CAPABILITY SHEET

ECODYNAMIC DEVELOPMENT & DESIGN TOOL (EDD-TOOL)
RESEARCH PROJECT ON DEVELOPMENT OF DREDGING-INDUCED TURBIDITY PLUMES

INCENTIVE FOR DEVELOPMENT OF TASS

Boskalis has been working on dredging projects for a century. During this period, dredging techniques have improved and enabled us to complete increasingly complex projects. The improvement in dredging techniques has also allowed contractor and client to claim smaller impacts on the environment. Efficient dredging of sediments is inherently associated with sediment stirring and an increase in suspended sediment concentrations. This generates dredging plumes which may have an impact on the surrounding environment and sensitive receptors in that area. Better insight into the generation and evolution of dredging-induced turbidity allows for improvement of environmental impact assessments and the development of sustainable construction strategies and techniques.

PROJECT CONTEXT, OBJECTIVES AND TIME PATH

Boskalis has coordinated a multi-year research project into the development of dredging-induced sediment plumes. The work was initiated by the Stichting Speurwerk Baggertechniek (SSB), a strategic research platform of the Dutch dredging industry, in 1998. Since 2010, the project has been part of the EcoShape | Building with Nature innovation programme. The project was set-up with a threefold objective:

- gain insight in dredging-induced turbidity to minimise environmental impacts and to facilitate realisation of projects;
- develop and validate a model to predict turbidity caused by dredging;
- share proven knowledge with third parties.

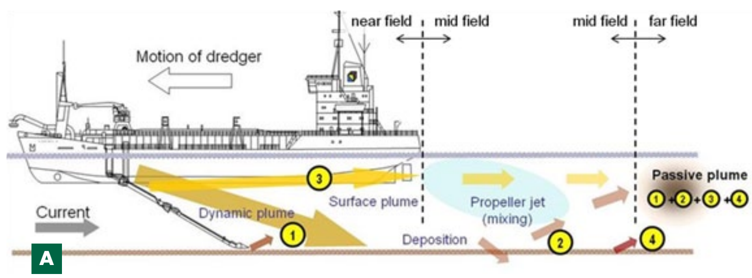
The project has resulted in a new model: Turbidity ASsessment Software (TASS). The software enables prediction of the far-field impact of dredging operations. This demands through understanding of sediment resuspension processes in the direct neighbourhood of the vessel, as well as successive plume dispersion with the ambient current. The project focuses on turbidity caused by trailing suction hopper dredgers (TSHD) rather than any other type of dredging equipment. The long project running time and substantial investments reflect the complex and innovative character of the project. Three phases are identified:

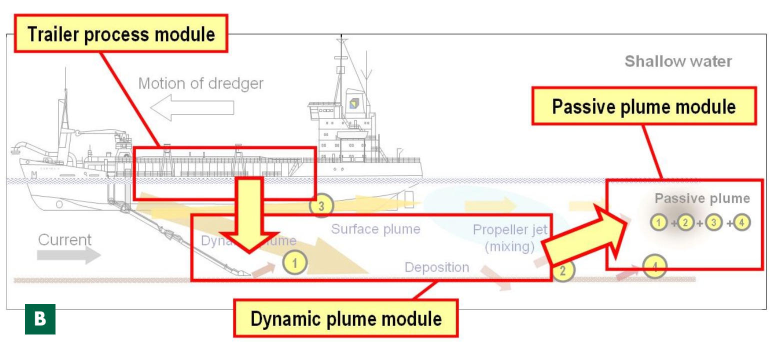
- efforts initially focused on development of measurement protocols and trial measurements in order to gain confidence in measurement equipment and collected data;
- collection of measurement data during three measurement campaigns in North Sea conditions and data interpretation;
- calibration of the theoretical model for dredging induced turbidity plumes and development of the TASS software.

The representative theoretical description of plume development has been the main objective throughout the project and was executed parallel to these phases.

DESCRIPTION OF DREDGING PLUMES

Several processes add to the development of turbidity plumes near dredgers. Some of these processes, such as sediment stirring due to propeller wash and ship movement-induced currents, are not specifically dredging-related. The dredging process mainly adds by means of sediment resuspension near the draghead and the resuspension of fines from overflow losses (i.e. the discharge of redundant process water containing sediment) (figure a). Drag head plume and overflow losses Measurements have shown that the development of dredging plumes is usually dominated by sediment resuspension from overflow losses. The sediment-water mixture leaving the overflow has a higher density than the ambient water and initially rapidly descends to the sea bed independently of the ambient hydraulic conditions, therefore identified as the dynamic plume. During the descent, water is entrained, causing dilution of the plume and slowing down the descent. The





A Schematic representation of sources for dredging-induced turbidity and plume development around a TSHD:
1. drag head plume;
2. resuspension of sediment settled from the dynamic plume;
3. sediment transported with the surface plume;
4. erosion of bed sediments.

B The TASS model comprises of three elements. The dynamic plume module models the residual increase in turbidity resulting from dredging operations in the far-field area and therefore directly represents the objective of TASS. The passive plume module can be replaced with other hydraulic computational software.

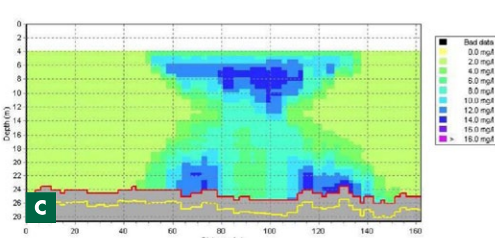
dynamic plume eventually impacts on the bed where it spreads radially as a density current and slowly settles further, all within a distance of a few hundred meters from the dredger Surface plume Directly underneath the overflow exit, part of the overflow mixture is stripped from the dynamic plume to form a surface plume close to the ship's hull. The stripping process is dependent on vessel movement, overflow discharge and mixture density, as well as the use of a green valve. For North Sea conditions, measurements suggest stripping percentages in the order of 5 to 15% without the use of a green valve and up to 5 % in case of a green valve. This surface plume is entrained by the ship movement-induced currents and stirred up again by propeller motions, causing a turbulent sedimentwater mixture. Resuspension of settled material and erosion of bed sediments The effect of the propeller wash may reach the local sea bed and bring original bed material and material settled from the dynamic plume in suspension. The combined effect of all resuspension processes finally yields a passive plume, which dynamics are governed by the settlement behaviour of individual particles and the hydrodynamic nature of the ambient flow.

INNOVATIVE MEASUREMENT TECHNIQUES TO COLLECT VALIDATION DATA

The description of dredging plumes was the base for the development of TASS. HR Wallingford was contracted to develop the model, SSB partners facilitated the collection of validation data. The TASS model comprises three elements (figure b):

- overflow module, to estimate the discharge and density of the overflow;
- dynamic plume module, to model the plume behaviour in the near-field area (up to 500-1000m) from the dredger;
- passive plume module, to predict the passive plume behaviour in the far-field area.

Three measurement campaigns were organised in 2006 and 2007 in the Netherlands (Hook of Holland, Den Helder) and Germany (Bremerhafen). Trivial data was recorded like the sailing route, vessel draught and sand volume in the hopper. Innovative techniques were used to measure specific parameters for TASS. The overflow discharge and density were measured with the Medusasystem, comprising a radioactivesource and detector. The development of the plume around the dredgers and associated high concentration and / or turbulent conditions demanded concise and accurate measurement techniques. Both optical (OBS) and acoustic (ADCP) signals were recorded in order to collect complimentary data (figure c). Several scenarios were assessed to incorporate the effects of variations in vessel movements, dredging operations, soil characteristics and hydrodynamic conditions. The results were assessed and measurement data was qualified for the validation of the software. The consecutive campaigns were used to gain experience in plume measurements, improve work methods for next campaigns and review theory of plume development (figure d & figure e).



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 turbidityis currently embedded in the EcoShape | Building with Nature innovation program, 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

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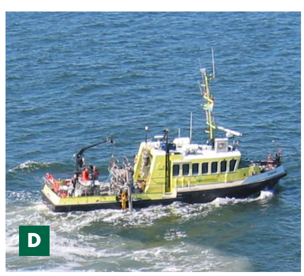

C Sediview was used to depict the measurements recorded with ADCP. This figure depicts measurements directly behind the dredger and shows turbidity plumes from the overflow and drag heads

D Measurement vessel Corvus identifying the location and intensity of turbidity plumes. Several transects were sailed at various distances from the dredger and various times after release of the sediment in order to monitor the development of the plumes

E The measurement fish contained an acoustic Doppler current profiler (ADCP) sensor to measure vertical turbidity profiles

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