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Since the start of the industrial revolution, people have treated the planet as though its natural resources were endlessly available. In the 1980s an abrupt shift occurred. An awareness of the limitation of these resources awakened a concern for the planet and for future generations. From this concern arose the concept of “sustainability”.

On March 20, 1987 the Brundtland Commission of the United Nations defined the concept as follows: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. In 2005 at the U.N. World Summit the goals of sustainability were reaffirmed and the reconciliation of environmental, social equity and economic demands – the “three pillars” of sustainability known also as the 3 E’s – were recognised.

What has this to do with dredging and maritime infrastructure construction? Everything. The roots of dredging are maintaining harbours, access channels and river depths, but over time the dredging industry has evolved into a major instrument for maritime sustainability, a major proponent for environmental consciousness. Dredging projects worldwide now give the issue of sustainability more and more attention. Dredging R&D is ever more dedicated to finding economic and environmental solutions that are in harmony with social development.

The articles in this issue of Terra demonstrate the multitude of ways in which dredging offers constructive approaches to finding sustainable solutions. The first article focusses on the economic viability of creating new land through reclamation versus attempts to construct homes, recreation and industrial sites in densely populated areas. Land expansion into nearby waters – be it the sea or a lake – gives urban populations room for growth, avoids overcrowding and its associated social ills, and all this with financially reasonable investments.

A second article describes the restoration of a waterfront area that had suffered terribly from a century of industrial development, followed by years of neglect. This newly dredged and remediated area is now a revitalised park and recreational area for the neighbourhood. Similarly, in another article, the difficulties of cleaning up a highly polluted river in a historically industrial site are described. This is a milestone that has taken 30 years to realise. Thanks to modern dredging techniques and environmentally sound treatment methods, as well as the political will to remedy the situation, a turnaround is taking place.

And lastly, the ingenuity of the dredging industry is seen in its ability to balance the economic necessity of a Caribbean country to expand its cruise harbour capacity for the tourist industry – an important economic driver – with a sustainable solution in which coral reefs and hundreds of thousands of indigenous marine life have been transplanted to safe maritime areas rather than being destroyed. The cruise terminal has been built and the ecosystem has been preserved.

As the major dredging contractors spend more time and energy pursuing sustainable solutions, exemplified in such efforts as the “Building with Nature” programme, more highly qualified engineers and environmental scientists are required. And the need for more comprehensive information for clients also increases. For this reason IADC’s Seminar on Dredging and Reclamation remains in demand and is being presented again in October in Singapore. As well the IADC-CEDA Environmental Aspects of Dredging Training Course is being offered in conjunction with CEDA Dredging Days in Abu Dhabi in December. Both events show the dedication of the dredging industry to sustainable development and the commitment of the industry’s leaders to create a better world for future generations.

Koos van Oord
President, IADC
ABSTRACT

Port cities and other coastal areas are centres of economic activity and act as motors for national prosperity. They are magnets for people from surrounding, often rural, areas who seek jobs and want to share in the prosperity. This is true both in the developed world and in economically emerging nations. The United Nations foresee a population growth up to 9 billion people in 2050 of which the majority will live in coastal zones. Adding population growth to the trend of migration from rural to urban areas means port cities face an enormous challenge to accommodate everyone in terms of housing, employment, education, recreation and transport.

More people create more economic activity, which attracts more people, which creates more economic activity. For governing authorities this self-perpetuating process is an enormous challenge to accommodate everyone in terms of housing, employment, education, recreation and transport. Land reclamation – making new land in the sea – can be the answer. To expand in the direction of the sea, port cities and coastal areas must fulfil specific technical and maritime requirements. When they do, land reclamation can be prepared in a way that preserves the maritime environment while providing new living and working spaces. The article will demonstrate through a case study that reclamation is a viable solution for seawards expansion. Early contractor involvement, stakeholder involvement, environmental monitoring and the business case itself will be addressed.

This article was originally published as an Internet contribution for the AIVP “13th World Conference Cities and Ports” and can be found at http://www.citiesandports2012.com or http://www.aivp.org. It is published here with permission in a slightly adapted version.

INTRODUCTION

In 2005 the global population was 6 billion. The United Nations predicts that by 2050 it will grow to 9 billion. While vast areas of land are available throughout the interiors of many countries, the same rule that applied in the ancient times when people settled near seas, oceans and rivers, applies now: Coastal areas attract people. Today about half the world’s population lives within 100 km of water. And this trend continues to grow. Eight of the largest ten cities are along a coast and urbanisation is evident around the world. The demand for additional land for housing, industry and recreation along the coasts is becoming steadily more acute. If cities can’t grow outward, they grow upwards resulting in more congestion in terms of industry, roads and demand for services.

While this trend might have at one time seemed insurmountable, from the 1970s onwards the dredging industry has developed new technologies for creating new land in the water. As a result, “buying” new land by “making” it through reclamation is turning out to be less expensive than developing old land. The old adage, “Buy land – they’re not making it any more” is no longer true.

PIONEERS IN LAND RECLAMATION

The first major land reclamation were done in the 1970s, when the Port of Rotterdam in the Netherlands was extended with sand suppletion from the sea with the first Maasvlakte reclama-
tion (Figure 1). This extension allowed the port to continue to develop and to accommodate more ships and it helped Europoort to add container terminals and become the largest in Europe at the time, providing jobs and stimulating the economy without infringing upon an already congested city.

This was the start of the modern era of land reclamation which rapidly spread around the world. In 1975 the government of Singapore decided to build a new airport on the eastern tip of Singapore. The now famous Changi airport was built with over 40 million cubic metres of sand reclaimed from the seabed, using 7 cutter suction dredgers working 24 hours a day. Reclamation is the highly populated island state has continued through the 1980s, 1990s to the present. Hong Kong’s Chek Lap Kok airport is now legendary for the skill and speed with which it was built – replacing the old airport that had passengers holding their breaths as they cruised in to land between skyscrapers (Figure 2).

But elsewhere airports were also being built on reclaimed land – in Brisbane and Sydney, Australia (Figure 3), and Kansai airport near Osaka, Japan (Figure 2). This trend has continued in the 21st century with projects such as the New Doha International Airport in Qatar (Figure 3).

**NEW TECHNOLOGY MAKES LAND RECLAMATION POSSIBLE**

Expansion into the sea is not just for airports. In the 1970s and ‘80s, land reclamation projects continued to increase. In Japan, near Kawasaki in Tokyo Bay land was developed for industrial estates where for the first time sand was extracted from the seabed from depths that exceeded 80 metres. This was made possible by a deep-suction dredging technique that opened up possibilities for large-scale reclamation. Jurong and Tuas along the coast of Singapore, Keelung and Yun Lin in Taiwan, and big parts of Hong Kong like Penny’s Bay have benefitted from the large-scale applications of the centrifugal pump and the ever-increasing size
Beach nourishment has long been seen as a necessity for coastal protection, but nowadays it is also a form of extending living and recreational possibilities. These improve the quality of life for millions of people. Australia’s coastline and fine beaches are an essential part of the allure of Australia – for its own population as well as millions of tourists each year.

Currumbin-Tugin Beach on the Gold Coast of Australia was in dire straits before reclamation took place (Figure 5). The same can be said of Spain’s Mediterranean and Atlantic coasts and many other coastal areas. The east and west coasts of the United States are also replenished each year and the coastlines of India, Sri Lanka and Indonesia have been restored after the tsunami. The coasts of the Netherlands and Belgium are also replenished annually and new projects such as the Flanders Bays and EcoShape / Building with Nature programmes initiated in those countries are researching more sustainable systems of maintaining these beaches such as the ‘sand motor’ (figure 6). These land reclamation projects are as much for coastal protection as for providing more land for overcrowded cities.

Perhaps the most famous recent coastline and waterfront improvement projects for

of dredging ships, which takes advantage of economies of scale.

In the waters near Amsterdam, the Netherlands new land was created called IJburg, which combined land reclamation and new techniques to build land for residential areas that are now thriving (see opening photo). Even in the Maldives, new land has been claimed from the sea to build a new island called Hulhumale next to Male, the country’s capital (Figure 4). What motivated these reclamation projects so far from each other was the same challenge: crowded, overpopulated urban areas and the availability of modern dredging technology.

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Perhaps the most famous recent coastline and waterfront improvement projects for
expansion purposes have taken place in the 21st century, centred in the Middle East, with massive development projects. Amongst them, the Palm Islands near Dubai, UAE which through land reclamation and construction, has increased Dubai’s coastline with some 150 kilometres. Off the coast of Doha land reclamation has added 400 ha of land, 30 kilometres of coastline and will eventually house 30,000 residents. Development in Bahrain since 2001 has also been extensive and includes the 4.6-km Sheikh Khalifa bin Salman Causeway, the Bahrain Financial Harbour reclamation works, the Bahrain Bay project, Ritz Carlton II and the Bahrain Financial Harbour reclamations works, the Bahrain Bay project, Ritz Carlton II and the Bahrain New Town project, as well as the North Manama Causeway. Although Bahrain, unlike Dubai, has an abundance of coastline, being an archipelago of thirty-three islands with 161 km of coast, its government as well was seeking ways to diversify its economic base (Figure 7).

IS LAND RECLAMATION REALLY LESS EXPENSIVE THAN “OLD” LAND?

As land reclamation techniques improved, so did the number of projects. Successful land reclamation is dependent on a number of factors:

- Removal of unsuitable mud layers
- Sailing distance to disposal areas
- Sailing distances to sand borrow areas
- Costs of dredging licences/permits
- Depth of the area to be filled
- Quality of fill material
- Wave and wind climate

- Available construction
- Availability of modern, hi-tech dredging equipment (Figure 8)
- Production capacity of dredging equipment
- Quality of the contractor
- Early contractor involvement and partnering with the client

After these factors are taken into consideration, the real estate values of each specific case must be considered. Although after the global economic crisis in 2008, real estate values in some of the major cities of the world declined, this has to be seen in the long term as a temporary setback. Both based on demographics, the need to preserve nature and the effects of climate change and consequent sea-level rise, the cost of land in major cities will continue to increase (see Table I). The need for urban space for residential and recreational facilities as well as for expanded ports for sea-borne trade will put pressure on all coastal areas.

Even when taking into account additional costs for elements like shore protection, soil improvement and site preparation, the all-inclusive costs of most reclamation projects have remained below € 500 per square metre. Based on this, land reclamation for residential and industrial purposes is on average less expensive than using existing land.

PRINCIPLES FOR COASTAL DEVELOPMENT

A publication from the Urban Land Institute (2007) suggests ten principles for developing coastal property. The report takes into account the vulnerabilities of coastal areas, as well as their attractiveness and consequently their intrinsic value. The aim of the publication is to draw attention to all aspects of the coasts and to encourage coastal development in a sustainable fashion. Reasonable planning – including dredging in a way that preserves natural habitats and increases accessibility for all citizens – are priorities. Seeking solutions

Table I. Seafront land prices per square metre (2006)

<table>
<thead>
<tr>
<th>Place</th>
<th>Range of land prices in € / m² in 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monaco</td>
<td>25,000 - 35,000</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>19,500 - 31,400</td>
</tr>
<tr>
<td>Singapore</td>
<td>4,600 - 6,200</td>
</tr>
<tr>
<td>Dubai</td>
<td>1,785 - 4,150</td>
</tr>
<tr>
<td>Tokyo</td>
<td>1,250 (average)</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>485 - 625</td>
</tr>
<tr>
<td>Reclaimed land</td>
<td>&lt; 250</td>
</tr>
</tbody>
</table>
that “Build with Nature” and take advantage of soft solutions instead of trying to stop or prevent erosion by hard solutions will increase the chances of success without disrupting the environment and the ecological balance. Be it up and down the European coasts, or the east and west coasts of the United States or the long shorelines of Indonesia, Sri Lanka and India, or Australia and Japan, land reclamation is used for expansion as well as for preventing coastal erosion and has become an important instrument for the conservation, expansion and management of valuable resources offered by living along a coast.

**TWO CASE STUDIES**

**Dubai’s diversified economy based on land reclamation**

Dubai’s economy has traditionally been based on its oil reserves and the industry involved in retrieving it. A few years ago, the Government realised that these oil reserves no matter how rich cannot go on forever and they will not be adequate to ensure a high standard of living indefinitely. The rulers decided that it would be good policy to diversify and find other sources of revenue such as tourism.

Dubai’s warm climate is inviting as a vacation destination, but with a coastline of only 70 kilometres the opportunities for recreational attractions were few. And then thoughts turned to land reclamation. The possibility of artificially expanding the coastline and creating more interesting residential and recreational water-related activities was seen as a viable alternative thanks to the innovative technologies of the modern dredging industry. The results: ‘Palm Jumeirah’, completed in 2005, added 78 kilometres to the existing coastline, which more than doubled the length of Dubai’s coastline. This was the first land reclamation project which used 110 million m³ of sand. It was soon followed by similar and even larger projects, like the ‘Palm Jebel Ali’, ‘The World’, which used 325 million m³ of sand, ‘Deira Islands’, ‘Palm Deira’ and ‘the Dubai Waterfront’. The economic impact of these projects on Dubai has been quite remarkable and has clearly given Dubai a central role in the tourist industry.

**The importance of Florida’s beaches to tourism**

Florida has always been an important tourist destination for Americans and it has one of the longest coastlines in the US with more than 800 miles of sandy beaches along the Atlantic Ocean and Gulf of Mexico. Floridians themselves, needless to say, also enjoy the pleasures of their beaches. For these reasons the Florida Department of Environmental Protection, Bureau of Beaches and Wetland Resources commissioned a study for the Economic Benefits Analysis/Florida Beach Restoration. The information here is adapted from this report, prepared by Catanese Center for Urban and Environmental Solutions at Florida Atlantic University.

To understand the importance of Florida’s beaches, in 1995 nearly 80% of Florida’s residents live in coastal counties and over 60% of Florida’s population lived within five miles of the coast. Over $25 billion, or approximately 25% of the value of Florida’s coastal real estate, could be attributed to beaches. Beaches in Florida are clearly an important economic engine, but erosion is a
serious issue and over 80% of erosion on Florida’s east coast is attributable to impacts of navigation inlets. Mitigating these impacts is essential to the economic health of the State (Figure 10).

According to the Catanese analysis, the economic impact of Florida’s beach visitors in 2000 included 442,000 jobs and over $700 million in sales tax directly paid by Florida beach tourists. According to the study, of the 71 million annual tourists who visit Florida, over 23 million reported going to Florida beaches as a primary vacation activity during their stay. In summary, the total direct and indirect spending by Florida’s beach visitors in 2000 was estimated at $41.6 billion, and over $8 billion in payroll resulted from additional spending related to the state’s beaches.

Using Miami Beach as an example of value for money of beach restoration, for every $1.00 spent on restoration, $700 in foreign revenue is returned. Over a long period the beaches at Miami Beach had eroded considerably, losing their appeal as a tourist destination. Along the East Coast of the US, the Caribbean islands provide significant competition for the tourist trade. To revitalise the tourist trade as an economic force, Miami had to do something. Beach nourishment was undertaken in the 1970s and the investment paid off. Miami attracted 21 million tourists in 1983 compared to 8 million in 1978 (Literature Review, 2003). Project costs were $64 million in 1980 covering 16 km and had a huge impact on the declining tourism industry: 8 million tourists visited a year before the beach nourishment and 21 million visited a year after the beaches were improved. Although this nourishment costs $2 million per year, the tourists in Miami spend $4.4 billion annually of which more than half comes from foreign tourists (Houston, 2002).

The same is true for the entire State of Florida. Data from 2001 shows 62.3 million out-of-state visitors to Florida, with an additional 8.0 million international visitors. Of the 62.3 million domestic visitors, a total of 22.4 million indicated that going to the beach was a primary activity during their stay in Florida.

Maintaining Florida’s lengthy shoreline is no easy task, but in terms of recreation for its residents and for both US and foreign tourists, the investment has proven well worth it. In addition, from an environmental perspective, the beaches provide marine habitat for many species, including endangered and threatened species, as well as storm protection for public infrastructure and private upland development.

CONCLUSIONS

Globally speaking, land reclamation has provided an important solution to increasing land areas for a variety of purposes. From a commercial perspective reclamation has been used for new airports and airport expansions as well as new ports and their expansions. Residential and recreational developments along waterfronts have been successfully constructed through land reclamation. And environmentally, the restoration of coastlines also provides coastal protection for the growing populations as well as for natural habitats of various habitats and species.

But can this land reclamation continue at the same pace as it has in the last 20 years? Does the international dredging industry have sufficient capacity to cope with the present demand for the realisation of maritime infrastructure projects? This is a realistic question that has no simple answer. To look at the international dredging contractors’ level of activity is to realise that their portfolios are quite full and that long-term planning is necessary.

On the other hand, these companies continue to invest in in-house R&D, as well as extensive co-operation with universities and knowledge institutes to maintain the economic advantage of offering land reclamation at a reasonable price. The purchase of innovative dredging plant, larger vessels and hi-tech systems also allows them to keep their cubic-metre price sharp. But the demand for new land is high and involving a dredging contractor early on in land development plans (“early contractor involvement”) is certainly the most economical way of ensuring the best cost price and finding the most feasible solution to match the needs assessment of the client.

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ABSTRACT

The Former Scott Paper Mill site at the Port of Anacortes, Washington State, USA was the location of lumber and paper manufacturing facilities for nearly 100 years. Historic industrial activities at the site contaminated upland soil, groundwater and marine sediments with petroleum-related compounds, dioxins/furans, PCBs, metals and wood waste. The project was a focal point for the Port of Anacortes and the Port sought to increase the public value of the land and provide significant improvements to the shoreline, public access and habitat while meeting the basic cleanup requirements for the site.

In late 2005, Washington’s Governor and the state legislature created the Puget Sound Initiative to clean up, preserve and restore Puget Sound by 2020. After ascertaining that Model Toxics Control Act (MTCA) funding could expedite the Port’s clean-up and redevelopment efforts, GeoEngineers recommended that the Port develop and implement a comprehensive cleanup strategy that would address their contaminated sites. In mid-2011 the Port celebrated the re-opening of the Seafarers’ Memorial Park and the completion of the former Scott Paper Mill clean-up project – the largest project in their comprehensive cleanup programme. This project was the recipient of the 2012 Environmental Excellence Award at the Western Dredging Association (WEDA) meeting in San Antonio, Texas in June 2012. The article here provides further details about the project at the Former Scott Paper Mill site.

INTRODUCTION

The community of Anacortes, Washington State (USA) is located on Fidalgo Bay in north Puget Sound, about 65 miles from Seattle (Figure 1). The Port of Anacortes currently owns multiple properties along Fidalgo Bay and the Guemes Channel. These were historically used for industrial purposes such as paper manufacturing that left behind toxic pollutants in the upland areas and shoreline sediments.

Figure 1. Location map of Washington State and the Port of Anacortes where the dredging cleanup took place.
In late 2005, Washington’s Governor Christine Gregoire and the state legislature created the Puget Sound Initiative to clean up, preserve and restore Puget Sound by 2020.

GeoEngineers recognised that the State’s initiative offered potential Model Toxics Control Act (MTCA) funding that could expedite the Port’s clean-up and redevelopment efforts. With the potential funding stream in place, GeoEngineers recommended that the Port develop and implement a comprehensive cleanup strategy that would address their contaminated sites.

The Port’s targeted sites include a boatyard and marine fueling facility, a former bulk fuel storage facility, a former log haul out facility, a former lumber and paper mill and an operating shipyard facility. In response to the recommendations, the Port engaged GeoEngineers’ team to work collaboratively with the Washington State Department of Ecology (Ecology) to develop its “Focus Fidalgo” environmental stewardship programme, a comprehensive environmental framework that the Port utilises to coordinate the expedited clean-up efforts on Port properties – in partnership with Ecology.

GeoEngineers is providing a full suite of services to the Port of Anacortes as part of their comprehensive cleanup programme, including strategic planning, site investigation, cost modelling and clean-up design, construction management and expert witness. Prior to the Former Scott Paper Mill cleanup, GeoEngineers had completed work for two other Port sites – Cap Sante Marine (Figure 2) and the Dakota Creek Industries marine area.

**THE FORMER SCOTT PAPER MILL SITE**

The Former Scott Paper Mill site at the Port of Anacortes was the location of lumber and paper manufacturing facilities for nearly 100 years. Historic industrial activities at the site contaminated upland soil, groundwater and marine sediments with petroleum-related compounds, dioxins/furans, PCBs, metals and wood waste.

The project was a focal point for the Port of Anacortes, and the Port sought to increase the public value of the land and provide significant improvements to the shoreline, public access and habitat while meeting the basic cleanup requirements for the site.

GeoEngineers worked with the Port to develop an integrated cleanup strategy that included a creative cost-recovery approach to provide funding, agency partnership to provide dedicated project oversight and an aggressive schedule to minimise overall project cost and risk.

The cleanup and restoration of the Former Scott Paper Mill was a three-year, $37 million project. The Port completed work on the project in partnership with Ecology and the Kimberly-Clark Corporation, successor to the mill’s former owner. The project resulted in the cleanup and restoration of the site, enabling the Port to contribute significantly to their environmental stewardship efforts within Fidalgo Bay and return a popular section of the waterfront to safe public use.

The Port of Anacortes’ project team included GeoEngineers as the environmental consultant.
ENVIRONMENTAL BENEFITS

The 41-acre Former Scott Paper Mill site is located on the west shore of Fidalgo Bay in downtown Anacortes. The site, which has approximately 2,000 feet of waterfront frontage, was used for industrial purposes from around 1890 to 1979, resulting in severe contamination of the upland soil and groundwater and marine sediments (Figure 3).

Though industrial activities had been discontinued for decades, the property remained contaminated and the potential costs of complete remediation and lingering technical and legal issues stalled any efforts to redevelop the site.

Under the Port’s Focus Fidalgo environmental programme, which takes an integrated approach to removing contaminants, restoring aquatic habitat and improving public facilities along the waterfront, the Port began working with GeoEngineers in 2007 to determine how it could remediate the site and recover the costs associated with the project.

The Former Scott Paper Mill site was not only the largest of the Port’s Focus Fidalgo projects, but was the largest and most comprehensive shoreline and sediment cleanup completed in Washington under Model Toxics Control Act (MTCA) and Ecology’s Puget Sound Initiative (Figure 4).

Its innovative combination of cost recovery, aggressive schedule and collaborative approach advances the state of the art for remediation efforts throughout Puget Sound and inland waterways elsewhere in the country.

The Former Scott Paper Mill project resulted in the cleanup and restoration of the site, enabling the Port to improve the environmental health of the region, return the site to safe public use and provide an unmatched example of how to effectively and efficiently expedite major cleanup projects.

The Port achieved the following environmental outcomes for the project:

- Cleaned up the site soil, groundwater, sediment and wood debris to the highest environmental standard required by Washington State regulations to ensure protection of human health and the environment.
- Successfully dredged and disposed of contaminated sediment at the site and backfilled with dredged material from an adjoining channel to create eelgrass habitat (see dredging details under “Innovations and Beneficial Uses” below).
- Created new shoreline habitat in a formerly degraded portion of the bay.
- Replaced an existing failing federal breakwater with a new structure that will facilitate better water circulation while protecting the newly remediated shoreline and adjacent marina facility.

INNOVATIONS AND BENEFICIAL USES

The Former Scott Paper Mill site is the largest of five projects that integrate remediation, habitat restoration, redevelopment and public access improvements into a single and coordinated effort. The project was divided into four phases to accommodate ongoing site uses and construction sequencing and included technical highlights which are described here further.
Complex dredging and disposal logistics

Approximately 54,000 cubic yards of sediment, wood, and debris were dredged at the Site for open water and upland disposal and 37,000 cubic yards of material were dredged from a nearby navigation channel and used on site as fill to create eelgrass beds at the site. Dredging was completed by Pacific Pile and Marine using a barge-mounted Hitachi 1200 with buckets and location control equipment especially adapted for marine construction (Figure 5).

Dredged materials that were determined to be not suitable for open-water disposal were offloaded at a pier-side processing facility and prepared for transport to an upland landfill facility. Approximately 21,000 cubic yards of material were eligible for open-water disposal at the Port Gardner, Washington open water disposal site. This is about a 12 hour round trip by barge from the site. The dredged material contained significant amounts of wood that periodically fouled the bottom dump barge. A sediment-processing facility was constructed to effectively remove the wood debris before returning it to a barge for open-water disposal and to process the contaminated dredged material that was brought directly to the landfill. Approximately 37,000 tonnes of contaminated sediment and wood debris were processed and transported by truck for landfill disposal.

Creative waste-stream management

Contractors excavated approximately 93,000 cubic yards of contaminated soil, sediment, wood and debris from upland areas for landfill disposal. Crews offloaded the upland material and parts of the dredged material to a sorting facility at a nearby marine terminal where they used screening machines to separate the wood and rock from the fine-grain sediments and amended the contaminated material for shipment. Rock reclaimed from the materials-sorting process was returned to the site for use as backfill, effectively lowering the overall disposal and materials purchase costs (Figure 6). Contaminated wood debris was separated and dried prior to transport to the landfill, effectively lowering the overall weight and saving on the disposal costs.

Habitat elements

A multi-acre offshore eelgrass habitat was created using dredged material from an adjacent channel and eelgrass salvaged from the site prior to construction. Also, the beach was softened for fish habitat by backfilling dredged areas with clean sand and gravel (Figure 7). A shoreline riparian area comprising native trees and shrubs was created to enhance the fish spawning habitat.
Overcoming site constraints
Shallow water around the entire marine area of the site required the team to carefully coordinate offshore construction activities around tide conditions. The project required extensive shoring to allow the shoreline excavations to be completed outside of the in-water work window and to assist dewatering. The team constructed wave attenuation structures offshore to control future erosion at the site. The project was also subject to intensive water-quality restrictions to prevent contaminant loss from the site. No water quality exceedances were measured throughout the duration of the project.

Data management and sharing
GeoEngineers developed an internet-based GIS system that was accessible by the multiple involved parties and allowed the project team to view construction progress data in real time, enabling efficient and sound decision making capabilities throughout the life of the project. The online system provided an effective mechanism for inspecting the offshore dredging, disposal and rock building work relative to the contract drawings.

ECONOMIC BENEFITS
The Former Scott Paper Mill project is notable for the creative and efficient strategy that the Port, GeoEngineers and Ecology used to address the cleanup challenge. This successful approach included a number of economic, cost-saving and community benefits.

Cost recovery
The Port had envisioned cleaning up the Former Scott Paper Mill site for many years, but the cost of fully remediating the contamination was prohibitive. The Port was successful at recovering the majority of its costs for the Former Scott Paper Mill cleanup through third-party funding and Ecology grants while maintaining desired land uses and redevelopment plans.

Aggressive schedule
One of the greatest threats to the health of Puget Sound is contamination that leaches into the water and sediments from historical industrial sites. This has been a pressing issue for decades, but most landowners lacked the financial and technical resources to clean up and redevelop these properties.

The project team and Ecology set an aggressive schedule for the site cleanup with the goal of creating a new model for cost and administrative efficiency on large cleanup projects. Crews kept the project on schedule and on budget by running 24 hours a day, seven days a week, when necessary (Figure 8). GeoEngineers led the efforts to successfully complete the Remedial Investigation, Feasibility Study, Draft Cleanup Action Plan, remedial design, permits and contract bid packages for this approximately $37 million cleanup project in about 36 months. By comparison, the Department of Ecology had reported that the average cleanup project of this nature can take up to 15 years to complete.

Contracting
The marine construction work was completed within the anticipated project schedule without significant non-owner directed change orders.

Figure 7. The beach was softened for fish habitat by backfilling dredged areas with clean sand and gravel.

Figure 8. Crews kept the project on schedule and on budget by running 24 hours a day, seven days a week, when necessary.
The use of relatively small scale water- and land-based equipment in coordination with tidal windows demonstrated how close coordination of the engineering and construction elements can achieve successful results in draft-limited environments.

The sediment processing system established as part of the project serves as a model for efficient materials handling. Reclaiming usable materials from the dredged material and dredging adjacent navigation channels for beneficial-use materials provides a solid example of how cost efficiencies and recycling can be applied with careful planning.

OUTREACH AND EDUCATION
Throughout the project, the Port participated in an educational outreach programme that provided training and study areas for the Anacortes School District and undergraduates attending Western Washington University, as well as providing a summer engineering intern position at the site. During the project, the Port provided workshops to multiple regulatory agencies to show the in-field application of innovative stormwater management and other best management practices. In addition, the Port held regular community tours and other community interest updates, and has provided educational interpretive signage along the new esplanade.

As a result of the Scott Paper Mill project and related cleanup efforts on Focus Fidalgo, the Port has embraced environmental stewardship as central to its mission, and the agency now enjoys a highly favorable relationship with the Anacortes community and is developing a regional and national reputation as an environmental leader.

Businesses were able to operate without significant disruption throughout the project and now benefit from improved infrastructure and access. Additionally, construction activities contributed millions of dollars to the local economy through purchase of goods and services and provided employment to a number of local workers.

Transferability
This combination of cost recovery, aggressive timeframe and collaborative approach resulted in a successful model that is transferable to other sites, advancing the state of the art for upland and nearshore remediation efforts throughout Puget Sound and inland waterways elsewhere in the country. For instance, the project serves as an example of how to safely conduct a major marine and upland construction project. No safety incidents were recorded for the duration of the project.

The project achieved the following key outcomes:
- Revitalised part of the Anacortes waterfront, delivering environmental, recreational and economic benefits to the Anacortes community.
- Cleaned up contaminated soil, groundwater, sediment and wood debris from a waterfront property in an important resource area.
- Used sophisticated dredging and marine construction approaches to both remove contaminated material and create new marine habitat.
- Successfully recovered the majority of the project costs and avoided expensive contract claims.
- Completed the project on a very accelerated schedule, helping to reduce overall costs and achieve regulatory approval.
- Provided significant economic stimulus to the State economy during a major economic downturn.
- The project was completed without a recordable health and safety incident.

In mid-2011 the Port, the contractors and the community celebrated the re-opening of the Seafarers’ Memorial Park and the completion of the Former Scott Paper Mill clean-up project.
ABSTRACT

To develop the Falmouth Cruise Ship Terminal in Trelawny, Jamaica, Boskalis Westminster St. Lucia Ltd. executed the dredging and reclamation works required. A large-scale environmental mitigation plan was conducted to preserve benthic marine resources and the magnitude of this project has made it potentially the largest coral relocation exercise in the world to date. Maritime and Transport Services Limited (MTS) executed this relocation project, which started in August 2009, and by April 2010, 147,947 items (8,975 soft coral; 137,789 hard coral and 1,183 sponges) were successfully relocated. An additional 2,807 sea urchins, mainly Diadema were relocated from the dredging area, as well as numerous sea cucumbers, hermit crabs, conchs, sea stars and lobsters.

To determine the biological success of the relocation exercise, time series photographs of 400 colonies were taken on three occasions: October 2009, April 2010 and April/May 2011. In April 2010, partial colony mortality and algal overgrowth were observed but no total colony mortality was found. In April 2011, cases of total colony mortality were observed, as well as new incidences of disease, but preliminary results indicate that 86% of the colonies relocated in 2009 were accounted for in 2011 and only 4% of the monitored colonies showed total colony mortality.

The authors wish to acknowledge the contributions of Peter Wilson Kelly and Timothy Burbury, both of Maritime and Transport Services Limited. The article was first published at the Proceedings of the 12th International Coral Reef Symposium (ICRS), Cairns, Australia, July 2012. It is published here with permission in an adapted version.

INTRODUCTION

In 2009, the Port Authority of Jamaica (PAJ) and Royal Caribbean Cruiselines (RCCL) received Permits and Beach licenses from the National Environment and Planning Agency (NEPA) for the development of a cruise ship terminal at the historical town of Falmouth in Trelawny. The project was awarded to E. Pihl & Son A.S. (main contractor) and to Boskalis as a subcontractor for the marine works.

The intended marine works consisted of dredging an access channel to -12.5 m CD through an offshore reef system and two berthing pockets alongside the terminal to a depth of -11.5 m CD (northwestern side) and -10.5 m CD (southeastern side) and land reclamation along the existing shoreline to improve berthing facilities. The Cruise Ship Terminal in Falmouth was designed to host the largest cruise ships in the world, “Oasis of the Seas” and the “Allure of the Seas” (Figure 1). The Environmental Impact Assessment (EIA) conducted in 2007 indicated that there were seafloor-dwelling marine resources within the footprint of the proposed structure (TEMN and Mott Mcdonald 2007) (colored patches in Figure 2) and sensitive ecological features in the vicinity of the project location (mangroves and bioluminescent phytoplankton). However, initial surveys showed that the entire northern section of the dredge footprint was also colonised by corals.

Therefore, specific conditions of the permits and licenses spoke to the need for the development of mitigation plans for the
sensitive benthos, mangroves and the luminous lagoon that would be impacted by the construction and dredging works to be conducted. The sensitive benthos included mobile organisms (urchins, cucumbers and starfish) and sessile organisms (sea grass, sponges, hard and soft coral). Impacts included the loss of habitat and biodiversity, loss of coral cover, loss of fish habitat, loss of seagrass beds, loss of bioluminescent phytoplankton, turbidity and sediment dispersal.

**ENVIRONMENTAL MANAGEMENT PLAN**

Boskalis developed an Environmental Management Plan (EMP) to mitigate and monitor environmental impacts as a result of dredging and reclamation activities. The EMP consisted of:
- Water quality monitoring; parameters to be monitored were turbidity, dissolved oxygen and water temperature;
- Installation of silt screens;
- Relocation of benthic flora and fauna;
- Installation of a submerged pipeline for sediment laden excess water;
- Installation of reef havens and reef towers.

The magnitude of the coral relocation during this project is potentially the largest recorded coral relocation exercise in the world to date. This article describes the applied work method and the results of the relocation.

**RELOCATION**

Maritime and Transport Services Limited (MTS) developed a large-scale benthic relocation (hard and soft corals, gorgonians, starfish, lobsters, sea cucumbers and other marine life) programme including an initial survey, gridding and tagging activities, as well as relocation activities. The survival (relative health and attachment status) of a subset of coral colonies was monitored over an eighteen-month period and an independent assessment of coral cover and general benthic health (in relation to reference sites) was also conducted.

**Site description**

The entire Jamaican coastline is fringed by an extensive reef which drops to roughly 1,000 m off the Falmouth coastline. The Falmouth Harbour can be described as a shallow, natural harbour with a depth of 1 m (by the Old Wharf) to a maximum of 12 m (in the shipping access channel).

The Oyster Bay (located east of the Falmouth Harbour) can be described as very shallow owing to the continuous influx of river sediments. Globally this is well known as the Glistening Waters (bioluminescent bay); one of only four of its kind in the world, it is considered a sensitive ecosystem (Seliger and McElroy 1968). Its bioluminescence is caused by the densities of *Pyrodinium bahamense*.
ASTRID KRAMER
has a MSc in Ecology from Leiden University, The Netherlands. She has been working as a project engineer for Hydronamic, the in-house engineering company of Boskalis for over five years. She advises projects in ecologically sensitive areas and is involved in large-scale environmental monitoring programmes. She has been working on Boskalis projects in a variety of countries such as Angola, Kenya, Canada, Abu Dhabi, The Maldives and Suriname.

IVANA KENNY
studied Zoology at the University of the West Indies continued with a MPhil in Scleractinian Coral disease and since then has been studying coral disease and reef organisms. She has undertaken marine assessments and benthic relocations for an assortment of environmental companies like Maritime and Transport Services (MTS), including that of the Falmouth Cruise Ship Terminal, which involved potentially the largest relocation globally to date.

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rang from 44,000 (Webber, et al., 1998) to 273,000 (Seliger, et al., 1970) individuals/L. The dominance of this bioluminescent plankton could be threatened by changes in water circulation and chemistry. The worksite is bounded to the west and south by the town of Falmouth and the mangrove system of the Martha Brae estuary. The impact assessment showed the presence of corals on the slopes of the existing access channel and nearby reef flats at depths which varied from less than 5 m up to 12 m (shown as reaping areas in Figure 4).

Some 112 animal species were identified on the reef in the footprint of the dredge area including 22 scleractinian corals, 29 algae, 8 sponges, 15 invertebrates and 45 fish species. Coral cover was as high as 30% in areas and Diadema antillarum, the keystone invertebrate herbivore (Lessios, et al., 2001), had densities of 8–13 individuals per m² (TEMN Ltd., 2007). The NEPA permit required the harvesting of all hard and soft corals with a colony diameter of 5 cm or larger from the dredge footprint and subsequent transporting of these colonies to nearby reception sites located between 500 m and 1,500 m from the donor area.

Work area delineation
The work area (footprint of or area to be dredged and the relocation sites) was defined by an extensive, continuous 10 x 10 m grid system. Using a compass and basic geometry, parallel north-south lines were fixed to the substrate, using rebar hammers and rope and then the east-west lines were overlaid. The grid system facilitated the systematic removal and reattachment of organisms, by allowing divers to clear an area in visible units. The grid system was classified, both in theory and on the ground, in order to facilitate underwater navigation and reporting.

Owing to time constraints dredging (Figure 3) and relocation activities had to take place simultaneously. Consequently, the dredging and relocation activities were carefully planned. There were four gridded reaping areas within the dredge footprint (Figure 4) comprising 1,107 grids (over 11 hectares). Corals were relocated to areas with features identical to their originals. Aspects that were taken into account here were:

• Water depth and movement
• Angle (slope or reef flat)
• Location (exposed or sheltered)

Figure 3. Work in progress at the Falmouth Cruise Terminal. Grab Dredger Packman was responsible for removing the soft dredged material during the first phase.

Figure 4. Layout of coral relocation programme with reaping areas in red (the access channel) and receiving area in blue.
Coral relocation
Divers, using both surface supply and scuba, were organised into four teams; harvesting, transporting, reattaching and monitoring. A topside support team was responsible for filling scuba tanks, and providing food, epoxy, cement and so on.

Harvesting
A reaping team responsible for the careful detachment of corals using hydraulic chain saws, disc saws, chipping hammers and wire brushes and the placement of the corals in transportation baskets (Figure 5).

NEPA specified that all hard and soft corals, with a colony diameter of 5 cm or larger, be harvested and transported to nearby reception sites (between 500 m and 1,500 m away). Colonies were detached with a 10-inch buffer using hydraulic chain saws and disc saws and eventually at the point of attachment (using impact tools like hammers and chisels or pry bars) to reduce fragmentation and facilitate handling. Where possible, colonies were detached in units (more than one colony or organism) to maintain community structure at a micro level.

Transport
The transport team was responsible for the transport of corals from the reaping area to the planting area. They packed the detached colonies in single layers and floated them sub-surface in mesh baskets using lift bags. These baskets were then towed from the harvesting area to the reattachment areas.

Reattachment
The planting team was responsible for the attachment of corals using epoxy or cement and in some cases, pins as well as pneumatic drills and compressors. Chipping hammers and wire brushes were first used to clean and prepare the substrate and the base of the colony; then epoxy or specialised cement, and in some cases, pins, pneumatic drills and compressors were used as bonding agents.

The specialised epoxy used could be kneaded underwater and the cement was premixed on deck and portioned into plastic bags, both were lowered to the divers on demand.

NEPA specified that colonies should be placed 0.5 m apart and where possible colonies were oriented based on shape; plates were fixed at an angle and the upper surface determined by the grooves and the potential for colony surface sand transport. Periodic checks were made to ensure reattached colonies were stable.

Monitoring
The environmental team was responsible for data collection, gridding and tagging, addressing scientific issues as they presented themselves and assisting the three teams when necessary. A colony/organism count of harvesting area 1 (29% of the gridded area) was conducted and the total number and species distribution of colonies to be relocated extrapolated. Each basket had a “license plate” and for each tow, the license was recorded as well as descriptive data, like the number of organisms. This along with the location of origin and destination was used to track the number of colonies reaped or planted per day. The monitoring team also verified whether grids were “cleared” by the reaping team or fully “planted” by the planting team.

In order to determine the biological success of the relocation exercise, a sample of colonies (15 grids) were photographed in October 2009. These grids were chosen based on the disparity in the conditions: depth, wave action, proximity to dredging, source of colonies and time of planting. On the completion of the project the representative sample size was determined according to Yamane (1967) and time series photographs were taken on two additional occasions; the

Relocated coral species distribution

![Figure 6. Distribution of coral species relocated in Falmouth, Jamaica. CARICOMP based species codes: *more than one species of same genus and similar growth form recorded as one; ** extensive branching growth form thus underrepresented in counts.](image-url)
end of the project (2010), and a year later (2011), eighteen months in total. The independent agency (TEMN) also monitored activities, before, during and after the relocation exercise.

RESULTS AND DISCUSSION
In eight months, a team of 93 people successfully relocated 147,947 organisms, including; 8,975 soft coral; 137,789 hard coral; and 1,183 sponges.

There were four gridded harvesting areas within the dredge footprint comprising 1,107 grids (over 11 hectares) and a variety of conditions – from dense sediment-laden channels, patch reefs, and walls to sparse reef flats. The relocated colonies come from 24 hard coral species and roughly 24% were *Siderastrea siderea*, 18% *Agaricia spp.*, 10% *Porites astreoides* (Figure 6). It was mandatory that all colonies, whether diseased, bleached, exhibiting partial mortality, branching or foliose were relocated and colony size ranged in diameter from 5 cm to >1 m.

Branching and foliose colonies proved difficult to harvest, especially large extensive colonies of *Madracis mirabilis* or *Agaricia spp*. While large colonies sometimes proved challenging to transport, some had to be walked or floated individually from harvesting site to planting site (Figure 7).

Monitoring
A representative sample size of 398 organisms was determined using Yamane’s sample size formula (Yamane, 1967). Consequently 11 grids (containing 400 colonies – both hard and soft coral) of the 15 grids photographed at time zero (October 2009), were photographed upon completion of the project (April 2010 - 7 months) and a year later (April/ May 2011 - 18 months).

Five of these grids (158 colonies) were in an area called Spider Reef, a shallow (<10 ft.), reef flat west of the dredge and fill footprint; 7 grids (257 colonies) in an area called Chub Castle, north-west of the main dredge and fill footprint in deeper water (<50 ft.). These grids were chosen because they used both epoxy and cement to fix colonies, would have been exposed to the elements for longest, were planted by the divers before they became experienced and would be differentially affected by sedimentation from the dredge activity owing to location. Colonies were not permanently tagged, instead they were tracked by photograph and the location of grids was mapped using “landmarks”.

The photographs were catalogued based on the area, grid and colony, i.e the first colony in grid 1 was called 1A and that of grid 2 called 2A and so on. In April 2010, of the photographs taken, 357 colonies were identified and catalogued as colonies photographed in 2009, and in April/May 2011, 345 colonies were identified and catalogued as colonies photographed in 2009 (Figure 8). The 14% of colonies not identified could be because of detachment or changes in morphology. Coral

![Figure 7. Left, A close up of a hard coral colony in a basket ready for transfer. Coral was transferred by being loaded into hanging baskets and then walked by divers to the designated reattachment area (middle) or towed by a boat when weather conditions allowed it. Right, Lowered basket being ready for planting.](image)

![Figure 8. Number of relocated colonies identified per year.](image)
colonies did not have permanent tags and sometimes colonies could not be recognised as a result of changes in appearance and attachment marks being overgrown.

The greatest difference was observed at Spider Reef in 2010. Spider Reef, the first shallow location planted, was discontinued because of severe wave action during storms. Some 39 colonies, both relocated and native colonies, were detached following a “north-wester” storm event and were relocated.

Initially the relocated colonies are easily differentiated owing to the removal of macroalgae, the visible epoxy or cement used to fix colonies and the flagged nail marking the location. Over time, however, natural processes made this more difficult: Macroalgae overgrew nails and colonies, while disease, bleaching and thus partial mortality changed the appearance. Consequently, some photographs were identified as relocated but could not be matched to a particular colony photographed in 2009.

Relative health
The relative health of the relocated colonies was also assessed. Colonies were classified as healthy (no obvious signs of ill-health – hyperpigmentation, hypopigmentation, new partial mortality), stressed (diseased, bleached, exhibiting partial mortality) or dead. Health increased in 2010 from 66% to 88%, but decreased in 2011 to 67% back to original levels (Figure 9).

The percentage of partial mortality and the occurrence of disease increased over time. At Spider Reef the percentage of colonies that exhibited partial mortality increased from 27% in 2009, to 30% in 2010 and 43% in 2011, while at Chub Castle partial mortality increased from 22% in 2009 and 2010 to 38% in 2011 (Figure 10). Four disease types were identified on the monitored colonies and an additional category, called disease (D), included diseases that could not be identified (dormant).

White plague (WP) was by far the most dominant in all sample. Black band (BB) was only observed during the 2011 sampling event, where it was the second most dominant disease (Figure 11). Note that only the occurrence of diseased colonies was noted, consequently, colonies which were previously diseased, but now dead were not counted.

The initial improvement in colony health (2010) is expected as the process of harvesting, transporting and planting can be stressful on a colony, resulting in changes in pigmentation and increased susceptibility.

Additionally, the conditions from which the colonies came were also variable; two source sites were very turbid (no visibility), because of the riverine input of the Martha Brae. Consequently changes in turbidity (light attenuation) led to changes in the clade and density of zooxanthellae and thus changes in pigmentation and initial assessments (2009) would reflect this.
The subsequent decline in health (2011) could possibly be attributed to seasonal outbreaks of diseases (colonies which contained diseases were relocated), which could have spread to other colonies, increased sedimentation as a result of started dredging activities or temporal increased sedimentation deriving from the Martha Brae River and land use in the upper watershed. Even though relative health, partial mortality and occurrence of coral disease has increased during the 18 months of monitoring, only 4% of the relocated colonies identified was observed dead (Figure 9). The independent monitoring exercise conducted by TEMN Ltd. (2011) indicated that at both relocation and reference sites no significant change in coral or macroalgal cover was observed between July 2010 and February 2011.

As Yap (2004) indicates: One year is sufficient to evaluate the success of a coral relocation and two distinct monitoring agents have reached the same conclusion. This confirms that the relocation has been successful and resulted in the survival of thousands of corals where as in the past these were usually sacrificed for coastal development (Figure 12).

BUILDING WITH NATURE
Sensitive ecosystems such as coral reefs, seagrass meadows and mangroves are being affected worldwide by the effects of large-scale processes like climate change. However, small-scale man-induced activities such as dredging can also have a serious impact. For this reason, dredging projects in sensitive environments usually come with severe environmental constraints, even though the underlying relationships between dredging impacts and ecosystem responses are only poorly understood.

Dredging is often a pre-requisite for sustainable development of coastal safety against flooding, marine and inland infrastructure and land reclamation. Historically, the role of dredging contractors in these projects concerning the protection of sensitive ecosystems can be characterized as "passive". Dredging contractors traditionally used to comply with these constraints and their role was focussed solely on carrying out appointed mitigation or compensation measures covering project impacts.

Understanding of the relation between dredging and ecosystem health was somewhat limited. The latter often resulted from the lack of available tools and knowledge to predict the behaviour of sensitive ecosystems as a function of dredging operations. However, stimulated by the tightening of environmental requirements and a growing awareness of the role of coral reefs, seagrasses and mangroves in biodiversity, the contractor’s perspective towards dredging near sensitive receptor sites has changed and they presently develop innovative approaches, which adopt the ecosystem as a starting point for the design and realisation of marine infrastructure projects.

The aim is to develop alternative work methods and mitigation measures that are effective, efficient, allow projects to be carried out in a responsible manner and reduce project risks. This perspective is illustrated by the strong collaboration between ecologists, biologists and Boskalis during the development of the Falmouth Cruise Ship terminal.
Worldwide, coral relocation, seagrass relocation and mangrove restoration have become a more common mitigating measure proposed or required by governance bodies. Large-scale relocations as demonstrated in the Jamaican project are logistically and financially complex and may have an uncertain survival success. Thorough understanding of the ecology and physical parameters of both the donor and the receiving reef is essential if corals are to be properly relocated and kept alive. Additionally there are many risks which can hardly be controlled such as the weather, ship groundings, and diseases. Direct cooperation with recognised coral scientists, capable of monitoring and adjusting the work method as required are therefore essential aspects of a relocation programme.

The new approach allows all “stakeholders”, including the natural eco-system, to benefit and aims to eventually develop a complete ecosystem-based approach where the ecosystem has shifted from being a side issue to becoming the focal point of a project. Coral relocation is already a step in this direction, but the focus is still on mitigation as direction, but the focus is still on mitigation as the coral reef system has still not been placed in the centre of the design. Clearly more time will be required to collect all the necessary data on the functioning of the ecosystems before work can begin with a fully ecosystem-based design. This comprehensive approach will require several key elements:

• A thorough understanding of the resilience of key species to dredging-related impacts;
• Inventory of information on size and nature of dredging impact;
• Validated tool to translate the impact of the dredging works on the key species and ecosystem as a whole.

The research and innovation programme “Building With Nature” of the EcoShape Foundation (www.ecoshape.nl) focusses on this approach by developing adaptive monitoring strategies that link impact measurements near sensitive habitats directly to dredging operations and aims to create useful tools to design dredging projects in a more sustainable way. The further development of the Building With Nature approach will contribute to the sustainable realisation of marine infrastructures near sensitive areas in the near future.

CONCLUSIONS

The coral relocation programme executed during the development of the Falmouth Cruise Ship Terminal is potentially the largest coral relocation project known to date. In eight months, a team of 93 people successfully relocated 147,947 organisms.

Based on colonies monitored, 86% of these colonies remained attached eighteen months later, and only 4% died. Although relative health increased within 6 months of relocation (2010), partial colony mortality, disease and algal overgrowth increased with each sampling event and by 2011 (eighteen months) relative health returned to 2009 levels, with cases of total colony mortality observed, as well as new incidences of disease. This success rate may be linked to the lack of selection pressure, as in compliance with governance requirements, colonies were transplanted with > 50% partial mortality, active disease, and evidence of bleaching, all of which limit the long-term viability of colonies. It may also be linked to lack of permanent identification tags and thus the inability to identify and match colonies resulting from changes in appearance.

Although, no reference site or colonies were monitored in this survey, the independent monitoring report, which included both reference and relocated colonies, reported no significant change in coral or algal cover at reference and relocation sites assessed.

REFERENCES


ABSTRACT

Dredging sediment to a depth of 3.7 metres (12 feet) below sediment surface and transporting it to a separate site for processing without increasing the volume of material and associated handling and disposal requires innovative approaches. The objective of the work is to remove sediments with the highest dioxin concentrations in the Lower Passaic River Study Area. Phase I of the Lower Passaic River Removal Project, currently underway, is being completed within a sheet pile cofferdam approximately 0.8 hectares (2 acres) in size to isolate the work area from the surrounding river and to control tidally-influenced water levels to provide adequate draft for dredging equipment. During pre-design investigations, the sediment was characterised in-situ as Environmental Media (EM; waste that does not demonstrate hazardous characteristics which can be directly disposed of at a landfill), or Hazardous Waste (HAZ; waste that requires incineration prior to disposal) to determine disposal.

The sediment is being mechanically dredged, screened and slurried, and transported through a hydraulic pipeline to an upland processing facility (UPF) approximately 0.4 kilometres (0.25 mile) downstream of the project site where it is being dewatered using membrane presses. The dredging is being sequenced to remove the sediments classified as EM separately of those classified as HAZ. Surveying and tracking techniques are being employed to track the sediments through the dewatering process to final disposal. From the UPF, the material is being transported by rail to either a landfill or an incineration facility depending on the waste classification. After dredging, the Phase I Work Area is being backfilled to grade.

Dredging started in March 2012, with production dredging beginning after a two-week startup period. Production rates are consistent with the target design rate of 382 cubic metres (500 cubic yards) per day. To date, the membrane presses are exceeding the percent solids design criteria.

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INTRODUCTION

An Administrative Settlement Agreement and Order on Consent (AOC; USEPA 2008) was entered into by USEPA, Occidental Chemical Corporation, and Tierra Solutions, Inc. in June 2008, specifying removal and disposal of 152,910 cubic metres (m³; 200,000 cubic yards [cy]) of Passaic River material located adjacent to Operable Unit 1 (OU-1) of the Diamond Alkali Superfund Site. The site is located at 80 and 120 Lister Avenue, Newark, New Jersey, at approximately River Mile 3.4. The AOC identified two distinct phases of work:

• Phase I, targeting approximately 30,580 m³ (40,000 cy)
• Phase II, targeting approximately 122,330 m³ (160,000 cy)

This article discusses the design and construction of Phase I of the work. The main objective of Phase I is to remove the highest concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and associated dioxin mass. To achieve this objective, dredging will be
conducted to 3.7 metre (m; 12 foot [ft])
below sediment surface (BSS) within the
footprint of the Phase I Work Area. The
Removal Action activities are being conducted
under the Comprehensive Environmental
Response, Compensation, and Liability Act
(CERCLA) and the National Oil and Hazardous
Substances Pollution Contingency Plan as a
Non-Time-Critical Removal Action. A Phase I
Engineering Evaluation/Cost Analysis (Phase I
EE/CA; Tierra 2008) was prepared to develop
and evaluate removal alternatives.

Initial Phase I construction activities, including
mobilisation, construction of the steel sheet
pile enclosure and preparation of the UPF,
began in July 2011. Dredging began in March
2012. The construction is scheduled to be
completed in November 2012.

SITE DESCRIPTION
The Phase I Work Area is located within the
Harrison Reach of the LPRSA; the LPRSA is
approximately 27 kilometres (km; 17 miles)
long and extends from the Dundee Dam near
Garfield, New Jersey, to Newark Bay. Figures 1
and 2 illustrate the extent of the LPRSA and
the Phase I Work Area.

The Phase I Work Area is approximately 0.8
hectares (2 acres) in size, measuring 229 m
(750 ft) long by 34 m (110 ft) to 41 m (135 ft)
wide. The Phase I Work Area is adjacent to a
federal navigation channel with an authorised
depth of -6.8 m (-22.4 ft) National Geodetic
Vertical Datum of 1929 (NGVD29). The Phase
I Work Area is located completely outside of
the navigation channel, but approaches the
navigation channel boundary at a distance of
approximately 7.6 m (25 ft) at its western
end. At the widest point of the Phase I Work
Area, the Passaic River is approximately 168 m
(550 ft) wide, and at the narrowest point,
it is approximately 122 m (400 ft) wide.
Generally, the Phase I Work Area sediment
is fine-grained, cohesive material classified
as moderate to high plasticity organic silt
and clay. The average flow near the Phase I
Work Area is approximately 41 cubic metres
per second (1,450 cubic feet per second).
The Passaic River is tidal, with about a 1.8 m
(6 ft) tidal fluctuation at the project site.
The Phase I Work Area is regularly exposed
during low tide conditions, as shown in
Figure 3.

Figure 1. LPRSA and
the Phase I Work Area.

Figure 2. Phase I Work Area
and Upland Processing
Facility location.
**REMOVAL ACTION OBJECTIVES**

The removal action objectives (RAOs) for the Phase I Removal Action, established to determine the relative success of the work, are listed below (USEPA 2009):

- **RAO #1**: Remove a portion of the most concentrated inventory of dioxin (2,3,7,8-TCDD) and other hazardous substances to minimise the possibility of migration of contaminants owing to extreme weather events.

- **RAO #2**: Prevent, to the maximum extent practicable, the migration of resuspended sediment during removal operations through appropriate engineering controls, monitoring, and such.

- **RAO #3**: Prevent, to the maximum extent practicable, the potential for spillage or leakage of sediment and contaminants during transport to the disposal facility.

- **RAO #4**: Restore habitat. (Restoration of the Phase I Work Area will be coordinated with the activities of the bordering Phase II Work and will not occur until Phase II is completed.)

**PROJECT DESCRIPTION**

The project consists of nine distinct components which are described below: Sheet Pile Enclosure; Sediment Removal; Hydraulic Pipeline; Upland Processing Facility (UPF); Sediment Processing; Water Treatment; Off-Site Transportation, Treatment and Disposal; Backfill; and Air Emissions.

**Sheet pile enclosure**

Per the 2008 AOC (USEPA 2008a), removal activities are being completed within a sheet pile enclosure. The enclosure consists of 3 sheet pile walls on the west (upstream), north (riverside) and east (downstream) sides of the Phase I Work Area. The enclosure is constructed with king piles embedded to approximately 16 m (53 ft) BSS for primary lateral support and interlocking Z-shaped piles to create the continuous enclosure.

The piles are sealed to mitigate water leakage and loss of sediment through the interlocks. The fourth side of the enclosure is the floodwall adjacent to the river in front of the OU-1 upland site. Owing to the depth of the removal, the floodwall required additional structural support to mitigate the loss of passive forces provided by the sediment, which was accomplished with the installation of grouted tieback anchors. Figure 4 provides a view of the completed enclosure.

![Figure 3. Looking east at the Diamond Alkali OU-1 Facility and the Phase I Work Area.](image)

![Figure 4. The sheet pile enclosure seen from the river and the barges inside the enclosure.](image)
Sediment removal

The material inside of the enclosure is being dredged to a depth of 3.7 m (12 ft) BSS, with a 9 cm (0.3 ft) overdredge allowance. The dredge area is made up of seven distinct dredge units, with two different waste classifications: Environmental Media (EM) and Hazardous Waste (HAZ).

The waste classifications of the dredge units were determined through pre-design investigation sampling. One sample per 382 m³ (500 cy) was collected for dredge material characterisation purposes. The results of the characterisation sampling were screened against Resource Conservation and Recovery Act (RCRA) regulatory levels to determine the applicable RCRA disposal requirements for each sediment sample and surrounding sediment. Segregation of EM and HAZ material is critical to preserving the application of in-situ characterisation of the material for disposal profiling purposes. Materials are handled in accordance with the in-situ characterisation results of the dredge unit from which they were generated and segregated for disposal in accordance with those characterisation results.

The dredge elevations of the dredge units are designated based on the waste characterisation of the material. In addition, overdredging is not allowed when dredging in a dredge unit designated as EM material which is underlain by a dredge unit designated as HAZ material. When the dredger approaches vertical transitions between HAZ and EM material, they have requirements to increase interim surveys and checks on the positioning equipment to ensure the dredge bucket is at the elevation it is reporting.

Prior to proceeding into a dredge unit with a different material type designation, dredging will be temporarily halted while the hydraulic pipeline is cleared and the tanks within the sediment processing plant (discussed in subsequent sections) are drawn down. This supports the dredge inventory tracking by providing an indication that dredging and processing of one type of material in one dredge unit has been completed and dredging and processing of another type of material from another dredge unit is beginning. It also provides a gap between materials of two different waste characterisations for purposes of loading transport containers.

The dredging is being conducted with a mechanical excavator fitted with a 3.8 m³ (5 cy) bucket. Approximately 30,580 m³ (40,000 CY) of in-situ material is being removed, with a design production rate of 382 m³ (500 cy) per day. The sediment is loaded onto a material barge located within the enclosure. Large debris (greater than 1.5 m [5 ft] in any one direction) is handled directly by the mechanical excavator, while smaller debris is screened out in the sediment processing step. Dredging progress is tracked using DREDGEPACK® dredge operator software, independent bathymetric surveys, manual soundings, and daily dredge reports. Figure 5 shows the dredging operations.
Hydraulic pipeline
Identifying an adequate upland processing facility (UPF) on which to construct the sediment dewatering plant and water treatment plant, as well as handle the dewatered sediment for offsite shipment, was a technical challenge. The UPF needed to have shoreline access, for conveyance of dredged material to the sediment dewatering plant; it had to be of sufficient size for the equipment and logistics associated with offsite transportation of the material; and the land had to be sufficient for the type of development necessary to handle the loads associated with the sediment dewatering equipment and tanks used for the water treatment plant. An adequate facility was identified approximately one-quarter mile downstream from the Phase I Work Area that fit the requirements. The engineering team then had to evaluate the best method for conveying the dredged material to the UPF. Passaic River navigation traffic, tidal fluctuations, and RAO #3 (preventing spillage or leakage of sediment during transport), were all factors in the evaluation.

The design team concluded that screening and slurrying the dredged sediment at the Phase I Work Area, and pumping it hydraulically using a pipeline to the UPF, was the most feasible and technically sound approach. Working closely with the dewatering subcontractor, Stuyvesant Environmental Contracting, Incorporated (SECI), and the dredging subcontractor, Weeks Marine, the engineering team designed a sediment screening and slurrying process, located within the enclosure, shown in Figure 6. The slurry feeds into a hydraulic pipeline floating along the shoreline between the Phase I Work Area and the UPF. The pipeline is show in Figure 7.

To get the material into the pipeline, the dredge material barge is first unloaded into a hopper fitted with a grizzly screen, followed by a trommel screen. These screens will remove debris greater than 12.7 millimeters (mm; 0.5 inch [in]). A sprayer is used to wash the material through the screens, which feed into a slurry makeup tank. A hydraulic feed pump is used to pump the sediment slurry, containing 14% solids by weight, into the hydraulic pipeline, which conveys the material at a flow rate of 3,331 liters per minute (880 gallons per minute). At the UPF, the hydraulic pipeline feeds directly into the sediment processing plant, discussed in more detail in a subsequent section.

Upland Processing Facility (UPF)
The UPF is the upland site where the sediment processing, decant water treatment and offsite transportation of the dewatered sediment (filter cake) occurs. To complete the UPF design, a geotechnical and civil design analysis was conducted, including settlement and bearing-capacity analysis for structures with high ground pressures, or settlement sensitive structures such as the tanks used for sediment processing and water treatment, and various components of the sediment processing plant. A pavement section analysis was also completed for the sediment processing, water treatment, and loading areas. Figure 8 shows preparation of the UPF, the installation in progress and the final facility.

Sediment processing
To reduce the disposal volume to the maximum extent practicable, mechanical membrane presses were selected to dewater the sediment. The design criteria for the target percent solids content of the dewatered filter cake is 57.5%, based on pilot testing and the capabilities of the membrane presses. Initial processing occurs at the enclosure, described previously, as a part of the slurrying process. After passing through
the hydraulic pipeline to the UPF, the sediment slurry is passed through another screen, followed by hydrocyclones, to separate out the coarse fraction of the material (greater than 0.0762 mm [0.003 in]). The coarse fraction of the material is dewatered by vibratory screen.

Following the hydrocyclone step, the resulting fine-grained sediment slurry is mechanically dewatered using mechanical presses (membrane presses). Following separation of coarse solids, the fine-grained slurry is pumped to a gravity thickener to thicken the slurry and increase the percent solids to approximately 15%. Thickened sediment slurry is pumped from the gravity thickener to sludge storage tanks which provide a process equalisation basin for feeding the presses and temporary storage of thickened slurry to allow for 24 hr/day operation of the presses. Polymer is added to the slurry prior to the gravity thickener and again prior to the mechanical press. The thickened slurry is then mechanically dewatered using membrane plate and frame (membrane) presses. The press plates are shown in Figure 9.

Membrane presses were selected owing to their higher performance, similar lead times, and slightly lower overall cost (when factoring in operations, transport, treatment, and disposal) compared with plate and frame presses.

Membrane presses are similar to standard plate and frame presses, but have an impermeable membrane in addition to the filter cloth. Half of the plates in a membrane press have a membrane on both sides of the plate behind the filter cloth, which allows membrane pressure to be placed on all of the recesses. In comparison with a belt filter press and standard plate and frame press, membrane presses generally achieve the highest solids contents as a result of the membrane pressure applied.

Membrane presses also typically have shorter cycle times than plate and frame presses. Four 344 cubic foot (13 cubic yard) capacity membrane presses were used to provide capacity to dewater 500 in situ cubic yards per day. The membrane presses were designed to be modular units that can be reused for subsequent projects by the sediment processing contractor. The membrane presses (DIEMME Model GHT 1,500 P13 Overhead Beam) were built especially for the project and had a lead time of over six months.

The resulting dewatered sediment (filter cake) is placed in lined containers and the containers are sealed as shown in Figure 10. The dewatered coarse fraction is placed in lined containers and the containers are sealed.

**Water treatment**

A temporary water treatment system is being used to treat water being generated from a variety of site processes. The system is capable of removing contaminants from the water generated during the sediment processing activities to the permit equivalency effluent limits. The hydraulic capacity of the temporary water treatment system accommodates the flows from the sediment process effluent, multimedia filter (MMF) backwash supernatant, hydraulic pipeline flush water, and Type 2 storm water (storm water that may potentially contact Phase I sediment or untreated process water) generated from the UPF.

The temporary water treatment system consists of coagulation, clarification, multistage filtration using multimedia filter, and liquid-phase GAC adsorption. Treated effluent is discharged directly to the Passaic River or reused at the UPF, as needed. Reuse is limited to polymer make-down and washing down sediment processing filter presses or equipment, provided the water is collected and treated again in the water treatment system after reuse. Samples of the water treatment effluent are collected to confirm that the discharge water to the Passaic River meets the effluent limits.

**Off-Site transportation, treatment and disposal**

The dredged material (i.e., debris, coarse fraction, and filter cake) is transported to, treated, and/or disposed of in a permitted treatment and/or disposal facility according to the material type designation of the dredge unit from which it was sourced (i.e., EM or HAZ), as described previously. Sediment that does not exceed RCRA regulatory levels is environmental media (EM) and is eligible for direct land disposal without any additional treatment or testing. It is disposed of at a RCRA Subtitle C disposal facility.

Sediment that is classified as characteristic Hazardous Waste (HAZ) requires treatment prior to disposal. HAZ material will be sent to a treatment facility for incineration, and the resulting incinerator ash will be disposed at a RCRA Subtitle C disposal facility. The debris and coarse fraction are classified and disposed of in the same way as the dredge unit from which it originated.

The material is placed into containers at the UPF (as shown in Figure 11) and transported via trucks to a transload facility nearby, where it is then transported by rail to the final treatment and/or disposal location.

**Backfill**

Following removal activities at the Phase I Work Area, including confirmation that the removal depth has been attained within the overdredge.
allowance, the area within the sheet pile enclosure will be backfilled and restored to its original grade. Part of the function of the backfill is to replace the passive pressures against the existing shoreline structures (the S-W Wall and the OU-1 Floodwall). To achieve this objective, the backfill must be placed to at least the pre-construction elevation.

The specified backfill material has similar physical characteristics to the in-situ sediment as practicable, but with improved engineering and structural properties, such as a lower plasticity index. In addition, it is important that the backfill material remain in place after the enclosure is removed. Excessive scour of the backfill material could result in destabilisation of the existing structures. A coarser material (D50 of 2 to 4 millimetres) was determined to be sufficient to help reduce surface scour of the backfill material after the enclosure is removed. A final bathymetry survey will be conducted upon completion of placement of the backfill material, to confirm the design objectives have been met. After this confirmation, removal of the sheet pile enclosure will commence.

Air emissions
During construction, as well as the handling and processing steps at the UPF, the potential for the generation of air emissions and odors from dredging are clearly present. To evaluate this potential, air modelling was performed. The main conclusions of the modelling of primary constituents of concern (COCs) from the Phase I Work Area are that concentrations are predicted to be below worker safety and short-term concentrations for the nearest industrial receptor, the nearest commercial receptor and the nearest residential receptor are expected to be lower than the New Jersey Department of Environmental Protection reference concentration for short-term exposure. Although the modelling estimates H2S emissions lower than worker safety and short-term exposure criteria, H2S is monitored because of the significant risks of overexposure and because of similar estuarine sediment dredging projects where H2S was an issue.

During dredging and sediment processing activities, perimeter air monitoring is being conducted for polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), dioxins, and chlorobenzene at both the Phase I Work Area and the UPF. Additionally, two nearby residential areas are being monitored.

CONCLUSIONS
The design performance to date has been evaluated as follows:
Dredging started in early March 2012, with production dredging beginning after a two-week startup period. Production rates are consistent with the target design rate of 382 m³ (500 cy) per day.

Additional debris handling considerations have been evaluated, including additional rinsing and sorting, as the debris being screened out at the enclosure is saturated with sediment and is more difficult to handle than expected in design.

Slurrying and transport of the material via hydraulic pipeline is operating as expected.

To date, the membrane presses are exceeding the percent solids design criteria of 57.5%, generally exceeding 60% solids in the filter cake. Coarse solids content has been around 10%, but is expected to increase to the design quantity of 14% as most of the coarser material was observed in discrete locations within the Phase I Work Area.

Water treatment samples and air monitoring results are within expected ranges as well.

REFERENCES


Changes in Flood Risk in Europe
EDITED BY ZBIIGNIEW W. KUNDZEWICZ, RESEARCH CENTRE OF AGRICULTURAL AND FOREST ENVIRONMENT, POZNAN, POLAND

The International Association of Hydrological Sciences (IAHS) has produced a book that examines the most prevalent natural hazard in Europe – floods. The simple dictionary definition of flood, “a rise in water level to a peak from which the water recedes at a slower pace”, completely ignores the millions of lives that are impacted by the misery of floods which leave in their wake famine, disease and epidemics as well as destroyed homes and infrastructure that may take years to rebuild. The book focusses on the fluvial floods in Europe, although other causes, such as heavy rains and groundwater floods, do exist. But whatever the cause of flooding the results can be disastrous.

The book poses and answers such questions as: Has flood risk increased on the European Continent? How, where and why? Are climate change impacts apparent? How do socio-economic trends and associated land-use and land-cover change the impact of flood risk? What effects do the gradual loss of agricultural land to urbanisation, deforestation and the loss of wetlands have? Are structural defences such as dikes, levees, dams and reservoirs protecting land from floods? Or do we need to reexamine the design of such defences?

In this collection of scientific papers, the frequency and causes of flooding in Europe are compared and the causal effects, such as increases in precipitation, are tracked. The detection and attribution of changes including recent trends are described. A Catalogue of Large Floods in Europe in the 20th century compiles information about such things as the 20 deadliest and 20 costliest flood events in Europe. Changes in Floods and in Intense Precipitation in Europe as well as Historical Floods in Europe in the Past Millennium are presented.

Several chapters are devoted to regional studies on flooding in multiple countries, including Austria, the Czech Republic, France, Germany, Greece, Iceland, Italy, the Netherlands, Norway, Poland, Switzerland, the UK, the Alpine areas of Europe and the Iberian Peninsula. In these, the specific features of the particular nation are considered. Generalisations are avoided and the studies here show that changes in flood risk are not uniform or valid for every country or every region of a country. Various contributors to the book analyse the statistics of flood risk, try to define the trends and attempt to give guidelines to develop strategy to cope with these trends.

Flooding remains a recurring threat. Flood control and management are based on design decisions. The book provides challenging data for an audience whose interest is in controlling water and perhaps, especially, for those involved with the “Building – Working – Engineering with Nature” movements.

The stated aim of the book is to make as much national information as possible available to a broad, international readership so that comparisons, syntheses and knowledge exchange can lead to a better understanding of what future flood risks may be and how we can best prepare for them.

MC
**DREDGING 2012**
**OCTOBER 22-25, 2012**
**SAN DIEGO, CALIFORNIA, USA**

Dredging 2012 is a four-day technical specialty conference on dredging and dredged material disposal, organised by PIANC USA and the Coasts, Oceans, Ports and Rivers Institute of American Society of Civil Engineers (COPRI ASCE). Since it has been almost 10 years since the last specialty conference was held in Orlando, Florida, in 2002, many new issues have emerged. Information will be presented regarding best practices and innovation in North and South America, Europe, and Asia. This will be an international forum bringing together professionals and practitioners from developed and developing areas of the world.

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**HYDRO12**
**NOVEMBER 13-15, 2012**
**SS ROTTERDAM, PORT OF ROTTERDAM, THE NETHERLANDS**

The International Federation of Hydrographic Societies’ 17th European conference will be held in Rotterdam from 13-15 November organised by the Hydrographic Society Benelux. To be held aboard SS Rotterdam, the former Holland-America liner now permanently moored at the Port of Rotterdam, in the Netherlands, the three-day event is aimed at a wide international audience drawn from all sectors of the hydrographic and related professions. “Taking Care of the Sea”, the main theme of the conference, will be supported by a major exhibition of equipment and services as well as practical demonstrations and technical workshops.

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**ENVIRONMENTAL ASPECTS OF DREDGING TRAINING COURSE**
**DECEMBER 10-11, 2012**
**ABU DHABI, UAE**

Last December’s “Environmental Aspects” course in Abu Dhabi was so successful that people were turned away. To meet this demand, IADC and CEDA decided to present the environmental course again in Abu Dhabi on December 10-11 – just prior to CEDA Dredging Days on December 12-13 – giving added value to both events. The course will again be organised under the sponsorship of the National Marine Dredging Company (NMDC), in co-operation with the Higher Colleges of Technology (HCT) Abu Dhabi at their high-tech premises. The Training Course is based on the book “Environmental Aspects of Dredging”, edited by Nick Bray and published by CEDA and IADC and Taylor & Francis. Lectures and workshop sessions are enhanced by hands-on session conducted by experts.

*Participants in both events (Course and CEDA Dredging Days) will receive a 10% discount on both registration fees.*

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Ceda dredging days 2012
December 12-13, 2012
Abu Dhabi, UAE

On December 12-13, CEDA Dredging Days 2012 conference and exhibition will take place in Abu Dhabi, United Arab Emirates. Theme of the conference is “Virtue, Venture and Vision in the Coastal Zone”.

“Virtue” in this context is environmental awareness. “Venture” is the development of the coast for commercial purposes, benefiting the local and regional economies. “Vision” is the long-term planning development for aesthetic reasons, creating a sustainable future which supports and delights those living and working in the coastal zone.

A technical exhibition will be located next to the technical session room. In addition, IADC and CEDA will be presenting their Environmental Aspects of Dredging training course in Abu Dhabi on December 10-11 – just prior to CEDA Dredging Days – giving added value to both events (see above). A 10% discount in fees is available to people attending both the training course and the conference.

On Thursday afternoon December 13, National Marine Dredging Company (NMDC) will host a technical visit to one of the many dredging projects in Abu Dhabi.

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www.cedaconferences.org/dredgingdays2012

Wind farm development: European offshore 2013
April 10-11, 2013
Edinburgh, UK

Wind Farm Development: European Offshore 2013 will provide presentations and interactive discussions lead by senior representatives from the leading companies operating in the offshore wind sector. Key industry players and decision makers will be present to discuss the development and future of this significant renewable energy source.

This is an opportunity to enhance your network and gain contacts from within the leading organisations making a difference in the offshore wind industry with two days of networking and open interactive discussions. Attendees will be Senior management from within the industry including: wind farm developers, wind farm operators, turbine manufacturers, engineers, consultants, ports and harbours, offshore shipping companies, energy analysts and lawyers.

Fees for the conference will be £1,495 (ex VAT).

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Call for papers
Wodcon xx
June 3-7, 2013
Square-Brussels Meeting Centre
Brussels, Belgium

Organised by CEDA on behalf of the World Dredging Association (WODA), which incorporates WEDA, CEDA and EADA, WODCON XX will showcase some 120 technical papers over three days covering all aspects of dredging and maritime construction. All WODCON XX papers will be peer reviewed and provide up to date, relevant and high quality information. The Congress also features a technical exhibition and technical visits. Various social events allow participants to meet fellow professionals from all over the world in a friendly and inspiring atmosphere. The 2013 conference marks the 20th edition of WODCON and coincides with the 35th anniversary of the current WODA and its three component associations.

Abstracts presenting both research and practical applications are encouraged. Papers must be original and should not have been published or offered for publication elsewhere. Purely promotional text will not be accepted. The Technical Papers Committee reserves the right to accept a submission as an oral or poster presentation. Authors must assign all copyright of the accepted papers to WODA. Prospective authors should submit titles and abstracts (maximum 300 words) online to be considered for the congress by 29 October 2012.

Interested CEDA authors (Africa, Europe and the Middle East) should submit their abstracts online on the congress website: www.wodcon.org. Please use the abstract guidelines available on the website and contact: Aneta Trajkovska
Tel: +32 (0)2 627 0166
Email: wodcon20@congrex.com

Interested EADA and WEDA authors should e-mail their abstracts directly to the EADA or WEDA Technical Papers Committee members (see below). The submission must include the name, affiliation, telephone number and e-mail address of each author. The corresponding authors’ name must be identified.

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