WHY HAVE AN ESCALATION CLAUSE?
reducing risk and speculation in dredging contracts

WORK SMART MEANS “WORK SAFE”
employees lead the way with practical solutions

PREDICTING TURBIDITY OF TSHDS
new software helps forecast environmental impacts

UNDERWATER SOUND TRAVELS FAST
what does that mean for dredging?
Terra et Aqua is a quarterly publication of the International Association of Dredging Companies, emphasising “maritime solutions for a changing world”. It covers the fields of civil, hydraulic and mechanical engineering including the technical, economic and environmental aspects of dredging. Developments in the state of the art of the industry and other topics from the industry with actual news value will be highlighted.

- As Terra et Aqua is an English language journal, articles must be submitted in English.
- Contributions will be considered primarily from authors who represent the various disciplines of the dredging industry or professions, which are associated with dredging.
- Students and young professionals are encouraged to submit articles based on their research.
- Articles should be approximately 10-12 A4s. Photographs, graphics and illustrations are encouraged. Original photographs should be submitted, as these provide the best quality. Digital photographs should be of the highest resolution.
- Articles should be original and should not have appeared in other magazines or publications. An exception is made for the proceedings of conferences which have a limited reading public.
- In the case of articles that have previously appeared in conference proceedings, permission to reprint in Terra et Aqua will be requested.
- Authors are requested to provide in the “Introduction” an insight into the drivers (the Why) behind the dredging project.
- By submitting an article, authors grant IADC permission to publish said article in both the printed and digital version of Terra et Aqua without limitations and remunerations.
- All articles will be reviewed by the Editorial Advisory Committee (EAC). Publication of an article is subject to approval by the EAC and no article will be published without approval of the EAC.
EDITORIAL
Prophetic words written 40 years ago

WHEN IS AN ESCALATION CLAUSE NECESSARY? DEALING WITH PRICE FLUCTUATIONS IN DREDGING CONTRACTS
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IADC 2011 ANNUAL SAFETY AWARD: “WORK SAFE” – AN INNOVATIVE SYSTEM OF SAFE WORK PRACTICES
Employees lead the way in safety awareness and in finding practical tools for use “right here and right now” resulting in greater overall on-the-job safety.

VALIDATION OF THE TASS SYSTEM FOR PREDICTING THE ENVIRONMENTAL EFFECTS OF TRAILING SUCTION HOPPER DREDGERS
JEREMY SPEARMAN, ARJAN DE HEER, STEFAN AARNINKHOF AND MARK VAN KONINGSVELD
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The Terra et Aqua you are holding in your hands is the 125th issue of the journal and this year marks the 40th anniversary of its founding in 1971. It was first published as Dredging/Drageage and had a worldwide distribution. Its publication was announced in many civil engineering and financial trade papers and according to reports “more than a thousand requests for additional copies” came from organisations and executives associated with the preparation of maritime projects. With this “proven demand”, the following year IADC decided to launch a second publication known first as Terra and soon after – as it is now – as Terra et Aqua, Land and Water. The name stuck. And so did the concept to provide all interested parties with information about maritime construction projects not generally available or easily accessible.

Looking at the history of Terra, we can do no better than to honour its first editor, Nic Oosterbaan, by quoting the editorial as he wrote it in that first issue stating the mission and the vision of this then-new dredging magazine:

Practically all countries feel the need to develop port facilities further, to deepen and widen access channels or to create land out of the sea. The basis is the desire to stimulate economic growth through modern technology. What is being done today was technically impossible a decade ago. This new scope makes viable projects which were once merely pipe dreams. Some, indeed, are now realities of great social and economic significance. Information concerning actual problems and actual solutions may stimulate responsible officers all over the world into thinking up new solutions for the particular problems with which they have to deal. Yet such information is often available only in scientific journals or technical trade papers which are sometimes not widely circulated or readily accessible. Terra is a response to that situation…. It is a journal devoted to the development of ports and waterways and the development of hydraulic engineering in general. Its aims are to disseminate information useful to the civil servant, politician or financial expert who is involved in local problems and bears responsibility for the decisions which have to be made. . . .

The words Nic Oosterbaan wrote 40 years ago were prophetic and could have been written now: “What is being done today was technically impossible a decade ago. This new scope makes viable projects which were once merely pipe dreams”, projects of “great social and economic significance” – the Hong Kong Airport, Maasvlakte 2, Palm Island and Dubai, Oresund Fixed Link and so many more projects are now dreams that have been realised.

Dredging technology continues to change, grow, improve; innovations occur at a rapid pace. The dredging industry continues to think big and accomplish engineering feats that were only dreams, and the mission of Terra is as compelling as when it was started: To disseminate useful information and capture the imagination of those engaged in dredging and maritime construction. To make clear to officials and the public the economic and technological advantages that the dredging contractor has to offer and the contribution of dredging to the ongoing social and economic prosperity of our world.

Koos van Oord
President, IADC
Escalation refers to a provision in a contract which calls for an adjustment in price in the event of an increase or decrease in certain costs. Escalation clauses are becoming increasingly common in dredging contracts as a means to cover unexpected costs resulting from fluctuations in the prices for raw materials, fuel and labour during the course of the construction project.

The Contractor when preparing a tender estimate includes for costs of fuel, steel and wages and has to evaluate the appropriateness of an escalation clause to cover the risk of price fluctuations during the execution period of the contract.

Based on the analyses presented here, the recommendation is made that any dredging contract of a duration of more than three to six months should have an escalation clause included. In this way, speculation is removed from the tasks of the Contractor and this results in a better focus on the projected works themselves.

Major contributions to the total dredging price subject to fluctuations are fuel, steel and labour costs.

An escalation clause is a clause in a contract that guarantees a change in the contract price once a particular factor beyond the control of either party results in an increase or decrease in the Contractor’s costs. It is also referred to as “Rise and Fall” which indicates that if the price of certain costs fall then the contract price will be adjusted in the client’s favour. What goes up may also go down after all.

In mature dredging markets like Europe, escalation clauses in one form or another are common, but they are not widely applied by clients in emerging dredging markets. Quite often escalation clauses are little understood by clients unfamiliar with the specifics of the dredging industry. Often the question arises, “Why do tenderers qualify their offers especially with respect to fuel escalation?”, which is a major component of unit price – usually 20 to 30%. Expecting Contractors to absorb the escalation risk of this in their rates is not exactly the perfect start for a professional contractual relationship between Client and Contractor. Moreover, it could well backfire for the Client with all Tenderers having no other option than to put a hefty risk premium into their prices to cover for sharp increases of component prices.

Based on research and experience, the recommendation is made that any dredging contract of a duration of more than three to six months should have an escalation clause included. In this way, speculation is removed from the tasks of the Contractor and this results in a better focus on the projected works themselves.

Price Fluctuations

The extent and the details of the escalation clause and formula can and do vary according to the situation at hand. A few examples are given below.

Fuel

The use of escalation clauses in dredging contracts goes back to the early 1970s when the oil crisis imposed a huge spike in oil prices. From September 1973 to March 1974 the oil price increased 260% in real terms paralysing
the world economy. Further spikes occurred in 1979 with the fall of the Shah in Iran and more recently from 2001 onwards the oil price has been driven up with the rise of demand from the emerging countries like China, India and Brazil competing with the continuous demand for oil in the US economy. Figure 1 shows a chart of the nominal and real fuel prices over about 150 year period.

With the current political and social unrest in parts of North Africa and the Middle East, fuel prices are very volatile and are expected to remain unstable in the coming years. Recent events (2011) have shown that the rise and/or fall of the fuel prices in even a short timeframe of say a few months can be very significant. Figure 2 shows the World crude oil prices from 1980 to 2009 and as projected to 2035.

**Steel**

From 2004 onwards steel prices more than doubled as a result of China’s unending demand for iron ore, with only a brief respite caused by the Global Financial Crisis. Now the demand for raw materials has resumed and steel prices have hit record levels. Figure 3 shows the average monthly price of Iron Ore Carajas in U.S. cents per Dry Metric Tonne Unit (Units) from 1980 through 2011.

Steel is not an obvious – but nevertheless important – element in dredging prices as the dredging contractors use steel in new-build vessels and for running repairs to their existing fleets. Dredging vessels have a life expectancy of over 25 years or more; maintenance and repairs (M+R) are a vital semi-continuous process with a distinct relation to the projects’ characteristics (like working in a hostile environment or pumping high-wear material).

Steel prices contribute significantly to these M+R costs. A drawback is that a balanced escalation clause is not easily achieved as there are differing factors and sources for data: CIRIA’s *A Guide to Cost Standards for Dredging Equipment* 2009 and the IADC’s annual published indexation is one source for calculating any increase in M+R costs but in practice it has not been applied by Clients on dredging projects. The usual accepted sources are governmental statistics (like the EU Eurostat) on industrial steel and likewise (see Figure 4).

Still the problem persists in determining a fair percentage of the total project costs for “steel escalation in M+R”. Obviously M+R also involves a significant amount of labour costs and it could be argued that a separate indexation on the wages is appropriate.

A specialised dredging consultant advising a client can produce a fair indication as part of the total project estimate. An alternative is to leave the percentage open for tenderers to fill in. This option will be discussed later in this article.

**Wages**

Even for the largest dredging equipment, the cost of crew wages is a major contribution to the total dredging price. Various developed economies around the world such as the USA, the European Union, Australia and Japan have government bodies which measure changes in wages. A Labour Price Index similar to the
and fuel costs. Material fuel costs are hedged the contract, particularly with regard to labour time, cost indexation clauses are included in especially on projects with a long completion cost element in their contract prices. And for dredging contractors have increasingly sought increases in their home country. Whilst to supply, these are usually hedged with financial instruments such as forward contracts or futures.

As the majority of European dredging contractors employ a core crew of their own nationality they are susceptible to wage increases in their home country. Whilst dredging contractors have increasingly sought to employ “Third Country Nationals” (TCNers) in order to reduce their labour costs they still are faced with labour forming a significant cost element in their contract prices. And for TCN crew, wage increases will likely be present as well.

The Contractor when preparing a tender estimate includes for costs of fuel, steel and wages, and has to evaluate the appropriateness of an escalation clause to cover the risk of price fluctuation during the execution period of the contract.

GUIDELINES FOR DEVELOPING ESCALATION CLAUSES

Principally two systems exist: Reimbursing actual costs with the use of payslips (i.e., for fuel and/or labour) or the use of price indexes where the relative index value is related to a base value (=100) at a reference date.

Reimbursing actual costs

A Fuel Escalation mechanism based on actual payslips appears to be a very straightforward system. Comparing the actual fuel price from a bunker invoice with the base value as has been stated in a Contractor’s offer yields a difference that can be remunerated.

However, there are two significant drawbacks to the system:

• In the case of a (large) number of equipment on site using various types of fuel quality the bunker administration can become a significant task. Furthermore, equipment arriving and leaving must be surveyed and an agreement is needed on what price for the in-survey and out-survey volumes will be used.

• The volume of fuel that is used by the Contractor is not part of an escalation clause. The payslip method has no inherent correction mechanism for this, i.e., the Client has to introduce an extra check that the amount of fuel used for the works does not exceed the contractually agreed volume. Projects with multiple activities and possibly a list of variations make this check and/or correction cumbersome if not practically impossible.

Clearly the practical simplicity of the payslip method raises unwanted issues. The indices-system though initially appearing somewhat bureaucratic in its set-up and use is very efficient and effective and therefore recommended.

U.S. Employment Cost Index is used by governments as an early indicator of wages pressure on inflation. An increase in the index suggests rising inflation pressures because firms tend to eventually pass higher labour costs onto clients in the form of higher prices.

The following is an excerpt from the Annual Report 2010 of one of the world’s leading dredging companies (Boskalis):

Risks related to price developments on the procurement side, such as increased wage costs, costs of materials, sub-contracting costs and fuel, are also taken into account in cost-price calculations. Wherever possible and especially on projects with a long completion time, cost indexation clauses are included in the contract, particularly with regard to labour and fuel costs. Material fuel costs are hedged in a number of different ways. Where possible, fuel cost variation clauses are included in the contract. Some contracts may also require fuel to be supplied by the client. In other cases, where substantial fuel risks exist, these are usually hedged with financial instruments such as forward contracts or futures.
Index System

(1) Establish the base selling price subject to escalation.

The item whose price is subject to escalation should be specified as precisely as possible:

- State whether the base price refers to a per-unit quantity or a certain volume of units.
- Give the effective date, month or year of this base selling price; this time period is often called the base period. In the authors’ opinion the base period has to be chosen a sufficient amount of time before the date pricing of the Contractor is finalised, making sure relevant indices of the base period are actually published instead of being merely processed by statistics agencies.
- Indicate the length of time the base selling price will remain in effect (for instance: does the escalation cease if a delay is caused by the Contractor’s own actions?)

(2) Select an appropriate index or indices.

Contracting parties may want to escalate the base price of a product by a single element such as fuel. Often, however, users may prefer to escalate on the basis of several data series, to reflect changes in costs of a variety of inputs. In some contracts, for example, costs of major materials and supplies are escalated with one or more indices, while costs of labour are escalated with other index series such as the Employment Cost Index. In such cases, the escalation clause should specify the percentage weight given to each index in calculating the total escalation amount. Clients may choose to list percentages themselves, but this is somewhat tricky and the preference is to have the Tenderer propose their own set of percentages (with an obligation for a Tenderer to substantiate in case the percentages are supposedly not realistic).

(3) State the frequency of price adjustment.

The escalation clause should specify whether price adjustments are to be made at fixed intervals, such as monthly, quarterly, or annually, or only at the expiration of the contract. To conform to the procedure, price adjustments have to be calculated over an interval whose beginning point is the contract’s base period. As mentioned above, this is the time period associated with the chosen base price.

Difficulties will be encountered with those contracts which do not designate a specific frequency for price adjustment, but rather state that the latest data available as of a certain date should be used for adjustment. In this case, or for any other case that does not cite a specific time interval, problems will arise.

(4) Provide for missing or discontinued data.

Occasionally any given index may be unavailable for a particular time period, usually because price information was not supplied by a sufficient number of survey respondents to meet index publication standards. Highly detailed indices are more susceptible to this problem than indices for broader groupings. Escalation clauses should provide procedures to be used when required data are missing.

Sometimes an index is permanently discontinued when a commodity declines in market importance; this most commonly occurs as a result of periodic resampling of industries and their output. Escalation clauses may provide for successor indices if original indices are discontinued, or for contracting parties to renegotiate a successor index.

A default provision that calls for using the next higher-level series might be included in the contract.

Note that if an index provider merely changes the title or recodes an index, the index is still considered to be the same series and therefore, presumably, should not necessitate any contract renegotiation.

A contract should not refer to an index value associated with a base price, but instead to its month and year alone. That is, what should not be written into the contract is language such as the following: “Divide the current index value by 103.9 (which is the value of the index for the base period January 1990) and then...”.

Rather, it should be written: “Divide the current index value by the index value for January 1990, which represents the base period, and then...”.

Contract clauses that incorporate specific index values will become problematic when the reference base is later changed by the index publisher; the index value incorporated into the contract will be incompatible with current official data after the index publisher has implemented the rebasing. Especially in the first few months after publication of an index value, small corrections by the publisher are quite frequent.

Define the mechanics of price adjustment

(a) Simple percentage method.

One method of price adjustment is to have the base price changed by the same percentage as...
that calculated for the selected index. To illustrate, suppose that the contract escalation clause refers to the Labour Price Index. Also suppose that the Labour Price Index was 110.0 when the base price was set. A year later when the first adjustment is made, the figure is 115.5.

This represents an increase of 5.0 percent in the Price Index as shown.

\[
\text{Index at time of calculation} \quad 115.5 \\
\text{Divided by Index at time base price was set} \quad 110.0 \\
\text{Equals} \quad 1.050
\]

This means that the base price should be increased by 5.0 percent. To proceed:

- **Base price (part associated with Labour)**: $1,000.00
- **Multiplied by**: 1.050
- **Equals adjusted price**: $1,050.00

In later years, this procedure would be applied again by taking the current Index value and dividing by the Index value at the time the base price was set and then proceeding just as described above.

**(b) Escalation of a portion of the base price.**

A common procedure changes only part of the base price so that only part of it is escalated by a selected index, while the balance remains fixed. This is commonly referred to as the “fixed portion” and is the element of the Contract Price which is not subject to price adjustment.

The percentage weight or escalation factor is an important element in the passing of risk between Contractor and Client.

To realistically work it should reflect the division of the Contractors’ costs as an element of the build-up of their unit rates. Too low a figure and the Contractor bears too much of the price fluctuation risk, and with too high a factor overcompensation of price fluctuations occurs.

By definition whether prices will go up or down is unknown and both are unwanted situations for both Client and Contractor. Principally any escalation system works best if the contractual percentages resemble the actual build-up of the Contractors’ costs.

To summarise, pitfalls to avoid are:

- Vague citation of “the applicable Labour Price Index” rather than a reference to a specific index by its title and any identifying code number.
- Use of unofficial price estimates derived from various sources during the estimate.
- Ambiguous reference to dates (“index as of May 30”).
- Lack of a provision for a successor Index should the designated index be dropped from the index system, or if it should become temporarily unavailable.
- Locking an index into a specific base period.
- Using ambiguous terms, for example, referring to “actual” indices.
- For an example of a basic escalation formula using index values, see the text box.

**REMARKS**

- The amount of fuel actually used or number of crew deployed by the Contractor is the Contractor’s risk/reward only (as part of the Contractor’s estimating process and commercial considerations). “Rise and Fall” clauses should only deal with the price fluctuations. This is again best achieved by having the Contractor state the percentage of the various parameters as part of the total contract sum.
- In case fuel usage is somehow part of award criteria (likely to become more popular as a result of sustainability concerns), the calculation of indexation costs for fuel prices and the usage target calculation shall not interfere in a way that makes practical administration impossible.
- It is perhaps rather obvious but still important for all parties to realise that fuel and steel prices can go down as well, which may result in a reduction of monthly payments.
- Using “No indexation” is only acceptable for (very) short contracts, say maximum 3 to 6 months. For any longer period “no indexation” poses the Contractor with the commercial problem of gambling on future price developments. In the end the Client will pay for this (through an additional risk premium either from the Contractor or though a fuel hedge contract entered into by the Contractor) or the Contractor will lose money for reasons beyond the Contractor’s control. Opportunistic Clients might consider that the Contractor should

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**EXAMPLE OF A BASIC ESCALATION FORMULA USING INDEX VALUES**

**Rise & Fall Formula:**

\[
A = P \times ((a \times L_1/L_0) + (b \times S_1/S_0) + (c \times F_1/F_0) + d)
\]

in which:

- \(A\) = Value of monthly Payment Claim in accordance with contract after adjustment for rise and fall
- \(P\) = Value of monthly Payment Claim, and:
- \(a\) = Agreed proportion for labour = 30%
- \(L_0\) = Base Labour Price = 1100 €/man/wk
- \(L_1\) = Current Labour Price = .... €/man/wk
  
  *(The Current Labour Price is the actual value for the Payment Claim period as published by the Government Statistics Bureau)*

- \(b\) = Agreed proportion for steel = 10%
- \(S_0\) = Base Steel Index = 100.0
- \(S_1\) = Current Steel Index = ....
  
  *(The Current Steel Index is deemed to be the latest released by Eurostat at the moment of issuing the Payment Claim)*

- \(c\) = Agreed proportion for fuel = 25%
- \(F_0\) = Base Fuel Price = 593.12 $/MT (excluding VAT, taxes, rebates, etc)
- \(F_1\) = Current Fuel Price = ....
  
  *(The Current Fuel Price is deemed to be the Fuel Gate price per metric tonne for Marine Gas Oil (MGO) averaged over the period of time since the last Payment Claim was made)*

- \(d\) = Agreed constant = 35%
bear this risk but they should realise that this will put immense pressure on the relationship and probably result in an overly firm and strict viewpoint of the Contractor as to any other issues popping up during the project.

- Clients should never bear any responsibility for delivery of fuel. Timing and Fuel Specifications or Quality would almost certainly become major problems.
- Clients are advised to exclude fuel escalation on mobilisation and demobilisation, as this occurs out of country and is a one-off payment whereas fuel for the project is continuing.

PRICE INDICES AROUND THE WORLD
Global

Increasingly many fuel users choose to follow fuel price fluctuations using data from publishers like Bunkerworld or Platts. Both are subscription services where prices are collected for all major bunker ports worldwide.

Prices for various types of fuel as used by marine equipment, like IFO (Intermediate fuel oil) and MGO (Marine gas oil) are shown daily (average and spread) (see Figures 5 and 6). This way, the price indication data is the most independent, up-to-date and true information that anyone could have access to. Historical data and extensive graphic presentation of the data are available as well. Bunkerworld has a limited part of the data available free of charge.

England

In England escalation was applied on construction contracts using data from the BCIS formerly known as the BERR Price Adjustment Formulae Indices. These monthly Indices are used in conjunction with the Formula Methods of adjusting building, specialist engineering and civil engineering contracts such as the NEC’s ECC Contract which has special clauses to allow for changes in the costs of labour, plant and materials. They are also familiarly known as either the NEDO or Baxter Indices and are widely used on Variation of Price Contracts.

They have been applied to dredging contracts for fluctuations in labour and steel costs. Fuel fluctuations have traditionally been dealt with

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Figure 5. Two examples from the recent past show the price volatility on the bunker market. Even in a short timeframe of 6 months prices can rise or fall as much as 50%. Hence the recommendation to include an escalation clause for every contract with a duration over 3 months – and not to include a first-year exemption period. (Courtesy of www.bunkerworld.com).

Figure 6. An example of daily fluctuations for various fuels (Courtesy of www.bunkerworld.com).
purchase prices from suppliers. This system is applied in many countries around the world as indices do not apply to fuel as the cost may vary considerably per location as the transport and delivery costs have to be taken into consideration (Figure 7).

**Netherlands**
The Dutch system often used for standard build-only contracts has its origin in road building. It is now used for the majority of major construction contracts lasting longer than a year. Using 22 different indices for a wide variety of commodities (including fuel, labour and steel) with a monthly update, the system has the advantage of a nationally standardised and clear administrative process. The way these indices are prepared is not entirely clear, and for specialist projects like most dredging, marine or offshore projects, the indices used are not overly appropriate. In a number of cases the indices become available only after some 4 months. This escalation system is applied to local dredging contracts, although as far as fuel is concerned, the Client predefines the percentage for fuel as part of the total contract price though during the first year after signing the contract no escalation is applied. Considering the volatility of the worldwide fuel market this is no longer defendable in the present market.

Furthermore, the system in which Client predefines the percentage of fuel can still leave the Contractor with some price risk that needs to be insured or to be included in the basic price somewhere. In general, however, both contract parties consider this system successful in taking most of the speculation out of the hands of the Contractor and thus helping competitive pricing.

**Germany**
German contracts for major waterway maintenance adopt the system where actual payslips for fuel are compared with the base fuel price in the Contract. The difference in fuel price is taken into account with the (monthly) payment of the works.

**HEDGING OF FUEL PRICES**
Those Clients looking for certainty as to their future expenses (and therefore shy of entering into an open-ended price escalation clause with a Contractor) might consider the option of entering into a fuel hedge contract with an oil company, a financial institution or a fuel trading company. Effectively a fixed fuel rate and volume usage prognoses is agreed between Client and the fuel hedging company, at the expense of a premium on top of the actual market price of the fuel to cover for the risks involved. The premium depends on the actual situation in the oil market and the prognosis for the contractual period. Principally this system is similar to a currency exchange risk insurance. However it requires insight from the Client to the fuel volume prognoses of the Contractor for the project at hand. It is up to each Client to decide for themselves, based on their specific financial situations and the way financial risks are managed, whether fuel hedging for a dredging contract should be considered beneficial. It is generally considered by Port companies who have their own existing fuel supply contracts rather than Clients who employ dredging companies in a one-off contract. In general it can be said that the hedging premium is hefty, especially in uncertain times in the world oil market as at present (2011). The possibility of hedging a part of the total consumption (for instance 33%, 50% or 67%) might be a good solution to cover part of the risk.

**CONCLUSIONS**
Reviewing the above considerations, the authors’ recommendation is that any dredging contract of a duration of more than three to six months should have an escalation clause included. Such an escalation clause will take speculation out of the tasks of the Contractor which results in a better focus on the projected works itself. Major contributions to the total dredging price subject to fluctuations are fuel, steel and labour costs.

The administration of an escalation clause is remarkably straightforward if the contract is drafted carefully in this respect. Of the two systems that exist for an escalation clause the use of price indices relative to base values is considered superior to the reimbursement of actual costs using payslips.

The percentages that apply to various indices chosen for an escalation clause in a dredging contract are preferably left open for Tenderers to fill in as part of their offer. A Client cost estimate for the project can yield figures for this as well.

Clients who prefer not to be exposed to inherent risks of, for instance, fuel price fluctuations can combine an escalation clause in their dredging contract with a separate fuel hedge contract with an oil company, a financial institution or a fuel trading company.
Each year the International Association of Dredging Companies (IADC) singles out a specific project or programme from its member companies as an example of excellence in safety. This year the IADC Board presented the 2011 Safety Award to Van Oord for its overall safety programme Work Safe that has been implemented over the last two years. Van Oord CEO Mr Pieter van Oord received the award from Mr René Kolman, IADC Secretary General and Mr Koos van Oord, IADC President at IADC’s annual meeting in September.

As part of the Work Safe programme, Van Oord has developed a number of Safe Work Practices (SWPs) that are aimed at people in the field. These people – on Van Oord’s vessels and projects – are increasingly safety conscious. This awareness means that employees are looking for practical ways to make safety work. In dredging, approaching safety too much from a theoretical angle is not overly useful. What people need are tools that can be used “right here” and “right now”. With the Safe Work Practices that have been developed, using input from the Safety Instructions of the Vereniging van Waterbouwers (the Dutch maritime organisation), the (Dutch) Arbo Catalogue and broad advice from people in the field, Van Oord has aimed to achieve just that: Tools for the people who are on the job, who are most likely to benefit from them.

**WORK SMART, WORK SAFE**

Achieving a safe working environment is part of every operation and the responsibility of every employee. After taking inventory of the accidents on site over the last few years, Van Oord’s management and Quality Health Safety Environment (QHSE) Department decided to implement a comprehensive programme to address overall safety. The result was Work Safe.

There are many challenges inherent to maritime construction. To meet these challenges and to realise innovative and sustainable solutions requires the dedication of all members of the team. To start, the QHSE team surveyed and interviewed employees about on-the-job safety, asking them what they saw as necessary to achieve a safer working environment.

For instance, what should one do – and especially not do – within the framework of safety during a particular task?

The rules in the “Safe Work Practice” (SWP) information sheets have been created based both on their answers plus an analysis of the most typical types of accidents that occur during dredging projects. From this process, “lessons learnt” have been derived. With the lessons learnt from the past, plus the guidelines of various safety organisations, as of 2010 new rules have been implemented.

An essential result in the Work Safe system was the creation of an instruction sheet for each specific process, for instance, anchor handling, working in and around excavations, working with gas and oxygen or procedures for lifting operations. Each action is addressed separately and a list of instructions has been written which describes the safety issues related to that particular operation. For each of these safety guidelines the rule of thumb is that they “apply to Van Oord projects” in the broadest sense. Additional control measures may be required, depending on project and country requirements” (Figure 1).

**THE INSTRUCTION SHEETS**

Each instruction sheet covers a specific subject and includes a section on: The Purpose, a
chart with the PPE Requirements (Figure 2), Responsibilities, Methods or Procedures and References for further information such as Applicable legislation, Safety instruction booklet and ARBO regulations. Training practices with life boats are an essential part of good preparation (Figure 3).

An example of how Safe Work Practices (SWPs) are defined is shown in the instruction sheet for Lifting operations entitled, “No Load Too Heavy If Lifted Safely”, issued in October 2010 (see box, Figure 4).

Some of the other subjects covered by the SWP Sheets, their purposes and date of implementation are summarised:

- **Welding with Acetylene, Propane and Oxygen – March 2010**
  This instruction describes precautions that need to be taken with regard to working with gas and oxygen as it is frequently done in dredging and marine works. Specialist welding and cutting techniques (such as laser welding and cutting) have been left out of consideration in this safety instruction, because these need additional assessment. Welding and cutting of steel mainly takes place on board of the auxiliary floating equipment and/or in the workshop.

- **“Chemical Management? When Things Get Hazardous!” – March 2010**
  This instruction describes activities and services related to chemical management. Setting up a construction site, workshop and/or site office requires chemical management that complies with the regulatory standards.

<table>
<thead>
<tr>
<th>Hard Hat</th>
<th>Safety Boots</th>
<th>Coverall</th>
<th>Safety Glasses</th>
<th>Life Jacket</th>
<th>Face Shield</th>
<th>Ear Protection</th>
<th>Gloves</th>
<th>Hivisbility Vest</th>
<th>Other</th>
</tr>
</thead>
</table>

Figure 1. For each of a broad variety of activities, an instruction sheet has been developed.

Figure 2. This PPE chart is part of each information sheet and indicates with a check mark which PPE element is necessary.
Arc welding of steel mainly takes place on board of the auxiliary floating equipment and/or in the workshop. The HSE safety precautions that are required differ for each situation; extra precautions are required above water.

- **Confined and Enclosed Spaces – October 2010**
  This SWP describes all activities and services that apply to Van Oord projects, vessels and yards where work involving, or tasks associated with confined spaces, takes place.

- **Excavations – October 2010**
  The purpose of this instruction is to outline the minimum requirements in relation to safety associated with working in and around excavations. These include consideration of soil stability, battering or stepping excavations, inspections, and extra attention spent to falls, collapses, over-running of vehicles, safe access to and egress from an excavation and hazardous atmospheres.

- **Hand Tools – October 2010**
  The purpose of this document is to ensure that the use, inspection and maintenance of hand tools are executed in a controlled and safe manner. This includes non-powered, powered, hydraulic and pneumatic tools.

- **Reclamation pipelines – March 2010**
  This instruction describes safety related activities and services related to pipe works, such as safety precautions for working with, caring for and properly storing both landlines and floating pipelines.

- **Electric Arc Welding – March 2010**
  This instruction describes necessary precautions that need to be taken with regard to electric arc welding of steel as it is frequently done in dredging and marine works. Specialist welding techniques (such as laser cutting) have been left out of consideration in this safety instruction.

- **Reclamation pipelines – March 2010**
  This instruction describes safety related activities and services related to pipe works, such as safety precautions for working with, caring for and properly storing both landlines and floating pipelines.

**“NO LOAD TOO HEAVY IF LIFTED SAFELY”**

Investigation results show that lifting incidents are increasing.

The incidents that have been identified can be traced to the following root causes:

- Lack of planning and competent supervision;
- Incorrect placement of cranes;
- Failure to correctly calculate or estimate the load;
- Failure of personnel to carry out the correct procedures;
- Carelessness and complacency; Use of wrong lifting gears;
- Faulty devices or machines;
- Lack of proper maintenance.

This source of this information was the Ministry of Manpower, Singapore.

Within Van Oord a significant increase of lifting incidents was reported in recent years. The purpose of this document is to ensure that lifting operations are executed in a controlled and safe manner in accordance with the applicable standards.

These standards are minimum Van Oord standards and provide a guide for the Works Manager / Superintendent to select lifting appliances and execute a lifting job within safety limitations.

The guidelines as referred to in this document apply for heavy lift (heavy lift = > 35 T) operations and for non-routine lifting jobs. Local requirements might be more stringent and if this is the case the local regulations prevail.

Definitions of:

- Lifting appliances: Any mechanical device capable of raising or lowering a load: cranes, forklift, manual hoist, lever hoist, rope hoist, beam trolleys, sheave blocks, winches, etc.
- Lifting accessories: Any device whatsoever which is used or designed to be used directly or indirectly to connect a load to a lifting appliance and which does not form part of the load; wire rope slings, chain slings, webbing slings, shackles, eye bolts, wedge sockets, etc.
- Lifting equipment: Lifting appliances and accessories
Working with A-frames includes welding and cutting of steel, lifting operations, working with wires, ropes and shackles; if this is the case reference is made to the applicable safe working procedure. A-frames assist the main dredging equipment and are not self-propulsive, which is why the maintenance and operation of the A-frames falls under the responsibility of personnel working on the main dredger/equipment.

- **Sinker Pipelines – March 2011**
  This document describes the work method and equipment to be used during the transport and placement of a sinker pipeline. The following steps are described: Preparations, Transport of sinker pipeline; Positioning of the sinker pipeline; Connection to the shore; Sinking of the sinker pipeline; Connection to the floating pipeline; Sinker pipeline position; and Raising the sinker pipeline.

- **Working Over or Near Water – April 2011**
  This SWP sheet aims to provide a practical practice to execute working over or near water activities. The scope of this SWP is to define the risk areas, prevention from falls in the water, when a buoyancy aid must be worn and which type can be used, as well as types of rescue equipment in case a person falls into the water.

- **Multicats – “Assisting With Speed, Accuracy and Safety” – March 2010**
  This instruction describes all activities and services related to working with multicast. Furthermore, working with multicats also includes welding and cutting of steel, lifting operations, working with wires, ropes and shackles; in this case reference is made to the applicable SWPs.

- **Safe Mooring and Working with Mooring Lines – March 2010**
  The purpose of this document is to ensure that mooring and working with mooring lines is executed in a controlled and safe manner, with subjects such as line handling, unmooring, snap back zones and correct use of stoppers.

- **Hot Work – September 2010**
  This document defines the principle hazards and the precautions to be taken when Hot Work operations take place. The following operations are considered “Hot Work”: All welding and cutting, grinding, brazing, gouging and other equipment producing heat, sparks or having naked flames.

- **A-Frame Work For Safety – December 2010**
  This instruction describes all activities and services related to working with A-frame.

**CONCLUSIONS**

The safety of all employees is always the highest priority when executing a dredging project. The people who know best how incidents occur and can be avoided are the workers themselves. Therefore surveying and analysing their experiences has proved invaluable in creating a safer work place.

At the end of the day, the responsibility for a safe work environment falls on everyone’s shoulders. Together working with QHSE team and employees to develop a safety programme, Van Oord has already had encouraging results. From 2010 to the present a significant decrease of on-job incidents has been noted.

These SWP information sheets are an on-going project and continue to be developed for other subjects.
TASS is a software programme that enables the user to predict the spatial development and concentration of turbidity plumes arising from dredging activities by trailer suction hopper dredgers. TASS has been developed because of a recognised need by the dredging industry to improve the quality of predictions of the effects of dredging in Environmental Impact Assessments. This article describes the TASS model and the validation of TASS predictions against validation measurements off the Dutch and German coasts.

The results show that the TASS system reproduces the observed concentrations of the overflow discharge well, as well as the observed increases in suspended sediment concentrations in the far-field. In addition the measurements highlight the fact that most of sediment released in the overflow is not seen in the far-field passive plume but descends to the bed as a dynamic plume. Evidence from the measurement campaign confirms the results of previous measurements undertaken in Hong Kong that the far-field plumes initially represent roughly 5-15% of the fine material released in the overflow discharge. Identifying how this percentage may be predicted a priori is an area on ongoing research.

Present efforts focus on further development and validation of the model for a variety of environmental conditions. Once thoroughly tested, the model will be made publicly available to facilitate sound predictions of dredging-induced turbidity.

The authors would like to thank the staff of Deltares, Rijkswaterstaat and Jim Rodger for their work in the TASS field measurement campaign upon which this study has relied. In addition the authors would like to thank Neville Burt, Hans Otten, Wim Rosenbrand, Nick Bray and the late John Land. Without their enthusiasm and persistence in the early stages of the TASS project this study would not have been possible.

TASS (Turbidity ASsessment Software) is a software programme that enables the user to predict the spatial development and concentration of turbidity plumes arising from dredging activities by trailer suction hopper dredgers (TSHDs). The project was initiated in the late 1990s and has been developed in collaboration between HR Wallingford and Rijkswaterstaat and Vereniging van Waterbouwers in Bagger-, Kust- en Oeverwerken (VBKO) and more recently, with Stichting Speurwerk Baggertechniek and the Dutch funded EcoShape project. The project has arisen because the often poor estimation of the effects of TSHDs can lead to unrealistically optimistic or pessimistic predictions of the effects of dredging in Environmental Impact Assessment which in turn can greatly impede the successful implementation of dredging works. This article briefly describes the model and its validation by measurements in the field. It also gives an outline of future developments and the planned release to the public in 2012.
The term **near-field** is defined as the zone near to the dredger where the dynamic plume phase occurs (see section on “Description of the TASS Dynamic Plume Module” below) and mixing of the plume is a function of complex processes.

The term **far-field** is used to mean the zone outside the near-field zone where the plume disperses as a passive plume (see section on “Description of Passive Plume Module” below). The spatial extent of these zones can be replaced with other detailed 2DH or 3D plume dispersion software.

For the purposes of this article near-field is defined as the zone near to the dredger where the dynamic plume phase occurs (see section on “Description of the TASS Dynamic Plume Module” below) and mixing of the plume is a function of complex processes. The term far-field is used to mean the zone outside the near-field zone where the plume disperses as a passive plume (see section on “Description of Passive Plume Module” below). The spatial extent of these zones...
Resolution in the vertical direction is represented as a series of layers of equal thickness, which will be referred to as the 1dv model (see Figure 4). This model is similar to other 1dv sediment transport models which have been used successfully by other sediment transport researchers (e.g., Winterwerp, 1999; Winterwerp and van Kesteren, 2004).

The aim of the 1dv model as used in this task is to distribute the discharge of water and the suspended sediment concentration sediment through the vertical. This means that the flux of sediment into the overflow is not merely the product of the depth-averaged (or cross-section averaged) velocity and the depth-averaged (or cross-section averaged) suspended sediment concentration, but the integral of the velocity and suspended sediment through the vertical.

The representation of the vertical structure of suspended sediment concentration improves the accuracy of the settling flux onto the bed of the hopper and better reproduces the slow increase in concentration that is commonly observed in dredging overflow as the sediment has to diffuse upwards through the model layers.

The TASS model consists of a 1dv model of the hopper processes. However, while many models of hopper processes consider just the vertical advection of sediment and water, the TASS 1dv model calculates both the horizontal advection and upward movement of water and sediment (Figure 4). Inherent in this calculation is the assumption of continuity, i.e., that horizontal discharge occurs in all layers along the hopper and, because flow at the weir occurs in all directions, out of the hopper. In this way the overflow concentrations are a function of both the distribution of concentrations in the hopper and the distribution of velocities. This effectively means that the clearer layers of water that often occur near the surface waters of the hopper do not dominate the output of sediment in the overflow.
Validation of the Tass System for Predicting the Environmental Effects of Trailing Suction Hopper Dredgers

Rotterdam Harbour. They were part of a larger measurement programme, including far-field plume measurements for the first time within this research project. The measurements were made on TSHD Oranje (Figure 6). The sediment dredged can be summarised as very silty fine sand, fine sand and very sandy silt. An example of the measured and predicted overflow sediment concentration at Rotterdam is shown in Figure 5.

Table I. Characteristics of the Trailer Suction Hopper Dredgers used in the field measurements.

<table>
<thead>
<tr>
<th>Field survey</th>
<th>Cornelia</th>
<th>Oranje</th>
<th>Geopotes 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement site</td>
<td>Bremerhaven</td>
<td>Rotterdam</td>
<td>Den Helder</td>
</tr>
<tr>
<td>Length (m)</td>
<td>112.76</td>
<td>156.00</td>
<td>133.54</td>
</tr>
<tr>
<td>Maximum draught (m)</td>
<td>7.45</td>
<td>12.02</td>
<td>9.07</td>
</tr>
<tr>
<td>Breadth (m)</td>
<td>19.60</td>
<td>28.00</td>
<td>23.64</td>
</tr>
<tr>
<td>Hopper capacity (m$^3$)</td>
<td>6,388</td>
<td>15,961</td>
<td>9,962</td>
</tr>
</tbody>
</table>

COMPARISON OF TASS OVERFLOW MODULE RESULTS WITH MEASURED OVERFLOW DATA

The field measurements of overflow discharge were made at three locations along the North Sea coast (Bremerhaven, Germany; Rotterdam and Den Helder, the Netherlands) using different sized dredgers (see Table I) working in different sediment types (fine/medium sand through to sandy silt).

The overflow measurements principally took the form of measuring the concentration in the overflow discharge. This was done by taking bottle samples of the overflow mixture which were later analysed in the laboratory for sediment concentration. Trial measurements were also undertaken using a density profiler but these were not used for the present study.

The experiments at Bremerhaven were undertaken in 2006 on TSHD Cornelia. The dredging took place at several locations within the approaches and estuary and the sediment dredged can be summarised as fine sand and silty fine sand. During these experiments the practicality of pumping samples of overflow discharge from inside the orifice chamber was explored. This was considered to be in principal a success but air bubbles in the overflow mixture were found to cause problems for the pump. This led to the use of an airflow method of pumping in the subsequent overflow measurements at Rotterdam and Den Helder. An example of the measured and predicted overflow sediment concentration at Bremerhaven is shown in Figure 5.

The Rotterdam experiments were undertaken in 2007 inside the Rotterdam Harbour, and seaward in the approach channel to the

Figure 5. Observed and predicted sediment concentration in the overflow discharge Trip 158 at Bremerhaven (top); Trip 11 at Rotterdam (middle); and, Trip 275 of the Den Helder field measurements (bottom).
The Den Helder dredging works were undertaken in 2007 to source sand for beach nourishments south of Den Helder. The measurements were made on TSHD Geopotes 15 (see Figure 6). The dredging took place, approximately 12 km offshore the Dutch coastline in an area of fine and medium sand. Based on samples from the dredged area the proportion of silt in the sediment is in the range 4-8% by mass. An example of the measured and predicted overflow sediment concentration at Den Helder is shown in Figure 5.

All seventeen sets of overflow measurements were used for comparison. A selection of the model results is given in this paper together with a summary of the results as a whole. The measurements are described in more detail in Aarninkhof et al. (2007, 2010).

RESULTS OF THE COMPARISON OF THE TASS OVERFLOW MODULE PREDICTION WITH FIELD DATA

- Overflow measurements were carried out at three locations along the North Sea Coast.
- Bottle sampling and a density profiler were used to measure the sediment concentration in the overflow.
- Seventeen sets of overflow measurements were used for model comparison.
- Prediction of loaded mass was (on average) within 7.5%.
- Prediction of overflow concentration was (on average) within 17% of the peak concentration measured.

DESCRIPTION OF THE TASS DYNAMIC PLUME MODULE

The paragraphs below describe the dynamic plume processes as well as the dynamic plume model used by TASS.

The dynamic plume processes

During TSHD operations material is disturbed and introduced into the water body via overflow as water is displaced from the hopper. The introduction of this sediment – which can have significant initial momentum – into the water column results in a body of water, denser than the surrounding water, that descends towards the seabed. This plume is referred to as the dynamic plume.

Under normal loading the plume ejected from the hull of the dredger creates both a dynamic plume (which descends towards the bed) and a surface plume (that is, the plume caused by all sediments not directly descending with the dynamic plume), which forms an often visible passive plume. Although the actual physical processes leading to the strength of the surface plume are not well defined, the evidence from measurements (Whiteside et al., 1995; John et al., 2000, Spearman, 2003 Nick Bray, HR Wallingford, pers.comm. and Aarninkhof et al., 2010) is that the bulk of the overflow sediment forms a dynamic plume and the surface plume represents a small proportion of the sediment released in the overflow.

Furthermore, the surface plume is known to be a function of the air content in the overflow because the surface plume is significantly reduced when air is excluded from the plume, for instance, by use of the so called “environmental” or “green” valve. The proportion of the overflow that forms a surface plume is at present a focus for study in the EcoShape Project including research into multiphase CFD modelling at Delft University of Technology (De Wit, 2010).

In the meantime the proportion is a user-defined value in the TASS model with a recommended value of 5-15% suggested based on the field measurements to date.

The dynamic plume eventually impacts with, and collapses onto, the bed to form a bed plume which may not initially mix with the overlying waters, depending on the density difference between this layer and the ambient concentrations and the magnitude of the ambient currents (and wave action).
As sediment settles out of this layer, however, and the thickness of the layer is reduced by further collapse, mixing will at some point occur and this layer may be re-entrained into the waters above to contribute to the passive plume. All of these processes are included in the dynamic plume model; a full description of the dynamic plume module is given in Spearman et al. (2003) and the TASS User manual (EcoShape, 2010).

Dynamic plume model

The TASS dynamic plume module reproduces the near-field mixing that occurs as the negatively buoyant jet of the overflow mixes with the surrounding waters. The initial descent of the dynamic plume is reproduced using a Lagrangian technique whereby a thin disc of the released dynamic plume is tracked as it moves downward under the forces of momentum and negative buoyancy.

The technique has been used for both dredger plume and outfall plume modelling (e.g., Koh and Chang, 1973, Brandsma and Divoky, 1976, and Lee and Cheung, 1990).

Entrainment of ambient water into the plume is modelled using the formulations of Lee and Cheung (1990) and accounts for both shear entrainment (i.e., as occurs in jets and dominates the initial stages of the dynamic descent) and forced entrainment (which dominates in the latter stages of descent and is due to the flow of ambient water into the plume) as shown in Figure 7.

The descent phase is terminated either when the plume impinges on the bed or when the vertical (downward) speed becomes less than zero (as may happen in strongly stratified conditions) or when the dynamic plume becomes sufficiently diffuse that it becomes a passive plume. Two experiments were chosen for the validation of the dynamic descent – Chu and Goldberg (1974) and Chu (1975).

In the case of these experiments, the plume was simulated by injecting dyed saline solution vertically downward/upward into a flume through a hypodermic needle/injection pipe. The results of these experiments are not shown here but are presented in Spearman et al., (2003) and the TASS user manual (EcoShape, 2010).

After the plume impinges on the bed the model reproduces the collapse of the dynamic plume as a density current. For dense thin layers, on a horizontal bed, the horizontal speed of propagation of the front of the resulting density current along the bed, is related to the thickness of the density current and the gravitational acceleration modified for buoyancy (Hallworth et al., 1998).

A “box-model” approach has been used to describe the shape of the density current, i.e., the density current height is assumed constant over the length of the density current. As the density current lengthens, continuity of mass implies that the thickness of the density current reduces. All of the fractions are considered to be uniformly mixed, vertically and along the length of the current. Deposition onto the bed is calculated by keeping a running total of the deposition flux for each fraction from the density current.

The validation of the bed collapse was undertaken by comparing the results of the model with the results of laboratory experiments by Hallworth et al., (1998). The results of these experiments are not shown here but are described in in Spearman et al., (2003) and the TASS user manual (EcoShape, 2010).

The bed collapse phase ends when the turbulence within the density current has reduced sufficiently to allow mixing with ambient waters at which point the density current can be regarded as a passive plume.

**DESCRIPTION OF PASSIVE PLUME MODULE**

The paragraphs below described the passive plume processes by which they disperse over time and the passive plume model used by TASS.

**Description of passive plume processes**

When formed, the passive plume of material will slowly disperse with the mixing effects of currents and waves. This effect, together with the settling of sediment particles, will reduce the concentration of the passive plume over time. There are three main mechanisms whereby this occurs:

- **Turbulent diffusion**, the small-scale temporal and spatial variations in current flow.
- **Shear dispersion**, the effect of different current velocities through the water column, which results in particles at different heights travelling in different directions and at different speeds, thus spreading the plume. This effect is generally much larger than (but is actually dependent on) turbulent diffusion.
- **The settling and re-suspension of sediment particles** to/from the bed.

**Passive plume model**

The passive plume model provided in TASS is intended to give a first order prediction of the resulting increases in suspended sediment resulting from dredging over and above background concentrations at a position some distance from the dredger. The model is not a
detailed 3D model but predicts the depth-averaged increase in suspended sediment concentration at a point rather than the distribution of the plume in space.

In the case of the trailer suction hopper dredger, the passive plumes formed by dredging are a combination of the release of sediment directly into the water column (the "surface" plume), the sediment that diffuses out of the dynamic plume density current into the overlying waters and the sediment eroded from the bed by the propeller jet (see Figure 1). In addition there may be a small disturbance of sediment on the seabed by the draghead of the dredger but this is currently not represented in the TASS model.

The flow within the study area is assumed to be uniform and uni-directional along a single axis direction. The depth in the area of interest is also assumed to be uniform. Dispersion along and perpendicular to the direction of flow is calculated using the formulae of Elder as described in Fischer et al., (1979). Under these simplifying assumptions, the solution for an instantaneous release of a slug of material into the water can be described by an analytical equation. The method of Carslaw and Jaeger (1959) is used to solve the problem for time varying release. Further detail of the passive plume model is provided in the TASS user manual (EcoShape, 2010).

The principle objective of the TASS project is to determine the source term for dredging-induced turbidity in the far-field area from the dredger. Instead of using the simple passive plume model provided in the TASS system, the TASS overflow and dynamic plume models can also be combined (as in the HR Wallingford SEDTRAIL-3D model) with a detailed 3D passive plume model (as used in the comparisons described in below). In this way the TASS system can be used to provide initial and detailed dredging plume predictions suitable for a range of environmental assessment studies.

**VALIDATION OF THE PASSIVE PLUMES PREDICTED BY THE TASS SYSTEM**

In the following section, the passive plume measurements and the description of passive plume simulations will be presented as well as the effect of the dynamic plume in reducing the release of sediment into the water column and the validation of these studies against field measurements.

Measurements of the passive plume

In 2007 a field study was undertaken at Rotterdam to measure the turbidity plumes arising from overflow, draghead disturbance and from the propeller jet. This was followed later in the same year by a further field study at Den Helder where further measurements of overflow plumes were carried out (Aarninkhof et al., 2010).

During the field studies in the Rotterdam waterway and offshore at Den Helder measurements of suspended sediment concentrations were made using ADCP backscatter. This methodology is based on the fact that the presence of sediment (or other particles such as bubbles or organic material) will cause reflection of the acoustic signal and the more particles present, the greater the reflection will be. The acoustic backscatter signal is therefore calibrated against water samples and, providing the results of the calibration process are satisfactory, this method can be used to record suspended sediment concentrations through depth.

As calibration can be complicated there are a number of software packages available to simplify and facilitate this process. SEDIVIEW software was used for this purpose. When used to make transects the methodology can prove highly effective in providing detailed descriptions of plumes or estuary cross-sections. A combination of OBS sensors mounted on a streamer and water sampling was used to collect point measurements in order to validate the ADCP measurements.

**Description of passive plume simulations**

The TASS v3.2.1 overflow and dynamic plume modules described above under the “Description of the Tass Dynamic Plume Module” and “Comparison of Tass Overflow Module Results with Measured Overflow Data” were used to provide source terms within a detailed passive plume dispersion model (SEDTRAIL-3D) to predict the suspended concentrations within the passive plume at some distance from the dredger. These predictions of the passive plume concentrations were then compared against measured data (ADCP backscatter and OBS) from the Rotterdam and Den Helder field experiments (Aarninkhof et al., 2010).

The flow model input used to reproduce the plume dispersion was composed of a simple "flume-type" model which was long enough to allow the motion of the plume over the course of the simulation, and wide enough to represent the lateral dispersion of the plume. The model was run to reproduce a nominal depth-averaged current speed and the current magnitudes adjusted up or down to match the

<table>
<thead>
<tr>
<th>Trip number</th>
<th>ADCP Frame</th>
<th>Distance from dredger (m)</th>
<th>Ambient current speed (m/s) *</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rotterdam</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>07018</td>
<td>380</td>
<td>0.55’</td>
</tr>
<tr>
<td>11</td>
<td>08000</td>
<td>230</td>
<td>-0.54</td>
</tr>
<tr>
<td>17</td>
<td>09010</td>
<td>200</td>
<td>-0.73’</td>
</tr>
<tr>
<td>17</td>
<td>09012</td>
<td>320</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Den Helder</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>272</td>
<td>37</td>
<td>430</td>
<td>0.7</td>
</tr>
<tr>
<td>272</td>
<td>47</td>
<td>480</td>
<td>0.8</td>
</tr>
<tr>
<td>277</td>
<td>65</td>
<td>3080</td>
<td>0.3</td>
</tr>
<tr>
<td>278</td>
<td>80</td>
<td>240</td>
<td>Low and variable</td>
</tr>
</tbody>
</table>

* A positive current speed indicates that the dredger was sailing against the current and a negative current speed indicates that the dredger was sailing with the current.
The validation exercise highlighted both the fact that there is a surface plume which forms a relatively small proportion of the sediment overflowed from the dredger and that there is currently no method for estimating this proportion \textit{a priori}.

The model results were therefore calibrated by adjusting the proportion of material released into the surface plume (a user-defined parameter in the TASS model) until the model prediction broadly matched the observations.

Figure 8 shows a representative sample comparison of the prediction for Trip 277 of dredging with TSHD Geopotes 15 at Den Helder with the measured observations. The release of fine material in the overflow is predicted by the TASS overflow model to be around 292 kg/s at this time. The measured flux of sediment in the far-field is around 2.9 kg/s.

By considering the different frames of reference of the dredger and the measured plume and accounting for the different speeds of the dredger and the tidal currents the overflow discharge of fine sediment that would account for the measured flux can be calculated and corresponds to 11 kg/s. The observed sediment in the water column in the far-field thus corresponds to only around 4% of the released fine material from the overflow. The model prediction gave the predicted sediment in the far-field as equivalent to 3% (in the measured part of the water column) and 4% in total.

Effect of the dynamic plume in reducing the release of sediment into the water column

As discussed previously, accurate measurements of the relative magnitudes of the surface and dynamic plumes are scarce at present. The lack of knowledge in these areas means that at present it is not possible to reliably and \textit{a priori} predict the balance of surface and dynamic plumes in a model by representing the physical processes. Having said this, relative proportions of sediment in the surface/dynamic plumes are based on measurements of dredging plumes in Hong Kong where the surface plume was estimated, on average, to amount to 15% of the overflow material discharged (\textit{pers. comm.} Nick Bray, HR Wallingford).

Inevitably this figure is based on limited measurements but the magnitude of the measured surface plume as being substantially smaller than the dynamic plume fits well with the discussion presented above and the results of the validation exercise presented below which found that the surface plumes represented between 5% and 15% of the fine sediment in the overflow discharge.

Validation against field measurements

The passive plume was predicted for the trips and measured ADCP transects as summarised in Table II. The prediction of overflow losses were undertaken for Trips 5, 11 and 17 from the Rotterdam 2007 field experiment and for Trips 272, 277 and 278 from the Den Helder 2007 field experiment.
RESULTS OF COMPARISON OF THE TASS MODEL AND DETAILED PLUME DISPERSION MODEL WITH FAR-FIELD DATA

In general small proportions of the fine sediment released are observed in the far field; this is reproduced by plume dispersion modelling using dynamic plume and passive plume modules. Modelling confirms that the surface plume accounts for 5-15% of the overflow discharge. Contributions are lower when using the environmental (“green”) valve. This is similar to reports from monitoring in Hong Kong in the 1990s.

FURTHER WORK: MODEL DEVELOPMENT AND DISSEMINATION

The aim from the start of the TASS project was to make this software available to the dredging industry as well as third party users. The research on dredging-induced turbidity is currently embedded in the EcoShape innovation programme, which aims at creating sustainable solutions for marine and inland water constructions. Present efforts focus on further development and validation of the model for a variety of environmental conditions, including the tropics. Once thoroughly tested, the model will be made publically available to facilitate sound predictions of dredging-induced turbidity by contractors, consultants, researchers and public authorities worldwide.

REFERENCES


De Wit, L. (2010), Near field 3D CFD modelling of overflow plumes. Proceedings of the 19th World Dredging Conference (WODCON XIX), Beijing (China).


CONCLUSIONS

TASS (Turbidity ASsessment Software) is a software programme that enables the user to predict the spatial development and concentration of turbidity plumes arising from dredging activities by TSHDs. The TASS-project is currently embedded in the EcoShape Building with Nature innovation programme.

The project has arisen from poor estimation of the effects of TSHDs, which can lead to unrealistically optimistic or pessimistic predictions of the development of turbidity plumes around dredging operations.

TASS has been validated against field data in a variety of locations and site conditions along the North Sea Coast. The model has been found to reproduce both the nature of the overflow and the far-field plume correctly. The model represents a useful tool for Environmental Impact Assessment studies associated with dredging plumes from trailer suction hopper dredgers.

EcoShape and HR Wallingford are currently cooperating to improve the robustness of TASS for use for sites around the world.

Current efforts focus on additional measurement campaigns in tropical waters and validation of the software in the next year. It is envisaged that TASS will become available to the public in 2012.
ABSTRACT
CEDA (the Central Dredging Association) is the only independent, international, professional association in Africa, Europe and the Middle-East whose sole interest is dredging and marine construction. It is the authoritative reference point and the meeting place for academics and industry professionals, decision makers and stakeholders. It aims to provide a platform for the exchange of knowledge and experience on all aspects of dredging and marine construction and is committed to the environmentally responsible management of dredging activities. This Position Paper was produced by the CEDA Environment Commission’s Working Group on Underwater Sound and aims to inform all parties concerned about sounds produced by dredgers.

INTRODUCTION
Dredging is an activity that is carried out for many purposes. The dredging process can simplistically be described as the excavation of sediment from a sea, river or lake bed and the handling and transport of the excavated sediments and soils to a placement site elsewhere.

Dredging is commonly applied for:
- Construction and maintenance of ports and waterways, dikes and other infrastructures
- Reclamation of new land
- Flood and storm protection and erosion control by maintaining river flows and by nourishing beaches
- Extraction of mineral resources from underwater deposits, particularly sand and gravel, to provide raw materials for the construction industry, and
- Environmental remediation of contaminated sediments.

Thus dredging provides many benefits to society with the goal of sustainable development while protecting natural resources and quality of life.

OBJECTIVES
Like many other activities, dredging produces underwater sound. Recently, the issue of effects of underwater sound on aquatic life has received broader attention within the scientific community, with stakeholders and the general public.

In this paper we will:
1) Summarise the effects of sound on aquatic life to set the scene
2) Describe in detail the underwater sounds generated by various components of the dredging process
3) Summarise what is known about potential effects of dredging sounds
4) Identify options for managing dredging-related sound, and
5) Provide conclusions and an outline of future areas of research.

EFFECTS OF SOUND ON AQUATIC LIFE
What is sound?
It can be described as a moving wave in which particles of the medium are forced together and then apart. This creates changes in pressure that propagate with the speed of sound. The speed of sound in water is more than four times faster than in air and attenuation is also much less in water compared to air. Thus, water is an ideal medium for sound propagation. Sounds can be described in terms of their intensity, which is measured or expressed in decibels (dB), pitch or frequency (in Hertz or kilohertz) and their duration (in seconds or milliseconds).
Sources of underwater sound

Both the natural environment and man can produce underwater sound. Natural sources of sound can be vocalisations of marine life – e.g. the elaborate songs of humpback whales or the snapping of shrimp. Wind, rain, waves, and subsea volcanic and seismic activity all contribute to ambient sounds in bodies of water.

Human-induced sound comes from construction of marine infrastructure (including dredging) and industrial activities such as drilling or aggregate extraction (including dredging); shipping; military activities using various types of sonar; geophysical exploration using seismic surveys, and a variety of other activities.

Anthropogenic sound sources can be broadly divided into high intensity impulsive sources, such as pile driving, and less intense but more continuous sources like shipping and dredging. It has to be noted here that the dredging fleet represents 0.5% of the world total shipping fleet.

Human activities in the aquatic environment have intensified since the last century and research has indicated that ambient sound has been increasing in some regions too. While ambient sound levels are the result of both natural and anthropogenic sources, it is the latter we have control over since these can be managed.

Use of sound by aquatic life

As sound transits very well underwater, many marine species use it for a variety of purposes. Both fish and marine mammals communicate with underwater sound. Some whales communicate over great distances of many tens of kilometres. Sound is also used for navigation and finding prey. Dolphins, for example, produce short ultrasonic clicks and use the echoes to form an acoustic image that can help them to detect food or obstacles. There is also evidence that naturally occurring sounds are used by fish and marine mammals for orientation.

The effects of sound are strongly dependent on hearing abilities, which differ greatly between marine organisms. In general, marine mammals have a wide hearing range with some toothed whales able to hear ultrasounds (sounds above 20 kHz) that humans cannot detect. Fish hear over a narrower band and generally their sensitivity is better at lower frequencies. Some fish, such as sole or salmon, only detect differences in the movements of the particles moving within the sound wave and have a poor sensitivity. Others, such as herring, are able to detect sound pressure and have strong sensitivity.

Effects of sound on aquatic life

Sounds can have a variety of effects on aquatic life, ranging from subtle to strong behavioural reactions such as startle response or complete avoidance of an area. It is well documented that short and impulsive sounds such as those produced from pile driving strikes, seismic airguns and military sonar can cause behavioural reactions by fishes and cetaceans (whales, dolphins and porpoises; see OSPAR 2009 for example) up to distances of several tens of kilometres from the sound sources.

Certain sounds can also mask biologically important signals such as communication calls between baleen whales or fish. If the level that the animals receive is high enough, sound can affect hearing either temporarily or permanently and extremes can lead to injury or even death. The latter, however, usually occurs only in the case where animals are very close to very high intensity sounds, without having the opportunity to move away.

Research on the effects of underwater sound on aquatic life has increased over the last decade, but there are still many unanswered questions, especially with regards to the significance of sound impacts for conservation objectives. In particular, the translation of individual effects into consequences at the population level involves great uncertainty.

Even when sound alone is not severe enough to affect the well-being of populations of concern, together with factors such as fishery by-catch, pollution and other stressors, sounds may create conditions that contribute to reduced productivity and effects on survival. It is therefore important to assess the effects of sound together with other stressors when undertaking assessments of impacts on ecosystems.

Dredging sound

Activities producing underwater sound

For the majority of projects, one or more of four basic types of vessel are used: cutter suction dredgers.
Various configurations of winches, generators, and hydraulic equipment specific to a given dredger’s design can also produce sounds. Lack of proper maintenance and lubrication can cause increased sound levels.

Both CSDs and TSHDs (Figures 1 and 2 respectively) use a suction pipe to transport entrained material from the seabed to a transport barge, to a pipeline or to a hopper. Depending on the material, a regular rumbling sound will be produced, possibly with irregular peak-pulses when pumping fragmented rock. When working stationary this sound is relatively low in frequency, fairly constant and continuous. For non-stationary equipment this sound production is less continuous (cyclic).

Sounds are also produced by the dredge pumps both above and underwater. Dredge pump sounds are relatively constant and continuous during operation. TSHD operations produce pump sounds intermittently during dredging, trailing and during self-discharge.

TSHD’s propellers continuously work during dredging and can produce sounds of high frequencies, particularly during episodes of cavitation. But because TSHDs depart the dredging site for the placement site on a regular cycle, exposures to such sounds would be limited to the period of active excavation.

Sound production during excavation is strongly influenced by soil properties – e.g. to excavate hard, cohesive and consolidated soils, the dredger must apply greater force to dislodge or entrain the material. Consequently, dredging these types of soils may involve more intense sounds than for excavation of soft, high water content soils. Soil type also influences the selection of dredger type as well the equipment used, including cutterheads, dragheads, grab buckets and backhoes.
and repair works, such as rust chipping and hammering, can be passed through the hull to the water and can contribute to underwater sound levels.

**Dredging sound measurements**

Although dredging sounds can be generally described as in the previous sections, few data and few published characterisations of dredging-induced sound levels exist.

The one investigation carried out on grab dredgers indicates that this activity is relatively quiet and that recorded sound levels were just above the background sound at approximately 1km from the source (Clarke et al. 2002).

Both CSDs and TSHDs are louder (see summary in Thomsen et al. 2009). A very recent investigation (Robinson et al. 2011) found that trailing suction hopper dredgers emit sound levels at frequencies below 500Hz that are generally in line with those expected for a cargo ship travelling at a modest speed – i.e. between 8kt and 16kt. It was also found that source levels at frequencies above 1kHz show elevated levels of broadband sound generated by the aggregate extraction process; however these sounds attenuate rapidly with distance.

There were strong indications that the presence of aggregate pumped through the pipe is a major source of these elevated levels at higher frequencies. Finally, the sound levels were dependent on the aggregate type being extracted, with coarse gravel generating higher sound levels than sand (Robinson et al. 2011).

Appendix 1 gives an overview of the currently available results of these monitoring campaigns and also lists other sources of natural and anthropogenic underwater sounds for comparison.

**Potential and documented effects of dredging sound**

Based on the information presented in Appendix 1, we can see that dredging is at the lower end of the scale with regards to emitted sound pressure levels in aquatic environments. These sounds primarily fall within lower frequency ranges where many toothed whales, such as harbour porpoises, are less sensitive. Although higher frequency sounds are emitted by the transport of sand and gravel through a suction pipeline, such
sounds can be expected to attenuate faster than the lower frequency sounds, thereby limiting potential impact ranges. With respect to underwater sound in general, insufficient knowledge exists to confidently predict at what levels sound can cause injury, such as temporary or permanent hearing threshold shifts.

Two study groups have developed suggestions for marine mammals and fish based on the limited information available (see Popper et al. 2006; Southall et al. 2007). Based on these recommendations, it is very unlikely that underwater sound from dredging operations can cause injury. Temporary loss of normal hearing capabilities might happen if individuals are in the immediate vicinity of a dredger and are exposed for a long time, which is unlikely.

Behavioural reactions, however, such as startle or avoidance behaviours and masking effects, cannot be ruled out. The ecological significance of these responses will vary among species. Both can have negative consequences for individuals if important behaviours such as mating or foraging are affected.

Very little research has been carried out on the effects of dredging on the behaviour of marine life and results are therefore sparse. Some investigations indicate that gray and bowhead whales avoid areas of dredging activity (reviewed by Richardson et al. 1995) and recent research also indicates that harbour porpoises leave areas during sand extraction. The reactions were relatively short term however (Diederichs et al. 2010).

No information exists about effects on seals or most species of fish.

Management of dredging related sound

Dredging conductors should have an interest in carrying out their activities in an environmentally friendly manner. In Europe, dredging is in most cases licensed through an Environmental Impact Assessment (EIA) that is usually comprised of a careful analysis of the baseline situation, including information on the distribution and abundance of sensitive species within the planning area, for which literature data and own investigation can be used. Based on these investigations, an impact assessment is then carried out that gives some detail on the expected intensity, duration and range of impacts. The decision to permit a project and to impose reasonable and appropriate restrictions lies with the licensing authority.

Recently, Boyd et al. 2008 developed a risk-based approach for assessing the impacts of sound on marine mammals that involves several steps leading to an overall assessment of risks of an activity to the well-being of mammal populations. CEDA acknowledges these new developments and encourages further steps in refining the methodology in relation to underwater sound.

APPENDIX 1. SOUNDS IN THE AQUATIC ENVIRONMENT

Table I. An overview of biological and manmade sound sources listed in decreasing order of source levels at 1m.

<table>
<thead>
<tr>
<th>Sound source</th>
<th>Source level at 1m</th>
<th>Bandwidth</th>
<th>Main energy</th>
<th>Duration</th>
<th>Directionality</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosives</td>
<td>272dB-287dB re 1µPa zero-to-peak</td>
<td>2Hz&lt;--1kHz&gt;</td>
<td>6Hz-21Hz</td>
<td>~1ms</td>
<td>Omni-directional</td>
<td>1)</td>
</tr>
<tr>
<td>Seismic air gun arrays</td>
<td>220dB-262dB re 1µPa peak-to-peak</td>
<td>5Hz-100kHz</td>
<td>10Hz-120Hz</td>
<td>10ms-100ms</td>
<td>Downwards</td>
<td>2)</td>
</tr>
<tr>
<td>Pile driving</td>
<td>220dB-257dB re 1µPa peak-to-peak</td>
<td>10Hz&gt;20kHz</td>
<td>100Hz-200Hz</td>
<td>5ms-100ms</td>
<td>Omni-directional</td>
<td>1), 2)</td>
</tr>
<tr>
<td>Echosounders</td>
<td>230dB-245dB re 1µPa rms</td>
<td>11.5kHz-100kHz</td>
<td>Various</td>
<td>0.01ms-2ms</td>
<td>Downwards</td>
<td>2)</td>
</tr>
<tr>
<td>Low-frequency military sonar</td>
<td>240dB re 1µPa peak</td>
<td>0.1kHz-0.5kHz</td>
<td>-</td>
<td>6s-100s</td>
<td>Horizontally focussed</td>
<td>3)</td>
</tr>
<tr>
<td>Sperm whale click</td>
<td>236dB re 1µPa rms</td>
<td>5kHz-40kHz</td>
<td>15kHz</td>
<td>100µs</td>
<td>Directional</td>
<td>4)</td>
</tr>
<tr>
<td>Mid-frequency military sonar</td>
<td>223dB-235dB re 1µPa peak</td>
<td>2.8kHz-8.2kHz</td>
<td>0.5s-2s</td>
<td>Horizonally focussed</td>
<td>1)</td>
<td></td>
</tr>
<tr>
<td>Sparkers, boomers, chirp sonars</td>
<td>204-230 dB re 1µPa rms</td>
<td>0.5-12kHz</td>
<td>Various</td>
<td>0.2ms</td>
<td>Downwards</td>
<td>2)</td>
</tr>
<tr>
<td>Harbour porpoise click</td>
<td>205dB re 1µPa peak-to-peak</td>
<td>110kHz-160kHz</td>
<td>130kHz-140kHz</td>
<td>100µs</td>
<td>Directional</td>
<td>5)</td>
</tr>
<tr>
<td>Shipping (large vessels)</td>
<td>180dB-190dB re 1µPa rms</td>
<td>6Hz&gt;30kHz</td>
<td>&lt;200Hz</td>
<td>Continuous</td>
<td>Omni-directional</td>
<td>1)</td>
</tr>
<tr>
<td>TSHD</td>
<td>186dB-188dB re 1µPa rms</td>
<td>30Hz-&gt;20kHz</td>
<td>100Hz-500Hz</td>
<td>Continuous</td>
<td>Omni-directional</td>
<td>6), 7)</td>
</tr>
<tr>
<td>Snapping shrimp</td>
<td>183dB-189dB re 1µPa peak-to-peak</td>
<td>&lt;2kHz-200kHz</td>
<td>2kHz-5kHz</td>
<td>Milliseconds</td>
<td>Omni-directional</td>
<td>8)</td>
</tr>
<tr>
<td>CSD</td>
<td>172dB-185dB re 1µPa rms</td>
<td>30Hz-&gt;20kHz</td>
<td>100Hz-500Hz</td>
<td>Continuous</td>
<td>Omni-directional</td>
<td>6), 7)</td>
</tr>
<tr>
<td>Construction and maintenance ships</td>
<td>150dB-180dB 1µPa re 1µPa</td>
<td>20Hz-20kHz</td>
<td>&lt;1kHz</td>
<td>Continuous</td>
<td>Omni-directional</td>
<td>1)</td>
</tr>
<tr>
<td>Drilling</td>
<td>115dB-117dB re 1µPa (at 405m and 125m)</td>
<td>10Hz&lt;~1kHz</td>
<td>&lt;30Hz-60Hz</td>
<td>Continuous</td>
<td>Omni-directional</td>
<td>1)</td>
</tr>
</tbody>
</table>

Once risks have been identified, there are a variety of options available to mitigate against adverse impacts. These range from temporal restrictions on dredging activities and spatial buffer zones to technical solutions that reduce the levels of sounds emitted into the sea (overview by OSPAR 2009). These methodologies, however, need careful consideration and clear justification based on clearly identified risks to the aquatic environment. This also guarantees the involvement of responsible developers and stakeholders in the process. Ideally, in a transparent decision making process, policy will effectively balance the risk of impact with social-economic benefits.

REFERENCES


**CONCLUSION & RECOMMENDATIONS FOR FURTHER STUDIES**

Dredging involves a variety of activities that produce underwater sounds. Most of these are relatively low in intensity and frequency, although recent investigations indicated that occasionally higher frequencies are emitted.

Compared to other activities that generate underwater sound, dredging is within the lower range of emitted sound pressure levels. While it is clear that dredging sound has the potential to affect the behaviour of aquatic life in some cases, injury in most scenarios should not be a concern, or should be preventable. It is very unlikely that dredging-induced sounds will lead to any population level consequences, although harm to individuals should not be overlooked.

To reduce remaining uncertainties, there remains a need to increase our knowledge about the effects of dredging sounds on aquatic life. In the meantime a lack of knowledge should not lead to unjustified restrictions on projects. More information on emitted sounds from all types of activities carried out during dredging are necessary to further identify risks and support informed decisions about the necessity of sound mitigation measures.

CEDA encourages the development of a standardised monitoring protocol for underwater sound, to facilitate evaluations of reasonable and appropriate management practices. It is also recommended that rigorous investigations of the effects of dredging on marine mammals and fish be undertaken either in the field or under more controlled conditions in the lab. CEDA is committed to sustainable management of environmental resources and therefore recommends a balanced approach to the management of effects of underwater sound from dredging.

We encourage prudent investment in research related to the environmental impacts of underwater sound so that human activities can be carried out with the lowest possible risk to the well-being of individuals and populations.
The Economics of Adaptation to Climate Change (EACC) study has been a large, multiyear undertaking managed by a core team of the World Bank’s Environment Department. The report was undertaken to address the issues that developing countries will face as the global annual average temperature rises to 2°C above pre-industrial levels by 2050. According to the report, this rise in temperature will cause more intense droughts, floods, heat waves and other extreme weather events. This will have dramatic implications for how countries manage their economies, care for their people and design their development paths. Both developed and developing countries will need to adopt measures to adapt to climate change. These measures offer a way to make the effects of climate change less disruptive and spare the poor and the vulnerable from shouldering an unduly high burden.

In 2007 the global community adopted the so-called “Bali Action Plan” at the United Nations Climate Change Conference. The plan calls for developed countries to allocate “adequate, predictable, and sustainable financial resources and new and additional resources…for developing country parties” to help them adapt to climate change. The need for international cooperation is clear in order to make these plans work. To support this, the Economics of Adaptation to Climate Change (EACC) study was launched early in 2008 by the World Bank in partnership with the governments of Bangladesh, Bolivia, Ethiopia, Ghana, Mozambique, Samoa and Vietnam, and funded by the of The Netherlands, Switzerland, and the United Kingdom. A country analyses was undertaken for each above-named nations, and the work of many contributors – too numerous to name here – for each country resulted in this report.

The focus of each country analysis and the overall report present lessons learnt, the costs of adapting to climate change, economic development and adaption to climate change, climate uncertainty and the need for robust strategies, current climate vulnerabilities and hard vs. soft approaches to adaptation. The cost of planned adaptations, the implementation of sound public policy and the timing of investments in water infrastructure, which is likely to be sensitive to climate change, must be carefully considered. According to the editors, the related messages of “uncertainty, flexibility, and time are central to this report”. Whilst there are some specific conclusions about the implications of climate change and appropriate adaptation measures, “even more remains uncertain”. In essence the report advises that adaptation to climate change means “learning how to cope with greater levels of uncertainty”.

The report is enhanced by more 29 figures and 27 tables which provide extensive information in a digestible format. The pdf is downloadable at no cost at: http://climatechange.worldbank.org/sites/default/files/documents/EACCSynthesisReport.pdf
For further information see: www.worldbank.org/eacc or www.worldbank.org/sdcc

**Towards A Sustainable Waterborne Transportation Industry**

*ENVICOM TASK GROUP 2, PIANC ENVIRONMENTAL COMMISSION*


PIANC has a number of Technical Commissions and this report is based on the findings of the one dedicated to environmental issues. In the report, the rise of globalisation and the resultant global transportation industry are examined from a position of sustainability. According to the commission, global trade, driven by low-cost labour in developing economies such as China, India and others, has boosted international trade and “waterborne transport carries over 80 percent of the total volume”. On the other hand, since the global transportation industry is a significant contributor of CO₂ and other greenhouse gases, policy makers around the world are trying to find ways to encourage sustainability. As waterborne transport is of prime importance in the total transportation industry, focusing on the benefits, challenges and opportunities posed by this key mode is logical. The aim of the report is thus to inform and influence long-term policy decisions concerning the maritime and inland navigation transportation sector to ensure that they are part of a sustainable global transportation network.

The report defines the term “sustainable waterborne transportation” as the long-term maintenance of environmental, economic and social well-being. Waterborne transportation already provides huge benefits towards sustainability and has the potential to make an even greater contribution. Whilst the benefits are large, the authors maintain that certain issues must be addressed in order to preserve and enhance these benefits and they warn the industry against unwarranted complacency. The EnviCom Task Group 2 in its Terms of Reference...
The preparatory work for large infrastructure projects often consumes an extraordinary amount of time, money and human resources and is not particularly cost-effective. Some of this inefficiency is caused by traditional procurement methods which bring contractors into the process after many key decisions have been made. The clients and consultants are asked to make design decisions with insufficient information and knowhow as to the available technology, equipment and potential innovative solutions. The early involvement of contractors provides an efficient means of designing and planning infrastructure projects in a cost-effective, more efficient and less adversarial structure. In this Facts About, the advantages of using ECI with a properly executed contract that reflects a partnering relationship are presented. ECI should lead to increased transparency and therefore reduce risk, increase shared responsibility and limit the reasons for litigation.


All Facts About are downloadable in PDF form at the IADC website: www.iadc-dredging.com. Printed copies can be ordered by contacting the IADC Secretariat: info@iadc-dredging.com.
Freddy Wen, PIANC - COPEDEC VIII IOC Secretary

PIANC-coPeDec VIII
FEBRUARY 20-24 2012
INDIAN INSTITUTE OF TECHNOLOGY MADRAS
CHENNAI, INDIA

The First International Conference on Coastal and Port Engineering in Developing Countries (COPEDEC) was held in Colombo, Sri Lanka, in March 1983, resulting in the creation of a Permanent Secretariat to organize this special conference once every four years in a developing country. Subsequent conferences were held in China (1987), Kenya (1991), Brazil (1995), South Africa (1999), Sri Lanka (2003) and Dubai, UAE (2008).

During the 2003 COPEDEC VI conference, a merger agreement between PIANC, the World Association for Waterborne Transport Infrastructure, and COPEDEC was signed and a new International Organizing Committee (IOC) was formed. The Eighth International Conference on Coastal and Port Engineering in Developing Countries (PIANC-COPEDEC VIII) is to be held in Chennai, a vibrant port city of south India. This is the first time that the Conference will be held in a developing country where the National Section of PIANC is actively participating in the event.

LOC and IITM
Dr. Vallam Sundar, Professor, Department of Ocean Engineering
Indian Institute of Technology Madras, Chennai 600 036, India
Tel: +91 44 2257 4809, Mobile: +91 94440 49629
Fax: +91 44 2257 4809 / 4802
• Email: vsundar@iitm.ac.in or copedec2012@iitm.ac.in

IOC and PIANC - CoCom
Freddy Wen, PIANC - COPEDEC VIII IOC Secretary

IADC SEMINAR ON DREDGING
MARCH 19-23 2012
RECIFE, BRAZIL

Each year the International Association of Dredging Companies (IADC) organises its International Seminar on Dredging and Reclamation in various parts of the world. This intensive week-long course has been successfully presented in Delft, Singapore, Dubai, Buenos Aires, Abu Dhabi, Bahrain and Mexico. And now at the request of interested parties, it will be coming to Recife, Brazil from Monday 19 through Friday 23 March 2012.

The Seminar is aimed at (future) decision makers and their advisors in governments, port and harbour authorities, off-shore companies and other organisations confronted with the execution of dredging projects.

By Professionals for Professionals
Since 1993 IADC, often in co-operation with local technical universities, has provided this Seminar especially developed for professionals in dredging-related industries and presented by professionals from the major dredging companies. With a combination of classroom lectures and workshops, as well as an on-site visit, “the students” receive invaluable hands-on experience. As is appropriate to a dynamic industry, the seminar programme is continually updated to reflect the advances and innovations in the industry. In addition to basic dredging methods, new equipment and state-of-the-art techniques are explained.

Seeing is Believing: Site Visit
An important feature of the seminar will be a trip to visit a dredging project in Brazil. This will give participants the opportunity to see dredging equipment in action and to gain a better understanding of the extent of a dredging activity. Each participant will receive a set of comprehensive proceedings with an extensive reference list of relevant literature and, at the end of the week, a Certificate of Achievement in recognition of the completion of the coursework. The seminar starts Monday 19th 8:45 hrs and ends Friday 23 March 17:30 hrs. Please note that full attendance is required for obtaining the Certificate of Achievement.

Costs
The fee for the week-long seminar is € 3,100.- (VAT inclusive). This includes all tuition, seminar proceedings, workshops and special participants’ dinner, but excludes travel costs and accommodations. Assistance with finding hotel accommodation can be given.

To optimise the chances of the successful completion of a project, contracting parties should, from the start, fully understand the requirements of a dredging project. Don’t miss this opportunity to learn more about dredging, how it works and the important role it plays in social and economic development.

For further information contact:
Jurgen Dhollander, IADC PR & Project Manager, Tel: +31 70 352 3334
• Email: dhollander@iadc-dredging.com
CALL FOR PAPERS

WEDA 32/ TAMU 43
JUNE 10-13, 2012
CROWNE PLAZA RIVERWALK HOTEL,
SAN ANTONIO, TEXAS

With the theme “The Nuts and Bolts of Dredging,” the Western Dredging Association (WEDA) will focus on North, Central and South American dredging contractors, port authorities and other government agencies, environmentalists, consultants, academicians and engineers working in dredging and related fields. All interested parties are invited to submit papers.

The Technical Papers Committee will review all one-page Abstracts and notify authors of acceptance and final manuscript instruction for production of the proceeding on CDs. One page abstracts must include: Descriptive title, author names, author contact information (company name, address, phone, fax and email address) and abstract (<300 words). Submission of Abstract implies a firm commitment from the author to present the paper at the Conference. Abstracts are to be submitted not later than 15 December 2011. Final Manuscripts are due not later than 29 March 2012. Interested Authors should send their one-page abstracts to one of the following:

Dr. Ram Mohan, Sr. Partner, Anchor QEA, LLC
Tel: +1 267 753 6301, Fax: +1267 753 6306
• Email: rmohan@anchorqea.com

Dr. Robert E. Randall, Professor & Director
Department for Civil Eng., Center for Dredging Studies
Tel: +1 979 845 4568, Fax: +1 979 862 8162
• Email: r.randall@tamu.edu

Robert Wetta, President, Dredging Supply Co., Inc.
Tel: +1 985 479 8050, Fax: +1 985 47913670
• Email: rbwetta@dscdredge.com

DREDGING 2012
OCTOBER 22-25, 2012
SAN DIEGO, CA

Dredging 2012 is a four-day technical specialty conference on dredging and dredged material disposal, organized by PIANC USA and the Coasts, Oceans, Ports and Rivers Institute of American Society of Civil Engineers (COPRI ASCE). The theme is “40 Years of Dredging and Environmental Innovation”. Since it has been almost 10 years since the last specialty conference was held in Orlando, FL, in 2002, many new issues have emerged. Participants and presenters are sought regarding best practices and innovation in North and South America, Europe, and Asia. This will be an international forum bringing together professionals and practitioners from developed and developing areas of the world.

Key Dates
Deadline for abstract submissions: January 23, 2012
Author Notification: March 1, 2012
Presentations Due: September 10, 2012
Conference: October 22-25, 2012

The Overarching Theme of the Conference is: “40 Years of Dredging and Environmental Innovation”. Suggested presentation topics are: State of engineering practice; Dredging contracting and management innovations; Environmental dredging (remediation/ restoration); Safety; Current engineering dredging research; Integrating dredging and dredged material reuse with environmental restoration; Working with Nature; Site characterisation and survey; Sediment resuspension/ residuals; Sustainable sediment management; Dredged material management; Ports/ navigation – case studies (coastal/inland); Regulatory challenges and solutions.

When submitting an Abstract please provide the required contact information (name, company, business address, phone and email) for the corresponding author and any co-authors. Also indicate who you expect to make the presentation at the conference. Submit a text-only summary description (limited to 1,000 words) of the presentation. Submit a statement about why the presentation will be of interest and benefit to conference attendees. Abstracts must be submitted online at: https://wwsc.us/events/abstracts/dredging/index.cfm

Only abstracts submitted online will be considered.

For questions regarding abstract submission, please contact PIANC USA at dredging@pianc.us. Note: Only presentations are required. Papers are not necessary and will not be requested.

For more information visit http://dredging12.pianc.us or
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