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DREDGED MATERIAL AS A RESOURCE

ABSTRACT

PIANC Working Group 14 has been studying worldwide practice on the use of dredged material. This study has been developed into a report to be published shortly ("Dredged material as a resource; options and constraints"), which provides guidance on the assessment of options for use and recommendations on how to overcome constraints.

The PIANC report is based on "lessons learned" from numerous case studies in different situations in various countries. This article summarises key messages from the report and two case studies are used here to demonstrate these principles, specifically, the rehabilitation of a brownfield site at Fasiver, Belgium and the creation of a wetland in Wallasea, United Kingdom. The main conclusion is that dredged material, far from being a waste, can be an important environmental and economic resource.

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INTRODUCTION

Dredging is essential for the maintenance and development of ports, harbours and waterways for navigation, remediation and flood management. Dredging of these waterways creates large volumes of dredged material. This material can be a valuable resource although much of it is currently disposed because of economic, logistical or environmental constraints (Bray 2008). In many countries disposal is getting more and more difficult owing to the lack of space as well as environmental concerns. Therefore, interest in alternatives is growing, especially the potential for use of dredged material as a resource. For this reason, PIANC Working Group 14 has been studying worldwide practice on the use of dredged material.

Most dredged material is largely uncontaminated and can be used directly underwater or on land after dewatering.

Above: Dredged material can be an important resource as seen in this aerial view of a former contaminated brownfield site at Fasiver, Belgium. This recent photo shows how the site, which had been abandoned, is now rehabilitated and ready to be used as an industrial area.

Contamination, however, does not rule out the possibility of use of dredged material, depending on site-specific conditions and legislation. Contaminants can be stabilised or removed by treatment techniques to make it suitable for use. It should be noted that any treatment or handling step will increase the costs of using dredged material (Bortone and Palumbo 2007). On the other hand, the observed reduction of contaminant load in dredged material through ongoing reductions of environmental emissions to water courses is improving the quality and increasing the quantity of dredged material available for use without pre-treatment.

For the purposes of the PIANC WG 14 report (in preparation) and thus this article, any use of dredged material, rather than mere disposal, has been considered to allow the inclusion of the widest range of options available.

This definition includes the "sustainable relocation" of dredged material, which can be described as, "The introduction of dredged material into aquatic systems to maintain and/or supplement sediment supply in order to sustain the natural processes".

Table I. Site-specific material selection for engineering use.

		Dredged material sediment type				
	Dredged material use options	Rock	Gravel	Sand	Clay/Silt	Mixture
	Construction materials					
1	Road foundations	•	•	•	•	•
2	Replacement fill	•	•	•	•	•
3	Dikes	•	•	•	•	
4	Mounds			•	•	•
5	Noise/wind barriers			•	•	•
6	Land reclamation		•	•	•	•
7	Land			•	•	•
8	Stabilisation		•	•		•
9	Sealing of CDFs (confined disposal facilities)				•	
10	Capping of disposal sites, landfills		•	•	•	•
11	Capping of contaminated sediments		•	•	•	
12	Rehabilitation of brownfields			•	•	•

Uses of dredged material aimed at the improvement or enhancement of the environment are examples of the principle "working with nature", which is endorsed by PIANC. Members of PIANC Envicom Working Group 14 who have worked on the report from which this article is drawn are: Lindsay Murray (Chairman), Cefas, UK; Siegfried D'Haene, DEME Environmental Contractors (DEC), Belgium; Pol Hakstege, Rijkswaterstaat, Ministry of Transport and Public Works, the Netherlands; Lena Paipai, Halcrow Group Ltd, UK; Yasushi Hosokawa, PARI, Japan; Jose Buceta, Ministry of Environment, Spain; Keita Furukawa, Ministry of Land, Infrastructure and Transport, Japan; Najat Chaouq, DRAPOR, Morocco; Jack Word, Weston Solutions Inc., USA; Alejandro Varas, Port of Aviles, Spain ; Liesbet van den Abeele, Ministry of the Flemish Community, Belgium; and Hugo De Vlieger, Baggerwerken De Cloedt, Belgium.

OPTIONS AND CONSTRAINTS

Although not yet common practice in all parts of the world, some countries already do make extensive use of dredged material. For example, in Japan up to 90% of dredged material is used. In other countries various constraints have prevented more extensive use. These include higher costs than traditional disposal, complex and inconsistent legislation and regulation, the difficulty of finding suitable schemes for using the material at the appropriate time or markets for treated products and, not least, a negative public perception.

The working group has identified a range of uses, which are classified into two broad categories:
- Engineering Uses
- Environmental Enhancement

ENGINEERING USES

Dredged material can be used as an alternative for some other resources in many engineering projects. Engineering uses of dredged material include:
- Construction including landfill and foundation materials
- Isolation of contaminated sites
- Flood and coastal protection, such as beach nourishment
- Land improvement
- Placement on riverbanks

The use that the material can ultimately be put to depends predominantly on the physical characterisation of the material and its level of contamination, i.e. its quality. Some site-specific uses of dredged materials for such uses are shown in Table I.

ENVIRONMENTAL ENHANCEMENT

Dredged materials can provide many of the materials required for environmental enhancement. However, the suitability of the material needs to be established on a site-specific basis taking into account the physical and chemical properties as well as the local legislative requirements.

Environmental enhancement using dredged material includes:
- Habitat creation and improvement
- Water quality improvement
- Aquaculture
- Agriculture
- Recreation
- Sustainable relocation
- Pit filling

Testing is needed to determine the physical and chemical suitability of a dredged material or blend of materials for environmental enhancement uses and to verify that the legislative requirements are met in the same way as for engineering uses.

Evaluation of the proposed site(s) where the environmental use is proposed is also necessary, in order to determine the likelihood of success and to avoid interference with other uses of the area. Some of the criteria that might be needed for site selection include the proximity to the dredged material site, proximity of the proposed development to similar habitats, and the physical/chemical characteristics of natural habitats that are being emulated. For habitat creation, isolation from human activities and isolation from potential feral or non-indigenous predators may also be important.

CASE STUDIES

A large number of case studies (24) are described in the PIANC report in preparation (Working Group 14) and analysed to

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extract "lessons learned". Table II shows the range of uses identified in the case studies.

From the list in Table II, two case studies, one in Belgium and one in the UK, have been selected to describe how dredged material was used for engineering and environmental benefits. These studies demonstrate that a combination of two or more activities, bringing together a need for dredged material with the need to dredge, can provide cost effective and environmentally sustainable solutions.

Table II. Engineering and environmental uses of dredged material in case studies.

No.	Name of Case Studies	Country	Construction Materials	Isolation	Flood and Coastal Protection	Placement on River Banks	Habitat Creation	Habitat Improvement	Aquaculture	Recreation	Sustainable Relocation
1	Controlled flood area	Belgium			•						
2	Mikawa Bay Project	Japan					•		•	•	
3	Fasiver	Belgium		•							
4	The Port of Oakland 50 ft Harbour Deepening Project	USA					•				
5	Galveston Bay, Texas	USA					•				
6	Backfill project at Chiba port	Japan	•					•			
7	New docks in the Port of Aviles	Spain	•								
8	La Victoria Beach (Cadiz)	Spain			•			•			
9	Hamilton	USA			•		•				•
10	Bird Island	USA					•				
11	Wallasea Wetland Creation Project	UK			•		•				
12	Nagoya International Airport Reclamation	Japan	•								
13	New Kitakyushu Airport Reclamation	Japan	•								
14	Onomichi-Itosaki Port	Japan					•		•		
15	Bricks	Germany	•								
16	Capping project: Haringvliet	NL		•							
17	Nature development IJssel delta	NL					•				
18	Scheldt Estuary/Walsoorden	Belgium					•				
19	Mounds of dredged material	NL	•		•		•				
20	Self cleaning road	NL	•								
21	Ca di Mezzo	Italy				•	•				
22	Large Scale Pilot Treatment	NL	•								
23	Humber	UK									•
24	Mudcrete	New Zealand	•								

An example of an engineering use: Rehabilitation of a brownfield site at Fasiver, Belgium
Contaminated and abandoned brownfield sites can be made suitable for industrial activities by covering the contaminated soil with dewatered dredged material. An example is the Fasiver site near Ghent in Belgium (Figure 1). The project at Fasiver provided a combined solution to three problems:

1. A lack of disposal/treatment sites and as a consequence the postponement of maintenance dredging of canals in the area of Ghent, Belgium.
2. The occurrence of brownfield sites (contaminated and abandoned sites) unsuitable for development.
3. The shortage of industrial development areas in the vicinity of Ghent.

In the Fasiver project, a contaminated site of 42 ha was turned into a treatment centre for dredged material. In total some 1.3 million tonnes dry matter (tdm) of dredged material will be processed. The dewatered and treated dredged material is being used to raise the level by

Figure 1. Aerial view of the Fasiver site in the process of being treated with millions of tonnes of clean dredged material.

5 m, ready for building works and the site will be sold as an industrial area. As a result of this combined action, the former soil and groundwater contamination has been cleaned up and industrial land created (Figure 2).

The various partners in a PPP (Public Private Partnership) construction worked together to provide the solution for the three-fold problem. The public partners are the Province of East Flanders and the city of Ghent. The private partners are DEC N.V. as a remediation contractor and DOMO N.V. as owner of the contaminated land.

At first sight, public and private partners had contradictory interests. The private partners want to reduce their risks (the insecurity of public policy and changing regulations) and increase financial return related to the investment, whereas the public partner wants to diminish financial risks and lower the level of financing, which required increased efficiency in execution. Through a public-private partnership these opposing interests were brought in balance and the risks were shared in common cooperation.

The different partners combined their know-how and expertise and worked out:

- The remediation of the site;
- The treatment of dredged material in order to use the treated material for the development of a new industrial area;
- The redesign of the 42 ha to create an industrial area: A master plan was elaborated for the future urban planning.

Fasiver started as a PPP in 1997 with the preliminary design phase. The operational phase started in 2000. By end of 2007 850,000 tdm of dredged material had been treated and used on site. An area of 15 ha will be ready for building and will be developed by the end of 2009. The project is proceeding well and the PPP construction

Figure 2. Dredged material being dried and worked upon at the Fasiver site. A total of 1.3 million tdm will be processed.

seems to be a good formula to operate the whole process in a successful manner.

Critical success factors (lessons learned) at this project are:

- Transforming brownfields into new building areas making use of dredged materials is a long-term project. The set up of the whole concept includes a time-consuming preparation process with all parties involved.
- Multiple risks are associated with the project. The risks should be allocated to the parties which can best control these risks. The PPP construction proved to be a good instrument in risk management.
- Financing the project was critical. As a result of environmental legislation pre-financing was twice as high as in a normal project:
  - acquiring contaminated land implies putting financial bonds in favour of the environmental authorities (an amount equal to the estimated remediation cost);
  - financing was needed for the execution of the remediation prior to the development of the site, i.e. before any financial return could be generated;
- Communication with pressure groups and neighbours is very important. Hearings, open-door days and consultations were organised to gain support from those stakeholders. Broad public support is essential for the successful realisation of a project with social sphere aspects.

An example of environmental enhancement: Wetland creation, Wallasea, UK

A new wetland has been created using dredged material on the north foreshore of Wallasea Island on the Crouch Estuary in the United Kingdom. This followed a decision that a replacement had to be found for an area of marine wetlands, mudflat and salt marsh, internationally important for birds, that was omitted from a Special Protection Area in order to allow port development. It was essential to choose a site on an estuary that would be big enough to attract the number of birds that had used the wetland previously destroyed, but also a site which would not cause damage to the surrounding area or have an adverse impact on those birds that were presently using the estuary.

After three years of study and public consultation, in 2004 Wallasea was chosen as the preferred site, because it is on an estuary big enough to attract the large number of birds using the wetlands.
In addition, the seawalls on the North shore were in poor condition, creating a high risk that without intervention the walls would fail resulting in flooding the island and causing damage to the estuary.

In order to achieve the necessary heights and configurations of wetlands, mudflat and salt marsh, first the height of the land behind the old seawalls had to be raised prior to breaching the walls (Figure 3).

Figure 3. Aerial view of part of Wallasea, prior to breaching the seawalls and flooding the area.

Figure 4. The dredged material was pumped through a pipeline from the vessel into a containment bund on the seaward side of the new seawall.

This allowed the tide to return to the old flood plain. Then a new higher seawall was constructed inshore of the old wall. Behind the new seawall is a new freshwater habitat, and to the seaward of the new seawall is a new area of salt marsh.

The Harwich Harbour Authority regularly dredges 1 million tonnes per year of fine material to maintain depths in the harbour and approach channel, more material than can be relocated within the estuary. This excess would ordinarily be disposed of at sea. After analyses of the material determined that it was of suitable quality and did not contain high level contaminants, this excess, some 700,000 tonnes of fine maintenance dredged material from the Port of Harwich, was pumped ashore into a containment bund on the seaward side of the new seawall (Figures 4 and 5).

The salt marsh arising from this material is 45 metres wide and forms an integral part of the new wall, providing a robust defence against flooding from the sea. In front of the salt marsh, a new landscape has developed consisting of shallow water lagoons and islands which provide feeding, nesting and roosting for the estuary birds (Figure 6). The site has also created open spaces and 4 km of footpaths and in addition to birdlife, the wetland is providing a nursery habitat for fish such as bass, herring and mullet.

The constraints of the project were:

1. Quite a number of permits were required from local and other authorities, but the process was aided by prior extensive public consultation.
2. Impacts on the environment were considered thoroughly, and several local and national nature conservation groups were involved at all stages of the planning process and thus were able to input and modify elements of the design. Also social-economic impacts on people, businesses, fisheries and boats were taken under consideration.
3. The importance of public perception was recognised and major efforts were made to consult with environmental groups and the local community. The public was invited to participate in certain events such as the first flooding of the site. A public footpath was located near the new seawall for viewing the site.

Planning permission was granted in early 2005. Following completion of the project in 2006, monitoring of the changes in morphology of the site and of the wildlife was put in place and will continue for five years until 2011.

Critical success factors (lessons learned) at this project are:

- One of the most critical success factors, as can be seen in the description of all three constraints above, was the participation of a large number of stakeholders in the planning, implementation and monitoring phases of the project. The cooperation amongst the parties, including the Harwich Harbour Authority who supplied the dredged material, the dredging contractor, Westminster Dredging, and those involved on the landward side, such as the land owner and tenant, the public that used the old as well as the new habitats, and those undertaking the construction works, was excellent.
- The tireless and enthusiastic involvement of the project manager, talking, listening and exploring concerns and ideas expressed by all parties was a major contribution to its success.
- Once completed, ownership of various aspects of the project belonged to local stakeholders.

The project showed that if there is good cooperation and planning from the early stage of a project right through to completion, dredged material can be used to provide a solution to a habitat and flood protection requirements.

THE WAY FORWARD

In view of these case studies, and others, the following actions are recommended to encourage and realise the use of dredged material:

Control emissions at source

The implementation of legislation to reduce emissions to water courses through increased source control is essential for a sustainable long-term strategy. Such legislation will improve the quality and increase the available quantity of dredged material for use without pre-treatment.

Promote sustainable relocation

The benefits of relocating dredged material into aquatic systems to maintain or supplement sediment supply should be recognised and thus relocation should be considered a preferred option, where this can be done without harm. Retaining sediments within a water body promotes the development and maintenance of wetlands by reducing the effects of erosion. Public involvement in understanding the value of maintaining these wetland environments through relocation of sediments within the water body is essential.

Adapt or develop legislation for use of dredged material

National policies should not classify dredged material as a waste by default. Regulators must be educated to recognise the usefulness of dredged material. The present legislation for use contains bottlenecks in countries where it is based on waste legislation. In many cases the standards are not adequate for use and may even be conflicting. Approaches, which are relevant for the specific engineering and environmental uses, should be developed. Adaptation or development of new legislation for use may be needed.

Develop methodology for evaluating the net benefit to society of using, rather than disposing, dredged material

Savings on costs for primary resources should be recognised and a proper evaluation of the costs and benefits to society made. Look for economies of scale. All stakeholders need to understand the total value of using dredged material resources. Effective understanding requires the development of methodology for evaluating the short- and long-term financial as well as environmental and societal benefits of using rather than disposing of these resources. This needs to be developed in a holistic manner for the total watershed. The public is a necessary partner with governments on local to global scales.

Develop mechanisms to bring together supply and demand

The demand for building and environmental construction materials needs to be determined on local and regional scales.

These demands then need to be coordinated with the supply and delivery rates of suitable dredged materials. In developing engineering uses, market research should be conducted to determine the capacity for uses. Synchronous timing of the activities may be of critical importance. Intermediate storage may be required. Good technical and management aspects are essential, including planning, process management and quality control. Availability and transport issues are key.

Figure 5. The fine dredged material from maintenance dredging at the Port of Harwich was transported to Wallasea by dredger.

Figure 6. A close up of the newly restored wetlands at Wallasea.

Site-specific conditions, such as the specific nature, heterogeneities in the quality of dredged material and discontinuities in supply, must be taken into account. Potential parties involved need to cooperate in developing schedules for use of the available dredged materials. A Public Private Partnership can be an effective and useful mechanism.

Promote better understanding of benefits and risks of using dredged material

Undertake research and disseminate information to promote better understanding of using dredged material in both engineering uses and environmental enhancement. This will occur through use of applied research on building materials and effectiveness of creating environmental benefits and reducing actual or perceived risks associated with using suitable dredged materials. Decisions need to be based on careful site-specific risk assessments and on possible mitigation measures. Monitoring the achievement of various objectives and developing an adaptive strategy for improving the conditions on these sites is needed.

Conduct pilot projects

Large-scale and real-scale size projects should be performed to gain experience under real conditions and larger-scale applications to better understand costs and benefits as well as potential for success.

Pilot projects are essential to test large-scale treatment and uses in order to gather expertise for use in other projects and to demonstrate effectiveness. These experiences can serve as an example for other projects and are very useful in communication.

Communicate, communicate, communicate

All of the above need to be communicated, for example the actual risks and benefits for the environment are essential to gain support. Communication through a variety of different types of publications, workshops and presentations to many different stakeholders needs to occur to develop a movement that considers dredged materials as valuable resources. The main imperative is to gain trust from the public, regulators and wider stakeholders to overcome the NIMBY attitude - an acronym for Not In My Back Yard which is used to describe opposition to new projects by stakeholders who are nearby the immediate location under consideration, and who would generally prefer the project to be in somebody else's vicinity.

The target group for communication is a broad spectrum of stakeholders in the dredging process, including port authorities, regulatory agencies, the dredging industry, NGOs, researchers, environmentalists, private sector consultants and the wider public.

CONCLUSIONS

Experience worldwide demonstrates that dredged material can be a valuable resource with uses both in water and on land. Major constraints such as locally inadequate legislation need to be overcome, but by far the most important factor in finding effective uses is the engagement of stakeholders at an early stage of planning and continuing to communicate throughout the implementation and monitoring stages of any project.

In both case studies presented here, the importance of winning public support was clear, and the efforts made toward creating understanding amongst all parties was crucial to the success of the projects. With good information the public was able to recognise that the careful use of dredged material can make an excellent contribution to sustainable development.

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