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Cover:
In 1996 during the Happisburgh to Winterton reef and recharge project (UK), an early dialogue between client and contractor led to an agreement on risk sharing and the adoption of a non-contractual ‘Partnering Charter’ (see page 3).
Editorial

Partnering: The Right Procurement Tool for Risky Contracts
Joep Athmer, Ben Hamer, Tim Kersley and Phillip Sanderson
A proactive partner philosophy for projects, instead of an adversarial approach, has made significant inroads in the UK.

Design Aspects for Cutter Heads Related to the Mixture Forming Process When Cutting Coarse Materials
Marco den Burger, Willem J. Vlasblom and Arno M. Talmon
Test models demonstrate that cutter head speed and pump capacity have a major influence on the spillage of a cutter.

The New IADC/CEDA Environmental Aspects of Dredging Seminar
Available on request to CEDA and IADC members, this new seminar has been successfully given in Mombassa, Kenya and at PAO, Delft.

Framework for Research Leading to Improved Assessment of Dredge Generated Plumes
T. Neville Burt and Donald F. Hayes
The environmental impacts of released sediment from dredging are considered within a comprehensive research programme.

Hamburg Declaration “From Gaps to Integration”
At WODCON XVII, September 2004, the WODA issued a statement further defining its environmental policy.

Books/Periodicals Reviewed
A new Spanish language text and reference book for a Dredging Course is available; as are the Hydro4 Proceedings from November 2004.

Seminars/Conferences/Events
A full roster of conferences in 2005 and EADA’s Call for Papers are presented.
EDITORIAL

With each passing day the enormity of the tsunami disaster in the Indian Ocean has become more apparent. The immediate response to the need for money, clothes, shelter, food and clean water has been overwhelming. This, however, is only the beginning. The problems caused by this disaster will continue for many years to come, and so will the demand for long-term dedication to relief and reconstruction. Well-planned strategic efforts to restore Asia to prosperity must be made. Therefore the Boards of the IADC member companies wish to express their commitment to assisting with reconstruction in any way possible.

The IADC member companies have decades of experience in the construction of coastal infrastructure: land reclamation, beach replenishment and the construction and maintenance of ports and inland waterways, as well of coastal defence systems. These are areas of expertise which Asia will desperately need. We stand ready to contribute our knowledge to any government agencies or international coordinating committees to help assess the damages and advise for rebuilding in the future. Working with other maritime related industries contributing time and service, we are certain that this present crisis can be met as speedily as possible – so that in the future such a horrible loss of life can be prevented.

The research, innovation, and dedication to finding appropriate solutions that are typical of our industry are clearly to be found in the articles that appear in Terra et Aqua: the search for environmentally sound methods, for improved techniques and equipment, and the implementation of “partnering” as a means of working together to meet challenges. We are sure that these same skills and the philosophy of team work and cooperation can be used to create a safer world for all those living at the water’s edge for now and in the future.

Rob van Gelder
President, IADC Board of Directors
Abstract

Partnering has been increasingly used both in the UK and internationally as a means to facilitate a proactive approach to problem solving as a project team rather than adopting a reactive, adversarial approach commonly associated with the more traditional forms of contract.

The Environment Agency, Halcrow Group Ltd and Van Oord UK Ltd are partners who have been active in promoting the use of partnering type procurement, design and construction since 1996. All partners participated in three distinct ‘Frameworks’ for the programme of flood defences in England and Wales. Namely, the National Environmental and Engineering Consultancy Agreement; the National Contractors’ Framework; and, the Combined Beach Management Framework. These ‘Frameworks’ apply the principles of Partnering by using the tools available within the New Engineering Contract (NEC), comprising both the Professional Services Contract (PSC) and the Engineering and Construction Contract (ECC).

The authors, through their respective organisations, have been actively involved in promoting and practising a partnering philosophy to the procurement and construction of various flood and coastal schemes in the United Kingdom.

In this article, the historic events that have influenced the UK flood and coastal construction industry in adopting a partnering ethos are presented.

The mechanics of partnering procedures are discussed and risk management is examined in detail. Auditing, value for money and cash forecasting are analysed together with strict reporting and early warnings of potential and real problems ahead. How team members relate to each other and to the public and to other stakeholders is also described. Finally, some relevant examples of partnering projects successfully completed are presented.

Introduction

Despite the recent progress, partnering in the UK continues to mean different things to different people. The difference between “project” and “strategic” partnering is fundamental and could reflect the difference between a client’s desire to partner on a short-term or long-term basis.

There are a number of purists who would argue that “project partnering” is a contradiction in terms: indeed, the 1991 National Economic Development Council (NEDC) Report adopts a definition of partnering, which requires that partnering be a “long-term commitment”. A proactive partnering approach opposed to a reactive, sometimes adversarial approach certainly gives many clear advantages. These include better forward planning of resources, better cost control and value for money. Partnering should be voluntary and willing on all sides, based on joint ownership of common objectives and commitment.
With more than 27 years experience, Joep Athmer has worked on projects ranging from large reclamation such as Chek Lap Kok, Hong Kong to offshore platform installations in the Beaufort Sea, Canada. He graduated in Civil Engineering from the College of Advanced Technology, Utrecht (1976) and in Business Administration from Breda (1989) both in The Netherlands, but has primarily lived and worked abroad. He is presently Managing Director of Van Oord UK and Ireland.

Graduated in Oceanography with Mathematics at Southampton University in 1989, Ben Hamer is a Chartered Engineer and a member of the Institution of Civil Engineers. Presently an Associate Director with Halcrow Group Ltd, he is responsible for delivery of coastal and estuarial engineering projects in England and Wales. Prior to joining Halcrow in 1995, Ben worked with HR Wallingford and in local government in Dorset, England.

Tim Kersley studied at the University of Plymouth and obtained BEng (Hons) and MICE (CEng). Tim has 14 years experience in Maritime Construction and Supply Chain Management. He has worked for 9 years, first as a Project Manager, then as Commercial Manager, and now as Operations Manager, all positions within the National Capital Programme Management Service for the Environment Agency.

Phillip Sanderson graduated from Portsmouth in 1980, was awarded the HSE Part 1 Offshore Air Diver Certificate in 1982 and became a Chartered Member of the Institution of Civil Engineers in 1985. He has been the Resident Structural Engineer at the Brighton Palace Pier, worked with Mobell Marine and with Geoffrey Osborne Ltd. He joined Dutch Marine Contractor Van Oord UK Ltd in 1988. Since April 2004 he has been a self-employed Consulting Engineer.

The partnering approach to procurement of Flood and Coastal projects in the UK has been seen as generally successful and is becoming, although slowly, acceptable in other countries. It is seen as the establishment of long-term arrangements between the parties involved with competent individuals carrying out the execution as one team.

**History of Partnering in Marine Contracts**

Whilst the initiative in the UK for the New Engineering Contract (NEC) dates back to 1985, it was only subsequent to Sir Michael Latham’s report “Constructing the Team” in 1994 and the publication of the second edition of the suite of NEC Contracts in 1995, that clients in both the public and private sectors really began adopting it.

Its utilisation was further encouraged after Sir John Egan’s report “Rethinking Construction” in 1998, which amongst other things espoused the benefits of all parties involved in the delivery of a project acting in a “spirit of mutual trust and co-operation”.

Contractors working in the field of marine civil engineering infrastructure have historic experience in supply chain partnerships. This has developed from “must-must” situations or events. “Only disasters make people change”.

For example, in 1953 the massive storm and North Sea surge were catastrophic and 2000 people were lost as a result of floods in the Zealand, in the south of Holland. A law in the Dutch Parliament was passed to ensure the swift, efficient, raising of flood defences. Client, consulting engineers and contractors were encouraged to work together in partnership by the Government. “Join Hands” was the rallying cry and was effective in bringing together all parties to complete the advanced flood defence works that have served Holland so well since that time (Figure 1).

In 1997, the Water Industry in the UK was many years ahead of flood defence in the procurement of projects using partnering philosophy. For example, by combining three new outfalls at Cambois, Hendon and Horden, Northumbrian Water were able to save money by agreeing favourable terms for an efficient single mobilisation of expensive marine plant. After a detailed assessment process, which included a major focus on the attitudes and values both consultant and contractor exhibited towards partnering, a design and construct alliance was formed between all parties. Risks were identified early, and managed by those best-placed to mitigate their effects. Fundamental issues addressed were joint objectives, development of appropriate behaviours, and agreement to joint problem solving.
been involved in a large number of partnering contracts within the marine and other fields of civil engineering, preferring to form long-term (5 years and more) relationships with a number of key clients.

Van Oord UK Ltd undertook their first NEC contract in 1998. In 2000 a significant part of their turnover in the UK was carried out under ECC Contracts and following from its success they strongly promoted the implementation of this Form of Contract to more clients. They have also been advising the Dutch Ministry of Public Works on the benefits of working with the ECC Form of Contract.

Partnering style contractual relationships are most valuable on high-risk construction projects such as those found on Coastal Flood Protection Schemes.

SUCCESSFUL PARTNERING PRACTICE

By incorporating specialist constructors into a multi-disciplinary team and giving them the opportunity to put forward ideas for better ways of working, clients are finding that there are considerable benefits to be gained. The use of just a few contractors, designers and suppliers means the supply side gains knowledge processes. Early contractor involvement resulted in custom-made site investigation saving €350,000, and other value management techniques were used to assess suitability of design. The outfall pipe at Horden was pulled from offshore through a tunnel and pre-dug trench so avoiding the need for an expensive cofferdam.

Van Oord UK Ltd ACZ had been successful on a number of large outfall schemes working with new forms of target based Conditions of Contract within a Partnering Framework. The ECC is particularly well-suited to partnering arrangements, as it seeks to minimise disputes, encourage good working relationships, and stimulate effective management. Timely communications, and the adoption of a forward-looking perspective, to identify and resolve potential problems before the financial and programme implications are actually encountered are the principal benefits of this contract form. A payment percentage for profit and overhead is agreed between the parties, and can then be applied to a transparent analysis of actual cost. This both reflects the client’s awareness that contractors require appropriate profit margins to remain in business, and provides the client with the confidence of value for money that can only be secured by an understanding of cost build-ups. The success of this style of working led Van Oord UK Ltd to consider its application to flood and coastal projects.

The Environment Agency for England and Wales commenced a series of new procurement “pilot” projects in 1998. This work sought to explore a number of ways in which more productive “Partnering” relationships could be realised. The progress of the Pilots was actively monitored and measured enabling the Agency to identify a preferred option. This led to the launch of the Agency “New Procurement Strategy” in 2000. The strategy seeks to radically change the Agency relationship with its suppliers and is founded on the principle of alignment of Agency and supplier objectives. This adopts the ECC form of contract underpinning a suite of five-year framework agreements.

Halcrow has been involved in partnering style of contracts within the coastal defence industry since 1996, when they assisted the Agency in developing a novel procurement approach for the second stage of the Happisburgh to Winterton sea defence project in Norfolk, UK; the first stage had resulted in an arbitration case between employer and contractor. The partnering project for stage two of this nearshore reef and beach recharge project was based on the Institution of Civil Engineer’s 6th Edition construction contract, and was supported by a “Partnering Charter” and a detailed Memorandum of Understanding setting out the results of negotiations between client (the Environment Agency) and contractor. Since that time, Halcrow has been involved in a large number of partnering contracts within the marine and other fields of civil engineering, preferring to form long-term (5 years and more) relationships with a number of key clients.

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and experience of the client’s business and is therefore in a much better position to produce “Best Value”. Clients are trying to find partnering contractors with aligned objectives who can give confidence that they are able to provide a quality job, value for money and strict financial control without claims at the end. Lessons learnt add value into the next project (Figure 2).

The consultant will usually produce the conceptual design after consulting with the client and other stakeholders. From the outline design, an outline budget will be produced for approval by the client prior to establishing the method of procurement followed by the “Partnering Team”.

The appointment of the client’s Project Manager (PM: note that this is not the Project Manager as defined under the ECC, which is a separate role) at an early stage is very important, as is their consistency through the project’s life cycle. The client should have such confidence in the ability of the PM that full authority is empowered to the PM. The PM should then select the members of the team on their technical, construction and financial skills together with their belief in the partnering philosophy. Can they work together as one team and consider themselves “one company”?

The PM retains responsibility for all programming, technical and financial issues throughout the duration of the project. Many specialists will require integration into the team and this process must be carefully monitored. A “bad apple” can destroy the good will generated by the rest of the team. People or companies that do not participate openly in the partnering process should be disengaged at the earliest opportunity.

**Partnering Charter**

The use of a “Partnering Charter” (see Figure 3) is appropriate where the aim is to engender a new approach or attitude to contracting without fundamentally altering the nature of the parties’ legal and contractual relationships. The crucial factor is that both the client and contractor together with their advisors have agreed that they wish to work together in an open and non-adversarial way. They have identified aims and objectives and believe that such an arrangement can be mutually beneficial. The Professional Services Contract (PSC) can be used to formally bind the parties together during the pre-construction contract period. It enables the contractor to be paid for his services in the same manner as the consultant. Joint incentives can be incorporated in the process to ensure maximum value for money is promoted in the design and planning.

The ECC “Option C – Target Contract with Activity Schedule” (with a capped Gain / Pain Share) is an option favoured by many Employers and Contractors. In this scenario, the Contractor is paid “Actual Cost” plus a “Fee” and if this is less than the Target Cost; a share of the savings. The so-called “Contractor’s (Gain) Share” is however normally capped to limit any unwarranted benefit accruing to the Contractor from a generously established / comfortable Target Cost. In the event that the Actual Cost plus Fee exceeds the Target Cost, then the Contractor is only paid an agreed percentage of the additional cost – the unpaid element being the Contractor’s (Pain) Share.

Two realistic examples are as follows:

**The Contractor’s share percentages and the share ranges are:**

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<th>Percentage Range</th>
<th>Share Percentage</th>
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<tr>
<td>Less than 80%</td>
<td>0%</td>
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<tr>
<td>From 80% to 100%</td>
<td>50%</td>
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<tr>
<td>From 100% to 105%</td>
<td>100%</td>
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<td>Greater than 105%</td>
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<td>50%</td>
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<tr>
<td>Greater than 100%</td>
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Following a number of estimating and target setting meetings, a "Target Price" should be agreed that is not amended until after the Contract has been signed. “Compensation Events” are events that, if they occur, and do not arise from the Contractor’s fault, entitle the Contractor to be compensated for any effect the event has on the “Prices” and “Completion Date”. There always will be a need to integrate suppliers and sub-contractors into projects. Frequently their involvement is a result of their specialist capabilities and knowledge of particular fields of construction or product manufacture. Regular weekly meetings with sub-contractors provide opportunities to communicate on all matters. The Project Team should endeavour to involve the employees of each specialist sub-contractor as part of the Team as early as possible, share their problems and assist in a resolution.

**The Management of Risk**

The process of risk assessment is the responsibility of the client Project Manager but should be carried out as a Project Team activity. Project budget estimates and target prices should be developed to include for risks (financial and programme). A clear, well-documented differentiation should be made between the client’s budget and the contract target. If budgets are set at or close to the contractor’s target price, then there is no room for change management, and it is not surprising that compensation events under such circumstances can quickly become points of contention. By agreeing

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**Figure 4. An overview of the process of risk management.**
risks that fall within the target price (i.e. those that would not form compensation events should they arise), and those that lie outside the target but within the client’s budget, the full project team have transparent and common understanding of the project constraints and can react to events accordingly.

Risk assessment and management will assist the delivery of sound projects to quality, time, environmental targets and cost. The risk management process should assist in the development of original thought and encourage innovation.

Whilst it is increasingly common, good practice to hold risk workshops in which all parties work together to identify risks on a “Risk Register”, it is all too often the case that these registers are then not used effectively as a basis for proactive management of risk. Figure 4 provides an overview of the process of risk management. Frequent areas of weakness include consideration of what is an acceptable level of residual risk (sometimes referred to as “risk appetite”), and the implementation of timely control measures.

Having considered the hazards to the project, consideration is given to how best to mitigate the risk. This may be to directly avoid the risk, to transfer it to another party (often to the contractor by way of the construction contract), to accept it, or to reduce it by taking some action (for example by commissioning site investigation studies in the absence of adequate data).

After this initial screening process, some form of risk quantification or prioritisation should be undertaken, ideally linked to programmed project activities, i.e. there needs to be information available to the project team on which are the key risks at any given time. In this case, rather than reviewing all risks at every progress meeting, which can make the process unfocused and laborious, appropriate consideration of the principal hazards can be given.

The risk management process then requires iteration back to the consideration of mitigation measures, given the information developed on the relative importance of specific hazards. The use of tornado graphs, for example, is very powerful in helping to keep focus on management of dominant hazards. The example provided demonstrates that the density of rock placement has the greatest potential for cost increases, and by applying management effort to the mitigation of this risk (and the next 2-3 hazards on the graph) would have a major impact on the project’s success.

By reviewing the risk register and the quantification of key risks at project milestones, risk management becomes a much more valuable mechanism for project delivery than is frequently the case today.

### Individual Characters

Putting to one side the technical, academic and professional qualifications, the key to a successful partnership is ensuring the “Right People” are involved. These people must not have contractual hang-ups, but must be enthusiastic and willing to make the success of any partnership. Where possible, it is not appropriate to have staff engaged in long-term partnering agreements with Client A at the same time that he/she is working in a more traditional, adversarial manner with Client B. Staff have characteristics and abilities that align to one method of working or another, and should be utilised accordingly.

Partnering will only work if all members of the team are willing to work in an open, honest, and trusting relationship. Co-operation and collaborative working are a must. The client has to be prepared to accept a realistic return for the contractor. There should be two design engineers on site, one from the client and one from the contractor. Advice with regard to modifications and “Changes” given to the Project Manager should be acted on without delay.

It is vital that competencies of different people compliment each other and that recognition exists of “needing each other”. The management of the client and contractor should hold weekly meetings to discuss any issues affecting progress and cost. Obviously the key staff are selected not only on their technical skills but also more importantly on competence. A Team Player must:

- Not subscribe to adversarial attitudes.
- Be able to build relationships across functional boundaries.
Look to assist and develop other members of the team.

- Want all partners to win.
- Listen to others, and take their views seriously.
- Understand that everyone has a positive contribution to make.
- Use language that is evocative (draws together) rather than provocative (alienates).
- Have people skills like ‘Team Player’.
- Motivate and be able to bring out the best in others (leader).
- Be open and willing to share.
- Possess listening skills.
- Be honest.
- Search for better solutions and ways to do things.

Construction Experience

A few schemes are described below that demonstrate the advantages of partnering.

The Happisburgh to Winterton and Lincshore Flood Defence Schemes, East Coast, UK

In 1996, the Happisburgh to Winterton reef and recharge project was tendered as an ICE 6th contract although, during post-tender clarifications, further discussion on the allocation and pricing of risks was initiated (Figure 6). This early dialogue between the Environment Agency and the contractor identified a mutual desire to find a better way of working together. This led to agreement on an element of risk sharing and the adoption of a non-contractual “Partnering Charter”. During the subsequent years 1998 to 2004 a number of further phases of the scheme were both competitively tendered and negotiated under formal partnering contract conditions using the ECC Options C and D. Option E was used for the Emergency Works Contract that required a rapid response to a serious flood risk (Figure 7).

Figure 6. By agreement some reefs were re-located to avoid additional costs.

Figure 7. During Emergency Works rocks were excavated and re-used.
Seaview Coast Protection Scheme, Isle of Wight, South Coast, UK

The Seaview CP Contract was originally tendered using traditional methods. It was recognised by the Client (Isle of Wight Council) that a number of uncertainties and risks could cause contractual difficulties. Further soil investigation was undertaken followed by the pile design. Land access and ownership negotiations were still ongoing. Critical time scales on weather, access for visiting holidaymakers, environmental restrictions and unforeseen service diversions were a good feeding ground for disputes, claims, litigation and lawyers during traditional contracting.

Negotiations were then commenced with the marine contractor. Through a negotiated route with full transparency of design criteria, expected cost and risk analysis the Contract was restated as a “Risk Sharing” ECC Contract with the emphasis on Partnering. “Option C – Target Contract with Activity Schedule” (with a capped Gain / Pain Share) was used. The outcome was completed on time and to budget, and without contractual dispute (Figure 8).

Hythe to Folkestone Coast Protection Scheme, Southeast England.

This DEFRA funded scheme, which forms part of the Folkestone to Rye Coastal Defence Strategy Study, used about 300,000 tonnes of rock to build a large headland and a number of other rock structures on the foreshore below the Folkestone’s Coastal Park. Approximately 4000,000 cubic metres of shingle will be used to “top-up” the existing beaches. Improvements were also completed to the existing concrete seawalls at Sandgate and Hythe along a length of 7 km.

The Contract was Tendered using the ECC Option C Form with Activity Schedule and was innovative in respect to a number of meetings and workshops organised by Shepway District Council with tendering companies before, during and after the tender date. Finalists were asked to make presentations to demonstrate best value in their approach to the work prior to selection and award (Figure 9).

A “Partnering Workshop” was also held at a location adjacent to the site that, with the assistance of a facilitator, produced the Partnering Charter. The site offices were established as a shared team facility with public access to the reception area for easy consultation with site management. Early in the contract a series of public meetings were held at locations along the 7 km frontage to gain the views and knowledge of the public. Public exhibitions were held and regular newsletters published and available at numerous locations. Very early in the project was found that the most economic method of transport for staff working on the long frontage was the use of mountain bikes. These were used in preference to the 4x4 standard site vehicle.

Figure 8. Early involvement of specialist sub-contractors improves final results.

Figure 9. An important aspect of the Hythe to Folkestone coast protection scheme was the continuous public involvement.
Lessons Learnt

The following list gives an overview of the lessons learnt by all parties:

- The use of the NEC Professional Services Contract (P.S.C.) by the client to procure the services of a contractor at an early stage will result in an efficient design giving best value.
- Design and Construct Contracts (D&C) can be used as an alternative to PSC and ECC especially for clients using contractors with that capability.
- Partnering will overall not only give savings and it often “adds value” to a scheme by innovative changes on site.
- Good news should be translated into a higher scheme value, longer lifetime, less maintenance, and so on.
- As on the Folkestone site, the team to report to the Project Board, which meets strictly every 6 weeks; commitment from the top from decision-makers.
- Overhead costs, depending on company profit; should be at least 5-10% for “staying alive”.
- Pain/gain gives contractors a real possibility to make some extra money by working hard and doing clever things.
- Partnering is only tested truly if things go wrong for the Client or Contractor and reimbursements are in place. (Contractor to reduce income or Client to pay extra costs in situations where genuine unforeseen events occur.)
- Use contractor’s experience also “up front” to arrange licences, talk to environmentalists, and make other contacts.

The Future of Partnering Style Contracts for Flood and Coastal Projects in England and Wales

The National Contractors Framework is the sole agreement with Contractors established under the “Agency New Procurement Strategy”. The frameworks have enabled strategic relationships to be established with contractors and have a “life” of five years (the longest possible under current EU law).

This permits the principles of partnering to be adapted across a programme of works with one supplier rather than having to establish relationships on a project by project basis. The relationship is managed through the use of Key Performance Indicators and includes a cross supplier management group where best practice can be identified and shared. The Management group also focusses its efforts on ensuring the “incentivisation arrangements” within the contracts adequately align objectives.

Since the commencement of the frameworks, relationships have been steadily improving. The development of truly integrated teams (Agency / Contractors / Consultants / Cost Consultants and such) are now starting to be realised. The teams are focussing strongly on improved Health and Safety and Environmental performance as well as challenging each other’s contributions to enable the Agency to deliver to its ambitious efficiency programme. Amongst the elements are:

- Early agreement on procurement policy for projects. Consultants to take practical advice from Contractor on materials available for integration into practical design.
- Communication is paramount. Stick to decisions on site and report rumours to the Site Team for investigation. Be open and transparent. Pick up the phone.
- Introduce self-certification with the Supervisor taking the role of auditing the quality system of the designer and the contractor.
- Improved Health and Safety as well as Environmental enhancement should be high on agenda for each scheme. What can we build in?
- On completion evaluate each Scheme with the Project Team and involve Stakeholders. Hold a lessons learnt one day workshop and agree who will take action on each improvement and use the output as start for next scheme.

Conclusion

Partnering should create a win-win situation whereby the contractor is allowed to make a reasonable return and the client gets a scheme, with Value Added, within budget and on time. Transparency of budget and programme constraints helps to converge the objectives of all parties. Effective management of risk is conducive to building common team objectives, and maintaining focus on what is important at any given time.

Strong positive and negative incentives are appropriate in long-term relationships, but when applied in short-term relationships can result in a “boom or bust” result, with associated strength of reaction through contractual lines.

If both the Client (with or without assistance from a Consultant) and Contractor are really trusting each other and willing to openly share their experience then Partnering is the ideal construction procurement tool for high risk projects. Historically both sides find it difficult to suddenly share and avoid confrontation. Paramount is the role of the Project Manager and the Contractors Construction Manager. They have to be dedicated team players, willing to give and take, challenging and active in finding better solutions. Since Partnering does not develop overnight, the true Value Added of Partnering comes from long-term relationships.
Design Aspects for Cutter Heads Related to the Mixture Forming Process When Cutting Coarse Materials

Abstract

Spillage, defined as the soil that is cut during the dredging process but not sucked up by the suction pipe, reduces the productivity of the cutter suction dredger and therefore needs to be minimised. Because insight into the phenomenon of spillage enables more accurate production estimates and makes it possible to design better cutter heads, a test model was set up.

Tests were performed that were representative for the cutting of rock or hard clay, whereby inertial forces play an important role. The tests have been carried out at the Laboratory of Dredging Technology of the Delft University of Technology. As shown from the test models, both cutter head speed and pump capacity have a major influence on the spillage of the cutter. Suggestions are made for improvements to both of these.

Introduction

In the PhD thesis “Mixture Forming in Cutter Heads” (den Burger, 2003), the processes associated with spillage for cutting relatively hard formations are identified and described. This research that was initiated by the dredging industry gives a better understanding of the occurrence of spillage when using a cutter suction dredger. Spillage, defined as the soil that is cut during the dredging process but not sucked up by the suction pipe, reduces the productivity of the cutter suction dredger and therefore needs to be minimised. Spillage rates can be up to 50% when relatively hard formations are cut, resulting in only half of the material that is cut actually is sucked up. Insight in this phenomenon enables more accurate production estimates and makes it possible to design better cutter heads. This article will describe briefly the research done in this field and particular the translation of the results to prototype values.
CUTTING TESTS IN CEMENTED BANKS OF GRAVEL

The research was focussed on the mixture forming processes rather than the cutting process. Furthermore, the tests had to be representative for the cutting of rock or hard clay, whereby inertial forces play an important role. Therefore, an artificial bank was made of weakly cemented gravel. That way, the cutting forces would never become dominant and the available torque on the cutter head drive shaft was not the limiting factor. Moreover, the density of gravel was 2650 kg/m³ and thus representative for cutting of rock or hard clay. By weakly cementing the gravel particles it was expected that single particles would enter the cutter head.

The tests have been performed on a 1:8 scale in relation to the large cutter suction dredgers. This scale was not chosen freely but results from the available test facilities and cutter heads at the Dredging Laboratory at Delft University of Technology.

Mainly the under-cut situation is investigated. In order to compare the simulated particle trajectories with the particle trajectories resulting from the cutting tests, a transparent back plate was used (see Figure 2, right, for the position and dimensions of the back plate). This made it possible to film inside the cutter head and visualizes the processes taking place inside the cutter head.

TEST FACILITIES AND EQUIPMENT

The tests have been carried out at the Laboratory of Dredging Technology of the Delft University of Technology. Figure 1 shows the cross section of the cutting tank. The numbers in the figure indicate:
1. radioactive density meter
2. suction pipe
3. cutter head
4. cemented gravel bank
5. main cutting tank
6. collecting tank (used for collecting the production during tests)

All tests have been carried out with the same cutter head. Figure 2 gives the geometry and the most important measures of the cutter head (dimensions in mm).

The angle of the cutter shaft was 45° in the majority of the experiments.
SCALING THE ROTATIONAL VELOCITY OF THE CUTTER HEAD AND SUCTION FLOW

In order to determine the values of the operational parameters on a model scale their values on prototype scale need to be defined. For the prototype cutter head the parameters based on the cutter suction dredger Ursa have been used. The model cutter head is not exactly scaled geometrically as the diameter of the cutter head is scaled with a different factor than the diameter of the suction pipe. The diameter of the suction pipe on a model scale is 9.5 times smaller than on a prototype scale while the diameter of the ring of the model cutter head is 7.8 times smaller.

Furthermore, the densities of the cut material on model and prototype scale are not alike. For the density of rock a value of 2200 kg/m³ is taken while the gravel particles have a density of 2650 kg/m³.

On a model scale there is the additional issue that the density of the bank differs from the density of a single gravel grain. This has some consequences for the filling degree of the cutter head and thus on the scaling of the haul velocity.

Directly applying the Froude scale for determining the values of the operational parameters on model scale will give a certain abnormality owing to the fact that the cutter head is not exactly scaled geometrically. This can be avoided by realising that scaling according to the Froude number is a way of realising dynamic similarity on prototype and model scale. This means that all the relevant force ratios should be equal on both scales.

To realise these two dimensionless groups can be formed by the ratio of forces (den Burger 1999).

First of all:

**Condition 1**

\[
\frac{F_{cf}}{F_{p}} = \frac{m_p R_c \omega_c^2}{\left(\rho_p - \rho_w\right) V_p g} = \frac{\rho_p R_c \omega_c^2}{\left(\rho_p - \rho_w\right) g}
\]

in which \(m_p\) is the mass of the particle, \(R_c\) the radius and \(\omega_c\) is the angular velocity of the cutter head. \(\rho_p\) and \(\rho_w\) are respectively the density of particle and water. \(V_p\) is the volume of the particle and \(g\) is the acceleration of gravity. Note that the buoyancy effect is included in the gravitational force. In the latter fraction the Froude number can be recognised.

The second dimensionless group is formed by the ratio of the centrifugal force at the blades and the suction force. The magnitude of the suction force acting on the particle equals the pressure gradient multiplied by the volume of the particle. The ratio then becomes:

**Condition 2**

\[
\frac{F_{cf}}{F_s} = \left(\frac{\rho_p \left(\frac{1}{2} V_m^4 R_{sp}^3\right)}{\rho_w \left(\frac{1}{2} V_m^4 R_{sp}^3\right)}\right)^2
\]

in which \(V_m\) is the mixture velocity and \(R_{sp}\) is the radius of the suction pipe.

The term between brackets represents the flow number.

In these two equations, the dissimilarity in geometrical scale factors is taken into account as the dimensions for the cutter head and suction pipe appear in the equations. Furthermore, the difference in densities of the cut particles on both scales is taken into account.

SCALING THE HAUL VELOCITY

The haul velocity and the cut-off area determine the amount of material that is cut per unit of time and if the fluid flow is not affected the amount, or rather concentration, of particles inside the cutter head. Hereby the cut-off area is the area perpendicular to the haul velocity, determined by the contour of the cutting teeth and the positioning of the cutter head in the bank. The concentration of particles inside the cutter head is important for the processes taking place inside the cutter head. It will determine the proportion of the following generalised forces:

- Forces resulting from fluid-particle interaction;
- Inter particle forces (such as friction or inter-particle collision).

Furthermore, the interaction between particles and the blades (friction, collisions) depends on the concentration of particles inside the cutter head. These forces are of the same category as the inter-particle forces. An important additional effect of large concentration of particles is the fact that the flow will be disturbed. This may have a significant influence on the production.

In order to have the same effects on model scale as on prototype scale, the filling degree of the cutter head (concentration) needs to be equal on model and prototype scale. Consequently the ratio of the mass flow of particles into the cutter head and the mass flow of particles through the suction pipe (discharge) needs to be equal on model and prototype scale. Thus

**Condition 3**

\[
\frac{\rho_p V_m A_{cut}}{c_{vd} \rho_p Q_s} = \text{constant}
\]

in which \(A_{cut}\) is the cut-off area and \(c_{vd}\) is the delivered
Table I. Values for Prototypes and Models.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prototype</th>
<th>Model</th>
<th>dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter suction pipe</td>
<td>0.95</td>
<td>0.10</td>
<td>[m]</td>
</tr>
<tr>
<td>Diameter ring cutter head</td>
<td>3.12</td>
<td>0.40</td>
<td>[m]</td>
</tr>
<tr>
<td>Mean particle diameter</td>
<td>0.078</td>
<td>0.01</td>
<td>[m]</td>
</tr>
<tr>
<td>Suction flow $Q_s$</td>
<td>3.00</td>
<td>0.021</td>
<td>[m$^3$/s]</td>
</tr>
<tr>
<td>Mixture velocity</td>
<td>4.20</td>
<td>2.64</td>
<td>[m/s]</td>
</tr>
<tr>
<td>Density rock particles</td>
<td>2200</td>
<td>2650</td>
<td>[kg/m$^3$]</td>
</tr>
<tr>
<td>Density cutting face</td>
<td>2200</td>
<td>1700</td>
<td>[kg/m$^3$]</td>
</tr>
<tr>
<td>Rotational speed</td>
<td>30</td>
<td>90</td>
<td>[RPM]</td>
</tr>
<tr>
<td>Haul velocity</td>
<td>0.2</td>
<td>0.1</td>
<td>[m/s]</td>
</tr>
<tr>
<td>Cut off area</td>
<td>1.4</td>
<td>0.023</td>
<td>[m$^2$]</td>
</tr>
</tbody>
</table>

or transport concentration of particles in the suction pipe. $p_p$ and $p_b$ are respectively the density of particle and the density of the bank. $v_h$ the hauling speed and $Q_s$ the pump capacity.

Using the above equations leads to the values for prototype and model as given in Table I.

Test Results for the Under-Cut Situation

The results of the model tests in under-cut situation with a cutter shaft inclination angle of 45˚ are shown in Figure 3 and Figure 4. In Figure 3 the production percentage is plotted against the rotational velocity. The different markers correspond with different mixture velocities and indicate the measured points. The dashed lines connect the measured points at similar mixture velocities (second order polynomial fit). These lines are merely used for representation purpose and hold no physical background.

The plot shows that the production curves at constant mixture velocity do have optimum values. An initial increase in rotational velocity of the cutter head results in an increase in production. After a certain optimum has been reached, further increasing the rotational velocity causes a decrease in production. Increasing the mixture velocity (at constant rotational velocity) always results in an increase in production.

In the second plot (Figure 4), the production percentage is plotted against the mixture velocity for the different rotational velocities. The plot shows that the maximum production percentage varies almost linearly with the mixture velocity between mixture velocities of 2 m/s and 3.5 m/s (indicated by the dashed line). Beyond a mixture velocity of about 3.5 m/s, the maximum attainable production starts to deviate from the dashed line.

The reason that the production percentage decreases when the rotational velocity becomes too high is, first of all, because of the larger centrifugal forces acting on the particles. Because of the large centrifugal forces the particles are thrown out of the cutter head (segregation). The higher the rotational velocity of the cutter head the higher the centrifugal forces and the lower the production percentage. Secondly, further increasing rotational velocities cause for an increasing pump effect of the cutter head and thus an increasing outgoing flow when the suction flow remains constant. Therefore, more particles will escape from the cutter head as they are dragged along with this outgoing flow.

Figure 3. Production vs. RPM at different mixture velocity.

Figure 4. Production vs. mixture velocity at different RPM.
The increase in production with increasing rotational velocity is more difficult to explain. At low rotational velocities the gravitational forces are clearly dominant and most particles will gather at the lowest point in the cutter head and can be considered as spillage. The most likely reasons for the increase in production percentage with increasing rotational velocity were thought to be:

- better mixing of the particles because of collisions of particles with the blades;
- positive change of flow inside the cutter head.

Additional tests have been performed to investigate these phenomena. In these tests gravel particles have been injected into the cutter head through the back plate by means of a silo and tube system (den Burger, 2001). Therefore the cutter head was not placed in the bank but rotating freely. A camera was placed on the right hand side of the cutter head to film the processes inside the cutter head through the gaps between the blades. The video recordings did not show the evidence of particles colliding with the cutter blades. In fact, the particles showed a sliding motion along the cutter blades towards the cutter ring, which increased with increasing rotational velocity. Figure 5 and Figure 6 emphasise this. Figure 5 shows the filling of the crown cutter head for a rotational velocity of 1 RPM and a mixture velocity of 2.5 m/s. Increasing the rotational velocity to 90 RPM (Figure 6) showed a clear axial motion towards the cutter ring.

Most particles were thrown out of the cutter head near the cutter ring and hardly any particle left the cutter near the hub. As the particle move closer towards the cutter ring they get closer to the suction mouth and are sucked up more easily. This is the reason for the increase in production with increasing rotational speed. The reason for sliding motion of the particles along the cutter blades is supposed to be the centrifugal forces acting on the particles in combination with the blade’s geometry. As this centrifugal force has a component along the blade’s inner surface directed towards the cutter ring, it can force particles towards this cutter ring if it is large enough.

To what extent the axial motion of the particles is caused by the component of the centrifugal force was not directly clear. Therefore a dynamic model was set up that describes the trajectory of a particle along the inner surface of a cutter blade for a cutter head rotating in a fluid (den Burger, 2001). The main purpose of the model was to verify that the component of the centrifugal force acting along the surface of a cutter blade could be responsible for the motion of particles towards the cutter ring. The model set up it is not restricted to one-blade geometry but can be used for any reasonable blade geometry. The particle is represented by a point mass with finite size.

The model was set up for single particles that slide (not roll) along the blade’s surface. Considering the elliptical shape of the gravel particles it is fair to assume that the particles do not roll over the blades. The absence of multiple particles in the model can be justified by the fact that attention was focused on the influence of the centrifugal force acting on a particle plus the blade’s geometry on the axial motion of a particle towards the cutter ring. For both single and multiple particles this effect should be present, although to different extents.

Simulations describing the trajectory of a particle along the cutter blade show that the blade’s geometry in combination with the centrifugal force can be responsible for the axial motion of particles towards the cutter ring. This could explain the increase in production with increasing rotational velocity as resulted from the cutting tests. The axial motion is certainly visible for rotational velocities of the cutter head beyond 80 RPM on model scale (which corresponds with 28 RPM on prototype scale). The axial transport of particles along the blade is generally higher near the hub due to the larger blade angle and the strong curvature of the blades near the hub. Therefore, in this region, the component of the centrifugal force along the blade’s surface is larger.

Figure 5. Filling model cutter head at 1 RPM.

Figure 6. Particles thrown out of the cutter head at 90 RPM.
In conclusion, by decreasing the cutter head diameter from 3.1 to 2.4 m the relative production percentage increases with a factor 2.7. In practice, the absolute production is of more interest than the production percentage. In the case that the smaller cutter head is positioned relative to the bank in the same way (on scale) as the original prototype head, the cut off area will decrease with the square of the diameters to:

\[
\frac{A_{\text{cut}}}{D^2} = \left(\frac{2.4}{3.1}\right)^2 = 0.59.
\]

However, to fulfil condition 3, the corresponding hauling velocity decreases from 0.2 to 0.175 m/s, which is a factor of 0.875. On the other hand, because of the increase in flow number, the production percentage will increase from 27.5% to 75%, a factor 2.7. In other words the absolute production will increase with a factor 2.7 x 0.59 x 0.875 = 1.39.

It should be noted that the mean particle size decreases from 78 mm to 63 mm to fulfil the scale laws, when the cutter head diameter is reduced from 3.1 to 2.4 m. In this situation both the cut off area (Figure 8) and the haul velocity are reduced, which means that the required cutting power reduces accordingly by a factor 0.59 x 0.875 = 0.52 under the assumption that the specific energy of the soil does not change.

So, in conclusion, an amazing absolute production gain is achieved of 39% in absolute sense with 48% less cutting power.

Even higher productions are possible when the installed cutter power is fully used. In general,
this either needs a larger cut off area or a higher haul velocity. Step size and cutting depth can increase as long as the maximum cut off area is not exceeded. When that is not the case the absolute production will lay between $1/0.59 \times 1.39 = 2.36$ and $1.39$ depending on the influence of the concentration in the cutter head on the mixture forming. If there is no influence the production percentage will increase even further than the 75%, because the cutter head is on the hauling side more surrounded by the bank, causing a more efficient flow towards the suction mouth.

Higher haul velocities may increase the particle size and result in less production efficiency as shown in Figure 9. An increase of the particle diameter from 10 mm to 15 mm on model scale decreases the production percentage with at least a factor 2 and can destroy the production gain completely. This phenomenon is well known in rock dredging practice. A higher cut off area is preferable above a higher hauling speed.

Conclusions

When dredging coarse materials two phenomena play an important role in the mixture forming process:

– An increase in production with increasing rotational velocity caused by the component of the centrifugal force acting along the blade and directed towards the cutter ring.

– Beyond the optimum rotational velocity the production percentage decreases with increasing rotational velocity as a result of the increasing magnitude of the centrifugal forces acting on the particles.

It looks if the existing rock cutter heads are over sized or do have too low pump capacities.

Large improvements can be expected when pump capacities and cutter head sizes are better tuned.

References


The New IADC/CEDA Environmental Aspects of Dredging Seminar

As part of their ongoing cooperation, the International Association of Dredging Companies (IADC) and the Central Dredging Association (CEDA) have developed a training package which focuses on the "Environmental Aspects of Dredging". Based on the seven volume book series of the same name, which they copublished a few years ago, this new Environmental Seminar has now been offered on two occasions.

**Mombassa, Kenya**
WODA (World Organisation of Dredging Associations) has observer status and is represented by CEDA at the London Convention (LC). Every two years the LC holds its Scientific Group Meeting in one of the developing regions and, in conjunction with UNEP (United Nations Environment Programme), organises a workshop for representatives from the region. WODA was asked by the LC and agreed to organise the "dredging day" of the 2004 Workshop in Mombassa.

As a result in April 2004, the IADC/CEDA Environmental Seminar, whose development had recently been completed, was incorporated into the programme in Mombassa. Neville Burt, Technical Director, HR Wallingford, Chairman CEDA Environment Committee, Polite Laboyrie (Netherlands Ministry for Public Works, Rijkswaterstaat) and several others from the USACE were presenters and facilitators. A number of presentation were also given by participating countries including South Africa, Tanzania, Mauritius, Eritrea, Seychelles, Mozambique and Comoros. Each of the 30 delegations attending was given the seven volume Environmental Aspects of Dredging guides free of charge, courtesy of IADC.

**Post Academic Education, Delft**
Acknowledging the academic quality of the programme, the Foundation for Post Academic Education (Postacademisch Onderwijs – PAO) in Delft, The Netherlands decided to organise this international course in October 2004. The two-day Seminar was conducted by Gerard H. van Raalte, senior engineer at Hydronamic, Papendrecht, The Netherlands and R. Nick Bray, maritime civil engineer and director at Dredging Research Ltd., Godalming, UK.

The 24 participants came from Nigeria, Israel, Belgium and The Netherlands. They were challenged in case studies to apply the principles discussed in order to get a full understanding of the scope and importance of the environmental aspects of dredging projects, the management of dredged material and the effects of environmental guidelines. Participants were awarded a certificate of achievement upon its completion.

**Further Implementation**
The Environmental Seminar developed by IADC and CEDA is aimed at consultants in dredging related industries and at professionals from various governmental bodies, be it municipalities, district water boards, ports and harbour authorities or central government. The course is global in approach and practical in application.

The use of the course material is available on request to members of IADC and to corporate members of CEDA for a reasonable fee. For further information about use of or participation in this Seminar on the Environmental Aspects of Dredging please contact the IADC (info@iadc-dredging.com, tel. +31 70 352 3334, fax +31 70 351 2654) or CEDA (ceda@dredging.org).

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Delegates at the IMO/UNEP/NEPAD workshop in Mombassa, where the IADC/CEDA Environmental Seminar was presented as part of the weeklong programme on port management.
T. Neville Burt and Donald F. Hayes

Framework for Research Leading to Improved Assessment of Dredge Generated Plumes

Abstract

At a meeting held in Washington DC in January 2003 a number of organisations in the USA, including US Army Corps of Engineers (USACE) and Environmental Protection Agency (EPA), and Europe recognised the need for a more structured approach to conducting research into the generation and impact of sediment released by dredging. The authors were commissioned to produce a framework for research and presented some of the preliminary findings at WEDA XXIII.

The aim of the research was to produce a framework of the steps and knowledge needed to properly assess dredge-generated plumes. This begins with improving knowledge of the source term and finishes with real impact assessment. For each item identified, the state of knowledge that already exists is being reviewed and this is leading to identifying what further research (if any) is needed. An attempt will eventually be made to prioritise what research is most needed and will achieve the greatest initial contribution to the assessment procedure. In this way it is to be hoped that future research funding may be well-targeted and that it will be possible to better protect the environment without the need to invoke the precautionary approach quite so often, which sometimes results in possibly unnecessary expense or restriction on development.

The research presented here is still in progress and is to some extent an invitation to contact the authors with information that will help in setting priorities for research. The scope of the article has been focused primarily on the physical processes involved and their impacts. The research will also include contaminant release and impacts and it is hoped to present this in the future. The paper was presented at the WEDA XXIV in July 2004, Orlando, Florida and published in the Proceedings. It is reprinted here in a slightly revised form with permission.
Introduction

There are two types of driving force that urge us to assess the effects of dredge-generated plumes, a genuine concern for the environment and the regulations that forbid us to dredge unless we can demonstrate that harm will not be caused to the environment. Ideally the two will work hand-in-hand but sadly this is not always the case. A brief summary of the latter pertaining to the USA and Europe is given first. The remainder of the article is then devoted to the research.

Regulations

London Convention 1972
The London Convention is a global convention with about 90 member countries. Members agree to introduce legislation in their own countries in order to implement the Convention. The aim of the Convention is to protect the marine environment. Its application is limited to non-territorial waters although many countries choose to apply it to their territorial waters, including estuaries. Impact assessment is supposed to include potential effects on human health, living resources, amenities and other legitimate uses of the sea. It has to define the nature, temporal and spatial scales and duration of expected impacts based on reasonably conservative assumptions.

At present the Convention covers only deliberate placement of dredged material in the sea. Some parties would like to see the scope of the convention increased to include regulation of the dredging process and the geographical boundaries extended. A paper presented by The Netherlands (LC 72, 2003) put forward a number of options about this but there was not much enthusiasm from most other parties for a major change in the scope. OSPAR is going through the same discussion.

OSPAR Convention
OSPAR functions in a similar way to the London Convention but only applies to countries bordering the North Sea and North East Atlantic. It too has dredged material guidelines that are very similar to the LC guidelines for dredged material and there is little value in repeating the above discussion.

More significant is that OSPAR is more enthusiastic about moving towards regulating dredging operations. A working group is in the process of preparing papers covering the effects of capital works, maintenance works and aggregate dredging. This is at an early stage so it is not possible to be precise about what new regulatory processes may emerge. However, it would be wise to take into account in any research the possible need to monitor dredging operations in addition to disposal. Most, perhaps all member countries apply OSPAR to their territorial waters.
**EC Water Framework Directive**
The European Community’s Water Framework Directive (EC-WFD) came into force on December 22 2000 and now has to be incorporated into national legislation in the Member States. Its aim is to bring about co-ordinated management of water systems, extending beyond national and state boundaries. It is expected that the Directive will stimulate an all-embracing approach to water protection with a stronger ecological focus and that, in addition, economic considerations will increase in importance. The Directive will affect the way that dredged sediments are handled.

The EC-WFD mentions themes of dredging and dredged material only indirectly, in Appendix VIII, in the sense that “suspended solids are some of the most important harmful substances”. Those who are experts in dredging and dredged material know that suspended solids are an essential part of the biological system of a river and will naturally become sediment in the river at some later stage further down stream. Eventually, this sediment will appear to dredging operators downstream as “material to be dredged”.

In future, bodies of water are to be managed according to standardised principles and objectives in relation to river basins, i.e. all the way through from tributaries to coastal waters. Administrative and state boundaries will no longer be relevant.

A good ecological and chemical status is to be achieved within 15 years in the case of surface waters, and a good ecological potential and good chemical status is to be achieved in 15 years in the case of heavily modified or artificial water bodies. In addition, the ban on deterioration will apply. In Annex X, the Directive contains a list of 32 priority substances, 20 of which accumulate in the material in suspension or in the sediment. Apart from known parameters such as mercury and cadmium, the list also includes new, previously less well-known groups of substances.

**Environmental Windows**
The US National Academy of Sciences (NAS) held a workshop in Washington DC in March 2001, resulting in “A Process for Setting, Managing and Monitoring Environmental Windows for Dredging Projects” (NAS 2002). On behalf of CEDA Neville Burt carried out a review of the windows concept as it is being considered or applied in Europe. The following is based on extracts from the resulting paper (Burt 2002).

One factor is common in the comments of those consulted, that there are inherent problems in the concept which may not only unreasonably restrict dredging operations (with consequences for social and economic costs) but may actually increase the risk of environmental harm.

In the USA the concept of Environmental Windows was introduced about 30 years ago and now about 90% of civil and maintenance dredging works are confined to specific periods of the year. In Europe, until recently the majority of dredging operations have been allowed to proceed all year round. However since the introduction of the EU Directives for the conservation of Natural Habitats and protection of birds (Habitats Directive and Birds Directive) the effects of dredging operations have and are being considered in more detail leading to the idea of introducing the concept Environmental Windows.

Whilst Environmental Windows appears to be a simple tool to limit the environmental impacts, people directly involved in environmental dredging issues in Europe are concerned at the severity with which it is being applied in the US and would seek to avoid such problems in Europe. The concept places a great deal of pressure on those promoting a dredging operation to prove that it will not cause harm to the environment. Scientifically this is a very difficult thing to do. All of this results in critical standards or windows being set based on something that is not yet capable of being measured or predicted and the actual environmental impact of which is hardly known.

In the face of these things the only solution would seem to be research to gain a better understanding of the real effects of dredging as opposed to the perceived effects, and further investigation into ways of mitigating those impacts. It will also be essential to communicate the results of the research in an effective way so that policymakers, decision makers and stakeholders understand and accept them.

**Review of Mechanisms of Sediment Release**
The mechanisms of sediment release by dredging operations have been presented previously (Burt and Land 2003) and to those involved they have become fairly familiar. However, quantifying them is another matter. Models of source terms have been produced (e.g. TASS, (Burt et al. 2000)) but remain largely uncalibrated. The problems are:

- the lack of a consistent definition of sediment release,
- the practical difficulty of taking measurements,
- identifying suitable opportunities, and
- the cost of obtaining the measurements.

To try to gain international co-operation in obtaining calibration data two initiatives have been taken, the production of a protocol for taking measurements (HR Wallingford and DRL, 2003) and the setting up of a co-operation group called ACCORD (Advice and Consultation Committee on Re-suspension by Dredging).
Development of the protocols was commissioned by a consortium of Dutch dredging contractors (VBKO) together with the Dutch Rijkswaterstaat. The draft protocol was circulated to selected experts worldwide and the comments received were taken into account in the version released in June 2003. It is seen as a living document and will be updated regularly in the light of practical experience. So far it has been used in Europe to monitor a trailing suction hopper dredger in Rotterdam in 2003 (Figure 1) and a grab dredger working on the River Tees in 2000 (a brief account was given of the Tees measuring exercise at WEDA XX and an account of the Rotterdam experiment was given at WODCON XVII in September 2004). It has also been used on the Providence River in the US in 2003.

The protocols include a definition of sediment release as illustrated in Figure 2. The protocols are available for general use and may be obtained from the authors. Protocols in summary form are available on the ERDC Vicksburg (Mississippi) website, http://el.erdc.usace.army.mil/dots/accord/index.html.

ACCORD was initiated following a meeting in Washington DC in January 2003, organised by the US Army Engineer Research and Development Center (ERDC) (Clausner 2003). The purpose of the Washington meeting was to bring together those involved in research on sediment and contaminant resuspension. It was attended by representatives of the Environment Protection Agency, the Minerals Management Service, ERDC, other Corps of Engineers offices, academia from the USA and number of researchers from Europe. ACCORD held its first meeting in London in November 2003 and its second meeting took place at the ERDC in Vicksburg in May 2004. At present it is simply a group of people with a common interest. It is thought that to be effective it needs to be more formally constituted. The main aim is to identify opportunities for measurement of sediment release using the internationally reviewed protocol and to share the knowledge gained from the results, though it may be extended as a forum for other areas of related research.

The sediment released or re-suspended by dredging operations should properly be seen in the context of natural variability due to river flow, wave action, etc. and the framework for research should take this into account (Figure 3).

Finally it should be noted that dredgers are not the only anthropogenic sources of sediment release. Shipping operations, particularly when large vessels are manoeuvring onto or off berths can cause bed sediment to be brought into suspension. This remains largely unquantified but is likely in most situations to be a much more frequent occurrence than a dredging operation (Figure 4).

**Review of Mechanisms of Contaminant Release**

Although many contaminants are associated with sediment they do not necessarily move or behave in the same way when disturbed by dredging.

Principally, the physicochemical environment controls the processes involved with the immobilisation and
mobilisation of sediment-associated contaminants. The main sediment properties affecting the reaction of the sediment with contaminants are clay type and content, organic matter content, cation exchange capacity, reactive iron and manganese, oxidation-reduction potential (redox), pH and salinity. Of these properties, it is the clay, organic matter, pH change and redox conditions that predominantly influence the mobilisation of contaminants from the sediment.

Contaminant mobilisation occurs owing to a dredging induced change in physicochemical sediment conditions. Where dredging causes a sediment plume to arise, the physicochemical environment changes considerably and substantial contaminant release can occur. This reaction is not always the case and a change in the physicochemical environment can release contaminants from the sediment yet favour other immobilising reactions.

There are various contaminants that pose a risk to the marine environment. The main contaminant groups include heavy metals, hydrocarbons and organochlorine compounds. In addition, there are other specific contaminants of environmental concern such as tributyl tin (TBT), the biocide agent used in anti-fouling paint formulations. The environmental effect of each contaminant differs, depending upon the receiving environment, but contaminants are often discussed in terms of their toxicity, ability to bioaccumulate and environmental persistence.

**Heavy metals**

Metals enter the aquatic environment from both natural and anthropogenic sources. Trace amounts of metals arise from the weathering of rocks and soils. Natural contributions can be high in areas of metal ore bearing strata. Large quantities of metals enter the environment through diffuse sources such as run-off and atmospheric deposition in addition to point sources such as domestic and industrial wastewater discharges. Metals are used in many industries including manufacturing processes and as chemical catalysts.

Metals discharged into the naturally turbid estuarine water can be rapidly bound onto the surface of fine suspended sediment particles, by various adsorption processes. As the suspended sediment settles to the bed, the associated metals are gradually buried and become immobilised in anoxic sediment conditions.

Metals (and other contaminants) are of concern because of their toxicity, persistence and tendency to bioaccumulate in living organisms. In addition to the amount of a metal present, toxicity depends upon the degree of its oxidation and the form(s) in which it occurs. The ionic form of a metal is generally the most toxic (e.g. cadmium 2+). Toxicity can be increased if the metal is complexed with natural organic matter. Metallo-organic compounds such as methyl-mercury form under certain natural conditions and exhibit greater toxicity than inorganic elements alone.

A metal's ability to remain in the environment is known as its persistence. Unlike some organic substances (i.e. hydrocarbon and organochlorine compounds), metals tend not to decay at any appreciable rate and
Tributyl tin (TBT) is often of concern during dredging projects. Since the discovery of its biocidal properties in the 1950s, the industrial application of TBT includes its use as the biocide agent in anti-fouling paints and coatings, molluscicides and agricultural fungicides.

TBT enters estuaries from a limited number of point sources including dry docks and marinas, and many diffuse sources such as vessel hulls. Because of its hydrophobic nature, once in the water column TBT readily comes out of solution and adsorbs to particulate matter and sediment. TBT also binds with phytoplankton, thereby introducing it to one of the lowest levels of the food chain.

Contaminant mobilisation between sediment and water

The risk of contaminant mobilisation affecting water quality and having subsequent environmental effects on aquatic life needs to be put into context with regard to the partitioning behaviour of individual contaminants. Contaminants have different degrees of solubility. Metals, such as lead, are quite insoluble and their partitioning from sediment is largely controlled by changes in pH. The potential for contaminant partitioning from the sediment to water can be measured through laboratory research. For example, sediment-water partition coefficients for TBT vary considerably, but are mainly in the order of 103-104 (Waldock et al. 1990). It should, therefore, be recognised that many of the contaminants mobilised by dredging actually remain bound to re-suspended sediment rather than become dissolved into the surrounding water (limiting therefore can remain indefinitely within the aquatic environment.

Aquatic organisms may bioaccumulate metals, depending upon the organism’s physiology and the degree of metal bioavailability. Bioaccumulation is the ability of an organism to accumulate contaminants in body tissues. Depending on the degree of bio-accumulation and the sensitivity of the particular organism, accumulated contaminants can cause toxic effects such as tumours, bodily deformation and even death.

Hydrocarbon and organochlorine compounds

There are many types of hydrocarbon compounds and organochlorine (OCI) compounds that can adversely affect the marine environment. The compounds most commonly occurring in dredged material are polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and OCI pesticides.

In the aquatic environment, PAHs are found at low concentrations in water due to poor aqueous solubility. However, they are easily adsorbed to organic matter and inorganic particles in the water column and, should local sources exist, are likely to arise in deposited river silt.

In the aquatic environment, PCBs tend to be adsorbed quickly by organic matter because of their hydrophobic nature.

Unlike many other contaminants, OCI pesticides are designed by manufacturers to be distributed in the environment, supposedly targeting a particular pest.

Other contaminants

Figure 4. Other anthropogenic sources of sediment release such as shipping operations, ferries and other vessels can be seen in this aerial view of Hong Kong.
their potential impact). The environmental impact of mobilised contaminants is more of a concern after sediment plumes have settled on the seabed.

**Impacts**

In the research here described the environmental effects have been related, as far as possible, to different types of dredging project, sediment types, plume types and dredgers. Short-term and long-term effects have been identified, highlighting how sediment plumes affect the water column and seabed in different ways and the influence of natural variability on this.

The baseline dataset must cover natural variations and seasonal patterns in order to provide the context within which to determine if a change constitutes an impact. A variety of factors need to be investigated in order to make predictions regarding the effects of dredging, including knowledge of existing water quality, biological communities, substratum, fisheries and shellfisheries resources.

It is important to determine the thresholds of acceptability in any particular environment, in terms of the tolerance of the species present, and to relate this, for example, to the environmental change caused by the re-suspension and movement of a sediment plume, particularly the concentration of re-suspended sediment that can be tolerated over the background concentration. Such thresholds will be site specific and species specific. Some fish species are tolerant of turbid water conditions and so dredging-induced increases in turbidity might not cause a significant long-term effect.

In essence, therefore, in order to determine whether an effect constitutes an impact, information is firstly needed on the plume’s concentration and its footprint, secondly on the duration of the plume, and thirdly how this compares to background levels and the tolerances of the species present.

The environmental effects associated with sediment plumes tend to occur as a result of two types of direct physical environmental change. Chemical changes can also occur if the sediment in the plume changes physicochemical conditions by reducing dissolved oxygen levels or introducing toxic contaminants to the marine environment.

The first physical change is associated with the presence of the sediment plume in the water column, which increases the concentration of suspended sediment in the affected water. In the context of marine biological resources, the effect of a sediment plume in the water column depends greatly on background suspended sediment concentrations and the ability of marine life to either cope with or adapt to a change in conditions.

The second change occurs when the sediment plume settles out of suspension, thereby changing the environmental conditions of the seabed. Denser, deeper sedimentation might occur when a dynamic plume reaches the seabed compared to shallower, dispersed sedimentation from a passive plume. In the context of marine biological resources, the effect of sedimentation on the seabed depends greatly on the existing substratum and the ability of benthic life to either cope with or adapt to changed conditions.

**Research Framework**

Since the aim of the research framework is to identify and prioritise areas where research is needed to be better able to assess the effects of dredge resuspension it seems logical that the framework should be based on an assessment framework. This will help to identify what we need to know to improve confidence in our decision making. Prioritisation can then be based on a more “joined up” approach than simply choosing things that we would like to study because they are interesting.

The assessment framework does not need to be complicated. In broad outline it consists of a number of basic questions. Of course this may lead to many more in-depth questions that can be difficult to answer.

A general assessment framework is given in Figure 5 and a draft research framework is given in Figure 6. It is a logical breakdown of the questions that need to be answered in making an assessment, the mechanisms (in very simple form) that we believe have the potential to bring about an impact and the tools that are either available or need to be developed to give quantitative predictions of impacts.

**Priorities**

It is not possible in the context of this paper to give a full priority assessment, partly because the information needs to be presented in a much more detailed way and partly because the review process is still underway. However, it is appropriate for the authors to make a few comments.

**How much sediment is released?**

Many of the measurements made over the last 20 years have been made in still water situations. This means that any sediment falling relatively quickly to the bed is not measured and the suspended solids concentrations that are measured are those due
primarily to diffusion out of the dredging area rather than advection. This suggests that release rates will be underestimated in the case of flowing water.

Measurements have also generally been made either with bottle or pumped water samplers or with turbidity meters. The main difficulty with water sampling techniques is the limited number of samples that it is possible to take in a plume that is transient, constantly changing in both dimension and sediment concentration. Calibration of optical systems is very poor when there is sand present in the suspension, again tending to give underestimates for any sediment coarser than silt. ADCP techniques show promise but still require a lot of effort and skill in calibration and interpretation.

Referring to the diagram of sediment release (Figure 2) it is clear that it will remain impossible to measure what happens in the "dredging zone". The fact that material settles back into the area being dredged is not of great concern since it is already accepted that the bed in this area is being greatly disturbed. It is of more importance to know how much sediment may travel out of the dredging zone and thereby affect the aquatic environment. The definition postulates a "virtual release rate" which, although virtual is very important to know because all other aspects of the assessment process depend on it. It does require measurements to be made at several sections downstream of the dredger.

**Dredging process**
To study this aspect process models are needed. As stated previously some models exist but lack field calibration. This has to be regarded as a high priority because until it is known how much sediment is released and at what rate, the impact assessments are based on guesswork. Additional models are needed for specialist dredgers that are used in environmental clean-up projects (Superfund projects in the USA) and calibration data are needed for all of them.

Related to this is the determination of how much sediment is released by the action of the draghead in the case of a trailing suction hopper dredger. The resuspension process is a combination of hydraulic erosion caused by turbulent kinetic energy and a bulldozing effect. The hydraulic erosion lends itself to computational fluid dynamics modelling (CFD) combined with classic bed erosion theory. A literature search has not revealed any formulations for the bulldozing effect. It does not lend itself to a purely theoretical approach and will probably require physical modelling to observe the processes taking place.

**Mitigation**
It is also important to know if the rate of sediment release can be controlled by operating the plant in a special way or selecting special plant (always with a cost penalty).
How much sediment is released by the dredging process and disposal and at what rate?

- **Dredging process**
  - Soil properties
  - Disaggregation
  - Erosion

- **Propeller wash**

Where does it go?

- **Dynamic plume**
- **Movement on the bed**
- **Resuspension from the bed**
- **Passive plume**

Impact at the bed?

- **Sedimentation on habitat**
- **Sedimentation on organism**
- **Change of bed type**

Impact in the water column?

- **Fish attraction or avoidance**
- **Physiological effect**

**Tools needed**

- **Process models**
- **Field calibration**
- **Empirical formulations**
- **Field or laboratory experiments**
- **Jet erosion model**
- **Field calibration**
- **Dynamic plume model**
- **Field calibration**
- **Fluid mud flow model**
- **Gravity and flow induced**
- **Change in sediment properties. Bed erosion models**
- **Plume and fate models**
- **Tolerance criteria**
- **Observation of behaviour**
- **Tolerance criteria**
- **Probability assessment**

*Figure 6. Research Framework A – Physical Impact.*
clay-size particles, is very strong. In that particular case the dredging process often results in the formation of clay balls rather than release of the very fine material. There is a need for research to identify and correlate the relevant soil properties and perhaps a new soil disaggregation test to be developed.

Propeller wash
The trailing suction hopper dredger may re-suspend sediment by the turbulence caused its propeller. Models exist for jet induced erosion but recent studies by Maynard (pers. com. 2004) have shown that the pressure wave caused by a passing vessel may actually re-suspend more material than the propeller.

The importance of both draghead and propeller re-suspension can be questioned on the grounds that in most muddy situations overflow is not efficient and often not allowed. In sandy areas where overflow improves the dredging efficiency the losses are orders of magnitude higher than those created by either the draghead or the propeller. The only relevant application is thus when dredging in sandy material in an area thought to be very sensitive to turbidity, for example in the case of coral.

Of course it is not only dredgers that resuspend sediment by propeller action or by towing equipment along the aquatic bed. Perhaps in making impact assessments the effects of dredging should be examined in the context of the effects of shipping and fish trawling.

Where does it go?
This is probably the question that has been given most attention in research, both pure and applied, to date.

Dynamic plume
The density-driven dynamic plume phase is complex but has been well researched and modelled. In the case of stationary dredgers the dynamic plume, if one exists at all, descends into the dredging zone so for reasons already discussed is probably not very important. For the overflowing trailing suction hopper dredger and especially in the case of aggregate dredgers, which also screen the material, the material may be released over a large area and could be important depending on the circumstances.

Another case where a dynamic plume forms is disposal either through pipe discharge into the aquatic environment or, more commonly, disposal on the aquatic bed by bottom dumping from a hopper.

An important factor regarding the dynamic plume is the extent to which it acts a secondary source causing a passive plume. Recent dynamic plume models include this element. However, the great lack is in calibration data to ensure that predictions are reasonably accurate.
greatly affect settling velocities. In the authors’ own experience of measuring settling velocities in the field an order of magnitude of difference can exist naturally between similar materials from different locations, without the added complication of the impact of dredging plant on the sediment (Burt 1986). Again the greatest need is for good quality field measurements of passive plumes to improve knowledge of this parameter.

It is noted that while some models do include re-suspension from the bed, others, such as SSFATE (Johnson 2000), currently do not. This is particularly relevant in some tidal situations where the only time during the tidal cycle when the turbulent kinetic energy is sufficiently low to allow settlement is at slack high or low water. The deposited material can in many cases be easily and quickly re-suspended by the accelerating flow in the next phase of the tide. Thus it is important, as in the previous section, to have a good knowledge of the relevant properties of the material (temporarily) deposited on the bed in order to predict how it will re-erode.

**Impact at the bed?**

**Sedimentation on habitat**

Should significant deposition of sand occur in areas that have a similar sediment type, the impacts on benthic communities are likely to be small. The benthic community in such an environment is likely to be adapted morphologically and behaviourally to a dynamic environment. It is, therefore, likely to be able to cope with the disturbance caused by sedimentation and this combination is not considered a high priority for research.

In gravel seabed environments, sedimentation is most likely to affect sessile species because they are unable to burrow or vertically migrate in response to an increased sedimentation rate. Sessile species include delicate organisms such as bryozoans and hydrozoans.

Sedimentation also affects filter-feeding epifauna, for example sponges. Coral and kelp forest communities are also susceptible to increased sedimentation rates (Selby and Ooms 1996).

The loss of key species in communities can lead to the collapse of the entire biologically-accommodated community even though individual species within the community may be apparently tolerant of environmental disturbance (Newell et al. 1998).

As shown in Figure 6 the main area of research needed is into the tolerance criteria. This applies to individual species and communities as a whole. “Tolerance” includes the ability of the species and/or community to recover because the temporary loss may have a lasting impact on species that rely on the habitat for spawning or feeding. Some research on recovery of seabed benthic communities is taking place in the UK at the present time but is still at an early stage.

**Sedimentation on species**

This includes direct smothering of susceptible organism life stages, such as negatively buoyant or adhesive fish eggs or larval shellfish that attach to the substrate. Most shellfish are able to cope with limited covering by sediment. Again the need is to establish reliable criteria for tolerance, including the ability to recover.

**Change of bed type**

This particularly applies to aggregate dredging where, for example, a gravel bed is dredged and the fine material is screened out and discharged back into the water. The benthic species that are adapted to gravel may not be tolerant of the new finer bed material. Again the need is to establish tolerance and recovery criteria.

**Impact in the water column?**

The physical, chemical and biological processes that take place in the water column are highly complex and it is beyond the scope of this paper to attempt to list them. With regard to the potential impact of additional sediment in the water column caused by dredging the effects are not well understood and there is much speculation about the impact on fish migration (Palermo et al. 1990), and Environment Canada (1994)). It seems obvious that fish have, in most practical cases, the ability to avoid a plume. Some have argued that far from avoiding a plume certain fish species are attracted to it because of the organic matter that is stirred up. This clearly requires research to clarify the issue because it has major implications on the application of Environmental Windows.

As with benthic impact the impact on the water column requires research into the tolerance of relevant species to temporarily increased sediment concentrations. This topic was recently reviewed by Wilbur and Clarke (2001). Additional research should include observation of the ability of species to tolerate natural variations such as during times of flood or storm, and other temporary elevations caused by shipping and fishing (trawling and shrimping).

**Conclusions**

The research presented here is still in progress and is to some extent an invitation to contact the authors with information that will help in setting research priorities.

It seems clear that there is much speculation about the impacts of sediment resuspended by dredging that is not backed by research. From the point of view of the authors it would appear that the greatest priority is to be able to measure and predict how much sediment is...
actually released by dredging and at what rate. Without this basic information it is not possible to produce meaningful correlations with environmental impacts. The development, verification and calibration of models is therefore an essential stage in the development of assessment tools. Furthermore, such models are needed to determine the effect of mitigative measures such as operating existing plant in a special way or using specialist environmental dredging plant.

It is also the authors’ view that research on impacts should be carried out in the context of the ability of individual species and communities to tolerate (and perhaps even require) natural variations in suspended solids concentration caused by normal variations in rainfall and tides as well as more extreme variations caused by floods and storms.

Finally, it will also be essential to communicate the results of the research in an effective way so that policymakers, decision makers and stakeholders understand and accept them. One possible mechanism for assisting in this process may be the ACCORD group that has already been referred to.

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Charles W. Hummer, Jr.

Books/Periodicals Reviewed

Organiza: Ministerio de Fomento/Puertos del Estado, Madrid, España. (Organised by Ministry of Development and the State Ports (of Spain), Madrid, Spain.). 18 cm x 26 cm, soft cover, 416 pp, illustrated in color, with table of contents, index.

This Spanish language book is both a textbook and reference book, and is a welcome addition to the technical literature for Spanish-speaking audience. The book is intended to be a basic course as well as a reference work for professional port and coastal engineers which incorporates the latest knowledge and encompasses all aspects related to this specialty of maritime engineering. In that sense, the book is comprehensive and current making it all the more valuable to the reader.

The book is organised into five parts with each part, in turn, subdivided into chapters. There are a total of 16 chapters presented within the five parts of the book as follows:

Part 1 Introduction or Generalities
Chapter 1 History and evolution of dredging
Chapter 2 Dredging Applications

Hamburg Declaration “From Gaps to Integration”

WODA (World Organisation of Dredging Associations) provides an independent forum for improving communication and technology transfer, and promoting integration and understanding of knowledge and experiences among all interested stakeholders to facilitate the economic and ecological sustainability of dredging and navigation projects.

WODA published its Environmental Policy during WODCON XV in Las Vegas in 1998. The foundation of the Policy rests upon the recognition that:
- Carefully designed and well executed dredging projects that are conducted in an environmentally sound manner contribute to a stronger economy, and
- Dredging projects can be conceived, permitted, and implemented in a cost-effective and timely manner while meeting environmental goals and specific regulatory requirements.

In conformity with and furtherance of that policy WODA,

Oberves that:
A key to successful implementation of the environmental policy is wide understanding of scientific, technical, regulatory, and managerial aspects of dredging and dredged material management;
- With regard to the development and implementation of dredging activities, there are gaps (i.e., different levels of knowledge and understanding between people and between organizations) between different geographic regions, between regulators and operators, between environmental and economic interests, between different stakeholders, and between disciplines;
- Gaps can result in inappropriate regulatory guidance, inefficiencies in project implementation, and potential harm to the environment.

Understands that:
- The objectives and requirements of dredging projects should be ecologically sustainable and technically feasible, while simultaneously enhancing the economy;
- Feasible dredging technologies and practices are available that can meet ecological sustainability objectives;
- Monitoring and evaluation of projects can be used by responsible authorities to improve the decision making process;
- A healthy environment is essential to our social
Part 2 Physical and Site Conditions
Chapter 3 Site Conditions
Chapter 4 Characteristics of material to be dredged
Chapter 5 Sediment dynamics

Part 3 Environmental Aspects
Chapter 6 The environmental impacts of dredging
Chapter 7 Management of dredged material

Part 4 Equipment and Project Performance
Chapter 8 General introduction to dredging equipment
Chapter 9 Mechanical Dredges
Chapter 10 Hydraulic Dredges
Chapter 11 Organisation and control of projects
Chapter 12 Special projects, Beach nourishment
Chapter 13 Disposal of Dredged Material

Part 5 Technical, administrative and legal aspects
Chapter 14 The planning of dredging projects
Chapter 15 Contracting dredging works
Chapter 16 The importance of dredging

The book is copiously and well illustrated. The coverage of case studies or examples is remarkable in scope. The chapters proceed in a logical fashion to take the reader through the technological, planning, environmental, contracting and actual performance of typical dredging projects. Each chapter is quite detailed and well presented, concise yet complete.

The history found in Chapter 1 is as complete or more so than can be found in similar books and very useful for those interested in putting information in an historical perspective. Chapter 2 presents a very adequate treatment of the various instances where dredging is necessary, performed and of major importance. The overall presentation certainly achieves its objective of reaching the technical audience. But it also is a valuable introduction for port administrators, environmental interests, as well as for an informed and interested public.

Any Spanish speaking organisation which has an interest or connection to maritime trade, engineering or port and coastal engineering will find this book an extremely useful tool for the neophyte as well as the seasoned engineer. The organisers imply that the book will be updated periodically to maintain currency with technology, equipment, and environmental considerations. That would definitely be an added value.

The publication is available from: Puertos del Estado www.puerto.es, click Publications.

£35 for IFHS members; £40 for non-members.

Edited by Dr Victor Abbott and Helen Atkinson

Proceedings of the Hydro4 Symposium in Galway, Ireland last November attended by delegates from over 30 countries, are now available from the International Federation of Hydrographic Societies, formerly The Hydrographic Society.

They comprise two opening addresses and 25 papers by leading specialists from Australia, Canada, Ireland, Netherlands, Norway, Slovenia, Sweden, UK and the US. Topics covered include Remote Sensing & Imagery, Charting, Data Analysis, Processing, Systems & Applications, Environmental Monitoring, and Coastal Surveys. Specific subjects include Merging of Hydrographic Functions for Efficient Dredging by IHC Systems’ representatives in addition to an historical review of early hydrographic developments by Sir Tipene O’Regan of the University of Canterbury, New Zealand. The proceedings have been carefully edited by Dr Victor Abbott and Helen Atkinson of the International Federation of Hydrographic Societies.

The publication is available from:
International Federation of Hydrographic Societies,
PO Box 103, Plymouth PL4 7YP, UK
tel/fax: +44 (0)1752 223 512
Email: helen@hydrographicsociety.org.
Seminars/Conferences/Events

Dredged Material Assessment and Management Seminar
Westin Copley Place, Boston, MA, USA
April 26-28 2005

Sponsored by the US Army Corps of Engineers (USACE), the seminar focuses on assessment and testing for waters regulated under the Marine Protection, Research and Sanctuaries Act and the Clean Water Act. Aimed at DM testing, assessment, and management specialists, Federal and State regulatory personnel and anyone managing contaminated aquatic sediments it includes subjects such as regulations and policies, testing manuals, sediment quality guidelines, DOTS, EPA Technical Framework, remediation and case studies.

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24th IAPH World Ports Conference
Shanghai International Convention Center, Shanghai, China
May 21-27 2005

This is the first IAPH conference to be held in China and it will be the official celebration of the IAPH’s 50th anniversary. The theme of the conference will be “The Challenges and Opportunities Facing the World’s Ports”. There will be six working sessions including: Impacts of Globalisation on Development of Port and Shipping Industry; Port Development Strategies; Port Security; Diversified Port Investment; Environment and Dredging Projects; and Maritime Innovation.

For further information contact:
International Association of Ports and Harbors
7th Flr. South Tower New Pier, Takeshiba
1-16-1 Kaigan Minato-ku, Tokyo 105-0022 Japan
www.iaphworldports.org

Second International Coastal Symposium
Nýheimar Cultural Center, Höfn, Town of Hornafjördur, Iceland
June 5-8 2005

The Icelandic Maritime Administration is organising the second conference on maritime issues in Höfn which is amongst the most productive fishing villages in Iceland. It is located at a tidal entrance on the heavily exposed southeast coast of Iceland in the immediate vicinity of Vatnajökull, Europe’s largest glacier. The livelihood of the population in this area depends on the tidal entrance to remain open and navigable. Eleven years ago an International Coastal Symposium was held in Höfn to discuss sea-land interaction, shore stability, tidal entrances, navigational problems and coastal management. The theme of the upcoming symposium includes: Tidal Entrances; Coastal Geophysics; Coastal Structures; Wave Climate; and Safety at Sea.

For general information contact: info@icecoast.is
For information regarding accommodation, excursions and registration, please contact:
Congress Reykjavik, Engjateigur 5, IS-105 Reykjavik, Iceland
tel: (+354) 5853900 / Fax (+354) 5853900
e-mail: congress@congress.is, http://www.congress.is

WEDA XXV and TAMU 37
Astor Crowne Plaza Hotel, New Orleans, Louisiana, USA
June 19-22, 2005

The twenty-fifth Western Dredging Association (WEDA XXV Annual Conference and membership meeting) and the Thirty-seventh Texas A&M Dredging Seminar (TAMU 37) will be held in New Orleans, Louisiana in
the French Quarters. Technical sessions will be presented June 20-22, 2005. The theme for the conference is “Dredging for Sustainability”, and will be a unique forum for discussion amongst dredging contractors, port authorities, government agencies, environmentalists, consultants, academicians, and civil and marine engineers who work in the fields of dredging, navigation, habitat restoration, environmental remediation, and marine engineering and construction.

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International Conference on Port-Maritime Development and Innovation
World Trade Center,
Rotterdam, The Netherlands
September 5-7 2005

The conference is the first jointly organised by the Maritime and Port Authority of Singapore and the Port of Rotterdam. It is a follow up on the conferences Port and Maritime R&D and Technology held in Singapore in 2001 and 2003. The objective is “to stimulate innovation in port and maritime management, operations and development through the presentation and exchange of the results of applied research and technologies”.

Themes include Port Planning and Design, Port and Marine Environment, Port Related Maritime Operations, Port Security and Port Related Transport, Handling and Logistics. The conference is aimed at port authorities, government agencies, the shipping community, port consultants and contractors, and academic and research institutions. A pre-registration form can be found on www.portofrotterdam.com.

For further information contact:
Port of Rotterdam, Mrs Deibel
PO Box 6622, 2002 Rotterdam, The Netherlands
tel. +31 10 252 1311, fax +31 10 252 1020
e-mail: secretary-td@portofrotterdam.com

Offshore Europe 2005
Exhibition and Conference Centre
Aberdeen, Scotland
September 6-9 2005

OE 2005, the oil and gas exhibition and conference, is one of the most innovative oil and gas events on the industry calendar. The conference theme is “Managing Mature Production: A Global Challenge”, with the Chairman and CEO of Schlumberger, Andrew Gould, as Chairman.

A new development at Offshore Europe 2003 was the hugely successful launch of the Real Time Zone. The RTZ was a ‘show within a show’ dedicated to the technologies that facilitate the continued march towards the web-enabled Digital Oilfield. For 2005, the RTZ has been re-branded as the Digital Energy Zone and looks set to give exhibition and conference goers a chance to immerse themselves in an online showcase for the next generation oil field.

For further information contact:
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www.oe2005.co.uk

International Maritime Expo-India 2005
MMRDA, Bandra Kurla Complex,
Mumbai, India
October 5 - 8, 2005

Keeping the momentum built up at the earlier editions of INMEX in 1999, 2001 and 2003, INMEX India 2005 will promote the innovations and developments available, for better understanding and effective utilisation by the maritime industry. INMEX India 2005 is organised to provide a common platform for the marine industry to interact with significant customers and key decision makers. Exhibitors, potential buyers and clients from the Indian sub-continent, South Asia, Southeast Asia, the Middle East, Africa and the European countries will be participating. A wide spectrum of products and the latest technologies serving the Shipping, Port and Offshore sectors will be on display at the trade exhibition.

The Business Forum: The integral feature of INMEX, the Forum and interactive session has always generated tremendous response in the previous editions. The Forum comprises of a series of sessions focusing on specific issues relevant to the maritime industry such as the global and regional maritime scenario, trade, policy matters, future projects, and so on. Panels consist of key officials and experts representing Government, Public and Private sectors.

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Also featured will be the EADA Dredging Seminar, with the theme “New Developments in Dredging Equipment and Planning” on October 7. See Call for Papers below.

For further information contact:
PDA House, #32/2, Spencer Road, Frazer Town, Bangalore - 560 005, India
tel: +91 80 2554 7434, fax : +91 80 2554 2258,
email: pdaexpo@vsnl.com
www.pdatradefairs.com

**Europort 2005**

_Ahoy’ Conference Centre_  
Rotterdam, The Netherlands  
November 1-5 2005

Owing to changing market conditions, the organisers of Europort (Amsterdam RAI) and Rotterdam Maritime (Ahoy’ exhibition, congress event management) have decided to merge these two international maritime trade exhibitions. The combined Europort and Rotterdam Maritime trade exhibition for the inland shipping, short sea shipping, ocean shipping, fishing, dredging and port equipment industries will be held for the first time in November 2005 in Ahoy’ Rotterdam and thereafter in odd years.

It will also feature the Marine Equipment Trade Show (METS) as well as various maritime trade association meetings including CEDA Dredging Days. Europort, which takes place every two years, is one of the premier events for all aspects of the maritime industry both nationally and internationally.

For further information contact:  
Amsterdam RAI, PO Box 77777  
NL-1070 MS Amsterdam, The Netherlands  
tel. +31 20 549 1212, fax +31 20 644 5059  
www.europort2005.com

**CEDA Dredging Days 2005**

_Ahoy’ Conference Centre_  
Rotterdam, The Netherlands  
November 3-4 2005

The theme of this year’s CEDA Dredging Days is “Dredging: The Extremes” and will look at how the industry responds to the extreme requirements, whether physical or regulatory, and how it produces extraordinary results in creating new land, valuable habitats and in dredging to allow ports to accommodate ever larger ships. The new challenges that our society presents to the dredging industry forces the industry to look for novel, innovative approaches in equipment and techniques. The conference will be held in conjunction with Europort Maritime exhibition (November 1-5 2005, see above).

The IADC will present its award to the best paper of the conference by an author less than 35 years of age. The prize includes a monetary reward as well as publication in _Terra et Aqua_. A special Academic Hour will be featured for young professionals and university students.

For the first time Dredging Days will include a small dredging exhibition adjacent to the technical session room. Space is limited and will be assigned on a first come first served basis.

For further information contact:  
Anna Csiti, CEDA Secretariat  
tel. +31 15 268 2575, fax +31 15 268 2576
email: ceda@dredging.org or  
www.dredging.org

**Call for Papers**

**EADA Dredging Seminar & Exhibition**  
Bandra Kurla Complex,  
Mumbai, India  
October 7 2005

The EADA seminar will be held to coincide with INMEX 2005 which runs from October 5-8 2005 at the same venue. The theme of the EADA seminar will be “New Developments in Dredging Equipment and Planning”. The registration fee is to be advised.

Abstracts submitted should outline major points to be covered, not more than two pages or 400 words, double spaced and should be in popular word processing format or Adobe PDF files. Deadline for submission: April 14 2005.

Abstracts should be emailed or posted to the following address:  
John Dobson, Chairman, Eastern Dredging Association  
GPO Box 388, Hamilton Central, Qld 4007, AUSTRALIA  
email: dobsoncj@hotmail.com

For further information please contact the following:  
Capt. David Padman, Secretary General,  
Eastern Dredging Association,  
Mail Bag Service 202, Jalan Pelabuhan,  
42005 Port Klang, Malaysia  
email: david@pka.gov.my, fax: 603-31670211.

Enquiries on the exhibition can be addressed to:  
PDA Trade Fairs, tel: +91 80 2554 7434,  
fax: +91 80 2554 2258,  
email: pdaexpo@vsnl.com  
Visit the CEDA website (www.dredging.org) for updates.
Membership List IADC 2005

Through their regional branches or through representatives, members of IADC operate directly at all locations worldwide.

Africa
Nigerian Westminster Dredging and Marine Ltd., Lagos, Nigeria
Van Oord Nigeria Ltd, Ikeja-Lagos, Nigeria

The Americas
Ballast Ham Dredging do Brazil Ltda, Rio de Janeiro, Brazil
Dragamex SA de CV, Coatzacoalcos, Mexico
Van Oord ACZ bv, Buenos Aires, Argentina
Van Oord Curaçao nv, Willemstad, Curaçao

Asia
Ballast Ham Dredging India Private Ltd., Mumbai, India
Ballast Ham Dredging bv Singapore Branche, Singapore
Ballast Ham Dredging Philippines Branch, Manila, Philippines
BHD Korea office, Busan, Republic of Korea
Dredging International Asia Pacific (Pte) Ltd., Singapore
Far East Dredging Ltd. Hong Kong, China
Hyundai Engineering & Construction Co. Ltd., Seoul, Korea
Jan De Nul (Singapore) Pte. Ltd., Singapore
Toa Corporation, Tokyo, Japan
Van Oord ACZ Marine Contractors bv, Shanghai, China
Van Oord Hong Kong Branch, Hong Kong, China
Van Oord (Malaysia) Sdn Bhd, Selangor, Malaysia

Australia
Dredeco Pty. Ltd., Brisbane, QLD, Australia
Van Oord Australia Pty Ltd., Brisbane, QLD, Australia

Middle East
Boskalis Westminster M.E. Ltd., Abu Dhabi, UAE
Gulf Coba (Limited Liability Company), Dubai, UAE
Jan De Nul Dredging, Abu Dhabi, UAE
Jan De Nul Dredging Ltd. (Dubai Branch), Dubai, UAE
Van Oord ACZ Marine Contractors Gulf FZE, Dubai, UAE

Europe
Aaneningsbedrijf L. Paans & Zonen bv, Gorinchem, Netherlands
Atlantic Dragage S.A., Nanterre, France
Baggermaatschappij Boskalis B.V., Papendrecht, Netherlands
Baltic Marine Contractors SIA, Riga, Latvia
Boskalis B.V., Rotterdam, Netherlands
Boskalis International B.V., Papendrecht, Netherlands
Boskalis Westminster Dredging & Contracting Ltd., Cyprus
Brewba Wasserbaugesellschaft Bremen mbH, Bremen, Germany
C.E.I. Construct nv, Zelte, Belgium
DRACE, Madrid, Spain
Dravo S.A. – Italia, Amelia (TR), Italy
Dravo S.A., Lisboa, Portugal
Dravo S.A., Madrid, Spain
Dredging International N.V., Zwijndrecht, Belgium
Dredging International (UK) Ltd., Weybridge, UK
Heinrich Hirdes G.m.b.H., Hamburg, Germany
Jan De Nul Dredging nv, Aalst, Belgium
Jan De Nul nv, Aalst, Belgium
Jan De Nul (U.K.) Ltd., Ascot, UK

Mijnster zand- en grinthandel bv, Gorinchem, Netherlands
N.V. Baggerwerken Decloedt & Zoon, Oostende, Belgium
Sociedade Española de Dragados S.A., Madrid, Spain
Sodranord SARL, Le Blanc-Mesnil Cedex, France
Terramare Oy, Helsinki, Finland
Tideway B.V., Breda, Netherlands
TOA (LUX) S.A., Luxembourg, Luxembourg

Van Oord Ireland Ltd., Cork, Ireland
Van Oord Nederland bv, Gorinchem, Netherlands
Van Oord nv, Rotterdam, Netherlands
Van Oord Offshore bv, Gorinchem, Netherlands
Van Oord UK Ltd., Newbury, UK
Westminster Dredging Co. Ltd., Fareham, UK