Alexandra Basin Redevelopment 2

Bringing Dublin Port To 2040

Environmental Impact Assessment Report

# Appendix 4-1 Outline Options to Manage Remaining Sediments

Volume 3



CALAFORT ÁTHA CLIATH
DUBLIN PORT

TETRA TECH

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# 1.0 Introduction

DPC has commenced a number of projects outlined in the masterplan including works at Alexandra Basin West and Berths 52/53, with activities to complete the works outlined in the masterplan expected to continue for a number of years. On completion the projects will:

- Redevelop Alexandra Basin West to include new quays and jetties, capital dredging to deepen the basin to achieve specified depths of -10m to -10.5m Chart Datum (CD) at the new berths, and remediation of contaminated sediments at the bed of the basin arising from historical industrial activities
- Provide infilling of the Basin at Berths 52 and 53 with treated sediment arising from Alexandra Basin West and construction of new river berths to replace the existing Berths 52/53

This report investigates the civil and environmental engineering requirements associated with a number of potential options to manage future treatment of dredged sediments to facilitate the completion of the above works in order to determine their feasibility and make recommendations on future actions required.

# 2.0 Management of Contaminated Sediment to Date

Environmental sampling of sediment within Alexandra Basin West has demonstrated that the bed of the basin is contaminated with a range of heavy metals and Tributyl Tin as a result of past ship building, maintenance and repair activities and handling of ores and other shipping activities. Levels of contamination of existing materials within ABW results in this material being unsuitable for disposal at sea. This conclusion has been reaffirmed following recent Site Investigation of less contaminated sediments at the entrance of ABW and analysis demonstrating that no material required to be dredged and removed from ABW may be disposed at sea.

Lower levels of contamination were recorded in the channel sediments adjacent to ABW, with further uncontaminated sediment being present within the main navigation channel. Materials dredged from these locations are disposed at sea.

## 2.1 Waste Management Hierarchy

Waste is defined as '"any substance or object which the holder discards or intends or is required to discard" under the Waste Framework Directive (European Directive 2006/12/EC as amended by Directive 2008/98/EC).

Once a substance has become waste it will remain waste until it has been fully recovered and no longer poses a potential risk to the environment or human health. From that moment onwards, the material ceases to be waste and it is no longer subject to the same legislative controls.

This applies to waste used as aggregate or construction material in civil engineering applications. Waste recovery can be achieved when such waste is incorporated into a road, building or other infrastructure works, or in the case of inert waste, after processing if such a process is conducted following the criteria specified in the relevant quality protocols.

The principal objective of sustainable resource and waste management is to use material resources more efficiently, where the value of products, materials and resources are maintained in the economy for as long as possible and the generation of waste is minimised. In the case of contaminated dredge material originating from ABW the sediment (following treatment) has been identified as being suitable for use to infill Graving Dock 2 (at ABW) and infill the existing basin at Berth 52/53 to provide increased capacity for Ro-Ro traffic in line with the masterplan for the development of the port. The use of treated dredge material replaces the need to use virgin materials that would otherwise be required for the development.

Figure 2.1 shows the decision making framework for the management of the contaminated dredged material on the land and sea for Alexandra Basin. If dredged materials are unsuitable for sea disposal then the materials must be managed on land and the alternative for the location can be either of a beneficial or a disposal type. Therefore, decisions on how to

handle the dredged material can be based on location (landfill or civil engineering application such as land reclamation) in addition to the contaminants present.

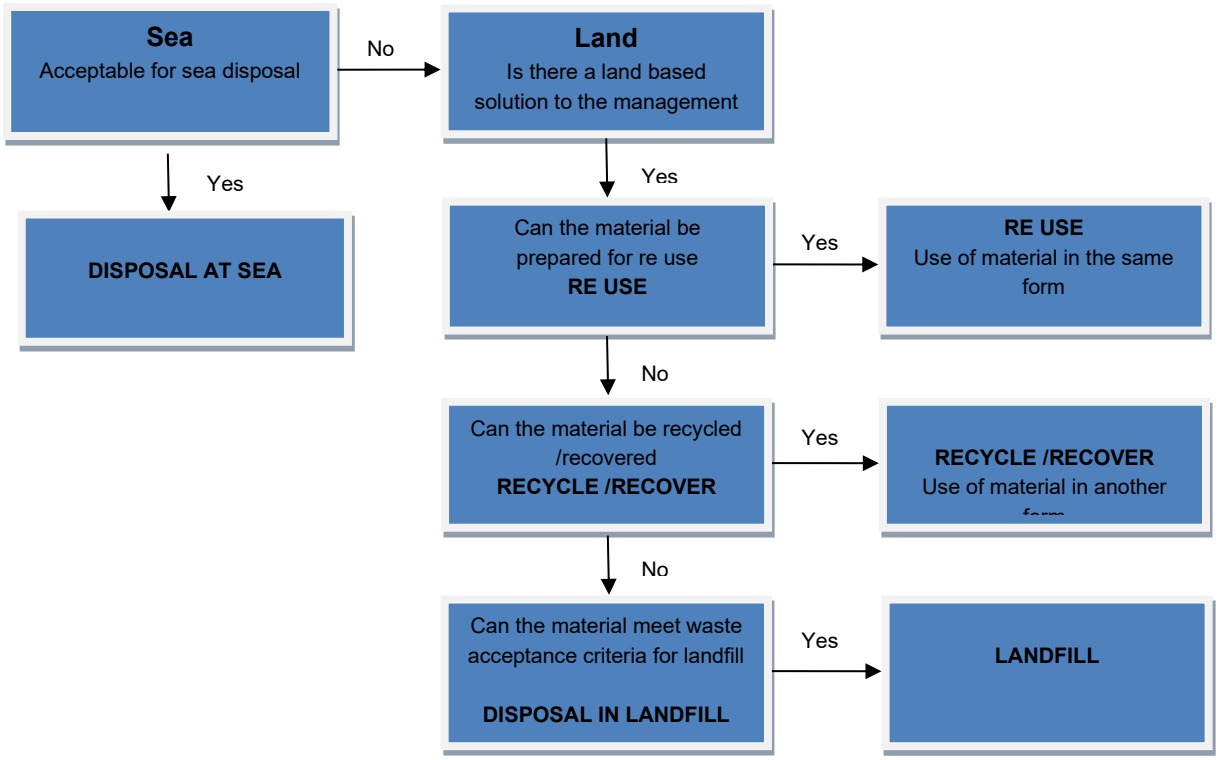



**Figure 2-1 Decision making framework for the management of contaminated dredged material on the land and sea for Alexandra Basin**

## 2.2 Sediment Handling

Disposal to landfill is the lowest priority in the hierarchy for dredge material management. The number of non hazardous landfills in Ireland accepting waste for disposal is continuing to decrease, as is the remaining licensed landfill disposal capacity.

It is therefore proposed as part of the development that the dredged material removed from Alexandra Basin will be treated to allow it to be recovered as fill material for reclamation works identified within the Port in accordance with the Hierarchy for Prioritising dredge material management. Only where the capacity of Berth 52/53 be exceeded will sediments be exported from site for off site recovery or disposal.

The sediment handling process is a chain of activities including dredging, transport and treatment until the dredged material reaches its final location. This is show in Figure 2.2 and further described below.




**Figure 2-2 Overview of the sediment handling process**

### 2.2.1 Dredging

Dredging can be divided into mechanical dredging and hydraulic dredging. Some of the techniques are also considered as being an environmental dredging method i.e. to remove contaminated sediment as efficiently as possible while minimising environmental impacts such as the re-suspension of contaminated sediments. Mechanically dredged sediments in general have solid content comparable to that of in situ sediments (about 50% by weight for most fine-grained sediments) whilst hydraulically dredged sediments are in slurry form (solids content typically in the range of 10-20%). The potential types of dredging are as follows:

- Mechanical dredging e.g. Grab dredgers, Backhoe dredgers, Bucket (ladder) dredgers
- Hydraulic dredging e.g. Cutter suction dredger, Trailing suction hopper dredgers, Combined dredging technologies, Freeze dredging
- Environmental dredging

### 2.2.2 Pretreatment

#### 2.2.2.1 Screening and Separation

Screening removes extraneous material unsuitable for treatment (e.g. debris). Separation techniques may be applied to separate dredge into fines, sand and gravel in order to take away contaminated fine particles from uncontaminated sediments. Uncontaminated sediment may be used without the requirement for treatment. The need for dewatering will be determined by the water requirements of the treatment technology and the solids content of the sediments following removal, transport and screening and separation pre-treatment.

#### 2.2.2.2 Dewatering Technologies

The need for dewatering is determined by the solids content of the sediments following removal and transport, and by the water requirements of the proposed treatment or disposal method. To prepare dredged sediments for most treatment or disposal methods, water must be removed and/or the solids content of the sediments must be made more uniform.

The possible types of dewatering technologies are as follows:

- Thermo chemical treatment
- Lagooning/drainage in settling ponds
- Mechanical dewatering
- Geotubes
- Combined technologies
- Thermally assisted dewatering
- Electro-Dewatering

### 2.2.3 In-situ Treatment Technologies

In-situ treatment allows soil and sediment to be treated without the need to be excavated and transported. This involves applying chemical, biological or physical processes to the subsurface to degrade, remove, or immobilise the contaminants in situ. Treatment methods can be categorized into three major groups:

**Table 2-1: In-Situ Treatment**

| Physical/chemical treatment | Biological treatment | Thermal Treatment |
|---|---|---|
| In-situ Stabilisation/Solidification | Monitored natural attenuation | Electrical resistance heating |
| Chemical oxidation | Enhanced natural attenuation | Steam injection and extraction |
| Electrokinetic separation | Phytoremediation | Conductive heating |
| In-situ Capping (ISC) | | Radio frequency heating |
| Soil flushing | | In situ vitrification |

### 2.2.4 Ex-situ Treatment

Ex situ treatment requires the excavation and transportation of the sediment. Ex-situ treatment generally requires a shorter time period to undertake than in situ treatment methods. With ex situ treatment there is more certainty about the uniformity of treatment process because the sediments can be pre treated through screening and mixing to homogenize the sediments. Treatment methods can be categorized into three major groups.

**Table 2-2: Ex-Situ Treatment**

| Physical/chemical treatment | Biological treatment | Thermal Treatment |
|---|---|---|
| Ex situ stabilisation/solidification | Bioslurry | Thermal desorption |
| Gas-phase chemical reduction | Biopiles | Hot gas decontamination |
| Liquefied gas solvent extraction | Landfarming | Incineration |
| Separation | Composting | Pyrolysis |
| Dehalogenation | Phytoremediation | |
| Soil washing | | |
| Solvent Extraction | | |

## 2.3 Treatment Process

The strategy for sediment handling process for Alexandra Basin will be to treat the contaminated sediment to allow it to be recovered as fill material for reclamation works identified within the Port. This is consistent with European and national policy objectives to reduce the amount of waste disposed to landfill. Therefore, the objective of pretreatment and treatment is to treat the contaminated dredged material to the appropriate criteria in order to allow it to be recovered as fill material on the site instead of using primary resources.

Stabilisation/Solidification (S/S) is a remediation technology that reduces the mobility of contaminants. Immobilisation is achieved by reaction of contaminants with reagents to promote sorption, precipitation or incorporation into crystal lattices, and/or by physically encapsulating the contaminants. The method produces a high strength monolith-like product that physically reduces the mobility and chemically binds contaminants to the produced matrix. The treated mass can then be recovered/recycled to serve as infill material or for beneficial use.

In the case of sediments originating from ABW studies have demonstrated that paste stabilisation treatment appropriately stabilised contaminant movement from the treated sediments. Paste stabilisation can be conceptualised as an ex-situ form of mass stabilisation, whereby mix designs are predicated on achieving water contents 3-5% above the liquid limit to enable self-weight compaction. The stabilisation mix design additives utilised to date are Cement (CEM1 52.5N) and Powder Activated Carbon (PAC). CEM1 is a cementitious binder and PAC acts as an organo-sorbent compound utilised predominantly to retain TBT within the stabilised mass. A test work programme was developed to assess optimal CEM1 binder and PAC application rates with respect to water content and TBT source term mass respectively. In Phase 1 of the project a threshold of 425µg/kg was set to determine whether PAC was required to be included in the additives for treatment purposes. Above this threshold increasing levels of PAC were added based on the measured TBT contamination within a defined zone in the basin.

## 2.4 Licensing of Treatment Process

An Industrial Emissions licence was issued by the EPA on 27 October 2016 (Licence Register No: P1022-01) to Dublin Port Company to regulate the treatment of contaminated dredge material within a licenced boundary at the port. This licence was subsequently reviewed and issued by the EPA on 14 February 2019 (Licence Register No: P1022-02), with a further technical amendment issued on 05 November 2024 (Licence Register No: P1022-02/B).

This licence is for the ex-situ treatment by stabilisation/solidification and recovery of contaminated dredge material at specific locations within Dublin Port as part of the Alexandra Basin Redevelopment Project at Port Centre, Alexandra Road, Dublin Port, Dublin 1. The waste to be treated will comprise contaminated dredged sediment taken from the Alexandra

Basin, which is contaminated with heavy metals, TBT, DBT, hydrocarbons and, to a lesser extent, PAHs and PCBs.

The licence permits the treated waste to be recovered by infilling at two locations within the port complex (at Graving Dock 2 and at Berths 52/53). A total of 1,262,800 tonnes of dredge sediment is permitted to be treated and recovered over the lifetime of the licence.

The licence sets out in detail a series of conditions under which Dublin Port Company is required to operate and manage the installation. There are a number of key conditions which can be interpreted to restrict the types of material which can be infilled within the basin at Berth 52/53 and potentially impact on the applicability of the options for management of dredge material considered in this report. These are highlighted further below.

## 2.5 Treatment Performance Criteria

As part of the Industrial Emissions licence application process a Detailed Quantitative Risk Assessment was undertaken which identified 2 primary Contaminants of Potential Concern within the untreated dredge (TBT and Nickel). The IE Licence conditions focuses on these 2 parameters in terms of remedial targets (Schedule B.6 of the Licence). Compliance with the set emission limits for leachate from the stabilised mass is demonstrated through the use of semi-dynamic diffusion-based tank testing.

## 2.6 Material Treated to Date

Alexandra Basin West contains a number of operational berths, and similarly the basin at Berths 52 and 53 remains in operation. This results in logistical issues with programming both access to ABW to undertake dredging and the availability of Berth 52/53 to receive treated dredge material if all dredging and stabilisation works were to be completed continuously.

To minimise the major disruption in port activity resulting from large civil engineering works occurring the works required to dredge, treat and utilise sediments from ABW has been commenced on a phased basis.

Dublin Port Company has undertaken some dredging activity in ABW (approximately 92,000m$^3$) to remove the most heavily contaminated sediments to a depth of approximately -8.0mCD. These sediments have been treated under the IE Licence and the treated material recovered for infilling within Graving Dock 2.

Treated sediments exceeding the capacity of Graving Dock 2 were initially stored in a bund structure at the southern end of Berth 53/Alexandra Road Extension. This material has been relocated northwards to a new location (directly east of Berth 53) to facilitate current construction works to provide the replacement Berth 53. This bund structure temporarily stores approximately 84,000m$^3$ of treated sediment which will be placed in its final recovery location in the coming years.

# 3.0 Review of Similar Projects

## 3.1 Alexandra Basin Redevelopment (Phase 1)

The ABR Project in Dublin Port aims to address a legacy contamination issue within Alexandra Basin West which restricts DPC's ability to carry out routine and essential maintenance dredging operations there. A variety of contaminants, including metals, tributyltin (TBT), dibutyltin (DBT), total extractable hydrocarbons (THE), polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), are present at relatively high concentrations within sediments in the ABR. This contaminated sediment was deemed to be unsuitable for disposal at sea. It was therefore proposed that it would be put to beneficial use by stabilising the material and backfilling the stabilised material in old graving dock, namely Graving Dock 2, and infilling two existing berths at Berths 52/53 to develop new lands at the port.

Logistics of the live port operations had resulted in the project being phased with the first phase requiring the removal of approximately 92,000m$^3$ of the most heavily contaminated sediments to a depth of around -8.0mCD. These sediments were treated in accordance with the IE Licence requirements, and the stabilised material was subsequently utilised for infilling within Graving Dock 2.

Surplus treated sediments exceeding the capacity of Graving Dock 2 were initially stored within a bund structure located at the southern end of Berth 53/Alexandra Road Extension. This material has since been relocated northwards to a site directly east of Berth 53, to accommodate ongoing construction works for the replacement Berth 53. The bund structure provides temporary storage for approximately 84,000m$^3$ of treated sediment, which is scheduled for final recovery placement in the coming years.

A conceptual model was developed to help evaluate the risks associated with the reuse of contaminated sediment. The conceptual model considered the post-development source of contamination (i.e. leachable contamination) associated with the source area (i.e. treated arisings from dredging). The predicted leachate concentrations were considered in relation to published water quality targets and existing baseline levels of surface water and groundwater contamination to establish if the treated sediment is likely to have a discernible impact on water quality. The exposure pathways assessed include typical hydrogeological pathways and additional factors such as the physical nature of the treated dredgings, the hydrogeological setting (taking into account the tidal fluctuations, reduced surface water infiltration due to the proposed hardstanding cover), existing physical structures (e.g. quay walls, etc) and proposed physical structures (e.g. a cofferdam and sheet pile walls). The receptors assessed included shallow groundwater associated with made ground and superficial deposits, the deeper groundwater associated with underlying limestone, and surface water quality associated with the Alexandra Basin and the River Liffey.

Paste stabilisation was identified as the preferred technique for treating sediments and mix design additives include Cement (CEM1 52.5N) and Powder Activated Carbon (PAC).

Samples of the treated dredge material were taken every 1,000m3 of processed dredge and allowed to cure for 28 days before being sent for standard method tank testing in accordance with the Licence.

The leachate was tested by an approved laboratory to determine if it falls within the specified leachate threshold limits. The actual tank test were undertaken in accordance with EA NEN 7375:2004, i.e., the Standard Method. Leachates were analysed for the parameters listed in C.4 at the specified leaching intervals in order to determine the leaching trajectory (mass flux rate) that were then be compared to the acceptable leaching trajectory determined during pre-works design. Comparison of observed leaching trajectories from verification specimens against design leaching trajectories (from mix design study) were used to demonstrate compliance.

### 3.1.1 Key Lessons Learned

Key lessons identified by the first Phase of the works for Alexandra Basib Redevelopment include:

- There is a significant lag between the treated sediments being filled to Graving Dock No.2 and the results being available. This is due to a number of factors including curing time, fraction periods and laboratory turnaround times. Programming of the works must account for the testing lag with contingency planning, spatial tracking of placed materials and the ability to isolate and remediate suspect area if required.
- The licence conditions focus on these 2 parameters, TBT and Nickel, in terms of remedial targets (Schedule B.4 of the licence).
- Nickel levels tested are typically less than 0.1% of the remedial target of 6.09mg/l.
- The use of flexible mix design (CEM1 + PAC) allowed effective management of widely varying TBT concentrations (from low to very high levels). The introduction of PAC at defined thresholds (>~425 µg/kg) proved essential to maintaining compliance.
- Regular sampling (every ~1,000 m³ and after mix changes) ensured continuous verification of compliance. Extended testing (beyond licence requirements in some cases) provided additional assurance of long-term leachability performance.
- Early-stage high-resolution characterisation of sediments is critical to inform treatment strategy, avoid over/under-design and optimise binder use.
- The Graving Dock cap demonstrated that long-term environmental performance is highly dependent on integrated low-permeability design and water management, not just the stabilisation of the underlying material. The use of low-permeability asphalt and high-strength concrete, combined with sealed joints, bond coats, and controlled drainage (minimum falls and channel drains), was critical in minimising vertical infiltration. The design effectively limits water ingress, thereby reducing the risk of contaminant mobilisation from the stabilised sediments over the long term.

- The closure process was guided by EPA guidance in relation to the Closure Restoration Aftercare Management Plan (CRAMP), which sets out detailed criteria for successful closure. The Closure Audit confirms that the closure plan has been validated through a series of inspections, document reviews, and environmental monitoring. The closure steps included thorough decommissioning and decontamination of plant and equipment, removal and proper disposal of stored wastes, and the installation of an engineered cap over all filled areas. The cap serves to isolate contaminated materials, prevent water infiltration, and reduce direct contact exposure pathways.

The project demonstrates that successful in-situ recovery of contaminated dredged material at scale is achievable, provided that treatment design is adaptive and data-driven, QA/QC systems are rigorous and traceable and containment and capping systems are engineered and verified to a high standard.

## 3.2 Port of Gothenburg (Arendal Stage 1B)

The Port of Gothenburg has constructed a container yard on land reclaimed stabilised and solidified dredged material arising from maintenance dredging and dredging work aimed at widening the entrance to the Port. The storage area was filled with approximately 157,000m$^3$ of dredged material, which was stabilised and solidified using CEM1 and Ground Granulated Blastfurnace Slag (GGBS), at a typical additive rate of 150kg/m$^3$ of dredge material generating circa 250,000m$^3$ of fill. The primary contaminant being treated was TBT, at similar (or higher) average levels than the sediment yet to be managed from ABW.

The receiving fill area was formed using crushed rock material and subsequently covered in an impermeable concrete mattress to retain water and treated sediments within the basin. A small sedimentation basin was formed towards which displaced water from infilling of treated sediments was directed for management.

Dredged materials were transported to the infill area by barges, and screened for oversize material at the receiving jetty, and subsequently pumped to a mixing unit, within which binder was mixed with the dredged materials. The mixed binder and dredged materials were then pumped into the receiving infill basin, progressing towards the wastewater treatment basin.

Water arising from the infill basin was treated by means of initial sedimentation before receipt into the treatment basin, addition of carbon acid (to adjust pH), and subsequent filtration through sand and activated carbon filters, with the following concentrations required to be achieved in discharges to the receiving waterbody:

- Suspended Solids: 25 mg/l
- Oil (measured as oil index): 1 mg/l
- TBT: 0.100 µg/l

Records indicate that the wastewater largely achieved the required standards, despite these being more stringent than the IE Licence at Dublin Port. It should be noted that no adjustment to water levels within the receiving basin were undertaken in advance of filling, and the

concentrations of contaminants within water in advance of treatment are therefore expected to have been significantly diluted.

Stabilised and solidified dredged material was filled to approximately 1.0m above the mean water level in accordance with the permit, and subsequently overfilled with 1-1.2m of surcharge consisting of crushed rock material (0-30 mm) to protect the infilled material and facilitate settlement in advance of service installation and surfacing.

### 3.2.1 Key Lessons Learned

Given the similarities in the processes and final use between the works undertaken at Gothenburg and those foreseen at Dublin Port the key lessons learned by the Port at Gothenburg (albeit smaller in scale) should be considered in the planning and execution of the works at Dublin Port. Key lessons identified by the Port of Gothenburg include:

- From a geotechnical perspective the designers at Gothenburg required that the shear strength of the stabilised and infilled material should exceed 100kPa to facilitate subsequent surfacing and loading. This was largely achieved, except in the initial phases of infilling, where sediment undergoing treatment had a higher than expected water content, resulting in lower strength gain overall. Additive rates were not amended initially to account for this high water content and rates should be monitored to ensure the infill material achieves design properties. Where cold weather was encountered additional additives were utilised to increase the temperature of the stabilised dredge and ensure strength gain was optimised.
- Monitoring of the infill following completion of the works indicated that substantial levels of differential settlement were observed of up to 0.7m, resulting in additional works being required to amend drainage for the subsequent shipping yard and road pavements to be re-laid. This was not attributed to the consolidation of the treated sediments, but rather to the consolidation and settlement of the underlying soft sediments within the receiving basin due to loading applied by the treated sediments. The Port of Gothenburg would, in hindsight, have dredged the soft sediments in advance of the works to have mitigated this issue, and increased the period between completion of infilling and the commencement of overlying works. It had been envisaged that one year would have been sufficient to achieve the majority of the settlement, but this took over two years.
- The initially consented concentrations of TBT in the discharge from the water basin were unachievably low, and this was increased to 0.1µg/l on review and was achieved throughout the works relatively comfortably. The concentrations were noted to increase as the volume of water within the basin reduced over time and infilling progressed towards the abstraction location, presumably due to limited settlement of suspended solids and reductions in dilution. The infill methodology at Dublin Port should take this into account from a phasing perspective to ensure consented discharge quality can be achieved.
- The degree of bulking of the stabilised dredge material was substantially higher than expected (amounting to approximately 59%), substantially higher than the observed bulking rates of 40-42% previously observed at Dublin Port. The Port of Gothenburg has primarily attributed this increase in bulkage to the dredge technique adding additional water to the process. It is unclear whether the infilling methodology (pumping the treated

sediment into a waterbody) may have also contributed to separation and bulking of the treated sediments, and this should be kept in mind for future works at Dublin Port.

It is also noted that sampling to determine additive rates in the design stage were undertaken on the basis of average contaminant concentrations of the source dredge. Similarly, the sampling and monitoring of the quality of water discharged from the works area/wastewater treatment plant was undertaken using a flow-proportional sampler which took samples continuously for 1 week to determine average values. This would likely be of substantial benefit to Dublin Port and limit the potential for suspension of discharge arising from the sampling of a peak/maximum concentration.

## 3.3 Howth Fishery Harbour Centre

Dredge sediment stabilisation works were carried out in 2021 as part of an upgrade of the Middle Pier at Howth Fishery Harbour Centre for use in extending/widening an existing pier and outlined in a published research paper[1]. Dredging of sediment was carried out to the west of the existing pier to allow access for larger vessels, generating approximately 6000m$^3$ of sediments. The works involved the construction of a retention berm, placing of the dredge material behind the berm, and subsequent stabilisation of the dredge material by injection of binders (Ordinary Portland Cement (OPC) and GGBS) following deposition in order to treat TBT within the dredge arisings. The concentrations of TBT managed at Howth are unknown.

This process involved setting up a batching plant onsite where water and binders were mixed at set concentrations to create a pumpable slurry for injection into the placed dredge sediment. The location, elevation, rate of pumping and rate of movement of the injection equipment was monitored continuously to provide a homogeneous treated mix. This injection treatment was undertaken in discreet cells, with some overlap between cells to ensure that all dredge materials would be treated.

### 3.3.1 Key Lessons Learned

The volume of material treated at Howth Fishery Harbour Centre is substantially smaller than that required by Dublin Port in future phases, were controlled by a waste facility permit issued by Fingal County Council with presumably substantially lower oversight, and appear to have been undertaken in largely dry conditions (to depths of 3-3.5m from the top level of the infilled dredged sediments). However, a number of lessons learned which may be applicable to Dublin Port should this treatment methodology progress, were outlined. These include:

- Despite the small scale of the works to be undertaken (<2,000m2 in area) and mixing to homogenise the source material before treatment, testing of the treated sediments suggest that there was a noted variability in the properties of the material following treatment. In order to improve the homogeneity of the mix wet mixing processes that mix the binders and sediment in advance of pumping into place (as per infilling of Graving Dock) should be considered. Alternatively, although not suggested in the research paper,

[1] Dredge Sediment Stabilisation Works at Howth Fishery Harbour Centre (Civil Engineering Research in Ireland 2022)

overtreatment could be considered (potentially at substantial cost) to mitigate any risks associated with the treated material not achieving the desired properties.

- It was noted that the methodology of using a wet mix of binders with a wet mix of sediments was successful, eliminating the need to reduce the high moisture content in the sediments before stabilisation. This appears to have been possible at Howth due to the small footprint of the infill area; this benefit is unlikely to be realised at Dublin Port due to the difference in scale and depth of material which may require treatment, requiring access directly on the infilled sediments by larger plant.
- In the case of works at Howth Fishery Harbour Centre consideration of a higher strength mix was investigated to achieve improved curing and strength gain in a shorter time period, and utilised GGBS to further improve long term strength gain. The importance and benefits of detailed trial mix testing and consideration of temporary works was highlighted to define the treatment process.
- A number of recommendations on sampling and testing have been made to provide more certainty in the results of samples and efficacy of the treatment process.

# 4.0 High Level Summary of Main Management Options Identified

A series of high-level treatment options have been presented for consideration which are summarised below.

## 4.1 Sub-aqueous Deposition of Stabilised Infill

Option 1 considers the placement of treated dredge material below the water level of the Berth 52/53 basin. It is proposed that under this option treatment of dredge material would be undertaken within a shore based treatment plant located in the vicinity of the Berth 52/53 as it is delivered to the berth. The treated sediment arising, and potentially the existing stockpile of treated sediments, could then be placed beneath existing water level with the quay wall structure closing off the basin acting to contain water affected by sediment, contaminants and additives within the basin.

## 4.2 Unbound Sub-aqueous Deposition with Stabilisation Post Placement

As an alternative to Option 1 a second option could be to infill untreated dredge material directly into the Berth 52/53 basin whilst retaining water impacted by the activities with the quay wall closing off the basin.

Following placement of a conventional imported surcharge layer to act as a working platform, stabilisation of the untreated infill material could be undertaken by injection methods within the Berth 52/53 basin. The nature of the stabilisation treatment undertaken may potentially undertake a number of forms, including potentially the treatment of higher fill layers (subject to geotechnical and environmental performance of underlying untreated layers), treatment of all infilled material to depth, or treatment of columns of the infill material followed by treatment of the upper layer(s) of material only to provide a load transfer platform supported by the columns of treated/stabilised materials.

## 4.3 Partial Unbound Sub-aqueous Deposition

A third high-level option proposed to be considered is a variation of Option 2 outlined above. In this case selected untreated dredge material (with low levels of contamination) would also be expected to be filled directly into the Berth 52/53 basin again with the quay wall structure closing off the basin. This material would then be subject to surcharging to improve geotechnical characteristics.

The environmental performance and nature of the sediments yet to be dredged from ABW would exclude the possibility of contaminated dredge arisings affected by TBT being used in the lower layers of infill in an untreated form, and this material would be required to be stored separately and to undergo some treatment. This is envisaged as including dewatering on land as the untreated fill within the basin undergoes consolidation. Following consolidation

the remaining contaminated sediments would be stabilised in a treatment plant onsite for subsequent infilling with the currently stockpiled treated sediments as the upper layers of infill within the basin.

## 4.4 Dock Dewatering and Conventional Compaction of Infill Materials

A final option considered includes an alternative variation of Option 3, consisting of a proposal to infill the dewatered basin at Berth 52/53, initially with dewatered and lightly contaminated dredge arisings from ABW, followed by dredge arisings with higher levels of contamination (which may require treatment) and the currently stockpiled treated sediments as the upper layers of infill.

These materials would be proposed to be infilled in a dry state as an engineered fill material using conventional engineering plant and equipment. Although this option is likely to improve geotechnical performance of the fill within the basin a number of risks and constraints have been identified which are likely to result in this option being unachievable from a constructability perspective.

# 5.0 Preferred Solution

The preferred solution for the Alexandra Basin West (ABW) project is to adopt a circular, site-based materials management strategy, whereby the majority of dredged sediments are treated and beneficially reused within Dublin Port, primarily through infilling of the Berth 52/53 basin, supplemented by selective offsite recovery for surplus materials. This approach is underpinned by a tiered treatment methodology, matching treatment intensity to contamination risk: low-contamination sediments are processed via soil washing to recover reusable granular fractions, while high-contamination sediments are treated using stabilisation/solidification (S/S) techniques proven in earlier phases of the project. The treated materials are then recovered for engineering use, either as structural infill within the basin or as capping materials in adjacent infrastructure works, thereby maximising reuse within the port estate.

This solution is considered to represent Best Available Technique (BAT) because it achieves an optimal balance between environmental protection, resource efficiency, and technical feasibility. Firstly, it maximises the recovery and beneficial reuse of dredged sediments, in line with the waste management hierarchy, significantly reducing reliance on landfill disposal and minimising the environmental footprint associated with offsite transport and disposal. Secondly, the application of soil washing for lower-risk materials ensures that only the minimum necessary treatment is applied, avoiding unnecessary use of carbon-intensive binders such as cement and therefore reducing embodied carbon and material consumption.

For more highly contaminated sediments, the use of stabilisation/solidification with cementitious binders and activated carbon is a well-established, regulator-accepted technique that effectively immobilises contaminants such as TBT, hydrocarbons, and heavy metals, ensuring compliance with Industrial Emissions licensing requirements and protecting controlled waters. The selection of this treatment route is supported by prior successful implementation at the Port, demonstrating proven performance, reliability, and regulatory acceptance, which are key BAT considerations

The reuse of treated sediments within the contained Berth 52/53 basin further strengthens the BAT case, as it provides a controlled, engineered environment for material placement, limiting pathways for contaminant migration while simultaneously delivering a constructive engineering outcome (land reclamation and berth development). This integration of remediation and construction aligns strongly with sustainable development principles and represents efficient use of available infrastructure.

Although a modest surplus of material is currently anticipated, the strategy incorporates adaptive measures—such as optimisation of dredge depths and flexible reuse pathways—to minimise excess generation. Where offsite management is unavoidable, the prioritisation of licensed recovery or treatment facilities over disposal ensures that environmental impacts are minimised and regulatory compliance is maintained.