habitat Regulations, the Council should ensure that all processes involved in the disposal activity as proposed are properly consented with appropriate permits kept up to date.

7.6 KEY ISSUES

1. ***As a fist step, sands and gravels should be extracted from the bund and then screened for re-use or stockpiled for beach recharge and thereby freeing up capacity within the bund.***

2. ***Analysis is required of the remaining material to establish its suitability for disposal to land or use as a capping material.***

3. ***There is a need to address the licensing of the lagoon. The lagoon (and stockpile at Garreg yr Imbill) is essentially a waste transfer station and appropriate permits are required from the Environment Agency. The site(s) needs to be consented by the Council as a waste holding area.***

4. ***The lagoon needs to be included within the dredge strategy with appropriate funds and activity in place to address the inspection, maintenance and security of the bund.***

8. DREDGING AND DISPOSAL METHODS

8.1 CLASSES OF DREDGING

The first point to note when considering the types of dredging in the context of Pwllheli harbour is the distinction made between capital dredging and maintenance dredging. The removal of accumulated sediments from harbour channels and berths to ensure a safe depth of water for navigational purposes is classed as maintenance dredging, where as removal of material to create “new depth” (or related to construction activities) is treated as capital dredging.

Technically if maintenance dredging is not conducted in an area for a period of 10 years the licensing authorities may consider that the dredging will constitute capital dredging due to the consolidated nature of the material.

In the context of this strategy the dredging proposed is maintenance dredging although if consents are to be applied for consideration should be given to the fact that there has been no dredging in the area of the Access Channel in the past 10 years. That said the reality is that the dredging that has been undertaken within the navigable waters of the harbour and whether the work relates to the entrance, Access Channel or marina basin is in itself a technical point that should not unduly concern the consenting authorities.

8.2 LICENCES AND CONSENTS

When considering the consents required for the maintenance dredging activities in Pwllheli Harbour it is useful to consider that most dredging activity is essentially made up of two component parts, the physical removal of the material from the harbour bed and its disposal.

The licences and consents required to undertake dredging are linked to the separate dredging and disposal activities. The licences and consents will therefore vary depending upon the dredging method. The main pieces of legislation are as follows:

8.2.1 Disposal Activity

1. Food and Environment Protection Act (FEPA)1985 Part II (Deposits in the Sea) – This licences the deposition of material below Mean High Water Springs and will usually relate to the disposal of material to a licensed disposal ground or for beneficial use e.g. beach recharge. Where material is removed to land for disposal FEPA controls do not apply.
2. Where land based disposal is proposed a waste management licence from the Environment Agency is required.

8.2.2 Dredging Activity

1. Harbour Act – Harbour Authority local powers generally control the extraction of material for maintenance of navigation.

2. The Coast Protection Act (CPA)1949 – where local powers do not exist or beyond harbour limits a CPA consent is required for the dredging of material

The licences and consents for the selected method will need to address the above consent requirements and will be adjusted to reflect the nature of the method.

8.3 CONSIDERATION OF ALTERNATIVE METHODS - GENERAL

When considering the most appropriate method for undertaking any dredging activity, the main considerations are: -

- The nature of the material (type, quality, grading, contamination, etc).
- Disposal site options
- Options for beneficial use
- Quantities (and frequency) to be dredged
- Depth of material to be removed
- Depth to be achieved
- Access
- Site constraints (tidal curve, exposure, timing considerations, other activities etc)
- Availability of appropriate plant.

Clearly many/all of these factors have been considered when previous dredging works have been undertaken and it is not the intention of this report to provide an exhaustive list of the various different types of dredging activity.

The most significant constraints that have the greatest influence on the selection of dredging method in Pwllheli Harbour are briefly summarised below and it is these factors that have led to the choice of method(s) currently adopted:-

- The dredged material is a mixture of gravels, sands and fine sediment.
- The nearest licensed off-shore disposal ground is Holyhead Deep, which is approximately 60 nautical miles away.
- The large scale removal from Pwllheli and transportation of material to this site is not economically viable.
- Furthermore, access for appropriate plant would have to be restricted to the off-season when down-time, due to inclement weather, would make this type of dredging and disposal even more costly.
- Cardigan Bay is an environmentally designated site which means that it is unlikely that a new disposal ground could be licensed in reasonable proximity to the site.
- Any direct discharge into the sea outside of the Harbour, would be resisted by CCW due to concerns over smothering of the interest features of the designated site.
- Direct disposal to land based sites would be problematic due to the high fines content and high water ratio of the dredged material. Immediate transfer would require a reasonable working area and the use of specialist sealed wagons in order to minimise the disturbance to the highway network.

Whilst the nature of the material would suggest that a range of dredging methods might be appropriate it is the constraints of the site in terms of disposal (outlined above) that have historically and will continue to dictate the dredging method.

It is the case that the nature of the dredging activity needs to be tailored to the specific requirements of each zone and recognise the type of material present. The following section describes the alternatives for each zone.

8.4 DREDGING METHODS – THE HARBOUR ENTRANCE

The method employed within the Harbour Entrance is entirely appropriate in the main because it is: -

- Efficient – the material is removed with readily available land based plant.
- Beneficial – the material is suitable for beneficial re-use of a local host site can easily receive the material.
- The quantity of material to be removed can either be accommodated at the disposal site or locally stock-piled.

A recommendation of the strategy will be that the existing dredging methods for the Harbour Entrance are retained due to the opportunities for beneficial use and cost effectiveness.

8.5 DREDGING METHODS – THE ACCESS CHANNEL

The only dredging previously employed within the Access Channel is some localised ploughing and a recommendation of Section 5.2 is that this method is retained as a means of dealing with localised problems.

Notwithstanding the limited use of ploughing evidence from review of the Access Channel in Section 5.0 confirms that the scale of future dredging in this area can be handled by any equipment that is employed to undertake dredging works within the Marina Basin. For this reason the section below considers the dredging methods for both zones.

8.6 DREDGING METHODS – THE MARINA BASIN (AND ACCESS CHANNEL)

Due to the distance to a licensed off-shore disposal site all previous dredging within the Marina Basin has used a local disposal site in some form. Even the capital dredge to form the basin utilised the dredged arisings as reclamation material. Unless there is potential to de-water the material as part of the dredging process the opportunity created by the presence of the stilling lagoon provides the ability to undertake dredging

in a far more cost effective manner than with other options which will require extensive handling or transportation of difficult material. It is clear therefore that the optimum solution will need to recognise the limitations of the location and disposal will require a local option site.

Alternative methods that might be considered are:-

8.6.1 Water Injection Dredging

This is a process where large volumes of water are pumped at low pressure into the accumulated sediments and the natural flows create a “current” which transports the material along the sea bed. The distance that the material can be transported is dependent upon the nature of the material (heavier material is deposited more quickly) and the strength of the natural currents.

Usually this process works best in fine sediments and in locations with strong natural flows.

There are drawbacks and advantages of this process which are pertinent to the Pwllheli location. These are summarised below: -

<u>Disadvantages</u>

- The marina basin is some 2.5m below the main channel and it appears very unlikely that the process could deal with this change in level.

- The material would need to be transported a significant distance, over 1km for dredged material in the marina basin to leave the harbour.

- The material is a mixture of sediments, sands and gravels, unless repeated dredging works were undertaken along the “current corridor” the material (particularly the gravels and sands) will be retained within the harbour system.

- For a short period of time after dredging the density of the bed material is greatly reduced such that a hydrographic survey cannot accurately assess the bed level, making the assessment of the quantity of material removed problematic.

- Dredging activity will be restricted to periods of ebb tide to ensure the material leaves the harbour rather than being distributed around the inner harbour.

- The material will create a discharge into the SAC which may very well be a concern to CCW.

Advantages

- The process does not require formal consent from the MFA, because technically the material does not "break the surface" of the water and is not being deposited. This consenting arrangement is likely to change with forthcoming legislation.

- The plant is road transportable and easily mobilised to site.

8.6.2 Backhoe Dredging (also Bucket/Grab)

This type of dredging activity is usually undertaken from a pontoon mounted excavator, loading the material directly into sea-going barges. Some backhoe dredges include the excavator and disposal unit in a single ship – although this generally is not particularly efficient.

The disadvantages and advantages of this method are:-

Disadvantages

- Labour and plant intensive

- Not generally suited to the Pwllheli location due to the significant distance to the disposal ground.

- Requires large scale relocation of the marina vessels and pontoon equipment - this may also include disconnection of internal services and removal of piles.

- High mobilisation costs associated with seagoing plant.

- Susceptible to weather delays.

Advantages

- Positive excavation of removal of material, readily identifiable results.
-
- Plant can be sized to suit the particular site requirements – consideration required of production rate and disposal rate.
-
- Can be cost effective provided reasonable quantity of material with disposal site in close proximity.
-
- Material excavated in a high ratio of material to water.

8.6.3 Cutter Suction Dredging

As the name suggests, this method has two processes. The cutter head loosens the material and transports it to the suction pipe. Large pumps draw the material through a discharge pipe. The material is discharged with a large volume of water usually into a settling or stilling lagoon, where the material is allowed to settle out. Transportation by barge is not usually economically viable due to the high water ratio.

The disadvantages and advantages relative to the Pwllheli location are detailed below:-

Disadvantages

- Pipeline can cause an obstruction to navigation

- Material in the stilling lagoon needs to be dealt with creating double-handling and additional cost.

Advantages

- Plant can be road transportable and mobilised to site in a cost effective manner.
- Dredging vessels are manoeuvrable and therefore limited pontoon dismantling is required.
- Method can deal with a range of material types from fine sediments to sands and gravels.
- Makes effective use of plant and labour further benefiting cost effectiveness.
- Material can be pumped long distances (up to 1km) and with a booster station these distances can be extended.
- Plant operating within the confines of the harbour at all time means that it can work in most states of weather and minimal down-time is experienced.
- Cost effective provided land for a stilling lagoon is available.

8.6.4 Trailing Suction Hopper Dredger (TSHD)

A TSHD trails the suction pipe alongside the vessel and loads the dredge spoil into one or more hoppers within the vessel. The vessel then proceeds to the dumping site to dispose of the vessel.

The size of the vessel, requirements to transit large distance to the disposal site and the manoeuvring requirements which would entail either large scale removal of the marina or double handling of the dredged material to an interim disposal site, make this alternative entirely inappropriate for the current circumstances.

8.6.5 SUMMARY / KEY ISSUES

Review of the above methods clearly indicates that the only cost effective methods appropriate for the site are either Water Injection Dredging or Cutter Suction Dredging with disposal to the local stilling lagoon.

There has to be real concern that Water Injection Dredging will not prove effective due to the nature of the material and the relative levels between the marina basin and the Access Channel. Furthermore, the ability of the method to transport the material the distance required to create effective removal suggests the method will not prove a practical solution.

Finally, the resultant discharge in to the designated SAC will cause concern for CCW regardless of whether consent is required or not.

1. ***The recommended strategy for the Marina Basin and Access Channel should include for the use of Cutter Suction Dredging with disposal to the local stilling lagoon.***

2. ***The recommended strategy for the Harbour Entrance should allow for the retention of local removal by land based plant with material either stockpiled or immediately reused as beach re-charge material.***

9. PROPOSED STRATEGY

9.1 BASIS OF STRATEGY / KEY ISSUES

It is clear that dredging in Pwllheli Harbour is problematic due to the prevailing constraints. Furthermore the level of accretion that occurs, makes dredging a significant cost consideration for the marina operation and the Council. At the heart of the strategy there is a need to reduce to the minimum level the annual maintenance dredging burden, to ensure the most cost effective and appropriate dredging works are undertaken and to ensure that a viable and sustainable strategy is in place that safeguards the Harbour activities. This will require ongoing review of the natural regime, which is subject to change, to ensure the strategy can be adapted and optimised.

Furthermore it is considered appropriate that any future strategy maintains a primary focus on ensuring that the Harbour Entrance and approach channel are maintained and adequately marked to ensure their use can be optimised by harbour users. This is not to say that dredging of the marina basin in not important but the relative level difference between the marina basin and the Access Channel means that maintenance of a viable channel is more important than the depth in the marina basin.

The following sections bring together the findings contained in the Chapters above into a series of Recommendations, both for immediate action and longer term review. These Recommendations essentially form the Maintenance Dredging Strategy which will need to evolve with experience and review of the natural processes and impact of maintenance dredging works. For this reason the Strategy should not be viewed as fixed and will require a process of review and updating.

9.2 SURVEYS

There is a wealth of data available within Gwynedd Council records relating to the development and operation of the Harbour.

With respect to the dredging strategy and due to the changing nature of the natural regime it is invaluable to have regular surveys i.e. at annual intervals as well as any contract specific surveys, for example pre and post dredge surveys at the Harbour

Entrance works. This information will enable the historic dredging picture to be built up and also for the effectiveness of dredging campaign information to be accurately assessed.

Recommendation 1 - Continue with the annual harbour wide hydrographic survey and ensure that all pre and post dredge surveys are captured in a similar format. The Annual survey each September/October is to be used as the basis for establishing the winter dredging programme / priority areas. This should include review and assessment of the capacity within the stilling lagoon

Recommendation 2 - The schedules within the Factual Sedimentation Report should be "rolled forward" with the full details of future surveys, allowance for dredging works and ongoing assessment of accretion rates.

9.3 HARBOUR ENTRANCE

On the basis of the Key Issues identified in Section 4.6 the following recommendations are made with respect to dredging in the Harbour Entrance.

Recommendation 3 – Ensure future dredging optimises the width of the channel at the Harbour Entrance. In this respect the profile outlined on Dwg No. CPF/1191/Spec Rev B should be adopted and localised dredging conducted on an annual basis (and as required) to maintain this profile initial works during winter 08/09. Over time the precise extent of dredging to be confirmed such that dredging once a year provides a maintainable profile in the channel throughout the season.

Recommendation 4 – Retain the current method of dredging using land based plant with arising material being either stockpiled or taken directly for beach recharge.

Recommendation 5 – A longer term aspiration (only once a viable and sustainable strategy is in place) will be to review the potential to increase the depth in the entrance (and Access Channel) by 0.5m

9.4 ACCESS CHANNEL

In consideration of the issues identified in this report and in particular those contained in Section 5.7 the following recommendations are made:

Recommendation 6 – Initially the channel profile outlined on Drawing No. CPF/1191/Spec B should be adopted. In due course an increase in channel width of 5m should be considered, but only provided that the additional dredging burden can be dealt with by the dredging strategy.

Recommendation 7 – The navigation marks identifying the position of the Access Channel (and entrance) should be re-established to accurately reflect the position of the channel.

Recommendation 8 – As a longer term aspiration (possibly combined with a potential increase in channel width refer to Recommendation 6) the position of the Access Channel could be relocated to reflect the natural deeper water channel, with the piled moorings opposite the Harbour Masters Office relocated. A separate study should be commissioned to review the operational benefits and cost / benefit implications.

Recommendation 9 – Dredging works to maintain the channel profile detailed on Dwg No. CPF/1191/SPEC B to be undertaken as a top priority – volume estimate by CES (Sept 08) suggests approx 7,500m^3 to be removed within the Harbour Approach Channel.

Recommendation 10 – Dredging Method for the Approach Channel and Marina Basin to be combined – refer to Section 9.5 for appropriate comment.

9.5 MARINA BASIN

The key input to the following recommendations are outlined in Section 6.4

Recommendation 11 – An alternative design profile is adopted for the marina basin which better reflects the nature of the vessels berthed in the marina and

their requirement for water depth when berthed on the pontoons. A recommendation alternative is outlined in Appendix X.

Recommendation 12 – Dredging work in the marina is combined with dredging in the Access Channel with the channel being given short-term priority. The most appropriate method is considered to be use of an appropriately sized cutter suction dredger with the dredged spoil being discharged into the stilling lagoon.

Recommendation 13 – In the longer term consideration might be given to an alternative pricing policy that reflects the additional costs of maintaining the deeper berths.

9.6 STILLING LAGOON

The recommendations in this section are largely based upon the issues identified within Section 7.0.

Recommendation 14 – The proposed trial excavation and screening of material across the lagoon should be undertaken at the earliest opportunity. This trial should seek to identify the profile / proportions of material within the bund, identify the opportunities for re-use and confirm the extent and sustainability of material for disposal.

Recommendation 15 – In advance of short-term dredging works remove suitable material to the stockpile at Garreg yr Imbill in order to maximise the capacity within the bunded area.

Recommendation 16 – based upon the evidence from the trial proposed above at Recommendation 14 establish an annual plan to clear a minimum of 6,000 m^3/ per annum from the bund. This being equivalent to the estimated annual dredging burden from the Access Channel and marina basin once allowance for consolidation has occurred. The annual quantity of material to be removed to be reviewed based on the developing strategy and experience.

Recommendation 17 – Ensure the requisite permits and licences are in place to authorise the stilling lagoon and associated activities.

Recommendation 18 – Ensure adequate provision is in place to maintain security, signage and the bund structure itself.

9.7 PROCUREMENT/EQUIPMENT/FUNDING

9.7.1 Procurement

The undertaking of maintenance dredging works within Pwllheli Harbour is a specialist activity, particularly where specialist plant and equipment is involved. Currently the Council owned plant and equipment resides in the boatyard adjacent to the Harbour. The dredger has been officially retired from active work and because of a combination of mechanical condition and principally because it is not able to meet current criteria for certification under the Work Boat Regulations is not suitable for use by the Council in a coastal location.

In order that the most cost effective solution is delivered to the Council and to minimise risk it is recommended that a professional dredging contractor is engaged to undertake the maintenance dredging works.

Recommendation 19 - It is recommended that a Contractor selection process is run during the forthcoming winter period. This to be based on the requirement for a package of works to address the immediate requirements in the entrance and Access Channel, subject to additional capacity in the Lagoon being available works should also be undertaken in the Marina Basin.

As a medium term aspiration consideration should be given to the establishment of a Term Contract for the harbour maintenance dredging works. As a minimum the Term Contract should include the following works:

1. Liaising with Council Officers to establish the priority dredging areas for each dredging campaign, confirmation of budget limits and identifying capacity requirements in the stilling lagoon.
2. Undertaking maintenance dredging, as directed, within the Access Channel and Marina Basin.
3. Maintenance of adequate capacity within the stilling lagoon, to include re-use of appropriate material and disposal of unsuitable material.

4. Production of post-dredge surveys in an appropriate format.
5. Security and maintenance of the appropriate licences and consents.
6. Annual inspection of the stilling lagoon structure and appropriate maintenance thereof – to include security fence, bund / rip-rap and signage – Lagoon to be "handed-over" to the Council in acceptable standard at the end of each contract period. (Between the contract works the Council to be responsible for maintenance, inspections and security).

Recommendation 20 - subject to identifying suitable contractors for the forthcoming works and confirmation of methods and licensing details the framework for a Term Contract can be outlined (see suggested structure above).

In due course consideration should be given to extending the remit of the Contract to include the following additional elements:

1. All harbour survey works (and updating the factual sedimentation reports) – Note: GC will need to consider whether they prefer to maintain the independence of the existing surveys.
2. Contractual obligation to maintain minimum depths in certain areas.
3. Extend scope to include Harbour Entrance and Beneficial Disposal / Beach re-charge.

9.7.2 Equipment

Recommendation 21 - On the basis of the above recommendation the Council owned Nessie Dredger and associated equipment can no longer be considered suitable for operational service in Pwllheli Harbour. The recommendation is that the dredger and equipment is offered for sale / disposal.

Another equipment consideration is the Syrfewr workboat which is currently operated by GC and maintained from the dredging budget. The Syrfewr is 6.4m aluminium workboat built in 1999 by Voe Boats, Shetland. The workboat is certified under the Small Commercial Vessel Code of Practice as a Category 4 with an operating distance of 20 miles from a safe haven and can carry 4 persons.

The workboat was purchased and adapted specifically for the Council's dredging operations; activities included carrying out hydrographic surveys, ferrying staff and there is a built in auxiliary tank specifically for refueling a dredger. At present the

workboat is not extensively used as it is only used a couple of times a year for survey works. Whilst the workboat could be utilised by the successful dredging contractor as a support vessel a professional dredging contractor should have their own workboat/survey boat.

Provided it proves possible to adapt other marina workboats to act as a survey platform, this will require the introduction of a weatherproof canopy to protect electronic equipment etc., the retention of the Syrfewr should be considered something of a luxury.

Recommendation 22 – review the economic case for the disposal of the Syrfewr workboat and any associated equipment, provided a suitable survey platform can be provided from within existing resources or the vessel supply is outsourced.

9.7.3 Funding

It is clear that an amount of work is required to bring the harbour areas back to sustainable levels such that the accretion levels provide for a manageable baseline against which future maintenance dredging can be planned. In the short term dredging is required to reinstate the proposed design levels to the Entrance, Approach Channel and Marina Basin. Over time the significant over dredge and take-up of over provision of depth within the marina basin has distorted the dredging burden both in terms of the volume of material to be removed and the associated costs. As importantly the lack of recycling of the material within the stilling lagoon demands expenditure related to the creation of some spare capacity and maintenance of this capacity over time.

Inevitably there will be some significant costs associated with these works which are not analysed within this strategy. However once a status-quo has been created then it will be possible to establish a realistic budget for the ongoing strategy based upon the assessed annual dredging burden.

The schedule at Appendix 6 provides the initial assessment of this budget which is based upon a number of assumptions. Costs have been provided from a number of sources including review of historic costs for the Harbour Entrance works, budget estimates from the Contractor Land and Water and local disposal costs. Due to the number of assumptions a reasonable contingency has been applied

The initial appraisal of the annual dredging budget amounts to some £180,000 and this assumes that dredging is carried out each winter; it is notable that over a third of the cost is associated with dealing with the material in the stilling lagoon. This annual budget exceeds significantly the budget allowance within the study brief and additional funding provision will clearly be required to prosecute this strategy. The existing annual budget allowance for the Harbour is understood to be in the order of £100k. It may prove possible to undertake maintenance dredging every two years, thus reducing the impact of mobilisation costs and providing better value for money. This will in large part be dependent upon ensuring that sufficient capacity can be created within the stilling lagoon. It is absolutely clear that capacity in the stilling lagoon is key to the strategy and identifying cost effective ways to re-use and/or dispose of the material will be one of the key budgetary constraints.

With the benefit of experience and once the strategy and any Term Contract has been established it may be possible to reduce the costs and assess these with more accuracy leading to reduced costs and a reduced contingency.

With respect to timing it is envisaged that the strategy will be established for the winter 2009/10 dredging. This is due to a need to resolve an amount of outstanding consultation e.g. with CCW, EA and the Harbour Consultative Committee and also the requirement to resolve the licensing requirements, particularly for the stilling lagoon. In the meantime it is envisaged that the following actions will occur over the next 6-9 months:

- Annual hydrographic survey and updating of the factual sedimentation assessments
- Insert expression of interest in suitable publications, carry out a contractor appraisal exercise and identify a preferred contractor
- Obtain all necessary waste regulation licences - new legislation e.g. Environmental Permitting Regulations, April 2008
- Revisit and review all environmental assessments as necessary
- Make an application to WAG for grant aid to support a nourishment strategy. The dredging and nourishment strategies have a symbiotic relationship.
- Prepare a dredging specification and contract documents
- Complete rip rap protection to the seaward side of the stilling lagoon bund

- Complete the replacement of timber posts with galvanized steel on the lagoon security fence
- Carry out comprehensive repair works to the bull head rail groyne.
- Explore ways of creating spare capacity in the stilling lagoon to include undertaking the trial proposed at Recommendation 14.

A budget for the 2008/09 dredging is also summarised at Appendix 6 and this amounts to some £88,000 assuming that the annual survey confirms the requirement to undertake limited dredging works in the Harbour Entrance.

9.8 SUSTAINABILITY

The scope of works requires the review the interim Defra Guidance on climate change policy and sea-level rise assessments. Essentially the guidance is looking at the sensitivities applied to the calculations prepared to assess whether a coast protection scheme is viable or not. Generally the input is forward looking for appraisals beyond October 2006; however the guidance note requires that Gwynedd Council should re-assess the current scheme due to the requirement to take on-board the recommendations within ongoing work.

In essence it is in the Council's interests to re-visit their plan in light of the new guidance on sea-level rise, but as it currently stands this will not impact the immediate future of the beach replenishment. This comment is based on the fact the current scheme is not considered to provide for the longer term.

Recommendation 23 - Once the dredging strategy is confirmed, review the basis of existing Shoreline Management Plan, Appropriate Assessment and Environmental Impact Assessments to ensure they remain fit for purpose and to ensure impacts as a result of any changes to dredging and disposal methods are noted. Assuming these changes remain negligible or manageable the assessments can simply be updated accordingly.

Appendix 1 – Drg No. MP115a-P-100 (Location Plan and Dredge Zones)

North Quay

Marina Basin

Harbour Entrance

Training Arm

Pwllheli Marina

Crib Groyne

Morfa'r Garreg Basin

Stilling Lagoon

Access Channel

Rev.	Description	CHKD	Date
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REVISIONS

Client / Project:

Gwynedd Council

Pwllheli Harbour Dredge

Drawing Title:

Location Plan and Dredge Zones

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Drawing No:

MP115a-P-100

Appendix 2 – Environmental Designations

Designation: Special Area of Conservation (SAC)
Site name: Llyn Peninsula and the Sarnau
Area in hectares: 146023
Distance from Harbour: 250m*
Reason for designation: Marine areas. Sea inlets (92.6%) Tidal rivers. Estuaries. Mud flats. Sand flats. Lagoons (including saltwork basins) (5.4%) Salt marshes. Salt pastures. Salt steppes (1.2%) Coastal sand dunes. Sand beaches. Machair (0.5%) Shingle. Sea cliffs. Islets (0.2%) Bogs, Marshes, Water fringed vegetation, Fens (0.1%)[5]

The management of the SAC is undertaken by a number of competent and relevant authorities and those relevant authorities within the Llyn Peninsula and Sarnau SAC area have formed the Relevant Authorities Group. The Group work closely together to safeguard the features of the SAC and complete their duties under the Habitat Regulations. Gwynedd Council are a member of the Relevant Authorities group and a competent authority. The Relevant Authorities Group has published a Management Plan[6] for the SAC and the relevant policies that Gwynedd OUcnil should have reference to when creating their Dredging Startegy are listed below.

6.2.2 Shoreline defence structures, including maintenance and improvement of existing defences and construction of new defences (5.4.1.2)

Actions
- Review extant planning permissions for coastal defence works (Competent authorities)
- Treat shoreline defence works as a Plan or Project (Competent authorities).
- Encourage the use of more modern, holistic approaches to the future design of coastal defence in the cSAC (Gwynedd Council, Ceredigion County Council, Snowdonia National Park Authority, Environment Agency Wales)
- Continue the programme of monitoring of coastal processes which has been set up as part of the work for Shoreline Management Planning to provide advice on best coastal defence options.
- Keep this programme under review and identify any new requirements as appropriate. (Gwynedd Council, Ceredigion County Council, Ynys Enlli to Llandudno Coastal Group).
- Ensure that the implications of possible alterations to sea level, wave exposure and other physical processes as a result of climate change are fully considered in the development and maintenance of new and existing coastal defence works. (Gwynedd Council, Ceredigion County Council, Ynys Enlli to Llandudno Coastal Group).

6.3.2 Capital and maintenance dredging (5.4.2.2)

Actions
- Review extant planning permissions for capital and maintenance dredging works (competent authorities)
- Seek clarification of the relationship between Harbour Revision Orders and Harbour Empowerment Orders and the Habitats Regulations. Assess the implications of existing and proposed HRO's and HEO's for the cSAC features.
- Treat capital and maintenance dredging as a Plan or Project. (Competent authorities)
- Produce Dredging Plans for the area within and immediately adjacent to the cSAC to clarify the future dredging requirements within the area and consider disposal options. Link to those being produced as part of the Cardigan Bay cSAC management plan. (Gwynedd Council)

[5] http://www.jncc.gov.uk/ProtectedSites/SACselection/sac.asp?EUCode=UK00131117
[6] Pen Llyn A'r Sarnau Candidate SAC Draft Management Plan August 2000

- Ensure that the cSAC is taken fully into account in the preparation and review of Harbour Revision Orders and Harbour Empowerment Orders. (Gwynedd Council).
- Ensure the cSAC is taken fully into account in the preparation of any regional development proposals (e.g. in relation to European or other funding). (Gwynedd Council, Ceredigion County Council).

6.3.3 Disposal/dumping of sediment / material (5.4.2.3)

Actions
- Review any extant authorisations for sediment disposal/dumping (Competent authorities)
- Treat sediment disposal/dumping as a Plan or Project (Competent authorities).
- Produce Dredging Plans to clarify future requirements for sediment disposal (Gwynedd Council, Ceredigion County Council).
- If new sea disposal site closer to the cSAC is considered, the assessment for this will need to include appropriate monitoring and surveillance to ensure the requirements of the cSAC features are taken fully into account. (MAFF &/or National Assembly of Wales)
- Ensure the cSAC is taken fully into account in the preparation of any regional development proposals (e.g. in relation to European or other funding) that may involve requirements for sediment disposal/dumping. (Local authorities and others).
- Ensure that any proposals for sediment disposal/dumping (in particular in coastal/intertidal areas) are assessed in the context of the relevant Shoreline Management Plans. (Local authorities and other competent authorities)
- Ensure that any proposals for sediment disposal/dumping (in particular within and adjacent to the estuaries) are assessed in the context of the relevant Local Environment Agency Plans (LEAPs). (Environment Agency and other competent authorities)

Consultation with the Environment Agency highlighted the importance of early discussion with CCW, with particular regard to the potential effects of dredging and sediment movements on the SAC features. The key features are:-
- Estuaries
- Reefs
- Coastal lagoons
- Atlantic salt meadows
- Grey seals
- River Lamprey
- Large shallow inlets and bays
- Otters
- Mudflats and Sandflats not covered by seawater at low tide
- Sandbanks slightly covered by seawater all the time
- Submerged or partially submerged sea caves
- Bottle nosed dolphin

Designation: Site of Special Scientific Interest (SSSI)
Site name: Morfa Abererch
Area in hectares: 98.64
Distance from Harbour: 2500m*
Reason for designation: Comprises a length of shoreline with geological, botanical and marine biological features. Habitats of importance include intertidal areas and rocky headland with lowland heath. Of particular mention is the nationally important community of piddocks in clay.

Designation: Site of Special Scientific Interest (SSSI)
Site name: Mynydd Tir y Cwmwd a'r Glannau yr Imbill
Area in hectares: 163.05
Distance from Harbour: 720m*

Reason for designation: Designated for its lowland heath, vegetated shingle and floodplain fen habitats. These support flora and fauna of national importance.

There are two Sites of Special Scientific Interest (SSSI) within proximity of the Glan y Don Peninsula at Pwllheli (as shown in Figure 3,1) and the designations recognise that the sites are nationally important for the species, habitats and geology they support. SSSI's are notified under the Wildlife and Countryside Act 1981.

Designation: Local Nature Reserve (LNR)
Site name: Lon Cob Bach
Area in hectares:
Distance from Harbour: 580m*
Reason for designation: Wet pasture and saltmarsh south of the road that divides the site, with intertidal mud flat and reedbed north of the road. The habitat is important for lots of species including the kingfisher and the otter.

There are a number of locally important wildlife sites designated as Local Nature Reserves (LNRs) under Section 21 of the National Parks and Access to the Countryside Act 1949, in and around Pwllheli.

Close to the proposed site and potentially impacted by any works within the Harbour is the Lon Cob Bach Local Nature Reserve. The reserve comprises wet pasture and saltmarshes to the South and extensive areas of intertidal mudflat and reedbed to the North. The site is important for both birds and animals, specific species mentioned being the kingfisher and the otter.

Designation: Biodiversity Action Plan Sites
Site name: Mudflat
Area in hectares:
Distance from Harbour: 0m*

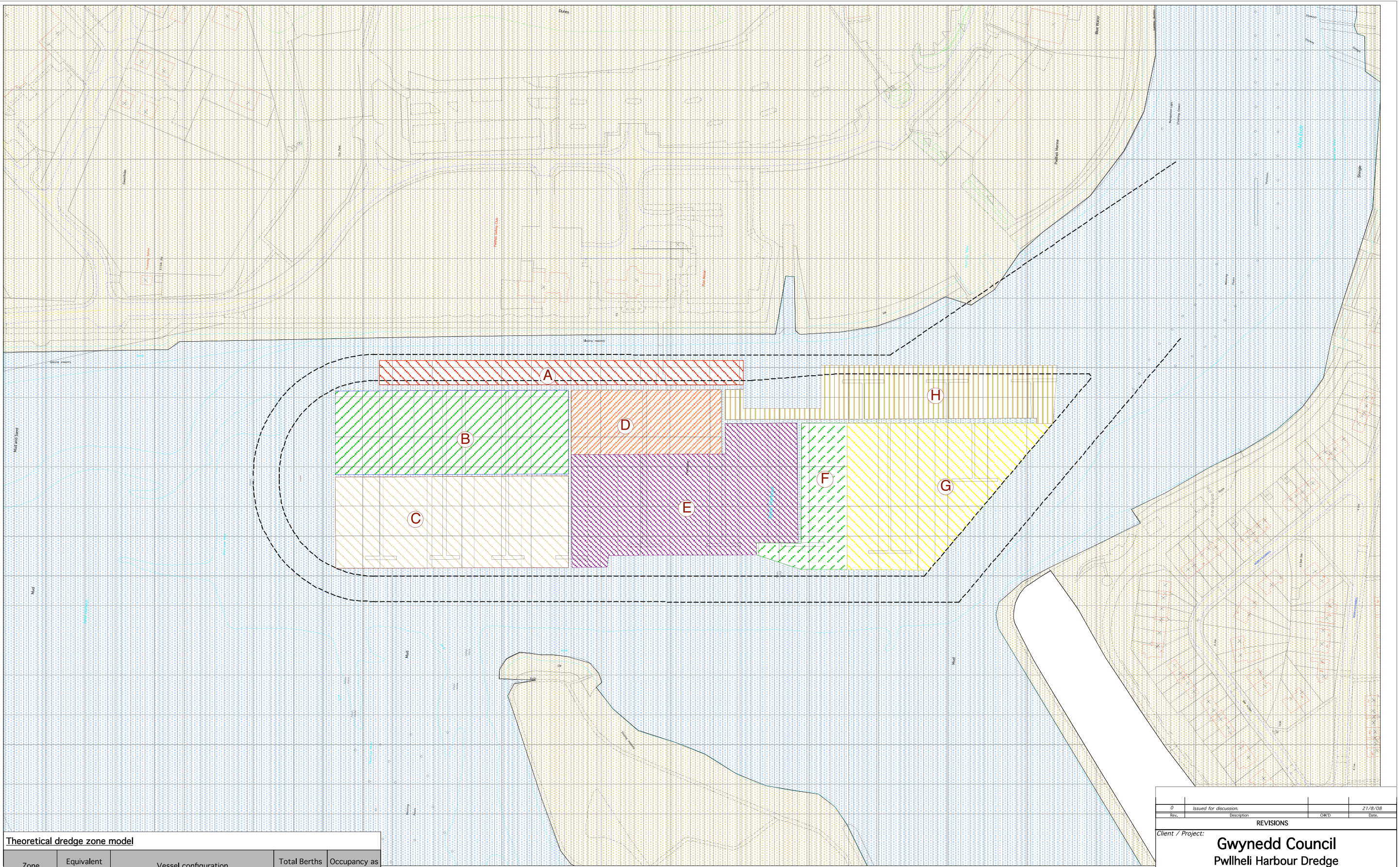
One final consideration is the Governments Biodiversity Action Plan - national strategies, plans and programmes for the conservation and sustainable use of biological diversity. Gwynedd Council has Natur Gwynedd, the Local Area Biodiversity Action Plan in place which identifies the priority habitats and protected species for Gwynedd and was formally adopted by Gwynedd Council in 2003. Gwynedd Council also supports biodiversity and Natur Gwynedd further within its Unitary Development Plan with Policy B20: Gwynedd Local Biodiversity Action Plan Habitats – "Natur Gwynedd". This Policy states that:

> *Proposals that are likely to have an unacceptable impact on habitats identified in "Natur Gwynedd" will be refused unless those effects can be minimised or mitigated through careful design or if appropriate the developer make take steps to provide habitats of a similar or better value that will restore the integrity or sequence of habitats.*
>
> *When a development is approved, planning conditions and/or agreements will be used in order to protect the nature conservation value of the site, or to ensure that appropriate mitigation measures will be provided by promoting or creating other new habitats either on the same site or in another suitable location.*

*Note: the 'Distance from site' is the approximate distance from the Marina Building to the closet point of the designated site and is only intended as a guide.

Appendix 3 – Drawing No MP115a-P-102 (Berthing Model)

Appendix 3 – Drawing No MP115a-P-102 (Berthing Model)



Theoretical dredge zone model

Zone	Equivalent design depth	Vessel configuration	Total Berths in Zone	Occupancy as at '08
A	-1.15	Sail up to 6 & Power 6 & 6 to 7m	52	42
B	-1.2	Power 8 to 10m	70	70
C	-1.7	Sail 6 to 7 &8 to 10m (Inc H/Hx12 to 15m)	90	90
D	-1.3	Power 10 to 12m	24	23
E	-1.9	Sail 8 to 10 & 10 to 12m (Inc H/H 5 x15+)	89	88
F	-2.6	Sail 15 +	14	14
G	-2.4	Sail 10 to 12 & 12-15m (Inc H/H 10x15+)	58	58
H	-1.3	Power 12 to 15m & 7 x120m Power	32	26
		Total	429	411

Pwllheli tidal conditions

Tide	Ordnance Datum	Chart Datum
Highest Astronomical Tide	3.26m	5.7m
Mean High Water Springs (MHWS)	2.56m	5.0m
Mean High Water Neaps (MHWN)	0.96m	3.4m
Mean Low water Neaps (MLWN)	-0.74m	1.7m
Mean Low Water Springs (MLWS)	-1.94m	0.5m
Lowest Astronomical Tide (LAT)	-2.44m	0m

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Client / Project:

Gwynedd Council
Pwllheli Harbour Dredge

Drawing Title:

Berthing Model

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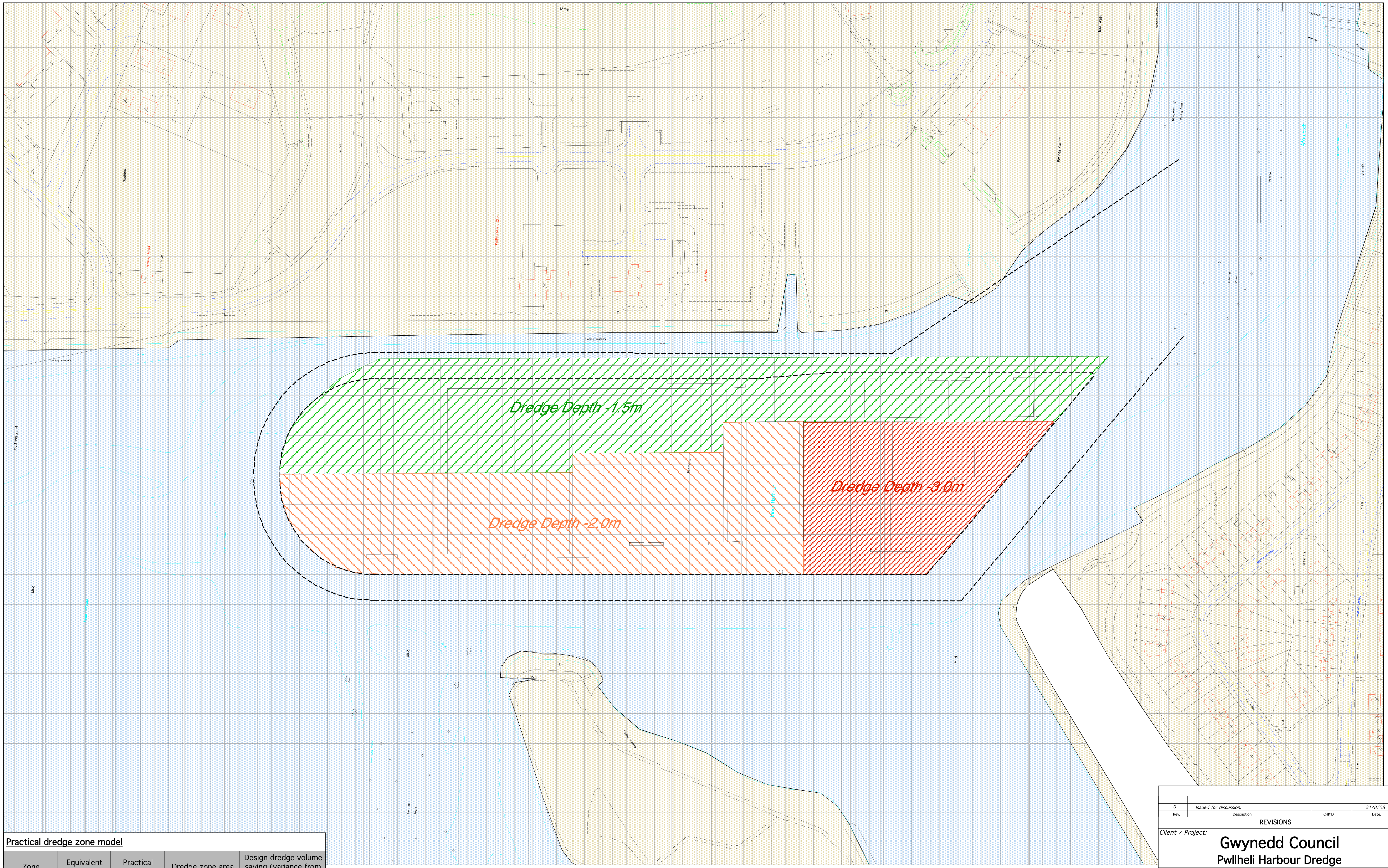
Drawing No:

MP115a-P-102

Appendix 4 – Drawing No MP115a-P-103 (Proposed Revised Dredge Levels)



Zone	Equivalent design depth	Practical dredge depth	Dredge zone area	Design dredge volume saving (variance from -3.0m C.D.)
A	-1.15	-1.5	22,744	34,116
B	-1.2	-1.5		
D	-1.3	-1.5		
H	-1.3	-1.5		
C	-1.7	-2	19,526	19,256
E	-1.9	-2		
F	-2.6	-3	9,618	0
G	-2.4	-3		
		Total design dredge volume saving		53,642

Practical dredge zone model

Pwllheli tidal conditions

Tide	Ordnance Datum	Chart Datum
Highest Astronomical Tide	3.26m	5.7m
Mean High Water Springs (MHWS)	2.56m	5.0m
Mean High Water Neaps (MHWN)	0.96m	3.4m
Mean Low water Neaps (MLWN)	-0.74m	1.7m
Mean Low Water Springs (MLWS)	-1.94m	0.5m
Lowest Astronomical Tide (LAT)	-2.44m	0m

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Client / Project:

Gwynedd Council

Pwllheli Harbour Dredge

Drawing Title:

Proposed Revised Dredge Levels

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Drawing No: MP115a-P-103

Appendix 5 – Photographs of the Stilling Lagoon

Appendix 6 – Indicative Annual Dredging Budget & 2008/09 Dredge Budget

Appendix 6 - Indicative Annual Budget Estimate

PWLLHELI HARBOUR - DREDGE STRATEGY
INDICATIVE ANNUAL BUDGET ASSESSMENT

Zone	Activity	Unit	Quantity	Rate	Value	Sub Total	Comment
General							
	Surveys	item	1	4,000	4,000.00		
				Sub Total		4,000.00	
Harbour Entrance							
	Annual Excavation to Stock pile	m3	10,000	2	15,000.00		Rate increased due to smaller quantities
	Annual transport to beach re-charge	m3	10,000	1	5,250.00		Beach Noursihment attracts 85% grant from WAG
	Post dredge survey	item	1	500	500.00		
				Sub Total		20,750.00	
Access Channel							
	Mob/Demob plant	item	1	15,000	15,000.00		
	Dredge to lagoon	m3	1,270	5	6,350.00		
	Post dredge survey	item	500	1	500.00		
				Sub Total		21,850.00	
Marina Basin							
	Mob/Demob plant	item	-	-	-		Assumes Mob/demob associated with Access Channel
	Dredge to lagoon	m3	7,650	5	38,250.00		
	Post dredge survey	item	500	1	500.00		
				Sub Total		38,750.00	
Stilling Lagoon							
	Excavate for re-use	m3	2,973	2	4,460.00		Allow for shrinkage due to 150% moisture content
	Excavate for disposal	m3	2,973	7	20,813.33		Allow for shrinkage due to 150% moisture content
	Disposal Costs	m3	2,973	12	35,680.00		Allow for shrinkage due to 150% moisture content
	Maintenance Costs	Allowance	1	5,000	5,000.00		
				Sub Total		65,953.33	
Crib Groyne							
	Maintenance Costs	Allowance	1	5,000	5,000.00		Ongoing annual allowance
				Sub Total		5,000.00	
General	Contingeny @ 15%	Item	1			23,445.50	
				Grand total		179,748.83	

Notes:

1. Assumed annual budget assuming that a level of maintenance dredging has been conducted to reinstate the design levels recommended within the Marina Projects Dredge Strategy
2. Volume Assessments based upon the average Annual Dredge Burden assessed within the Strategy Report
3. Assumed 50% of the material in the stilling lagoon is suitable for local re-use and there is shrinkage due to the high moistrue content

2008-09 Budget Estimate

PWLLHELI HARBOUR - DREDGE STRATEGY
INDICATIVE ANNUAL BUDGET ASSESSMENT

Zone	Activity	Unit	Quantity	Rate	Value	Sub Total	Comment
General							
	Spend to Date				9,000.00		detail to be confirmed
	Strategy and Expression of Interest	item	1	24,000	24,000.00		
	Survey	item	1	1,500	1,500.00		October 2008
				Sub Total		34,500.00	
Harbour Entrance							
	Annual Excavation to Stock pile	m3	6,250	1.5	9,375.00		based on the annual dredge burden for this zone
	Annual transport to beach re-charge	m3		1	-		Beach Noursihment attracts 85% grant from WAG
	Post dredge survey	item	1	650	650.00		of entrance area only
				Sub Total		10,025.00	
Access Channel							
	Mob/Demob plant	item	-	15,000	-		
	Dredge to lagoon	m3	-	5	-		
	Post dredge survey	item	-	1	-		
	Ploughing & testing	item	1	7,000	7,000.00		Costs confirmed by GC
				Sub Total		7,000.00	
Marina Basin							
	Mob/Demob plant	item	-	-	-		
	Dredge to lagoon	m3	-	5	-		
	Post dredge survey	item	-	1	-		
				Sub Total		-	
Stilling Lagoon							
	Excavate for re-use	m3	-	2	-		
	Excavate for disposal	m3	-	7	-		
	Disposal Costs	m3	-	12	-		
	Disposal Trial - plant hire	Allowance	1	750	750.00		Estimated trial costs
	Complete Rip rap	Allowance	1	18,000	18,000.00		
	Fence Repairs	Allowance	1	10,000	10,000.00		
				Sub Total		28,750.00	
Crib Groyne							
	Maintenance Costs	Allowance	1	10,000	10,000.00		Condition survey required
				Sub Total		10,000.00	
General		Item	1				
				Grand total		£ 90,275.00	

Notes:
1. Rip rap, fencing and Crib groyne maintenance costs £45k - from GC
2. Volume Assessments based upon the average Annual Dredge Burden assessed within the Strategy Report

Appendix 7 - Drg No. CPF/1191/Spec/B

METHODS FOR DETERMINING APPROACH CHANNEL WIDTH

A THE YACHT HARBOUR ASSOCIATION

A CODE OF PRACTICE FOR THE DESIGN, CONSTRUCTION AND OPERATION OF COASTAL AND INLAND MARINAS AND YACHT HARBOURS

- STATES OPTIMUM WIDTH IS 30m, BUT NOT LESS THAN 5Bm (where B is the beam of the widest boat in the marina) OR 20m.
- BEAM OF WIDEST BOAT IN THE MARINA IS 5m ∴ 5B = 25m

B THE INSTITUTION OF CIVIL ENGINEERS

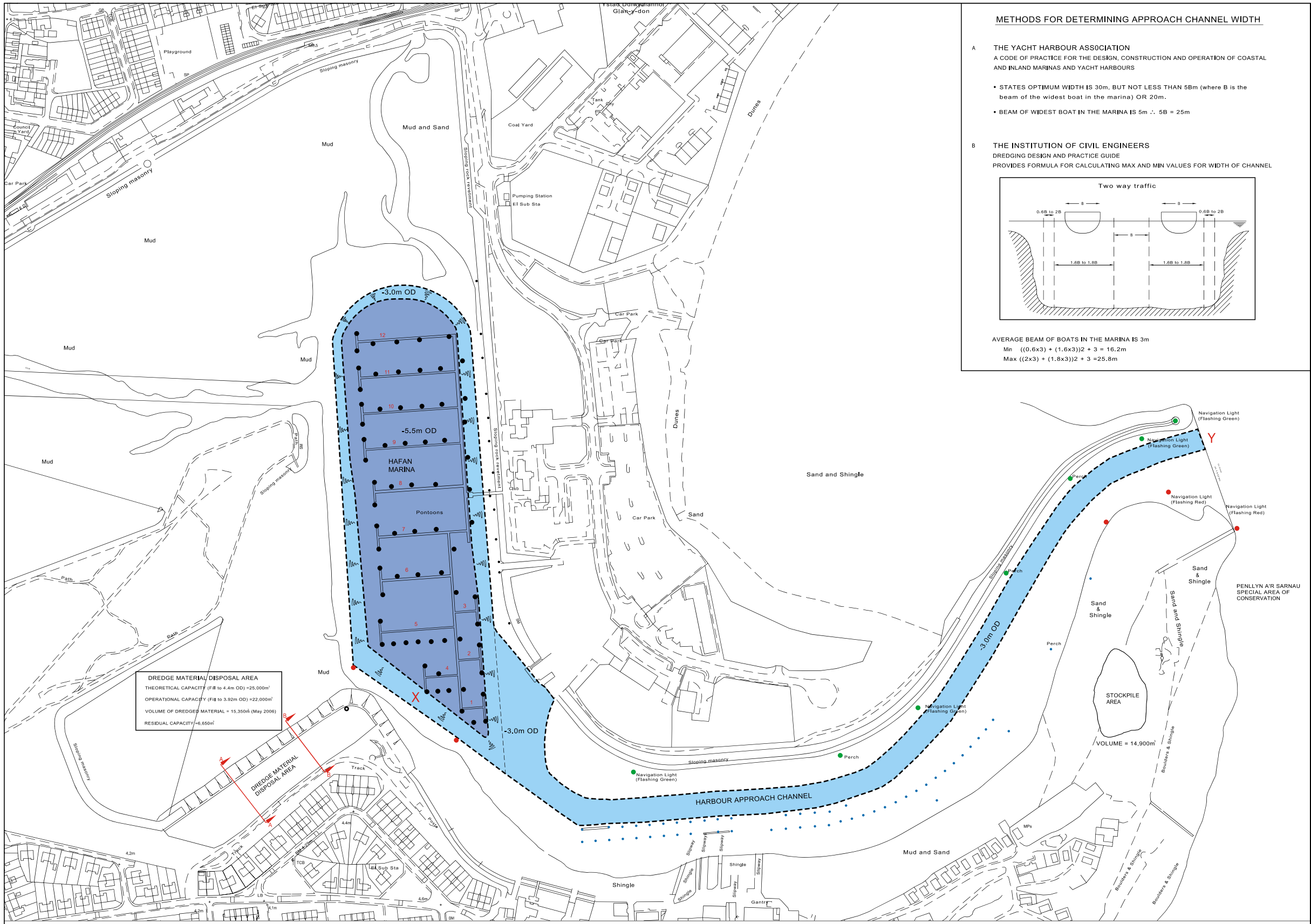
DREDGING DESIGN AND PRACTICE GUIDE

PROVIDES FORMULA FOR CALCULATING MAX AND MIN VALUES FOR WIDTH OF CHANNEL

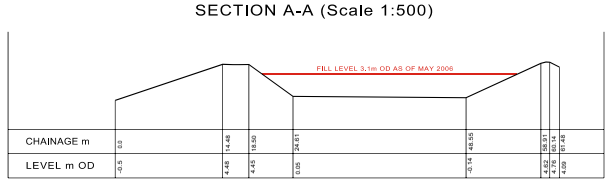
AVERAGE BEAM OF BOATS IN THE MARINA IS 3m

Min ((0.6x3) + (1.6x3))2 + 3 = 16.2m

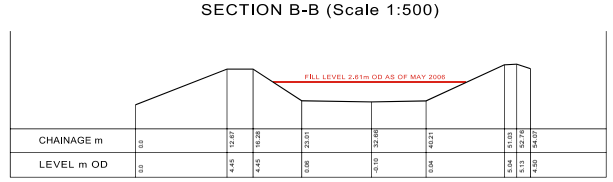
Max ((2x3) + (1.8x3))2 + 3 =25.8m



SECTION A-A (Scale 1:500)



SECTION B-B (Scale 1:500)



NODIADAU/NOTES

DESIGN DREDGE LEVELS

PWLLHELI HARBOUR DEVELOPMENT PHASE 1 - 1989
(Posford Duvivier)
GIVES VALUES OF:-
ENTRANCE & OUTER HARBOUR -3.0m OD (-0.56m CD)
MARINA BASIN -5.5m OD (-3.06m CD)

KEY

- TROT MOORING PILES
- STARBOARD NAVIGATION MARKERS (GREEN)
- PORT NAVIGATION MARKERS (RED)
- REVETMENT TOE MARKERS
- MARINA PONTOON PILES

OD ORDNANCE DATUM

CD CHART DATUM

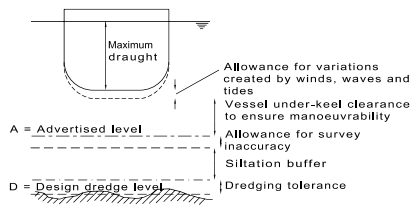
1-12 PONTOON REFERENCE NUMBERS

APPROACH CHANNEL (X-Y)

LENGTH X-Y = 1000m
WIDTH = 25m
LEVEL =-3.0m OD

THE INSTITUTION OF CIVIL ENGINEERS

DREDGING DESIGN AND PRACTICE GUIDE
ADVERTISED LEVELS



For approach channel
D-A =300mm ∴ advertised level = -2.7m OD (-0.26m CD)

For marina basin
D-A =500mm ∴ advertised level = -5.0m OD (-2.56m CD)

RHIF NO.	NEWIDADAU MODIFICATIONS	GAN	DYDDIAD	GWIRIWYD
B	GRAB SAMPLES (Babtie 1999) REMOVED	AW	09/10/08	
A	ADVERTISED LEVELS AND PONTOON PILES ADDED PLUS GENERAL TEXT EDITS	AW	01/10/07	

CYNGOR GWYNEDD COUNCIL

UNED AMDDIFFYN YR ARFORDIR
COAST PROTECTION UNIT

Huw Williams
Pennaeth Gwasanaeth
Ymgynghoriaeth Gwynedd
Head of Service
Gwynedd Consultancy

CYFADRAN YR AMGYLCHEDD
ENVIRONMENT DIRECTORATE
YMGYNGHORIAETH GWYNEDD
GWYNEDD CONSULTANCY

CYNLLUN/SCHEME :

PWLLHELI HARBOUR MAINTENANCE DREDGING

TEITL LLUNIAD/DRAWING TITLE :

DREDGE AREAS SPECIFICATION

DARLUNWYD GAN : DRAWN BY :	AW	DYDDIAD DARLUNWYD : DATE DRAWN :	25/09/07
GWIRIWYD GAN : CHECKED BY :		DYDDIAD GWIRIWYD : DATE CHECKED :	
Taflen Sheet	o of	GRADDFEYDD : SCALES :	1:2000

Rhif Lluniad Drawing No. CPF/1191/Spec DIWY REV B