Appendix 4 - Attachment E

Malachy Walsh and Partners
Engineering and Environmental Consultants

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LICENCE REFERENCE No.	RISK ASSESSMENT METHODOLOGY STAGE & STEP	REPORT VERSION
Bantry Inner Harbour Dredging Phase 1	Stage 1 – Site Characterisation Step 3 – Quantitative Risk Assessment	Final Issue for Waste Licence

Viridus Consulting Ltd on behalf of:

Malachy Walsh & Partners

Consulting Engineers

Environmental Quantitative Risk Assessment

March 2016

For Bantry Inner Harbour Dredging Works Waste Licence Application

Project Title:	Bantry Bay Inner Harbour Dredging Project – Phase 1
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LIMITATION

This report takes into account the particular instructions and requirements of our client Malachi Walsh & Partners Consulting Engineers, It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

The report refers, within the limitations stated, to the condition of the site and waters at the time of the inspections and sampling work. No warranty is given as to the possibility of future changes in the conditions of the site and waters.

The report is based on site inspection, referenced to accessible referenced historical records, the physical sampling work as detailed, information supplied by those parties referenced in the test and on the previous sampling data available for the site. Some of the opinions are based on unconfirmed data and information and are presented at the best that can be obtained without further extensive research. The test results that are available can only be regarded as a limited but likely representative sample assessed against current guidelines.

Viridus Consulting Ltd., take no responsibility for the conditions that have not been revealed by the site sampling or which occur below or between the sampling points. The possibility of the presence of contaminants, perhaps in higher concentrations, elsewhere on the site or the possibility of encountering ground conditions at variance with the groundwater sampling results elsewhere on the site cannot be discounted. Whilst every effort has been made to interpret the conditions between sampling locations, such information is only indicative and liability cannot be accepted for its accuracy.

With reference to any sediment/water contamination, whilst the findings detailed within this report reflect our best assessment, because there are no exact Irish Definitions of these matters, subject to risk analysis, we are unable to give categorical assurances that they will be accepted by authorities or funds without question, as such bodies may have unpublished more stringent objectives. This report is prepared and written for the proposed uses stated in the report and should not be used in a different context without reference to Viridus Consulting Ltd. In time, improved practices or amended practices or amended legislation may necessitate re-evaluation.

The report is limited to the environmental aspects specifically reported on, and is necessarily restricted and no liability is accepted for any other aspect, especially concerning gradual or sudden pollution incidents. The options expressed cannot be absolute due to the limitations of time and resources imposed by the agreed scope of works, the nature of the dredge material and the possibility of unrecorded previous incidents in the proposed site area or adjacent areas.

The objectives of the Bantry Harbour Quantitative Risk Assessment (QRA) were completed as per the original proposal issued to the client. The brief was to complete the QRA Report based on the recent sampling completed for the Phase 1 dredge program in order to assess the potential for contamination to arise from the proposed work. The work was completed as part of the overall environmental assessment of the development.

The completed site investigation and sampling work was reportedly completed successfully under good conditions and no issues regarding the acquired samples were reported by the independent laboratories which completed the analysis. The work brief was not deviated from and the proposed objectives were achieved.

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E□ECUTIVE SUMMARY

The Port of Cork are proposing to improve and develop part of the Bantry Bay Inner Harbour area, which is adjacent to Bantry Town in West Cork, for commercial and recreational boating activities. An EIS was completed for the project (RPS, 2012) which provided a detailed overview of the baseline conditions at the site. A Planning Application for development of the whole inner harbor area was submitted in December 2012. (Planning reference 12/00735). The Notification of Decision to Grant Permission (with Conditions) was issued by Cork County Council on 18/07/2013, with the final Grant of Permission (with Conditions) being issued by Cork County Council on 29/08/2013.

The original Scheme to develop the whole Inner Harbour area cannot be fully constructed at this time (due to financial constraints) and therefore a revised Phase 1 Scope of Development Works is proposed.

This Phase 1 Development will comprise:

(a) Dredging of an area of the inner harbour to a depth of between -3m and -4m Chart Datum,

(b) The reuse of dredge material as fill within the proposed pier/quayside structures and amenity area,

(c) The treatment of fine grained dredge material by mixing it with cement in order to solidify and stabilise it for re-use as an engineering backfill material within and behind the proposed Town Pier/Quayside structures and within the proposed reclaimed amenity area which will be developed behind a Perimeter Engineered Revetment Structure (PERS),

(d) The protection of the proposed PERS using rock armour geotextile linings over an imported engineering aggregate core in the bund,

(e) The refurbishment of the existing Town Pier; the construction of a length of Quayside; (giving 2,300m^2 of additional area), and the construction of an Amenity Area, giving about 7,000m^2 surface area), and the installation of Marina and Breakwater type Pontoons.

Site investigations completed for the initial scheme in 2009 and for the Phase 1 Development in 2015 identified the presence of potential polluting parameters in the upper layer of fine sediments in the proposed dredge area. The contaminants of concern that were identified at some of the sample locations are:

- Petroleum hydrocarbons (including Mineral Oil and Polycyclic Aromatic Hydrocarbons (PAHs)),
- Polychlorinated Biphenyls (PCBs); and
- Heavy metals such as Mercury (Hg), Tributyl Tins (TBTs) and Lead (Pb).

The volumes of material to be excavated have been calculated as 25,000m^3 of finer grained clay, silt and sand sediments and 20,000m^3 of coarser sandy gravelly material. Approximately 8,000m^3 of fine material is in the upper 0m to 1.0m depth, (□18% of the total volume of material), which has been identified as being potentially contaminated.

Assessment of the laboratory results for the Environmental Quantitative Risk Assessment (QRA) identified that the potential sources of contamination in the sediments have the potential to be mobilised into the water column during dredging. However the potential elevated concentrations would be of very short duration as sediment settles out and the dispersion and dilution in the water column instantaneously occurs. Detailed tidal and sediment modelling completed as part of the EIS show that there is no risk to receptors outside the immediate dredge area.

The data assessment of leachate concentrations from untreated sediment indicates that there is potential for elevated values to occur in the associated pore water (post dredging) in the material but these would be rapidly brought below any required EQS limits following dilution in the adjacent sea water.

The Stabilisation and Solidification of the finer dredged sediments for use as engineering backfill by adding cement is proposed; this has the added advantage of immobilising and retarding the potential leaching of contaminants from the treated material. Data assessment of the laboratory results and the generation of a dilution factor for the assessment of the interaction of the tide along the seaward edge of the treated material in the amenity area indicates that, even before considering the presence and effect of the PERS, the potential for leaching to occur is negligible. The surface of the amenity area will be covered with top soil and grassed over.

Treated sediment material placed behind the quayside and pier structures will be isolated from the adjacent sea water by engineered sheet pile structures and will be covered by engineered surface material such as concrete or tarmac.

The Source-Pathway-Receptor Conceptual Site Models for the various scenarios where the dredge material is either being excavated, treated and/or placed indicate that the potential concentrations of pollutants that could arise, especially during the excavation and untreated phases of work, will not be of a magnitude that the sea water pathway will carry or mobilse them to the potential environmental flora and fauna receptors located in the Inner or Outer Harbour areas, (such as the local commercial shrimp and mussel fisheries). The Stabilisation and Solidification treatment of the dredged sediments will greatly reduce or eliminate the potential for contaminated leachate to occur even prior to any dispersion and dilution factors in the sea water pathway.

The Environmental QRA indicates that the risk from the proposed development works would be negligible in the construction period and imperceptible in the long term.

See below the flow chart illustrating where this report sits in the overall site assessment. The QRA report will form part of a comprehensive Waste Licence Application being submitted to the Environmental Protection Agency which is required as part of the regulation of the proposed dredge sediment treatment and re-use process.

EPA Contaminated Land □ Groundwater Risk Assessment Methodology		**Report Reference**	**Report Date**	**Status**
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1.3	□□□□□□□□□□□□ □□□□ □□□□□□□ □□ □	VCL Env QRA Report	(March 2016)	(Final)
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1. INTRODUCTION

1.1. PROJECT CONTRACTUAL BASIS & PARTIES INVOLVED

Viridus Consulting Ltd., (VCL) were appointed by Malachy Walsh & Partners, (MWP) on behalf of the Port of Cork Company (PCC) to undertake a Quantitative Risk Assessment (QRA) relating to the quality of sediments intended to be dredged from an area of Bantry Inner Harbour and subsequently solidified/stabilised and used as engineering backfill as part of the Phase 1 development of the site.

The work was completed by Mr. Darragh Musgrave an experienced Environmental Scientist from VCL, in conjunction with the project engineering team from MWP, using data from previous site investigation works by specialised contractors and laboratory results from independent accredited laboratories.

Modelling input for the QRA was provided by risk assessment consultant Kim Grey and the peer review was undertaken by Andy Singleton both from specialist UK environmental company ESI Ltd.

1.2. BACKGROUND INFORMATION

Bantry town is located about 90km west of Cork City at the east end of Bantry Bay which is Ireland's longest bay and one of the naturally deepest in Europe. The head of the bay forms a shallow tidal estuary in the foreshore area adjacent to Bantry town and this area is referred to as the 'inner harbour'.

The eastern end of the inner harbour at Bantry is often inaccessible as the substrate of mud flats are exposed at low water There are also significant constraints in terms of the quayside access and berthing facilities at the two piers in the town, which are located at the western end of the inner harbour area, with restrictions on the size of craft and frequent congestion giving rise to health and safety issues for the people using boats at the piers. Refer to the Phase 1 Location Map presented in Figure 1 below.

Figure 1: Site location and Scheme Outline - (Figure duplicated within main figures section also).

Bantry Bay Harbour Commissioners (BBHC) commissioned RPS Consulting Ltd., (RPS) to examine options for developing the Bantry Bay Inner Harbour area in 2008. An Environmental Impact Statement (EIS) was completed for the project (RPS, 2012) which provided a detailed overview of the baseline conditions at the locality and formed part of a Planning Application for the development of the Inner Harbour, which was submitted in late 2012. The application sought '*permission for the development of a 2□0 berth marina within Bantry Inner Harbour along with enabling works, required at neighbouring sites*'. The planning reference for the application is 12/00735. The Notification of Decision to Grant Permission (with Conditions) was issued by Cork County Council (CCC) on 18/07/2013, with the final Grant of Permission (with Conditions) being issued by CCC on 29/08/2013.

The full scale of the original scheme cannot be fully constructed at this time and therefore it is proposed to complete the initial Phase 1 scheme which focuses on improvements to the western end of the Inner Harbour area on and between the two exiting town piers, (as outlined in Figure 1).

The proposed Phase 1 development of Bantry Harbour includes dredging to achieve required depths of -3m to -4m Chart Datum in the developed harbour area and the use of this dredge material to reclaim/fill areas of the works including the development of an amenity area behind a new Perimeter Engineered Revetment Structure (PERS) on the northern site of the harbour. It is proposed that all the seabed material dredged as part of the Phase 1 development will be used in the construction of the scheme and in the development of the new public amenity area.

Detailed site investigations undertaken in 2009 and 2015 identified that the seabed within the development area consists of a layer of fine grained material overlying a coarser grained material. The intention outlined in the EIS for the overall development was that the fine material would be treated and stabilised for use as engineering fill in the new amenity area and within the quay and pier constructions, and that the coarser material would be used as nourishment on Beicin Beach and Cove to the north of the inner harbour area. It is now proposed, due to the volumes of material involved, that all fine and coarse material excavated from the Phase 1 development area will be re-used as solidified/stabilised engineered fill and there is no proposal to use any material for beach nourishment elsewhere.

Based on environmental sampling and laboratory analysis in the Phase 1 scheme area the upper fine grained material can be divided into two types: (1) potentially contaminated and (2) uncontaminated. Analysis of sediment samples taken from the shallow seabed, (almost exclusively from 0 to 1.0m), indicated that some of the sediment had variable concentrations of potential contaminants including:

- Heavy metals such as Mercury (Hg), Tributyl Tins (TBTs) and Lead (Pb).
- Petroleum hydrocarbons (including Mineral Oil).
- Polycyclic Aromatic Hydrocarbons (PAHs) and,
- Polychlorinated Biphenyls (PCBs),

It will be necessary to treat all fine material before it can be used as engineered fill in the construction process and all fine grained sediments will need to be dewatered, stabilised and solidified to improve their load carrying capacity. The solidification and stabilisation (S/S) process will also help immobilise any elevated contaminants that may be present in the upper horizons of the marine sediments.

It is proposed that the dredging will excavate all the material down to the required level in one mobilisation with the upper fine grained material dredged with the deeper fine material and then the coarse grained layer before the excavator is moved to the next area. This will mean that the fine material can be segregated for ex-situ treatment while the coarser sediment can be placed directly in the base of the backfill area before the treated fine sediments are deposited on top of them.

There are two areas of proposed sediment re-use:

(1) Behind sheet piles located out from the edge of the existing Town Pier and quayside (on the south side of the inner harbour), which will be backfilled to form the area for the pier extension. Note that existing sediments located behind the sheet piles will not need to be dredged.

(2) Behind a newly constructed revetment structure located out from the foreshore area near the existing Railway Pier; the backfilling will form a new public amenity area on the northern side of the inner harbour.

The volumes of material to be excavated have been calculated as 25,000m^3 of finer grained clay, silt and sand sediments and 20,000m^3 of coarser sandy gravelly material. Of the total of 45,000m^3 of material approximately 12,000m^3 of finer material is in the upper 0m to 1.0m depth, (□27% of the total volume of material), which has been identified as being potentially at risk of being contaminated.

Based on the proposed construction design there will be 2,300m^2 of additional area developed by the backfilling at the Town Pier quay site, pier side and pier head and the new amenity area near the Old Railway Pier will be about 7,000m^2 in surface area.

1.3. PROPOSED SCHEME – PHASE 1 PRO□ECT OB□ECTIVES

The proposed Phase 1 Scope of Development Works will comprise:

(a) The refurbishment of the existing Town Pier; the construction of a length of Quayside,

(b) Dredging of an area of the west end area of the inner harbour to a depth of between -3m and -4m Chart Datum,

(c) The stabilisation of finer grained dredge material to solidify and immobilise the material, including any contaminants, prior to reuse as engineering backfill material within and behind the proposed Town Pier and quayside structures and within the proposed amenity area,

(d) The construction of an amenity area and the installation of Marina and Breakwater type Pontoons, including the protection of the proposed amenity area using an engineered rock armoured perimeter revetment structure which includes geotextile linings over a core of imported engineering aggregate material,

(e) The reuse of treated dredge material as fill within and behind the proposed structures.

Refer to the scheme layout presented in Figure 1.

1.4. PREVIOUS INVESTIGATIONS □ SAMPLING

As presented in the EIS issued for this project in 2012 a number of detailed site assessments were undertaken by various specialists including marine ecology, water quality, tidal processes, geotechnical and environmental site investigations, sediment sampling, noise, traffic and landscape. Some elements of the EIS, which are relevant to the QRA, are included in this report but the full EIS, which is presented as part of Section D of the Waste Licence Application, should be read in conjunction with this document.

A summary of the environmental site investigations undertaken in the Phase 1 area are given below.

Table A: Site Investigation Summary.

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□an 201□: P□□SI □n□ironmental sediment sampling	1□Boreholes□16 sediment samples	S□01 to S□1□	Sediment □RPS□
	30 soil samples	S□01 to S□1□	□ AC testing □Chemtest□
□an 201□: P□□SI □n□ □ater sampling	□0 □ater samples	S□01 to S□1□	□B□ □esting □RPS□
Summer 201□: P□□ Sediment Sampling	6 sediment samples	SS□01 – SS□0□□ SS□ Pier Sample	Metals □ AC □esting □Chemtest□
□uly 201□: AS□ □ ater □ Sediments	3 □ater □ 2 sediment samples	S1□S2 □ S3 □S□01 □ S□o2	□ AC □ MI □□ □ □A□
Sept – Oct 201□ Monolith □an□ □est	One sample tested at 1□2□4 □ □days	SS□02	□luate Metals for □□ □10□ □ 12□ cement mi□ □Chemtest□

The locations of the sediment sampling and baseline water sampling are presented in Figure 2.

1.4.1 Geotechnical Site Investigation □200□

A detailed Site investigation (SI) was undertaken over the whole Inner Harbour area by Priority Geotechnical Ltd. (PGL) in □uly and August of 2009. The investigation comprised 17nr boreholes (both cable tool and rotary core), 16nr dynamic probes, a bathymetric survey and sub-bottom profiling, marine sediment sampling with associated laboratory testing and grab samples for environmental testing. The full PGL geotechnical SI report is included as Appendix A.

The site was characterised by very soft to very stiff, slightly sandy slightly CLA□/SILT, very loose to dense silty very gravelly SAND and clayey/silty very sandy GRAVEL to depths of 13.1m below existing sea bed level.

Shallow bedrock was only encountered in the eastern end of the harbour near Bantry town. Groundwater was identified at 7m bgl in BH07 on the southern side of the harbour but not elsewhere.

The site investigation identified that there would be no excavation of rock material and that there would be no interaction with groundwater in either of the Phase 1 dredging or backfill areas.

1.4.2 Initial Environmental Sediment Sampling 200□

The environmental sampling completed during the PGL SI focused on shallow borehole samples (BHS) and follow up grab samples (GS) from a depth of 0.0m (sea bed) to about 0.5m below ground level of unconsolidated marine sediments. As well as comprehensive geotechnical testing samples were sent to the National Laboratory Service in the UK for analysis for a range of environmental parameters. The results identified some elevated heavy metal concentrations in some samples with dentified Contaminants of Concern (CoC) included Mercury, Lead and Tributyl Tin. Refer to Appendix C of the PGL SI Report.

Six shallow BHS and 12 GS were acquired from adjacent to or within the area of the proposed Phase 1 dredging and development works. The results are presented in Table 1 and locations in Figure 2.

The results of the initial 2009 and some follow up deeper sampling and analysis indicated that the elevated concentrations of potential contaminants are limited to the top 0.5 to 1m of the fine sediment and tended to be close to the edge of the pier structures. This is very typical for recent pollution in shallow marine environments as the contamination settles on the surface and in the shallow substrate of the sea floor in close proximity of where boats are moored, being serviced or are regularly passing.

It was identified that most elevated contamination was more prevalent in the eastern end of the inner harbour towards the town and generally outside the proposed Phase 1 dredging and development area.

A number of locations with high concentrations of metals identified during the 2009 SI such as BH03, BH04 and GS10 and GS19 will now not be dredged as the construction design will drive sheet piles out from the pier and treated material will be backfilled on top of the original sediment material. This will entomb some areas which were identified to have a potential contamination source if dredged.

(Note that the data tables and calculations have conservatively included these locations as they may be representative of other locations not encountered during the SI works).

1.4.3 Inner Harbour Mouth Environmental Sediment Sampling 2011

Additional sampling of the area outside the inner harbour mouth was undertaken at a number of locations as part of the completion of the EIA in 2011. Some elevated metal concentrations were identified in this sampling round. However these samples are outside the proposed dredge area and are not considered as part of this assessment. Refer to the EIS Appendix D.

1.4.4 Phase 1 Development – Specific Sediment Sampling □□anuary 2015

Site specific shallow sediment sampling and analysis was undertaken primarily in the proposed Phase 1 dredge and works area during □anuary 2015 for the purposes of detailed design and the regulatory applications for the development. Analysis for Waste Acceptance Criteria (WAC) parameters and their leachable eluate analysis was undertaken on 30 sediment samples while 16 sediment samples were tested for PCBs, PAHs, Herbicides, TBTs and Metals. These samples taken from 13 locations (of the 15 boreholes) across the proposed work area – refer to Figure 2 for the sampling locations.

The results indicated that nickel, mercury and arsenic tended to be elevated above the lower Marine Institute (MI) Guideline Limits across the work area but there was one location (SL14 - which is outside the dredge footprint), with slightly elevated TBT in the area of proposed Phase 1 development, only a few other sporadic locations had elevated cadmium, copper, lead and zinc metals above the lower MI guidelines . One sample SL02 (which will not be dredged as it falls inside the quayside pile wall structure), had slightly elevated PAHs and PCBs. PAHS at SL06 were at similar levels but all TPHs were generally low with concentrations <10mg/kg and a maximum of a modest 36mg/kg. The summary results of the 2015 sediment analysis from 16 samples are presented in Table 2 and Table 3.

As part of the site specific assessment 50 water samples were acquired from 15 locations and tested for TBT with no concentrations identified above the laboratory detection limit at any location.

The full 2015 PGL SI report including the TBT and Waste Acceptance Criteria (WAC) results (tested by ChemTest) with metal/hydrocarbon results (tested by RPS Laboratory) are presented in Appendix B.

1.4.5 Phase 1 Specific Sediment Sampling for Monolith Testing – August 2015

Six additional sediment samples were acquired from across the Phase 1 development area for testing of heavy metals and WAC parameters. While there was no significantly elevated contamination identified in these samples one sample (SST-02) was chosen, (because although it is outside the main dredge area it had slightly more elevated contaminant concentrations relative to the other samples), for monolith tank testing. The laboratory results for these six sediment samples and associated eluate values are compared to the relevant MI and EQS limits and are presented in Table 4.

Small monoliths were made of material from this sample after it was mixed by the laboratory with three different concentrations of cement at 8%, 10% and 12% before being re-tested for leachable parameters after1, 2, 4, and 9 days as per the EA NEN 7374:2004 standard.

The Tank Test Data results from ChemTest for the SST-02 sample are presented in Table 5.

1.4.6 Baseline Surface Water Sampling – 2015

The Aquatic Services Unit (ASU) were appointed to undertaken six rounds of baseline surface water sampling at three locations in Bantry Harbour located in the open water west of the Inner Harbour and proposed Phase 1 dredge and backfill areas. The surface water samples were acquired during the Spring and Neap Tides during the Winter, Spring and Summer periods of 2015. One round of sediment sampling at two locations was also completed in May 2015.

No elevated potentially polluting parameters were identified in the water column or in the sediment samples acquired by the ASU. The full ASU Assessment Report is presented in Appendix C.

1.4.7 Hazardous Waste Classification Assessment

As part of the assessment of all the completed sampling a specialist waste contractor (Lehane Environmental Industrial Services LEIS) was requested to complete the Hazardous Waste Classification Tool on all the sediment results from 2009 and 2015. This assessment identified the dredge material as **non hazardous.** The LEIS Reports are presented in Appendix D.

1.5. ASSESSMENT OF DREDGE SEDIMENT MATERIAL FOR DISPOSAL AT SEA

Generic assessment criteria for sediment quality have been developed by the Irish Marine Institute (MI) for comparing against dredge sediment quality as published in the MI Guidelines on the *"Assessment of Dredged Material for the Disposal in Irish Waters (2006)".* The guidelines, which are designed to assess the suitability of disposing of dredged material at sea, identify a Lower Level 1 and Upper Level 2 of contamination which characterises the marine sediments into three categories or classes of potential contamination:

1. Class 1: Where contamination concentrations are less than Level 1 the sediment is considered to be uncontaminated - with no biological effects likely.
2. Class 2: Where contamination concentrations are between Level 1 and Level 2 the sediment is considered to be marginally contaminated; further sampling and analysis should be considered to delineate problem areas, if possible.
3. Class 3: Where contamination concentrations are above Level 2 and the sediment is considered to be heavily contaminated and very likely to cause biological effects/toxicity to marine organisms. The MI guidelines recommend that alternative management options to be considered for this level.

The comparison of the heavy metal concentrations in all the sampled sediments and the MI Levels indicates that the majority of results for all parameters tested within the Phase 1 dredging area fall into Class 1 uncontaminated and Class 2 marginally contaminated categories. (With the majority of the

Class 2 sediment results nearer the Class 1 limit rather than elevated towards the Class 3 limit). Refer to the data Tables 1 and 2.

For the area within and adjacent to the proposed dredge area 3 parameters exceeded the MI Sediment Quality Upper Level in 4 of the 18 relevant 2009 samples:

- BH03 - had lead with a concentration of 254mg/kg, modestly in exceedance of the 218mg/kg upper level,
- BH04, GS18 and GS19 had mercury concentrations of 1.97mg/kg, 1.13mg/kg and 1.18mg/kg respectively, above the 0.7mg/l upper level,
- GS19 had a TBT/DBT level of 0.562mg/kg just above the 0.5mg/l upper level.

All samples were acquired from the sea floor to a maximum depth of 0.5m below the sea bed level. It is notable that samples BH03, BH04 and SG19 where all taken from locations that will not be dredged under the current proposals. As such, only a single metal result from a single sample location (taken from within the proposed dredging area; GS18) exceeded the adopted MI upper level concentration.

Other metal parameters showed concentrations above the MI lower level at a number of locations; these included Arsenic, Cadmium, Copper, Lead, Mercury, Nickel, Zinc and TBT. Refer to Table 1.

Other results from sampling outside the proposed Phase 1 area, especially further east in the shallowing estuary towards Bantry Town, indicated more consistently contaminated material when compared to the Marine Institute Guideline Limits. The occurrences of elevated concentrations of potentially polluting parameters which would have restricted dumping as well as the logistics of having to transport the dredge material over very long distances to get to any dumping at sea location outside Bantry Harbour meant that the disposal at sea option was not feasible for this project.

Therefore a plan of dredging, solidification/stabilisation and reuse of the excavated material as engineered backfill was deemed the most environmentally appropriate as well as affordable and the planning application and EIS completed in 2012 was progressed on this basis.

Examination of the more recent 2015 laboratory data for the area within and adjacent to the proposed Phase 1 dredge area indicated that two parameters exceeded the MI Sediment Quality Upper Level in 3 of the 16 samples analysed in 2015:

- SL02 and SL05 from 0m had mercury concentrations of 2.37mg/kg and 4.61mg/kg respectively, above the 0.7mg/kg upper level,
- SL07.1 from 1.0m had a Cadmium concentration of 4.34mg/kg, marginally above the 4.2mg/l upper level.

It is notable that sample SL02 was taken from a location that will not be dredged under the current proposals.

Other metal parameters recorded during 2015 with concentrations slightly above the MI lower limit included Arsenic, Cadmium, Copper, Lead, Mercury, Nickel, Zinc and TBT. These were primarily from shallow sediment samples acquired from the surface level to 1m depth. Refer to Table 2.

Concentrations of PCBs were also tested for the 2015 sampling works. When compared to the MI levels no results were elevated above their respective upper level value and only one result from sample SL02 had a slightly elevated total PCB concentration of 114ug/kg above the lower level of 68ug/kg.

Concentrations of TBT were all below the MI lower level of 0.1mg/kg except for the SL14 sample which had a concentration of 0.18mg/kg. Note that this location is outside the proposed dredge area.

Of the six additional samples acquired in August 2015 only SST2 had one metal concentration (copper) elevated above the relevant MI Upper Level value. Similar to previous sampling most parameters were below the MI Lower Level apart from slightly elevated concentrations of Arsenic, (6 samples), Mercury (3 samples), Nickel (2 samples), Cadmium (1 sample) and Copper (1 sample) which were all close to the IM Lower Level limit. Note that SST2 is outside the proposed dredge area.

Table B: No. of samples in Phase 1 area with concentrations above the MI lower & upper limit levels.

Deteriminand	Units	LOD	MI Sediment Quality Guideline Limits (mg/kg)		Number of samples	Count above MI Lower level	Count above MI Upper level[1]
			Lower Level	Upper Level			
Aluminium (Total)	mg/kg	100			40	0	0
Arsenic	mg/kg	1	9	70	34	26	0
Cadmium	mg/kg	0.1	0.7	4.2	34	9	1 (1)
Chromium	mg/kg	1	120	370	34	0	0
Copper	mg/kg	0.5	40	110	40	14	1 (0)
Lead	mg/kg	0.5	60	218	34	7	1 (0)
lithium*					28	0	0
Mercury	mg/kg	0.1	0.2	0.7	40	23	5 (2)
Nickel	mg/kg	0.5	21	60	34	26	0
Selenium	mg/kg	0.2			22	0	0
Zinc	mg/kg	0.5	160	410	18	4	0
Total TPH >C10-C40	mg/kg	10			22	0	0
Total of 17 PAH's	mg/kg	2	4		22	9	0
Tributyl Tin	mg/kg	0.01	0.1	0.5	40	5	1 (0)
Total BTEX	mg/kg	10			6	0	0
Total PCBs (7 Congeners)	mg/kg	0.1	0.068	1.26	16	1	0

[1] Brackets show number of exceedances within the proposed dredging area

As shown in Table B above - while the sediments are not consistently contaminated, when compared to the Marine Institute Guideline Limits, the occasional occurrences of elevated concentrations of potentially polluting parameters in the phase 1 Development area would have restricted dumping at sea and the earlier decision that the disposal at sea option was not feasible for this project holds true for the proposed scheme as it did for the original plan for the whole scheme.

1.6. CONCEPTUAL SITE MODEL (CSM)

As part of this assessment, and in line with current guidance (e.g. EPA Code of Practice 2007, BS10175:2011 Investigation of Potentially Contaminated Sites, and Model Procedures for the Management of Contaminated Land (EA 2004)), and best practice the available information is used to develop a Conceptual Site Model (CSM) for the site.

The CSM is a written or pictorial representation or working description of an environmental system on the site and the surrounding area and its purpose serves to draw together, (1) the potential sources of contamination (hazards) that may be present on or surrounding the site that have the potential to cause harm or pollution to the surrounding environment,(2) identifies the sensitive receptors, such as flora/fauna, water, etc. that may impacted by a given source, and (3) identifies the pertinent pathways or route that may be present between and link the two.

The potential pollutant linkages and nature of the sources, pathways and receptors are site specific and will vary depending on such things as site history, ground and water conditions, and current and proposed end uses of a particular site.

While each of these elements can occur independently an environmental risk can only exist if all three elements of the Source - Pathway – Receptor linkage are present. If one element is missing then there is no pollutant linkage and no associated environmental risk can occur.

For the Bantry Phase 1 Development the Conceptual Site Model for the QRA looks at both:

1. the short term sediment dredging scenario, and
2. the longer term reuse of the stabilised sediment in the retaining pier structures & amenity area.

Conceptual Site Model drawings have been developed for the potential Source - Pathway - Receptor scenarios:

- during dredging,
- from deposited treated dredge material behind the three Town pier structures, and
- from deposited treated dredge material behind the Perimeter Engineered Revetment Structure at the amenity site.

Refer to the CSM cross sections presented in Figures 3 to Figure 9 of this report.

1.6.1 Potential Sources of Contamination

Marine sediments arise from both natural and man-made sources. As a watercourse enters an estuary it loses energy and deposits the sediment, which is gathered along its course through erosion of the river bed and banks, onto the harbour floor. Tidal and wave activity can be an additional source of sediment and can also move sediment within the harbour.

Sediments generally contain metal concentrations which are orders of magnitude greater than in the overlying water column (Shropp et al. 1990). Due to the semi enclosed nature of Inner Bantry Harbour it is subject to enhanced anthropogenic impacts as a result of restricted transport and dispersal of contaminants – as outlined in the RPS EIS (2012). The marine sediment within Bantry Harbour will also contain matter which arrives naturally, from local rivers and water courses, and from man-made sources such as wastewater discharges from Bantry Town and any industries (manufacturing, commercial, agricultural, marine), which are located around the harbour and from ship and boats using the harbour.

The small sized grains (<0.025mm fraction) of sediment is one of the major sinks for contaminants introduced to waters. This is a natural phenomenon and is largely due to the presence of mineral clays with organic coatings and iron and manganese (oxy-) hydroxide coatings. The clays scavenge dissolved trace metals from the water column and bind the metals into the sediment.

Additionally, there is a tendency for organic compounds which do not dissolve in water to accumulate in sediment by sorption (taken up by) natural organic matter. The extent of sorption will depend, in part, on the organic matter content of the specific sediment. The quantity of organic matter in sediment tends to vary naturally across a harbour.

The completed site investigations and sediment analysis have identified the occasional presence of some elevated heavy metals such as Cadmium (Cd), Lead (Pb), Copper (Cu) Mercury (Hg) and Organotin Compounds such as Tributyltin (TBT), with some modestly elevated Polychlorinated Biphenyls (PCBs) and Polycyclic Aromatic Hydrocarbons (PAHs), in the upper unconsolidated sediments from the sea floor down to between 0.5m and 1m into the marine sediments. These analytes are considered potentially detrimental to the aquatic environment as they are persistent, toxic and bio-accumulate in the food chain. They pose a potential source of aqueous contamination if in situ sediments are disturbed during dredging and backfilling works.

The fine sediments disturbed by the dredging and backfilling activity also pose a potential contamination risk as elevated concentrations of Total Suspended Solids (TSS) can be detrimental to aquatic organisms as they restrict natural light, can clog fish gills, and (as mentioned previously), the sediments themselves act as a potential source of heavy metals in the environment.

Dredging Sediment Source

The source of potential contamination during dredging is short lived due to dilution and dispersion in the open harbour water and settlement of the sediment. Metals such as lead, mercury and TBT are 'relatively dense' and settle out of suspension quickly.

Detailed tidal modelling work completed for the EIS (Section 15) indicated that tidal currents in the area are very low (in the region of 0.0 – 0.2 m/s), with very little difference between neap and spring conditions. Tidal flow patterns are typically dominated by meteorological and wave induced conditions, incurring significant eddying. The model was run for a complete typical month of tides and results indicated that the tidal flow velocities around the entrance area of Inner Bantry Harbour are very low, (EIS Section 15.2.2.2).

The EIS modelling of potential sediment plumes identifies that they would not migrate far from the active dredge area, (Section 15.4.3).

An assessment of the potential sediment dispersion was modelled as part of the EIS (Section 15.4.4) and it was calculated the potential mobilisation of mercury contamination would not be at concentrations above the required Surface Water EQS or Shell Fish EQS values during the work.

As part of the QRA the range of potential contaminants were assessed for potential sediment dispersion, following the same methodology as used in the EIA, (as described in Section 15.4.4 of the EIA - RPS 2012), using the maximum soil concentration identified during the completed site investigation works. Refer to Table 6.

These worst case scenario calculations identified that there was potential for average Tributyl Tin concentrations to be elevated just above (i.e., in the order of 2.12 to 2.3 $x10^{-6}$), the annual average EQS value for marine waters in the dredge sediments in the immediate area of the dredging work. All other analyte concentrations were below their respective EQS values. (It is also worth noting that the most elevated TBT result from GS19 from the SI in 2009 will not be dredged as it is behind the sheet pile wall at the quayside but the result was included in the assessment as a precaution approach.)

Only a proportion of any potential contamination will go into the aqueous phase due to sorption; subsequent dilution effects would reduce Tributyl Tin concentrations below the AA EQS values almost instantaneous within the inner harbour waters.

Stabilised and Solidified Sediment Source

The leachate testing of the sediments indicates that there is potential for concentrations of eluate from Chromium, Copper and Mercury to be above the average and maximum EQS limits prior to any treatment occurring. Tidal prism modelling of the edge of the sediments exposed along the edge of the amenity area (taking away the mitigating effect of the engineered revetment structure) gives a dilution factor of 0.003 (refer to Table 9) and calculations indicate that once the dilution factor is applied then the average leachate values do not exceed the EQS limits for these or any other parameters.

In order to re-use the sediment as engineering backfill material it needs to be Stabilised and Solidified and this process will also have the advantage of greatly reducing the polluting potential of the dredged sediments.

Stabilisation/solidification (S/S) is a widely used remediation technology that relies on the reaction of a binder and sediment to reduce the potential mobility of contaminants. The process of stabilisation involves the addition of substances (reagents) to a contaminated material which produce more chemically stable constituents while solidification involves the addition of reagents to a contaminated material to impart physical stability to contain the contaminants in a solid mass and also reduce the interaction with external agents such as air, surface waters, rainfall, etc. Cementitious materials such as treated dredge sediments exhibit low permeability characteristics typically of the order of 1x10-6m/s to 1x10-8m/s.

For this project the S/S this will greatly limit water infiltration through the mass of treated dredge material and thus limit the potential contaminant flux to the harbour waters. In addition to this the use of interlocking sheet piles in the Town Pier expansion works will greatly reduce contact with, and potentially isolate, the re-used treated dredge sediments from the adjacent harbour waters. While for the amenity area development the construction of a perimeter engineered revetment structure (PERS) with low permeability geo-membranes will further reduce the connectivity of the harbour waters with the treated material as well as protecting the treated sediment from normal tidal flows and any potential erosive current or wave action.

ESI has completed calculations using appropriate Partitioning Coefficient (Kd) values for the various contaminants of concern as their solubility will limit the potential leachable concentrations. (The Kd values used for metals were the average values used in the UK LandSim 2.5 Model while the hydrocarbon values are based on USEPA 2009 model data).

Table 8 presents calculations which indicate that in their untreated state there is potential for leachate levels within the pore water in the untreated sediment mass to be above average and maximum EQS values for selected analytes. Increasing the Kd values by a factor of 10 will reduce the potential average leachate concentrations for all heavy metal parameters to below the average AA EQS while a factor of 50 increase will reduce the potential for maximum EQS values to be exceeded.

The process of stabilising and solidifying the contaminated dredged sediments will effectively provide an attenuation medium for any contaminants with the key process being retardation. However for all Kd calculation scenarios once the pore water interacts with sea water the potential contaminant levels after dilution are all well below the average AA EQS values.

Other Contaminant Sources

As well as the potential contamination from the dredged sediments there are potential sources of contamination from the machinery/equipment (including fuels and oils), and/or raw materials (i.e. cement), used in the dredging, stabilisation and backfilling works.

1.6.2 Potential Environmental Pathways

The primary pathway for the mobilisation of potential contamination is in sea water during both the short term dredging and backfilling processes and also in the longer term interaction between the sea water and/or surface water interacting with stabilised material backfilled in the structural pier elements and amenity area.

The results of detailed modelling of potential sediment plume from dredging and backfilling activities are presented in Chapter 15 "Water Processes" in the RPS EIS (2012). These indicate that the extent of any plume would be limited to the immediate work area and due to the site conditions the modelling does not indicate any environmental risk in the locality.

The only pathways for potential contaminants from the treated sediment source(s) is through direct contact with sea water in the inner harbour and/or rainwater percolating from the surface percolating through the material and reaching the sea water of the inner harbour.

The dilution factor used in this assessment derives from a tidal prism calculation which calculates the potential volume of the solidified sediments that will become saturated during the neap tide. This conservative calculation, (which does not take into account the presence of the geotextile lined perimeter engineered revetment structure, which will be located between the treated sediment and the inner harbour), assumes that the water influx into the solidified sediments equals the rate of the rise in tide and uses a conservative permeability of $1x10^{-5}$m/s in this calculation. Scoping calculations indicate that the dilution associated with this contaminant flux is of the order $3x10^{-4}$. A conservative value of 0.003 has been used in the assessment. Refer to the Tidal Prism Data in Table 9.

Air is not considered to be a potential pathway as no vapours or gases will occur and the potential for dust is very limited as the process is completed in a wet environment.

Groundwater is not considered a pathway as this is not in connectivity with the dredging works or backfilled stabilised material.

1.6.3 Potential Environmental Receptors

The primary sensitive environmental receptors are identified as marine flora and fauna in the vicinity of the Phase 1 works and in particular the commercial mussel growing and shrimp fishing occurring in the eastern end of the Bantry Harbour area located to the west of the dredge and backfill sites. Detailed assessment of the potential ecological receptors is presented in Chapter 10 of the EIS (RPS, 2012).

Human receptors are considered to be at potential short term risk due to potential dermal contact and/or accidental ingestion of dredged sediments during the construction phase.

No relevant groundwater receptors have been identified; the bedrock under the site is classified by the Geological Survey of Ireland (GSI) as a poor aquifer and there are no groundwater users in the vicinity of the Phase 1 development or coastal fringe of the Inner Harbour area.

Table C: Conceptual Site Model Potential Source, Pathway and Receptors

Source	Pathway	Receptors
Contaminants in sediments & construction materials (i.e. cement, hydrocarbons etc.)	Direct dermal contact, inhalation and/or ingestion	Site users during construction phase
Sediment and contaminants mobilised in sediment during dredging	Sea water movements within the Inner Harbour	Flora & Fauna of the Inner Harbour and commercial shrimp & mussel farming in eastern end of the Outer Harbour
Contaminants dissolved in water during dredging		

Treated sediments behind the Town Pier piled structures	Rainfall ingress into the stabilised sediment mass and subsequent leachate generation Sea water movements within the Inner Harbour	
Treated sediments behind the Amenity Area Perimeter Engineered Revetment Structure		

2. QUANTITATIVE RISK ASSESSMENT

Of 30 samples acquired from the 15 sampling locations completed specifically for the Phase 1 development 16 were sent to an independent laboratory for analysis for a range of potentially polluting parameters as identified during previous SI work. The Contaminants of Concern (CoC) including Heavy Metals, TBTs, PCBs and PAHs were analysed and are presented in Table 2 and Table 3.

Waste Acceptance Criteria (WAC) leachate eluate analysis was completed on all 30 samples – eight samples under Single Stage WAC testing and 22 under 2 Stage WAC testing giving a total of 52 eluate results. When compared to the Landfill Waste Acceptance Criteria Limits none of the results exceed the Inert Waste Landfill Limits for the Heavy Metal, PCB, Mineral Oil or PAH CoCs. The results are presented in the PGL Site Investigation Report presented in full in Appendix B.

As part of the Generic Quantitative Risk Assessment the eluate leachate results were compared against the *"European Communities Environmental Objectives (Surface Waters) Regulations 2009 – SI No. 272 of 2009"* and the Water Assessment Criteria outlined in Annex A of the MI Report – "*An assessment of dangerous substances in Water Framework Directive Transitional and Coastal Waters: 2007 – 2009, (Dated October 2010)".* The MI Criteria provide Shellfish Waters Imperative Values (as Mac-QS) where there are gaps in the Surface Water Regulation Data.

The sediment leachate results are presented as 10:1 eluate ratio for the Single Stage WAC test and as 2:1 and 8:1 values for the 2 Stage WAC test. While these ratios are conservative the eluate results for heavy metals have been compared to the available SW Regulations and MI Water Standards. The comparison shows that there are some parameters which are elevated above the assessment criteria as presented in Table 7. The results included the WAC analysis completed on the six follow up samples completed in August 2015 giving a total of 58 samples – which are discussed in more detail below.

The Single Stage WAC 10:1 Ratio elute and the 2 Stage 2:1 Ratio eluate analysis results indicate that:

- Arsenic (As), Barium (Ba), Cadmium (Cd), Nickel (Ni), Lead (Pb) and Zinc (Zn) are all below their respective MAC-EQS for all 58 samples.
- Total Chromium (Cr) is elevated above the UK Statutory Guidance Level of 15ug/l in 11 of the 58 samples. (Note the AA EQS Cr value is for the more toxic Hexavalent Cr VI and analysis for this parameter in the sixteen 2015 SI samples indicated no concentrations above the laboratory detection. Refer to Table 3).
- Chromium (Cr) results are elevated above the MAC-EQS of 32ug/l in 14 of the 58 samples.
- Copper (Cu) is elevated above the MAC-EQS of 10ug/l in 13 results.
- Mercury (Hg) is elevated above the AA-EQS of 0.05ug/l and MAC-EQS of 0.07ug/l in 6 samples. All remaining 52 samples had concentration below the available laboratory detection limit of 0.5ug/l, however this is above the required EQS concentrations.
- TBTs were not leach tested as all the 2015 sediment results in the dredge area were below the MI Lower Limit. One sample SL14, (which is outside the dredge area), had a value of 0.18mg/kg which is above the MI lower limit of 0.1mg/kg. Analysis of 50 water samples for TBT as part of the 2015 SI did not show any concentrations above laboratory detection levels.

Analysis of the WAC Single Stage 2:1 ratio elute when compared to the higher dilution 8:1 ratio elute indicates that the metal concentrations decrease for all parameters in 21 out of 22 samples and in the case of copper the elevated levels drop below the AA-EQS limit in 20 of 22 samples.

2.1. ENVIRONMENTAL RISK DURING DREDGING

Comparison of the laboratory analysis of the sediments in the proposed Phase 1 Development Area against the Marine Institute *"Assessment of Dredged Material for the Disposal in Irish Waters (2006)* indicates that the sediment quality is dominantly Class 1 (uncontaminated) to Class 2 (moderately contaminated). As identified in Table B there are only three results in the proposed dredge area which are indicative of Class 3 (contaminated material) as per the MI Guidelines.

The WAC eluate laboratory results are by their nature conservative as small volumes of liquid are diluted with the sediment sample. In the dredging environment the volume of water in the harbour is very large and it would be expected that the modestly elevated metal concentrations would be diluted below the surface water EQS standards very quickly and in close proximity to the works.

Detailed modelling and assessment of a number of Coastal Processes were completed in Chapter 15 of the RPS EIS. The EIS demonstrated that the very low tidal velocities in and around the Inner Harbour area will limit spatial impacts of any contaminant loading.

Assessment of the Dredging of Contaminated Material, (EIS Section 15.4.4), indicates that for one of the key CoC the Priority Substance Mercury & its compounds should have a MAC EQS of 0.07ug/l. Based on a derived concentration of 0.198mg/kg in the sediment and a conservatively modelled sediment dredge load of 0.04kg/m3 then this would represent an equivalent 0.0097ug/l of Hg in the water column – which is well below the critical MAC EQS limit.

Using the same procedure the average mercury sediment values for the 2009 SI data and 2015 sampling data from within the Phase 1 Development area are 0.409mg/kg and 0.42mg/kg respectively. Applying these higher sediment values to the 0.04kg/m3 of sediment modelled in the dredge plume would give equivalent values of 0.0164ug/l and 0.0168ug/l respectively. While higher than the EIS results these values are still well below the Surface Water Regulation value of 0.07ug/l MAC EQS.

A summary of this assessment is presented for each of the contaminants of concern in Table 6. Two sets of results are presented: one calculated assuming all the sediment concentration dissolves into the aqueous phase and the second allowing for sorption onto the sediments.

The results indicate that while there is a potential source of TBT in the dredge sediments no other parameters exceed the AA EQS. As described in the EIS the extent of the contamination and the measured concentrations indicate that they will not mobilise outside the immediate dredge area and will not impact the mussel, shrimp or other fisheries in the Bantry Bay area which are a good distance (>750m) away from the Phase 1 development area.

The potential impacts of dredging are transient rather than permanent and the short controlled period of dredging works will also help limit the potential impact of this activity.

2.2. ENVIRONMENTAL RISK OF USE OF STABILISED/SOLIDIFIED SEDIMENTS

It is proposed to add a reagent such as cement to stabilise and solidify all the fine grained dredge material and to reuse it as engineering fill behind the pier extension and in the amenity area.

This is a common and accepted method of re-use for contaminated and uncontaminated dredged sediments and has been completed successfully at a number of locations in the UK and Europe previously. Previous assessments of contaminated dredge material in Ireland has shown that mixing the sediments with cements, clays and other materials will successfully contain the potentially polluting parameters and prevent them leaching back into the environment (for example Dublin Port Assessment of re-use of contaminated dredge material by RPS in 2015). The UK Environment Agency has issued, Guidance on the use of Stabilisation/Solidification for the Treatment of Contaminated Soil, (UK EA 2004).

For the Bantry inner harbour six additional sediment samples (SST1 to SST5 & Pier Sample) were acquired from around the Phase 1 Development Area in August 2015. The laboratory results for the dry samples was similar to the previous sampling rounds with slightly elevated heavy metal concentrations including Arsenic, Nickel and Copper with levels above the MI lower level. Only one sample had a copper concentration above the MI upper level. Subsequent WAC testing showed eluate with elevated chromium in all samples and copper in two samples. Refer to the results Table 4.

One sample (SST2) was selected for monolith Tank Testing as per the EA NEN 7375 standard and three sediment samples were mixed with cement at concentrations of 8%, 10% and 12% in the laboratory. The monoliths were held in pure water and tested for elute after 1, 2, 4 and 9 days.

The monoliths all reportedly behaved in a similar manner in terms of their solidity in the water and while no cement mix was more favourable in terms of retaining the elevated metal fraction parameters of cadmium, chromium and zinc, all samples showed a decrease in concentrations for the 9 day monolith test with cadmium, copper, mercury, nickel, lead, TPH and BTEX parameter concentrations below laboratory detection levels. The laboratory results from the monolith Tank Testing of SST2 are presented in Table 5.

2.3. RESULTS OF QUANTITATIVE RISK ASSESSMENT

The assessment of the sediments and leachate elute identify some elevated potentially polluting parameters in the Phase 1 Development area above the average EQS concentration during dredging. However the EIS modelling work indicates that dilution and dispersion in the water column will mean that no concentrations elevated above the relevant surface EQS will arise.

Mixing of the material with different percentages of cement indicated that the potential leachability of any contaminants would be greatly reduced. The connectivity of the treated material with the open waters of the Inner Harbour would be reduced further by the low permeability of the engineered materials contained behind the pier structures and perimeter engineered revetment structure. The tidal prism calculations indicate that even if some leaching of contaminants was to occur their dilution in the water column would result in no concentrations of potentially polluting parameters arising from the treated dredge material in the short or long term.

Table D: Conceptual Site Model and Risk Assessment

Source	Pathway	Receptors	Mitigation	Risk
Contaminants in sediments & construction materials (i.e. cement, hydrocarbons etc.)	Direct dermal contact, inhalation and/or ingestion	Site users during construction phase	Construction phase: Use of PPE, good housekeeping & environmental management during construction. Operational phase: All treated sediments covered; no exposure anticipated. No management required.	**Low**
Suspended sediment Material and contaminants mobilised in sediment during dredging	Sea water movements within the Inner Harbour	Flora & Fauna in the marine waters of the Inner Harbour especially commercial shrimp & mussel farming in the eastern end of the Outer Harbour.	Modelling calculations show that the potential contamination would be of relatively modest concentrations and of short duration and spatial extent due to the effects of dilution. No persistently elevated concentrations are anticipated which could impact any receptors. It is noted that the identified shellfish farm is a significant distance (over 750 m) from the harbour / potential contaminant source.	**Negligible**
Contaminants dissolved in water during dredging				
Treated sediments behind the Town Pier piled structures	Rainfall ingress into the stabilised sediment mass and subsequent leachate generation Sea water movements within the Inner Harbour		Stabilisation/Solidification will greatly reduce the long term leaching potential. The engineered piles & PERS will greatly reduce contact with marine waters & any residual contamination would be dispersed/diluted with no impact on any identified receptors (as above).	
Treated sediments behind the Amenity Area Perimeter Engineered Revetment Structure				

3. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

3.1. SUMMARY AND CONCLUSIONS

It is proposed to dredge sediment from an area of the Bantry Inner Harbour and expand the surface area of the Town Pier in order to improve access and facilities for marine craft using this area in the future. As part of the works all fine grained dredged sediments will be dewatered and treated with cement in order to use the material as engineered backfill (1) behind impermeable sheet piles near the Town Pier to extend the width of the pier and (2) behind an perimeter engineered revetment structure near the Old Railway Pier to create a large open amenity area.

Certain heavy metals, tributyl tin and to a lesser degree PCBs and PAHs have been identified in the shallow sediments at some sample locations within the Phase 1 Development Area. Modelling of the potential mobilisation of these potential pollutants during the dredge phase indicate that while some slightly elevated concentrations may arise in the water column during dredging the source is not extensive, is only modestly elevated and will be short lived; as such, the dilution and dispersion of the contaminants will be relatively instantaneous and no elevated concentrations are identified to be dispersed outside the dredge area to any of the ecological receptors located in Bantry Harbour.

The solidification and stabilisation of the fine sediment material will greatly reduce its potential leachability and permeability. Its placement behind interlocking pile structures for the pier development will act as a physical barrier to it contacting the harbour waters while the construction of the engineered revetment structure around the sea ward perimeter of the amenity area will great reduce its expose to and interaction with the inner harbour waters.

Modelling of the potential impacts of the pore water concentrations in the treated sediments on the adjacent marine water (including the effects of both reduced contaminant leachability and sea water dilution) indicate that no concentrations of potentially polluting parameters will be above the relevant Surface Water EQS and no potential receptors are at risk from the post treatment phase of works.

3.2. RECOMMENDED WAY FORWARD

VCL understand that the contractor will complete further testing on the fine sediments to more accurately quantify what percentage of cement mix will be used in the treatment process and it is recommended for completeness that leachability testing of the trial mixes are undertaken so that the optimum treatment process for the required engineering and environmental objectives are achieved.

Ensure that regular sampling of the surface water at the baseline location at the mouth of the inner harbour and the chosen locations near the ecological receptors is undertaken during the project. As outlined in Figure 10.

It is recommended that the appointed contractor executes the dredging work and treatment of the fine sediment material as per the contract documents which hold the protection of the receiving environment as a priority for the project. The contractor will undertake regular sampling of the dredged and treated sediment materials as outlined in Figure 11 which shows the proposed dredging and deposition monitoring cells.

oo0oo

Respectfully submitted

On behalf of Viridus Consulting & Malachy Walsh & Partners,

Darragh Musgrave

Senior Environmental Scientist

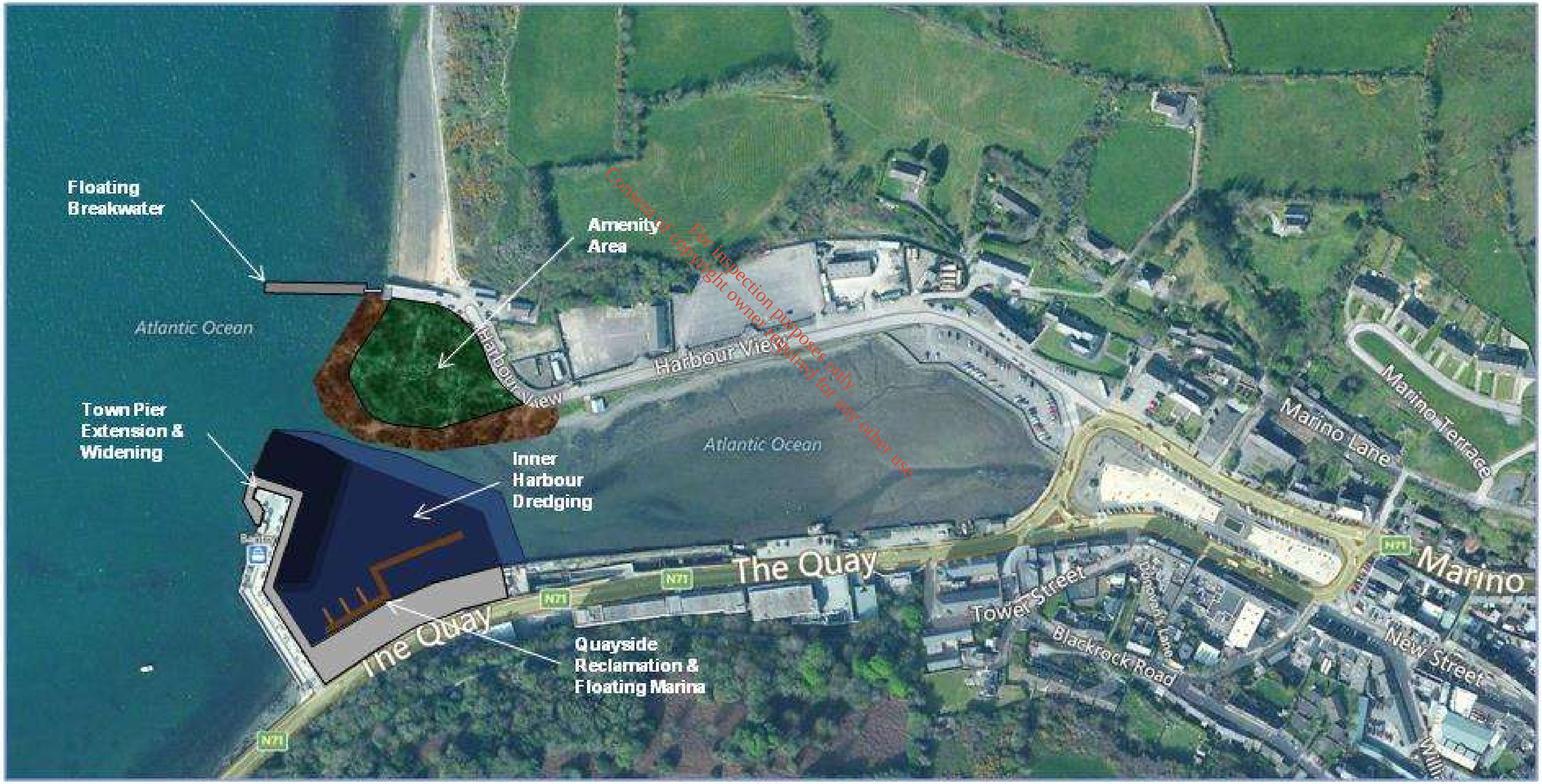
Viridus Consulting Ltd.

Bantry Inner Harbour - Phase 1 Development

Environmental Quantitative Risk Assessment

Report Figures 01 to 11

Bantry Inner Harbour Development - Phase 1



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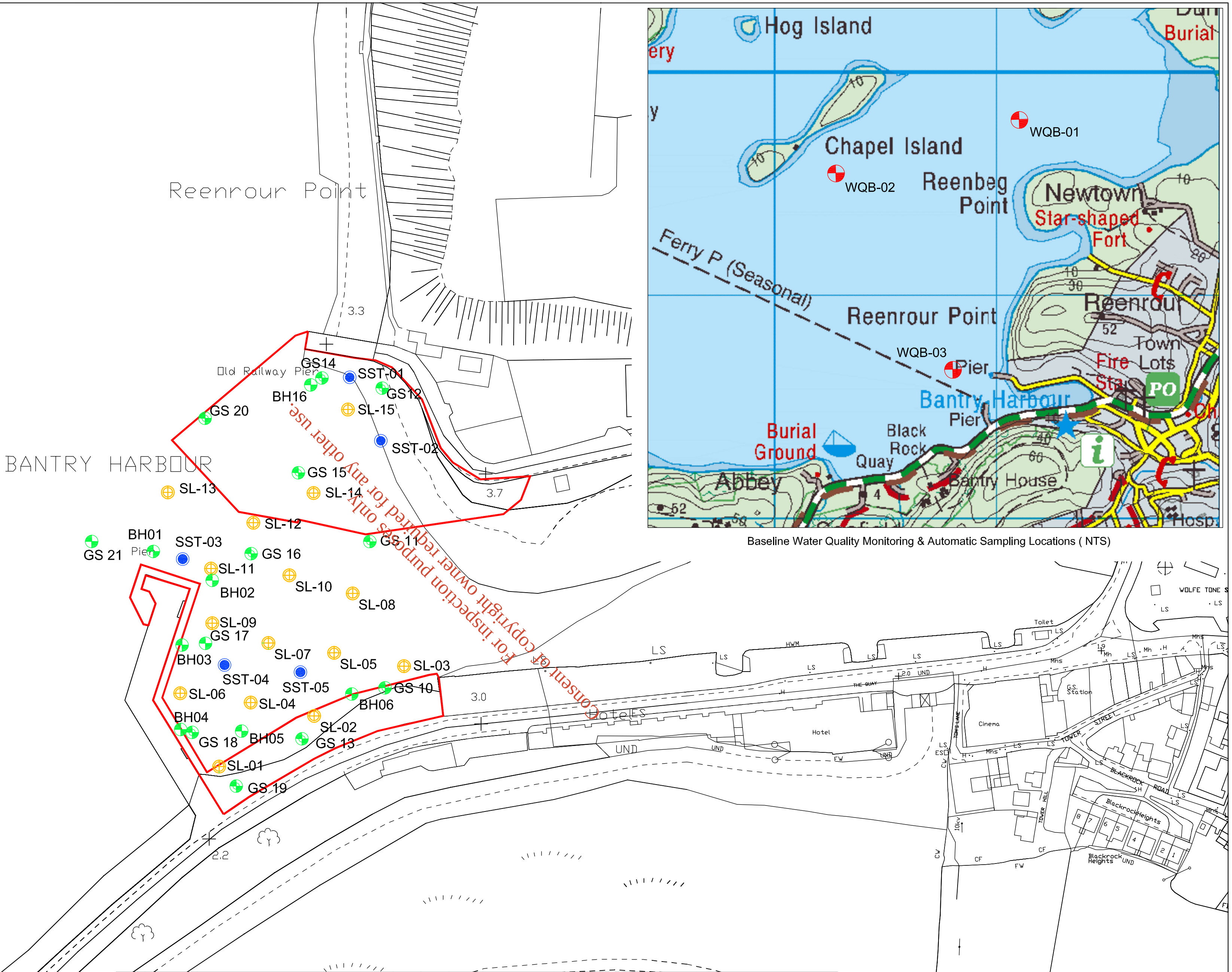

Baseline Water Quality Monitoring & Automatic Sampling Locations (NTS)

Notes

1. All dimensions are in millimetres unless noted otherwise.
2. All levels are in metres related Ordnance Datum Malin Head.
3. Drawings are not to be scaled.

Legend

- Licence Boundary
- SL - Sediment Sample 2015 (Pre Construction)
- SST - Additional Sediment Sample 2015 (Pre Constuction)
- BH - Sediment Sample 2009
- WQB - Water Quality Monitoring (Baseline)

Map Reproduced From Ordnance Survey Ireland
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Scale (m)

Rev.	Date	Description	by	ch'd	app
A	04.03.16	ISSUED FOR QRA	BMP	MOS	PP

Client: PORT OF CORK

Project: BANTRY INNER HARBOUR DEVELOPMENT PHASE 1

Title: PRE CONSTRUCTION PHASE SAMPLING

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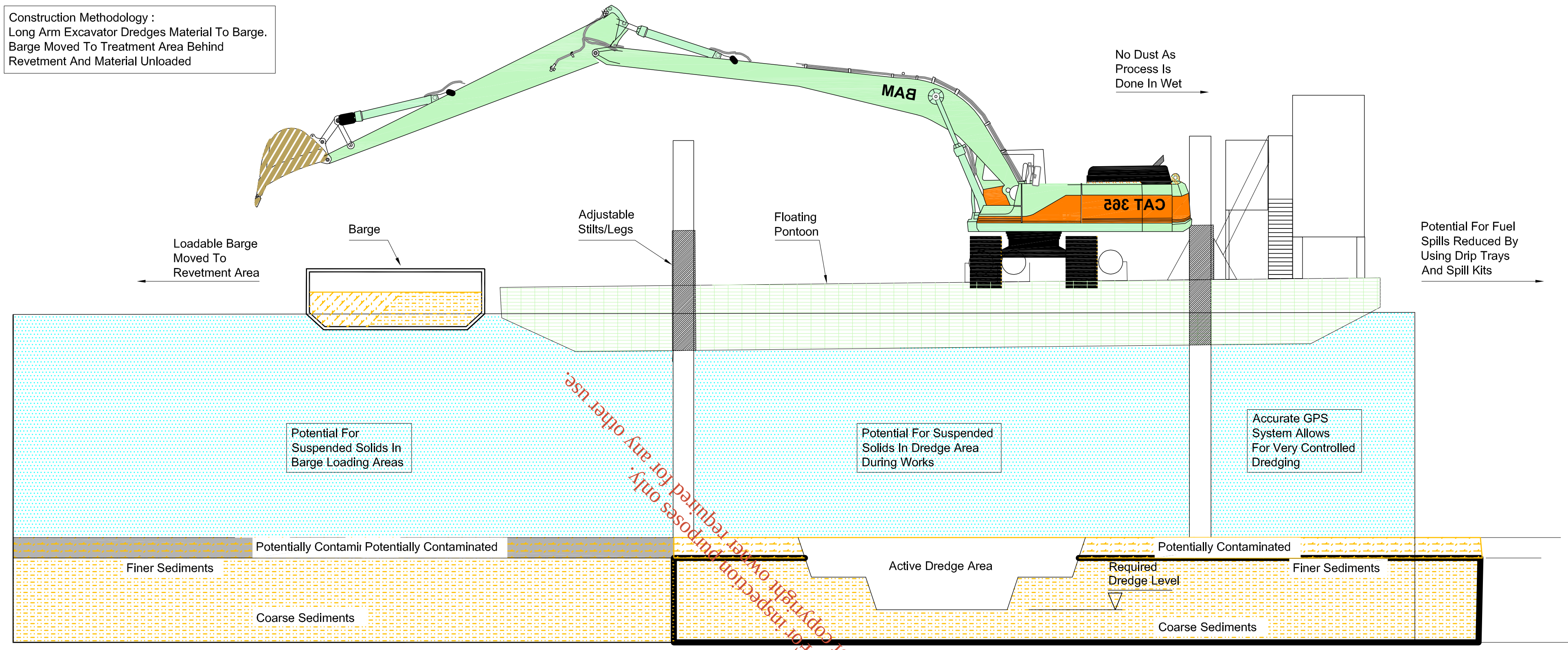
Scales (A3)	1:2000	
Drawn	MOS	Jan. 2016
Checked	PP	Jan. 2016

Drg. No. 16341-FIG.02 Rev. A



Schematic Section Of Dredge Process

SCALE : NTS

Notes

1. All dimensions are in millimetres unless noted otherwise.
2. All levels are in metres related Ordnance Datum Malin Head.
3. Drawings are not to be scaled.

Rev.	Date	Description	by	ch'd	app
A	04.03.16	ISSUED FOR QRA	BMP	MOS	PP

Client: PORT OF CORK

Project: BANTRY INNER HARBOUR DEVELOPMENT PHASE 1

Title: SCHEMATIC DRAWING OF DREDGE PROCESS

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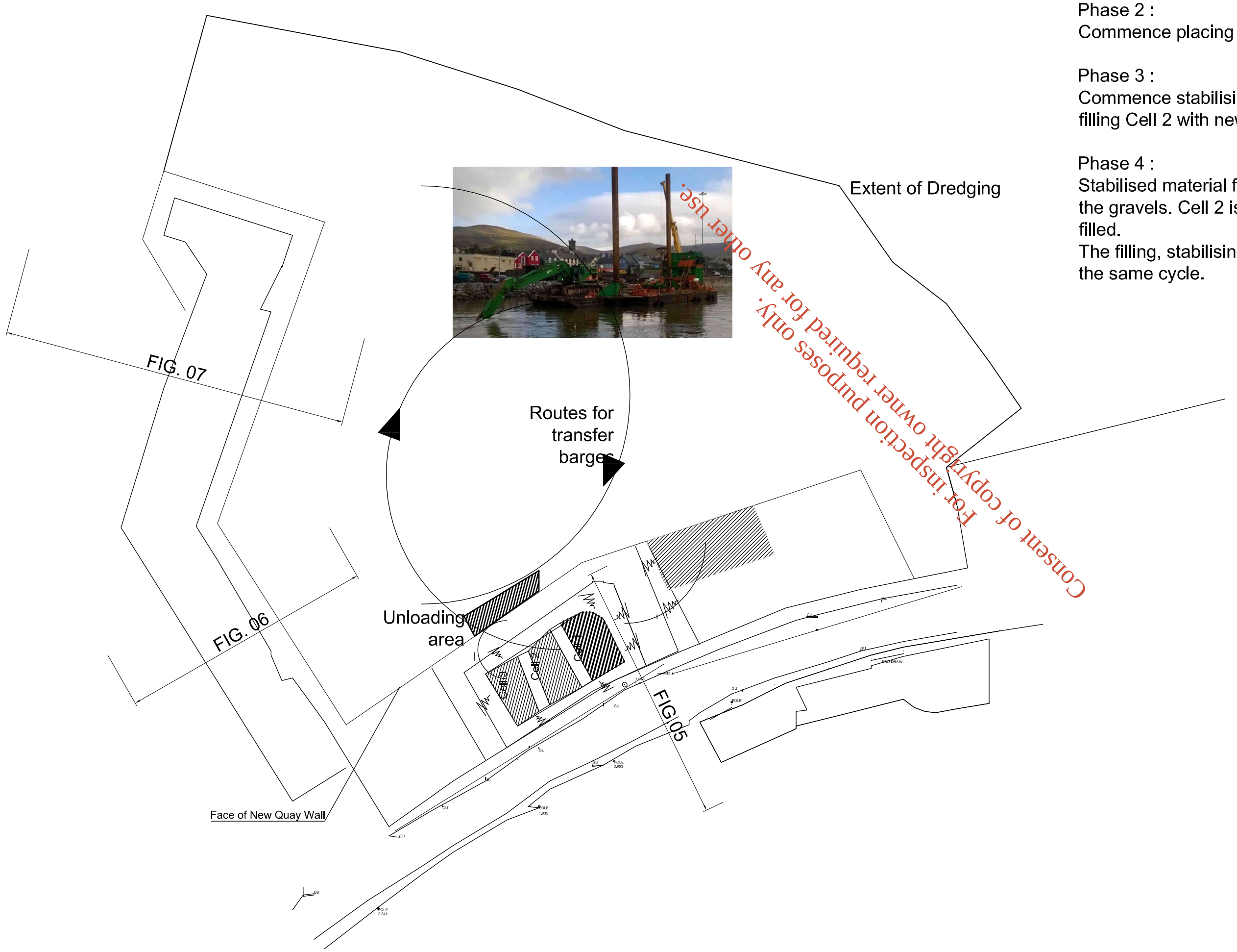
Scales (A3)	NTS	
Drawn	MOS	Jan. 2016
Checked	PP	Jan. 2016

Drg. No. 16341-FIG.03 Rev. A



Phase 1 :
Cell 1 is filled with dredged silts

Phase 2 :
Commence placing dredged gravel material

Phase 3 :
Commence stabilising the dredged material in Cell 1 while filling Cell 2 with newly dredged material

Phase 4 :
Stabilised material from Cell 1 is removed and placed over the gravels. Cell 2 is being stabilised while Cell 3 is being filled.
The filling, stabilising and unloading of the cells will follow the same cycle.

Notes

1. All dimensions are in millimetres (UNO)
2. Drawings are not to be scaled.
3. All levels are to Ordnance Datum Malin Head unless otherwise noted.
3. Conversion for Malin Head to Chart Datum ; 0.00m ODM = 2.18m CD
4. Schematic Drawing for Information Purposes Only

Legend

Reference Drawings

Rev.	Date	Description	by	ch'd	app
A	04.03.16	ISSUED FOR QRA	BMP	MOS	PP

Project: Bantry Bay Inner Harbour Development Phase 1

Title: Inner Harbour Development Quayside Area Treatment Phasing

Client: Port Of Cork

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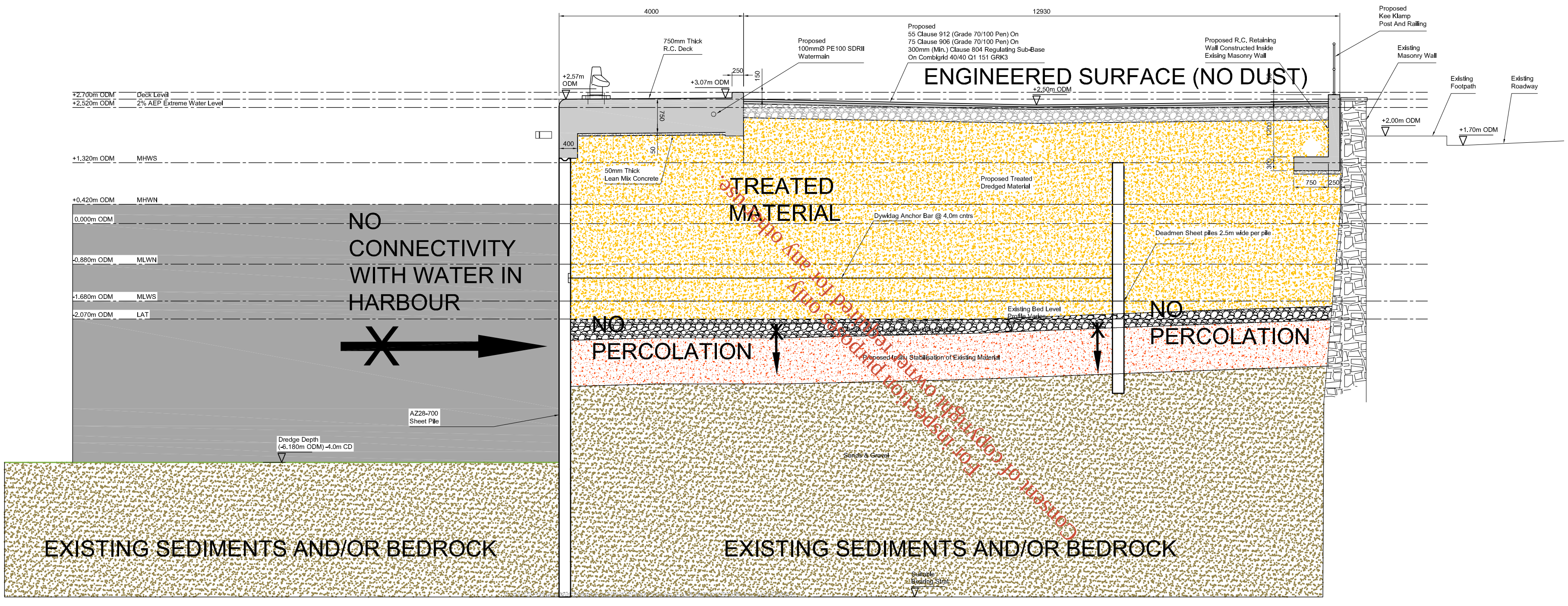
Scales (A1)	NTS	
Drawn	MOS	Feb. 2016
Ch'd(D.O.)	PC	Feb.2016
Ch'd(Eng.)	PC	Feb.2016
Approved	PC	Feb. 2016

Drg. No. 16341-FIG.04 Rev. A



Section A-A (Typical Quayside Reclamation Cross Section)

SCALE : 1:50

Notes

1. All dimensions are in millimetres (UNO).
2. All levels are in metres related to Ordnance Datum Malin.
3. Drawings are not to be scaled.

Legend

Reference Drawings

Rev.	Date	Description	by	ch'd	app
A	04.03.2016	ISSUED FOR QRA	BMP	MOS	PP

Project: Bantry Bay Inner Harbour Development Phase 1

Title: Conceptual Site Model For Pathways From Quayside Reclamation Area

Client: Port Of Cork

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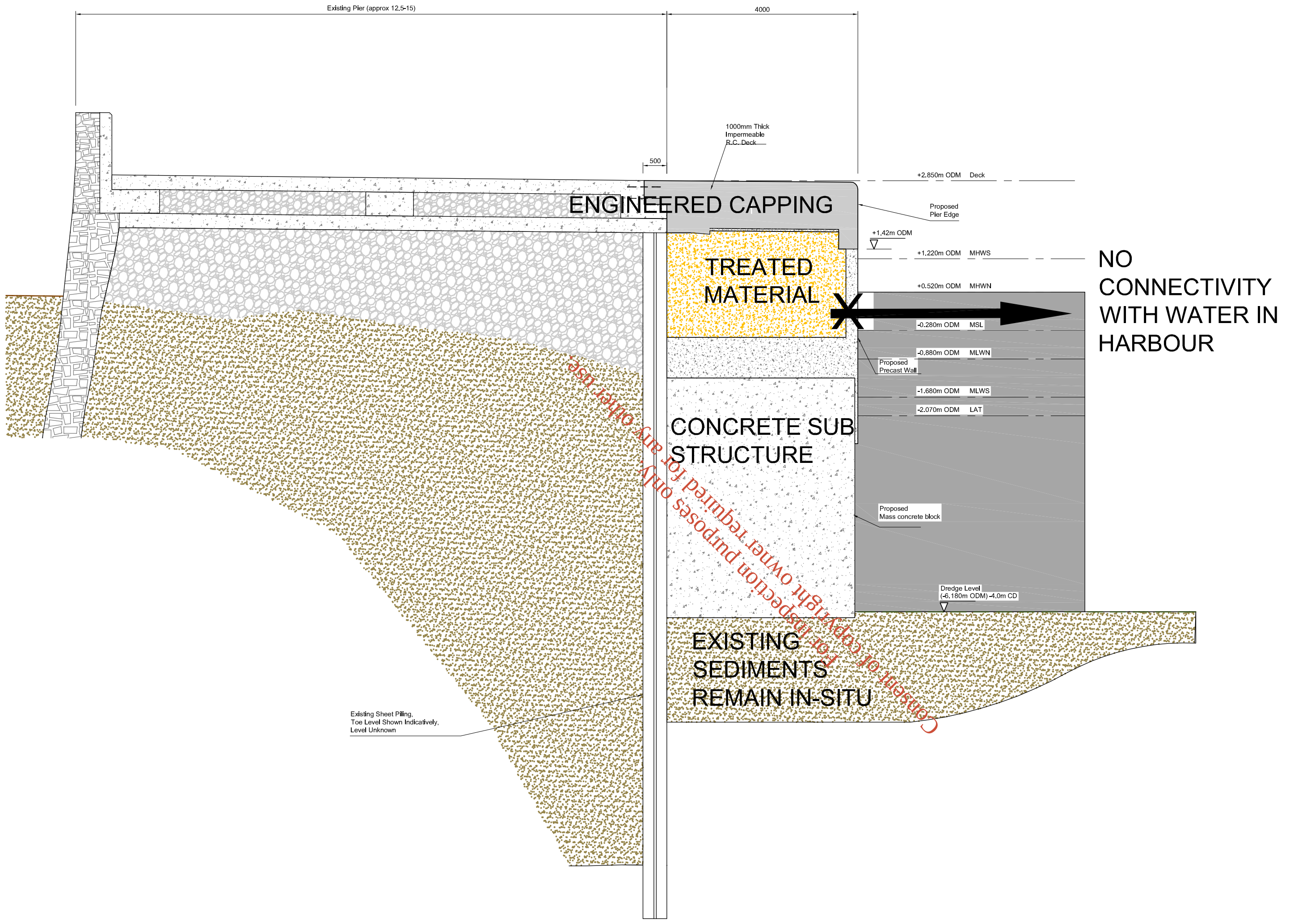
Scales (A1)	1:50	
Drawn	MOS	Feb. 2016
Ch'd(D.O.)	PC	Feb.2016
Ch'd(Eng.)	PC	Feb.2016
Approved	PC	Feb. 2016

Drg. No. 16341-FIG.05 Rev. A



Section A-A Typical Section Through Fishing Pier (Inner)

SCALE : 1:50

Notes

1. All dimensions are in millimetres (UNO).
2. All levels are in metres related to Ordnance Datum Malin.
3. Drawings are not to be scaled.
4. Any discrepancies between these documents shall be brought to the attention of the engineer.

Legend

Reference Drawings

Rev.	Date	Description	by	ch'd	app
A	04.03.2016	ISSUED FOR QRA	BMP	MOS	PP

Project: Bantry Bay Inner Harbour Development Phase 1

Title: Conceptual Site Model For Pathways From Inner Fishing Pier Section

Client: Port Of Cork

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Scales (A1)	As Indicated	
Drawn	SJ	Sep. 2015
Ch'd(D.O.)	JD	Sep. 2015
Ch'd(Eng.)	CH	Sep. 2015
Approved	PC	Sep. 2015

Drg. No. 16341-FIG.06 Rev. A