Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing
Bestek 16EB/05/04

Survey Vessel De Parel II (left) & Deurganckdok – East terminal (right)

Deelrapport 2.4 13-uursmeting Sediview gemiddeld tij
27/09/2006 Parel II

Report 2.4 Through Tide Measurement Sediview Average Tide
27/09/2006 Parel II

February 5th 2007
I/RA/11283/06.119/MSA
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1. INTRODUCTION

1.1. The assignment

This report is part of the set of reports describing the results of the long-term measurements conducted in Deurganckdok aiming at the monitoring and analysis of silt accretion. This measurement campaign is an extension of the study "Extension of the study about density currents in the Beneden Zeeschelde" as part of the Long Term Vision for the Scheldt estuary. It is complementary to the study 'Field measurements high-concentration benthic suspensions (HCBS 2)'\(^1\).

The terms of reference for this study were prepared by the 'Departement Mobiliteit en Openbare Werken van de Vlaamse Overheid, Afdeling Waterbouwkundig Laboratorium' (16EB/05/04). The repetition of this study was awarded to International Marine and Dredging Consultants NV in association with WL|Delft Hydraulics and Gems International on 10/01/2006.

Waterbouwkundig Laboratorium- Cel Hydrometrie Schelde provided data on discharge, tide, salinity and turbidity along the river Scheldt and provided survey vessels for the long term and through tide measurements. Afdeling Maritieme Toegang provided maintenance dredging data. Agentschap voor Maritieme Dienstverlening en Kust – Afdeling Kust and Port of Antwerp provided depth sounding measurements.

The execution of the study involves a twofold assignment:

- Part 1: Setting up a sediment balance of Deurganckdok covering a period of one year
- Part 2: An analysis of the parameters contributing to siltation in Deurganckdok

1.2. Purpose of the study

The Lower Sea Scheldt (Beneden Zeeschelde) is the stretch of the Scheldt estuary between the Belgium-Dutch border and Rupelmonde, where the entrance channels to the Antwerp sea locks are located. The navigation channel has a sandy bed, whereas the shallower areas (intertidal areas, mud flats, salt marshes) consist of sandy clay or even pure mud sometimes. This part of the Scheldt is characterized by large horizontal salinity gradients and the presence of a turbidity maximum with depth-averaged concentrations ranging from 50 to 500 mg/l at grain sizes of 60 - 100 μm. The salinity gradients generate significant density currents between the river and the entrance channels to the locks, causing large siltation rates. It is to be expected that in the near future also the Deurganckdok will suffer from such large siltation rates, which may double the amount of dredging material to be dumped in the Lower Sea Scheldt.

Results from the study may be interpreted by comparison with results from the HCBS and HCBS2 studies covering the whole Lower Sea Scheldt. These studies included through-tide measurement campaigns in the vicinity of Deurganckdok and long term measurements of turbidity and salinity in and near Deurganckdok.

The first part of the study focusses on obtaining a sediment balance of Deurganckdok. Aside from natural sedimentation, the sediment balance is influenced by the maintenance and capital dredging works. This involves sediment influx from capital dredging works in the Deurganckdok, and internal relocation and removal of sediment by maintenance dredging works. To compute a sediment

\(^1\) Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slibsuspensies
balance an inventory of bathymetric data (depth soundings), density measurements of the
deposited material and detailed information of capital and maintenance dredging works will be
made up.

The second part of the study is to gain insight in the mechanisms causing siltation in
Deurganckdok, it is important to follow the evolution of the parameters involved, and this on a long
and short term basis (long term & through-tide measurements). Previous research has shown the
importance of water exchange at the entrance of Deurganckdok is essential for understanding
sediment transport between the dock and the Scheldt river.

### 1.3. Overview of the study

#### 1.3.1. Reports

Reports of the project ‘Opvolging aanslibbing Deurganckdok’ are summarized in Table 1-1.

Reports of the measurement campaign HCBS2 for which the summer campaign has been carried
out simultaneously with measurements in this report are listed in APPENDIX I.

<table>
<thead>
<tr>
<th>Table 1-1: Overview of Deurganckdok Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report</td>
</tr>
<tr>
<td>Sediment Balance: Bathymetry surveys, Density measurements, Maintenance and construction dredging activities</td>
</tr>
<tr>
<td>1.1</td>
</tr>
<tr>
<td>1.2</td>
</tr>
<tr>
<td>1.3</td>
</tr>
<tr>
<td>1.4</td>
</tr>
<tr>
<td>1.5</td>
</tr>
</tbody>
</table>

Factors contributing to salt and sediment distribution in Deurganckdok: Salt-Silt (OBS3A) & Frame measurements, Through tide measurements (SiltProfiling & ADCP)

| 2.1 | Through tide measurement Siltprofiler 21/03/2006 Laure Marie (I/RA/11283/06.087/WGO) |
| 2.2 | Through tide measurement Siltprofiler 26/09/2006 Stream (I/RA/11283/06.068/MSA) |
| 2.3 | Through tide measurement Sediview spring tide 22/03/2006 Veremans (I/RA/11283/06.110/BDC) |
| 2.4 | Through tide measurement Sediview average tide 27/09/2006 Parel 2 (I/RA/11283/06.119/MSA) |
| 2.5 | Through tide measurement Sediview neap tide (to be scheduled) (I/RA/11283/06.120/MSA) |
| 2.6 | Salt-Silt distribution & Frame Measurements Deurganckdok 13/3/2006 – 31/05/2006 |
1.3.2. Measurement actions

Following measurements have been carried out during the course of this project:

1. Monitoring upstream discharge in the Scheldt river
2. Monitoring Salt and sediment concentration in the Lower Sea Scheldt taken from on permanent data acquisition sites at Lillo, Oosterweel and up- and downstream of the Deurganckdok.
3. Long term measurement of salt distribution in Deurganckdok.
4. Long term measurement of sediment concentration in Deurganckdok
5. Monitoring near-bed processes in the central trench in the dock, near the entrance as well as near the landward end: near-bed turbidity, near-bed current velocity and bed elevation variations are measured from a fixed frame placed on the dock’s bed.
6. Measurement of current, salt and sediment transport at the entrance of Deurganckdok for which ADCP backscatter intensity over a full cross section are calibrated with the Sediview procedure and vertical sediment and salt profiles are recorded with the SiltProfiler equipment
7. Through tide measurements of vertical sediment concentration profiles -including near bed highly concentrated suspensions- with the SiltProfiler equipment. Executed over a grid of points near the entrance of Deurganckdok.
8. Monitoring dredging activities at entrance channels towards the Kallo, Zanvliet and Berendrecht locks
9. Monitoring dredging and dumping activities in the Lower Sea Scheldt
In situ calibrations were conducted on several dates to calibrate all turbidity and conductivity sensors.

1.4. Structure of the report

This report is the factual data report of the through tide measurements at Deurganckdok on the 27th of September, 2006. The first chapter comprises an introduction. The second chapter describes the measurement campaign and the equipment. Chapter 3 describes the course of the actual measurements. The results and processed data are presented in Chapter 4, whereas chapter 5 gives a preliminary analysis of the data.
2. THE MEASUREMENT CAMPAIGN

2.1. Overview of the parameters

The first part of the study aims at determining a sediment balance of Deurganckdok and the net influx of sediment. The sediment balance comprises a number of sediment transport modes: deposition, influx from capital dredging works, internal replacement and removal of sediments due to maintenance dredging (Figure 2-1).

A net deposition can be calculated from a comparison with a chosen initial condition $t_0$ (Figure 2-2). The mass of deposited sediment is determined from the integration of bed density profiles recorded at grid points covering the dock. Subtracting bed sediment mass at $t_0$ leads to the change in mass of sediments present in the dock (mass growth). Adding cumulated dry matter mass of dredged material removed since $t_0$ and subtracting any sediment influx due to capital dredging works leads to the total cumulated mass entered from the Scheldt river since $t_0$. 

Figure 2-1: Elements of the sediment balance
Figure 2-2: Determining a sediment balance

The main purpose of the second part of the study is to gain insight in the mechanisms causing siltation in Deurganckdok. The following mechanisms will be aimed at in this part of the study:

- Tidal prism, i.e. the extra volume in a water body due to high tide
- Vortex patterns due to passing tidal current
- Density currents due to salt gradient between the Scheldt river and the dock
- Density currents due to highly concentrated benthic suspensions
These aspects of hydrodynamics and sediment transport have been landmark in determining the parameters to be measured during the project. Measurements will be focussed on three types of timescales: one tidal cycle, one neap-spring cycle and seasonal variation within one year.

Following data are being collected to understand these mechanisms:

- Monitoring the freshwater input (discharge) from the tributaries into the river Scheldt.
- Monitoring salinity and sediment concentration in the Lower Sea Scheldt at permanent measurement locations at Oosterweel, up- and downstream of the Deurganckdok.
- Long term measurement of salinity and suspended sediment distribution in Deurganckdok.
- Monitoring near-bed processes (current velocity, turbidity, and bed elevation variations) in the central trench in the dock, near the entrance as well as near the current deflecting wall location.
- Dynamic measurements of flow pattern, salinity and sediment transport at the entrance of Deurganckdok.
- Through tide measurements of vertical sediment concentration profiles -including near bed high concentrated benthic suspensions.
- Monitoring dredging activities at the entrance channels towards the Kallo, Zandvliet and Berendrecht locks as well as dredging and dumping activities in the Lower Sea Scheldt and Deurganckdok in particular.

In situ calibrations were conducted on several dates to calibrate all turbidity and conductivity sensors.
2.2. **Description of the measurement campaign on September 27th**

Flow velocity, Turbidity, Salinity and Temperature measurements were conducted on the 27th of September from 6h10 MET until 19h10 MET.

The purpose of the measurements was to determine the cross-section distribution of the suspended sediment concentration, the sediment flux and flow velocity during a complete tidal cycle.

Measurements were undertaken on the DGD transect (Figure 2-4), being the cross section between the river Scheldt and the dock itself.

For measurements in Deurganckddok the terms ‘left bank’ and ‘right bank’ will be used to address the North quay wall and South quay wall respectively.

From the survey vessel Parel II a measurement cycle was completed every 30 minutes. The vessel with a mounted ADCP sailed a fixed transect from the left bank to the right bank and vice versa (Table 2-1). Profiles were gathered to calibrate the ADCP transects for temperature, salinity and suspended sediment concentration to be used in Sediview.

Two calibration profiles were collected for each transect (Table 2-2):

- One before sailing the transect at the bank where the start of the transect was (Left bank during the flood; Right bank during the ebb)
- One after sailing the transect at the bank where the transect ended (Right bank during flood, left bank during the ebb).

During these calibrations, a fish with a CTD-OBS was lowered to the bottom. The downcast was interrupted at two depths, one in the upper half of the water column (between 4 and 7 m from the water surface), and one at 4 meters above the bottom. At these depths samples were taken for calibration, and are used as ‘ground truth’ for all suspended sediment concentration measurements (OBS and Sediview). The other instruments logged continuously during the downcast. Conductivity, Temperature and Depth was logged by the CTD-probe, while turbidity was recorded by the OBS.
Table 2-1: Transect of the Flow Measurements (UTM31 ED50)

<table>
<thead>
<tr>
<th>Measurement location</th>
<th>Left Bank Easting</th>
<th>Left Bank Northing</th>
<th>Right Bank Easting</th>
<th>Right Bank Northing</th>
<th>Avg Length [m]</th>
<th>Avg Course [degr.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transect DGD</td>
<td>588541</td>
<td>5684527</td>
<td>588765</td>
<td>5684056</td>
<td>521</td>
<td>334.6</td>
</tr>
</tbody>
</table>

Figure 2-4: Map of sailed transect and calibration points

Table 2-2: Positions of the calibration points for September 27th 2006 at Deurganckdok.

<table>
<thead>
<tr>
<th>Measurement point</th>
<th>Bank</th>
<th>Easting (UTM31 ED50)</th>
<th>Northing (UTM31 ED50)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Flood</td>
<td></td>
</tr>
<tr>
<td>DGDa</td>
<td>Left</td>
<td>588561</td>
<td>5684369</td>
</tr>
<tr>
<td>DGDb</td>
<td>Right</td>
<td>588682</td>
<td>5684113</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ebb</td>
<td></td>
</tr>
<tr>
<td>DGDa</td>
<td>Left</td>
<td>588823</td>
<td>5684470</td>
</tr>
<tr>
<td>DGDb</td>
<td>Right</td>
<td>588745</td>
<td>5684214</td>
</tr>
</tbody>
</table>
2.3. The equipment

2.3.1. ADCP

The current measurements were conducted using an RD Instruments ADCP 600 kHz Workhorse. For positioning the dGPS onboard the vessel Parel II was used. For the measurement of the heading a gyrocompass was installed.

This 600 KHz ADCP system was mounted on a steel pole underneath the central axis of the vessel. The transducer set was looking vertically downwards to the bottom. Transceiver unit and computer system were connected to peripherals such as the differential GPS-receiver, the heave compensator and the gyrocompass.

During the measurements the ADCP constantly measured upstream from the vessel. The acquisition software of Winriver was used. The main settings are given in Table 2-3.

<table>
<thead>
<tr>
<th>Main configuration settings:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell depth : 0.5 m</td>
</tr>
<tr>
<td>Number of Water pings per ensemble: 2</td>
</tr>
<tr>
<td>Number of Bottom Track pings per ensemble: 2</td>
</tr>
<tr>
<td>Time between ensembles: 0</td>
</tr>
<tr>
<td>Averaging: None</td>
</tr>
<tr>
<td>Speed of Sound: Fixed 1500 m/s</td>
</tr>
<tr>
<td>Salinity 0 psu</td>
</tr>
<tr>
<td>3-beam solution: enabled</td>
</tr>
</tbody>
</table>

2.3.2. OBS - CTD

A D&A type OBS 3A was used to measure depth, conductivity, temperature and turbidity.

Measured parameters by the OBS 3A sensor: temperature (°C), conductivity (µS/cm), absolute pressure (m), turbidity (NTU)

On the Parel II, the OBS 3A device was mounted on a towfish. The resulting record is filled-up with GPS-time, sample number, and planimetric position of the GPS-receiver. Sampling frequency is 1 reading per second.

The technical details on the OBS 3A are given in the February Survey Reports of the HCBS 1 measurement campaign.

2.3.3. Pump Sampler

A water sampler was attached nearby the turbidity sensor taking water samples. Samples were collected in 1 litre sampling bottles. The pumping speed of the water sampler was tested at the start of the measurement campaign on board. Dye was used to time the duration between the intake of the dye and exit at the sampling end of the sampler on board. The duration between intake and exit at the end was 32 seconds.
3. COURSE OF THE MEASUREMENTS

3.1. Measurement periods
At Deurganckdok ADCP tracks were sailed once every 30 minutes for 13 hours, in total 27 cross-sections.

Calibration profiles were taken at 2 locations (left bank, right bank). During every cycle, 1 calibration profile was taken serving as the second calibration of the previous transect and as the first calibration point of the current transect, resulting in a total of 53 profiles. APPENDIX A gives the start and end points of the tracks, the sailed length and the course.

3.2. Hydro-meteorological conditions during the measurement campaign

3.2.1. Vertical tide during the measurements
The vertical tide was measured at the Hansweert, Liefkenshoek and Schelle tidal gauges. Graphs of the tide at Hansweert, Liefkenshoek and Schelle on the 27th of September can be found in APPENDIX B. Table 3-1 gives the most important characteristics (high and low tide) of the tide at those gauges on the 27th of September 2006.

<table>
<thead>
<tr>
<th>Time [hh:mm MET]</th>
<th>Water level [m TAW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>27/09/2006</td>
<td></td>
</tr>
<tr>
<td>LW (1)</td>
<td></td>
</tr>
<tr>
<td>23:20</td>
<td>00:20</td>
</tr>
<tr>
<td>0.23</td>
<td>-0.07</td>
</tr>
<tr>
<td>HW (2)</td>
<td></td>
</tr>
<tr>
<td>05:10</td>
<td>05:50</td>
</tr>
<tr>
<td>4.82</td>
<td>5.31</td>
</tr>
<tr>
<td>LW (3)</td>
<td></td>
</tr>
<tr>
<td>11:30</td>
<td>12:30</td>
</tr>
<tr>
<td>0.36</td>
<td>0.05</td>
</tr>
<tr>
<td>HW (4)</td>
<td></td>
</tr>
<tr>
<td>17:20</td>
<td>18:00</td>
</tr>
<tr>
<td>4.86</td>
<td>5.29</td>
</tr>
</tbody>
</table>

In Table 3-2 the tidal characteristics of the tide on the 27th of September are compared to the average tide over the decade 1991-2000 (AMT, 2003).
Table 3-2: Comparison of the tidal characteristics of 27/09/2006 with the average tide, the average neap tide and the average spring tide over the decade 1991-2000 for Liefkenshoek (Lie) and Schelle (Sch)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LW (1)</td>
<td>Han 0.61   Lie 0.39   Sch 0.34</td>
<td>Han 0.27   Lie 0.05   Sch 0.03</td>
<td>Han 0.02   Lie -0.18   Sch -0.18</td>
<td>Han 0.23   Lie -0.07   Sch -0.03</td>
</tr>
<tr>
<td>HW (2)</td>
<td>Han 4.29   Lie 4.63   Sch 4.95</td>
<td>Han 4.76   Lie 5.19   Sch 5.45</td>
<td>Han 5.11   Lie 5.63   Sch 5.83</td>
<td>Han 4.82   Lie 5.31   Sch 5.54</td>
</tr>
<tr>
<td>LW (3)</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
</tr>
<tr>
<td>HW (4)</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
</tr>
<tr>
<td>Tidal difference [m]</td>
<td>Han 3.68   Lie 4.24   Sch 4.61</td>
<td>Han 4.49   Lie 5.14   Sch 5.42</td>
<td>Han 5.09   Lie 5.81   Sch 6.01</td>
<td>Han 4.59   Lie 5.38   Sch 5.57</td>
</tr>
<tr>
<td>Duration [hh:mm]</td>
<td>Han 6:14   Lie 5:59   Sch 5:53</td>
<td>Han 6:02   Lie 5:34   Sch 5:30</td>
<td>Han 5:54   Lie 5:16   Sch 5:15</td>
<td>Han 5:50   Lie 5:30   Sch 5:20</td>
</tr>
<tr>
<td>Tidal coefficient</td>
<td>Han 0.82   Lie 0.82   Sch 0.85</td>
<td>Han 1      Lie 1      Sch 1</td>
<td>Han 1.11   Lie 1.13   Sch 1.11</td>
<td>Han 1.02   Lie 1.05   Sch 1.03</td>
</tr>
</tbody>
</table>

The tidal coefficients from 0.99 up to 1.05 for the measured tide of the 27th of September indicate that this tide has a quite equivalent tidal range as the average tide for the decade of 1991-2000.

### 3.2.2. Meteorological data

Meteorological data at Antwerpen, Hove meteorological station for 27/09/2006 have been obtained from [www.wunderground.com](http://www.wunderground.com) as the monthly report from KMI (Koninklijk Meteorologisch Instituut = Royal Meteorological Institute of Belgium) for September 2006 wasn’t available yet.

On the 27th of September 2006, the air temperature varied between 8.6 and 18.6°C. The wind blew from SW at an average velocity of 4.4 km/h. The sky was almost clear and no rainfall occurred.

### 3.3. Navigation information

An overview of the navigation at the measurement location is given in APPENDIX C.
3.4. Remarks on data

Shipwakes were removed from the data. Before transect 6017DGDt_sub a seaship passed with a tugboat (8:32 MET). This is probably the cause of the high parallel velocities (APPENDIX F).

Transects have been sailed just outside of the dock, starting before and ending behind the dock entrance corners (see Appendix A.3). Start and end ensembles of the processed transects have been determined as the first and last ensembles between the projection of the quay walls. This explains that flux and discharge estimations for left and right side close to zero most of the time. For this reason some side estimated concentrations in summarizing table, defined as flux divided by discharge, could not be determined (NaN Values).
4. PROCESSING OF DATASETS

4.1. Calibration of the turbidity sensors

A crucial aspect of the accuracy and reliability of the data concerns the calibration of the instruments before the measurement campaign. These calibration procedures are described in Report 6.2 summer calibration.

4.2. Methodology of processing of the ADCP data with Sediview

DRL Software’s Sediview was used to process the ADCP data. Sediview is designed to derive estimates of suspended sediment concentration throughout the water column using acoustic backscatter data obtained by ADCPs manufactured by RD Instruments of San Diego, California.

4.2.1. Acoustic backscatter theory

The acoustic theory governing backscatter from particles suspended in the water column is complex, but the following simplified formula serves to introduce the main factors that are relevant:

\[ E = SL + SV + \text{Constant} - 20 \log(R) - 2\alpha_w R \]

Where:
- \( E \) = echo intensity,
- \( SL \) = transmitted power,
- \( SV \) = backscatter intensity due to the particles suspended in the water column,
- \( \alpha_w \) = a coefficient describing the absorption of energy by the water,
- \( R \) = the distance from the transducer to the measurement bin.

The term \( 20 \log(R) \) is a simple geometric function which accounts for the spherical spreading of the beam. The constant is required because each ADCP has specific performance characteristics.

In order to measure the suspended sediment concentration in the water column it is necessary to relate the backscattered sound intensity to the mass concentration in the water. For the purposes of measuring solids concentration on site, it can be shown that the relationship is as follows (derived from Thorne and Campbell, 1992 and Hay, 1991 in DRL (2003)):

\[ \log M(r) = \left\{ dB + 2r(\alpha_w + \alpha_s) - K_s \right\} S^{-1} \]

Where:
- \( M(r) \) = mass concentration per unit volume at range, \( r \)
- \( S \) = relative backscatter coefficient
- \( K_s \) = site and instrument constant
- \( dB \) = the measured relative backscatter intensity (corrected for beam spreading)
- \( \alpha_w \) = water attenuation coefficient
- \( \alpha_s \) = sediment attenuation coefficient, which is a function of the effective particle size

In this expression there are four unknowns: \( S \), \( K_s \), \( \alpha_w \) and \( \alpha_s \). These parameters are to be determined within Sediview.
4.2.2. Water sampling and transect sailing

To calibrate Sediview for suspended sediment concentration, two water samples are taken at the beginning and at the end of each transect (see 3.1). Both samples are taken within the range of reliable data of the ADCP. For the near-surface sample this means in bin 3 or 4, for the near-bed sample this means at about one or two meter above the sidelobe.

Water sampling is done together with CTD-OBS measurement in order to have two independent suspended sediment concentration measurements for each sample. OBS measurements were compared to the water samples and recalibrated as mentioned in § 4.1. These OBS SS concentrations were recalibrated using the conversion equations in 4.1. The water samples were used for Sediview calibration, while cross-calibrated OBS measurements were used as a back up check. The salinity and temperature was used to compute the acoustic water absorption (water attenuation coefficient). All water samples were analysed as is described in 4.2.3.1.

4.2.3. Calibration for suspended sediment concentration within Sediview

4.2.3.1. Calibration workset

The calibration workset consists of ADCP-files, sampling times, sampling depths, SSC obtained from water samples and SSC, temperature and salinity obtained from CTD-OBS readings.

The suspended sediment concentration of the water samples was determined. One-litre samples were filtered over a preweighed desiccated 0.45 micron filter, after which the filter is dried in an oven at 105°C, cooled and weighed (NEN 6484).

4.2.3.2. SSC calibration per ensemble pair

In the Sediview calibration process the following parameters must be defined: the site and instrument constant (Ks), the relative backscatter coefficient (S) and the effective particle size per ensemble-pair (near-surface sample and near-bed sample) in order to fit the Sediview-estimate with the suspended sediment concentration of the water samples. These parameter sets may not differ too much from the previous parameter sets, as the environmental conditions will not change that much over a small time interval. To obtain a smooth progress in time of Ks, S and effective particle size an iterative approach is used.

4.2.4. Sediview configuration

4.2.4.1. Discharge and suspended sediment concentration estimates

The ADCP measures most of the water column from just in front of the ADCP to 6% above the bottom. The shallow layer of water near the bottom is not used to compute discharge and suspended sediment concentration due to side-lobe interference. When the ADCP sends out an acoustic pulse, a small amount of energy is transmitted in side lobes rather than in the direction of the ADCP beam. Side lobe reflection from the bottom can interfere with the water echoes and can give erroneous data. The thickness of the side lobe layer is 6% of the distance from the transducers to the bottom.

Near the banks the water depth is too shallow for the ADCP to profile.

For each of those unmeasured regions, Sediview will make an estimate of the discharges and suspended sediment concentration. The measured and unmeasured regions in the cross section are shown in Figure 4-1 and Figure 4-2.
4.2.4.1 Top/bottom estimates

The sediment concentration and discharge at the top of the water column is assumed to be the same as the concentration and discharge in the first measured bin.

The sediment concentration between the bottom and the lowest valid bin is assumed to be 125% of the lowest valid bin. Siltprofiles taken by the SiltProfiler on board the Stream near Deurganckdok on 26/09/2006 (IMDC, 2007f) show that the bottom value of the SSC is approximately 150% of the SSC-value at 2 meter above the bottom (position of the sidelobe). As the concentration grows approximately linear from the lowest valid bin to the bottom, and as Sediview uses a constant concentration factor for these deepest bins, we use a concentration factor of 125% (Figure 4-3).

Figure 4-1: Unmeasured regions in the cross section (from RD Instruments, 2003)

Figure 4-2: Measured and estimated discharges and sediment fluxes within Sediview (DRL, 2005)
The discharge for the bottom water layer is estimated by using the power method. Chen (1991) discusses the theory of power laws for flow resistance. Simpson and Oltmann (1990) discuss Chen’s power law equivalent of Manning’s formula for open channels (with $b=1/6$) (RD Instruments, 2003).

$$u / u^* = 9.5(z / z_0)^b$$

Where:
- $z$ = Distance to the channel bed [m]
- $u$ = Velocity at distance $z$ from bed [m/s]
- $u^*$ = Shear velocity [m/s]
- $z_0$ = Bottom roughness height [m]
- $b$ = Exponent (1/6)

4.2.4.1.2 Edge estimates

The shape of the edges of the cross section is assumed to be near-rectangular due to the quay walls of Deurganckdok. Five data ensembles are to be averaged to determine the left and right bank mean velocities used for calculation of edge estimates.

The distance from start- and endpoint to the bank is calculated from the theoretical start- and endpoint at the bank to the effective start- and endpoint. The theoretical points are taken at the quay walls.
The formula for determining the near shore discharge is:

$$Q_{shore} = CV_m L d_m \ [m^3/s]$$

Where:

- $C = $ Coefficient (0.35 for triangular, 0.91 for rectangular shape)
- $V_m = $ Mean water velocity in the first or the last segment [m/s]
- $L = $ distance from the shore to the first or the last segment specified by the user [m]
- $d_m = $ Depth of the first or the last segment [m]

The coefficient (C) has been set to 0.91 (rectangular shape of Deurganckdok quay walls).

### 4.2.4.2. Contour plots of the transects

All contour plots show perpendicular and parallel projected values on the straightened sailed transects. The heading of the straightened sailed transect is defined by picking 2 points in the straight part of the line after having corrected the heading of the ADCP compass. The compass offset is derived from a comparison of the ADCPs bottom track with the external GPS data.

### 4.2.5. Output

General transect information containing start-stop coordinates of each sailed transects with stop time, track length and heading is given in APPENDIX A.

In APPENDIX F, four contour plots were generated for each transect showing the distribution of suspended sediment concentration & sediment flux as well as the flow velocity perpendicular and parallel to the transect. The following conventions were used:

- Distances on the X-axis were referenced to the starting point of the transect, the start of the sailed transect is always at distance equal to zero.
- Left bank is always shown left, right bank on the right side. For Deurganckdok, left bank was taken to be the western quay wall and the right bank to be the eastern quay wall considering the dock as being a tributary to the Scheldt river.
- Perpendicular flow velocities and fluxes are positive for downstream flow (ebb, out of Deurganckdok), negative for upstream flow (flood, inbound).
- Parallel flow velocities are positive for flow going from the left bank to the right bank, and negative for flow going from the right bank to the left bank.
- Absolute Depth is given in meters above TAW.

Also a depth-averaged velocity plot was generated for the flow velocity perpendicular to the transect. (See APPENDIX F).

Tables in APPENDIX G give the values for discharges and sediment fluxes for the total cross-section:
- Mid = measured part of the cross-section
- Top = top part of the cross-section
- Bottom = bottom part underneath the sidelobe
- Edge (left, right) = edge estimates to left & right bank
- Total = Mid+Top+Bottom+ Edge values

The graph in APPENDIX H gives the temporal variation of the total flux and total discharge for the whole through tide measurement at Deurganckdok.
5. PRELIMINARY ANALYSIS OF THE DATA

5.1. September 27th 2006 survey

As Deurganckdok is situated along the part of the Scheldt river under tidal influence, it is subject to complex current fields near its entrance. The measured current field shows a vortex pattern dependent on the tidal phase. During ebbing tide the vortex at the entrance of the dock is a counter-clockwise one and during rising tide it is a clockwise one. This is shown in the contour plots by inflow (negative) on the western side (left) and outflow on the eastern side of the entrance during ebbing tide and vice versa for flooding tide. (APPENDIX F).

During slack water we see a current field with opposing current directions in the upper part of the water column compared to the lower part of the water column. For high water we see inflow (negative) near the bottom and outflow (positive) near the surface. This particular pattern is probably an example of the expected salt density currents occurring near the entrance of Deurganckdok. The same event is seen at low water when the dock contains waters of higher salinity than the river, here we see an outflow near the bottom and inflow near the surface.

From the backscatter interpretation into suspended sediment concentration we see in general a higher concentration during slack water and during rising tide compared to during ebb tide.

Considering the sediment fluxes (APPENDIX H) shows that incoming transport is dominating. Only during a very short period going from 3 hours before LW to 1 hour before LW a residual outgoing sediment transport can be observed.

5.2. Intercomparison with earlier surveys on November 17th 2005 and March 22nd 2006

On November 17th 2005 and March 22nd 2006 the same transect has been sailed during through tide measurements, a description is given by IMDC (2005) and IMDC (2006c). Conditions near the entrance of Deurganckdok have been simulated in Delft3D and processed by IMDC (2006g) in order to compare simulation with observed data.

It is important to underline that lower fresh water discharges from the tributaries were recorded during the measurement campaigns (Figure 5-1, Figure 5-2 and Figure 5-3,): on 17/11/2005 and 22/03/2006 the discharges prior to the measurements were around 90 m³/s; and on 27/09/2006 around 30 m³/s. All measurement days correspond to the mean discharge -1σ, which is rather low (Figure 5-4).

The results presented in Figure 5-4 are based on a long-term simulation over a period of 30 year (1971-2000) with the SIGMA-model for MKBA (IMDC, 2006g). The mean discharge is the annual average ten days’ discharge, calculated with simulated long-term measurements. The high and low discharges are also annual average ten days’ discharges, but with an absolute maximum of mean discharge +2σ and an absolute minimum of mean discharge -2σ.

The same circulation pattern as described above is found to have occurred at those days. In Figure 5-5 and Figure 5-6 the three measurements have been compared for about 3h after high water, sediment distribution as well as current pattern in the cross section are almost identical. The western side of the dock is situated at the left of these figures, the eastern side at the right. Current velocity is about 0.2-0.4 m/s on the right bank side and in the upper part of the water column and about -0.2 m/s on the left bank side. Suspended sediment concentration ranges from 50 to 100 mg/l going up from top right side towards bottom left side.
In Figure 5-7 and Figure 5-8 the circulation pattern and sediment concentration have been compared for the same days but at about 1h after high water. Again the current pattern is almost identical on both days with a salt wedge intruding near the bottom of the dock and compensatory outflow of fresher water near the surface. Sediment distribution ranges for both measurements between 50 and 150 mg/l with a very similar pattern across the cross section at the dock’s entrance.

The volume water, crossing the dock’s entrance during flood or ebb on a measurement day, was calculated by integrating the discharge curve (Figure 5-9) during flood and ebb respectively. Table 5-1 shows the results. During flood on 27\textsuperscript{th} September of 2006, 5 224 000m\textsuperscript{3} water crossed the entrance and during ebb 5 914 000m\textsuperscript{3}. Comparing to the other campaigns, the volume during ebb is rather low and for flood rather moderate. This measurement day corresponds to average tide, the other days to neap and spring tide, resulting in a moderate value during flood. The volume during ebb is rather low because the low fresh water volume, combining with average tide. Theoretically, the net volume between flood and ebb is equal to the fresh water volume. The fresh water volume, during the tidal cycle on 27/09/2006, was estimated at 1 473 000m\textsuperscript{3} and is not similar to the net volume of 690 000m\textsuperscript{3} (Table 5-1). There is not a straight explanation.

The mass of the suspended sediment, crossing dock’s entrance during flood or ebb on a measurement day, was calculated on a similar manner as the volume. The flux curve was integrated (Figure 5-10) and Table 5-2 shows the results. During ebb 27\textsuperscript{th} September of 2006, 126 tonnes SS crossed the entrance and during flood 256 tonnes. So 382 tonnes SS was deposited in the dock during the tidal cycle. Comparing with other campaigns, 382 tonnes are rather low (Table 5-2).

![Figure 5-1: Fresh water discharge 11 – 21 November of 2005.](image)
**Figure 5-2: Fresh water discharge 14 – 24 March of 2006**

**Figure 5-3: Fresh water discharge 21 September – 1 October of 2006**
Figure 5-4: Mean fresh water discharge
Figure 5-5: a) Perpendicular current velocity on 17/11/2005, b) on 22/03/2006 and c) on 27/09/2006 at 3h after high water.
Figure 5-6: a) Suspended sediment concentration on 17/11/2005, b) on 22/03/2006 and c) on 27/09/2006 at 3h after high water
Figure 5-7: a) Perpendicular current velocity on 17/11/2005, b) on 22/03/2006 and c) on 27/09/2006 at 1h after high water
Figure 5-8: a) Suspended sediment concentration on 17/11/2005, b) on 22/03/2006 and c) on 27/09/2006 at 3h after high water
Table 5-1: Water volume during ebb, flood and measurement campaign on 17/11/2005 (Spring tide), 22/03/2006 (Neap tide) & 27/09/2006 (Average tide)

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Figure 5-10: Total Flux 17/11/2005, 22/03/2006 & 27/09/2006

Table 5-2: SS Mass during ebb, flood and measurement campaign on 17/11/2005 (Spring tide), 22/03/2006 (Neap tide) & 27/09/2006 (Average tide)

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6. REFERENCES


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IMDC (2006b) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.1 Through tide measurement Siltprofiler 21/03/2006 Laure Marie (I/RA/11283/06.087/WGO)

IMDC (2006c) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.3 Through tide measurement Sediview spring tide 22/03/2006 Veremans (I/RA/11283/06.110/BDC)

IMDC (2006d) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.4 Through tide measurement Sediview average tide 27/09/2006 Parel 2 (I/RA/11283/06.119/MSA)


IMDC (2006f) Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slibsuspensies Deelrapport 6.1 Winter Calibration (I/RA/11291/06.092/MSA)

IMDC (2006g) Mer verruiming Westerschelde, Nota Bovenafvoer Scheldebekken, (I/NO/11282/06.104/FPE).


IMDC (2007e) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 1.5 Annual Sediment Balance (I/RA/11283/06.117/MSA)
IMDC (2007f) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport
2.2 Through tide measurement Siltprofiler 26/09/2006 Stream (I/RA/11283/06.068/MSA)

IMDC (2007g) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport
2.5 Through tide measurement Sediview neap tide (to be scheduled) (I/RA/11283/06.120/MSA)

IMDC (2007h) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport
2.7 Salt-Silt distribution & Frame Measurements Deurganckdok 15/07/2006 – 31/10/2006 (I/RA/11283/06.122/MSA)

2.8 Salt-Silt distribution & Frame Measurements Deurganckdok 15/01/2007 – 15/03/2007 (I/RA/11283/06.123/MSA)

3.1 Boundary conditions: Three monthly report 1/1/2007 – 31/03/2007 (I/RA/11283/06.127/MSA)

IMDC (2007k) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport
3.2 Boundary conditions: Annual report (I/RA/11283/06.128/MSA)

IMDC (2007l) Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van
LTV Meetcampagne naar hooggeconcentreerde slibsuspensies Deelrapport 6.2 Summer
Calibration and Final Report (I/RA/11291/06.093/MSA).


APPENDIX A.

OVERVIEW OF MEASUREMENTS
A.1 Overview of the measurement locations for the whole HCBS2 measurement campaign
Overview of the measurement locations at Deurganckdok
Transect S in Schelle
Legend

- Transect
- Grainity & Turbidity
- RCM9
- Silty Matter
- Frame

Transect W in Waarde
A.2 Overview of all measurement locations HCBS measurement summer campaign 26-28/9/2006

Table with coordinates of theoretical transects

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Table with coordinates of SiltProfiler gauging locations

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### A.3 Measurement overview Deurganckdok 27/09/2006

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<th>Time of HW [hh:mm]</th>
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<th>Northing start (UTM31 ED50)</th>
<th>Easting end (UTM31 ED50)</th>
<th>Northing end (UTM31 ED50)</th>
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<th>Transect heading [°]</th>
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Location of start en end points of the sailed tracks
APPENDIX B. TIDAL DATA
11283 - Winter 2006 SURVEY

Measured tide on 27/09/2006

Location: River Schelt
Date: 27/09/2006

Data processed by: IMDC
In association with: Delft Hydraulics

I/RA/11283/06.119/MSA

versie 2.0 - 07/02/07
APPENDIX C.

NAVIGATION INFORMATION AS RECORDED ON SITE
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APPENDIX D.

CALIBRATION GRAPHS FOR OBS DATA
11283 – September 2006 SURVEY

Calibration Graph of OBS3A

Location: Deurganckdok  Date: 23/06/2006

Data processed by: In association with:

IMDC

I/RA/11283/06.119/MSA

versie 2.0 - 07/02/07
APPENDIX E.

UNESCO PPS-78 FORMULA FOR CALCULATING SALINITY
Practical Salinity Scale (PPS 78)  Salinity in the range of 2 to 42

Constants from the 19th Edition of Standard Methods

\[
R = \frac{C}{42.914 \text{mS/cm}}
\]

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<td>rt</td>
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<td>(\Delta S)</td>
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<td>S = Salinity</td>
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R = ratio of measured conductivity to the conductivity of the Standard Seawater Solution

Conductivity Ratio R is a function of salinity, temperature, and hydraulic pressure. So that we can factor R into three parts i.e.

\[
R = R_t \times R_p \times R_t
\]

\[
R = \frac{C(S,t,p)}{C(35,15,0)}
\]

C = 42.914 mS/cm at 15 deg C and 0 dbar pressure i.e C(35,15,0) where 35 is the salinity

Ocean pressure is usually measured in decibars. 1 dbar = 10^-1 bar = 10^5 dyne/cm^2 = 10^-4 Pascal.
APPENDIX F. CONTOURPLOTS OF FLOW VELOCITIES, SEDIMENT CONCENTRATION AND SEDIMENT FLUX PER SAILED TRANSECT
Aanslibbing Deurganckdok

Equipment(s):
ADCP

Location:
Transect DGD

Sourcefile: 6002DGDt_sub2.csv

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
06:18 - 06:21

Time after HW [HH:MM]
0:29

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with: F/RA/11283/06.119/MSA
Suspended Sediment Concentration (mg/l)

Sediment Flux (g/sm²)

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
06:18 - 06:21

Time after HW [HH:MM]
0:29

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s): ADCP

Sourcefile: 6005DGDT_sub.csv

Location: Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
06:36 - 06:40

Time after HW [HH:MM]
0:48

Data Processed by:
In association with: MSA

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

Equipment(s):
ADC

Sourcefile:
6005DGDt_sub.csv

Location:
Transect DGD

Date / Time [MET]:
27-Sep-2006
06:36 - 06:40

Time after HW [HH:MM]
0:48

Data Processed by:
In association with:
F/RA/11283/06.119/MSA

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/sm²)

Tidal Elevation 27-Sep-2006

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

 hw/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6008DGDt_sub.csv

Location:
Transect DGD

Para lle l C u rre n t V e lo c ity  [m/s]

Parallel Current Velocity [m/s]

Perpendic u la r C u rre n t V e lo c ity  [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
07:01 - 07:04

Time after HW [HH:MM]
1:12

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6011DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
07:31 - 07:34

Time after HW [HH:MM]
1:42

Data Processed by:
In association with :
I/RA/11283/06.119/MSA

Tidal Elevation 27-Sep-2006

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6011DGDt_sub.csv

Location:
Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/m²)

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
07:31 - 07:34

Time after HW [HH:MM]
1:42

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with: F
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6014DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
08:07 - 08:11

Time after HW [HH:MM]
2:19

Data Processed by:
In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6014DGDt_sub.csv

Location:
Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/sm²)

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
08:07 - 08:11

Time after HW [HH:MM]
2:19

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with: F

I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6017DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET] :
27-Sep-2006
08:32 - 08:36

Time after HW [HH:MM]
2:44

Data Processed by:
In association with :
I/RA/11283/06.119/MSA

Tidal Elevation 27-Sep-2006

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile: 6017DGDt_sub.csv

Location: Transect DGD

Suspended Sediment Concentration (mg/l)

Date / Time [MET]:
27-Sep-2006
08:32 - 08:36

Time after HW [HH:MM]
2:44

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile: 6020DGDt_sub.csv

Location: Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
09:11 - 09:14

Time after HW [HH:MM]
3:22

Data Processed by:
In association with: F

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

IMDC
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6023DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
09:37 - 09:41

Time after HW [HH:MM]
3:49

Data Processed by:
In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6023DGt_sub.csv

Location:
Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/sm²)

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
09:37 - 09:41

Time after HW [HH:MM]
3:49

Data Processed by:
In association with :  F

I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

Equipment(s):
11283
ADC

Sourcefile: 6026DGDt_sub.csv
Location: Transect DGD

Parallel Current Velocity [m/s]

<table>
<thead>
<tr>
<th>Z [m + TAW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
</tr>
<tr>
<td>-15</td>
</tr>
<tr>
<td>-10</td>
</tr>
<tr>
<td>-5</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Perpendicular Current Velocity [m/s]

<table>
<thead>
<tr>
<th>Z [m + TAW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
</tr>
<tr>
<td>-15</td>
</tr>
<tr>
<td>-10</td>
</tr>
<tr>
<td>-5</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Depth Averaged Velocity [m/s]

<table>
<thead>
<tr>
<th>Projected distance [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-500</td>
</tr>
<tr>
<td>-450</td>
</tr>
<tr>
<td>-400</td>
</tr>
<tr>
<td>-350</td>
</tr>
<tr>
<td>-300</td>
</tr>
<tr>
<td>-250</td>
</tr>
<tr>
<td>-200</td>
</tr>
<tr>
<td>-150</td>
</tr>
<tr>
<td>-100</td>
</tr>
<tr>
<td>-50</td>
</tr>
</tbody>
</table>

Date / Time [MET]:
27-Sep-2006
10:00 - 10:04

Tidal Elevation 27-Sep-2006

<table>
<thead>
<tr>
<th>Time</th>
<th>h [m + TAW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00</td>
<td>-1</td>
</tr>
<tr>
<td>03:00</td>
<td>-0.5</td>
</tr>
<tr>
<td>06:00</td>
<td>0</td>
</tr>
<tr>
<td>09:00</td>
<td>0.5</td>
</tr>
<tr>
<td>12:00</td>
<td>1</td>
</tr>
<tr>
<td>15:00</td>
<td>-0.5</td>
</tr>
<tr>
<td>18:00</td>
<td>0</td>
</tr>
<tr>
<td>21:00</td>
<td>-0.5</td>
</tr>
<tr>
<td>00:00</td>
<td>-1</td>
</tr>
</tbody>
</table>

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:

In association with:
I/RA/11283/06.119/MSA
Equipment(s): ADCP

Sourcefile: 6026DGt_sub.csv

Location: Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/m²)

Projected distance [m]

Date / Time [MET]:
27-Sep-2006
10:00 - 10:04

Time after HW [HH:MM]
4:12

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with: IMDC
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6029DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
10:30 - 10:34

Time after HW [HH:MM]
4:42

Data Processed by:
In association with:
I/RA/11283/06.119/MSA

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Suspended Sediment Concentration (mg/l)

Proyeed distance [m]

Sediment Flux (g/sm²)

Projected distance [m]

Tidal Elevation 27-Sep-2006

Date / Time [MET] :
27-Sep-2006
10:30 - 10:34

Time after HW [HH:MM]
4:42

Data Processed by:
In association with : I/RA/11283/06.119/MSA

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Aanslibbing Deurganckdok
11283

Sourcefile: 6029DGDt_sub.csv

Equipment(s):
ADCP

Location:
Transect DGD
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6035DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
11:31 - 11:34
Time after HW [HH:MM]
5:42

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6038DGDt_sub.csv

Location:
Transect DGD

---

Parallel Current Velocity [m/s]

---

Perpendicular Current Velocity [m/s]

---

Depth Averaged Velocity [m/s]

---

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
12:03 - 12:06

Time after HW [HH:MM]:
6:15

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6041DGd_sub.csv

Location:
Transect DGD

**Parallel Current Velocity [m/s]**

**Perpendicular Current Velocity [m/s]**

**Depth Averaged Velocity [m/s]**

Date / Time [MET]:
27-Sep-2006
12:30 - 12:33

Time after HW [HH:MM]
-5:27

Data Processed by:
In association with:
l/RA/11283/06.119/MSA

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

Sourcefile: 6041DGt_sub.csv
Location: Transect DGD

Equipment(s): ADCP

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/m²)

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
12:30 - 12:33

Time after HW [HH:MM]
-5:27

Data Processed by:
In association with:
I/RA/11283/06.119/MSA

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6044DGt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
12:59 - 13:03

Time after HW [HH:MM]:
-4:58

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with:
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6044DGDt_sub.csv

Location:
Transect DGD

Date / Time [MET]:
27-Sep-2006
12:59 - 13:03
Time after HW [HH:MM]
-4:58

Data Processed by:
In association with: F

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283  

Equipment(s):  
ADCP

Sourcefile: 6047DGDt_sub.csv  
Location: Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:  
27-Sep-2006  
13:35 - 13:38

Time after HW [HH:MM]  
-4:23

Data Processed by:  
in association with:  
IMDC

HW/LW:  
05:50: h = 5.31 m+TAW  
12:30: h = 0.05 m+TAW  
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6047DGt_sub.csv

Location:
Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/m²)

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
13:35 - 13:38

Time after HW [HH:MM]
-4:23

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with: F
Fl/RA/11283/06.119/MSA

IMDC
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6050DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
14:00 - 14:04

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Sourcefile: 6053DGt_sub.csv

Location: Transect DGD

Equipment(s): ADCP

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006 14:31 - 14:35
Time after HW [HH:MM]
-3:26

Data Processed by:
In association with: F

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Tidal Elevation 27-Sep-2006
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6053DGDt_sub.csv

Location:
Transect DGD

---

**Suspended Sediment Concentration (mg/l)**

**Sediment Flux (g/sm²)**

**Projected distance [m]**

**Tidal Elevation 27-Sep-2006**

**Date / Time [MET]**:
27-Sep-2006
14:31 - 14:35

**Time after HW [HH:MM]**
-3:26

**HW/LW**: 05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

**In association with**: IMDC

**Data Processed by**: I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6056DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
14:59 - 15:02

Time after HW [HH:MM]
-2:58

Data Processed by:
In association with: F

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile: 6056DGDt_sub.csv

Location: Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/m²)

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
14:59 - 15:02

Time after HW [HH:MM]
-2:58

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6059DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
15:36 - 15:39
Time after HW [HH:MM]:
-2:22

Data Processed by:
In association with: F

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Tidal Elevation 27-Sep-2006

5
3
1
-1
-3
-5
-1
-0.5
0
0.5
1

00:00 03:00 06:00 09:00 12:00 15:00 18:00 21:00 00:00
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6059DGDt_sub.csv

Location:
Transect DGD

Suspended Sediment Concentration (mg/l)

Projected distance [m]

Sediment Flux (g/s m²)

Projected distance [m]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
15:36 - 15:39

Time after HW [HH:MM]:
-2:22

Data Processed by:
In association with:
I/RA/11283/06.119/MSA

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6062DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
16:00 - 16:04

Time after HW [HH:MM]
-1:57

Data Processed by:
In association with:
I/RA/11283/06.119/MSA

Tidal Elevation 27-Sep-2006

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

Equipment(s): ADCP

Sourcefile: 6062DGDt_sub.csv

Location: Transect DGD

Suspended Sediment Concentration (mg/l)

Date / Time [MET]:
27-Sep-2006
16:00 - 16:04

Time after HW [HH:MM]
-1:57

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6065DGt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Perpendicular Current Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
16:29 - 16:34

Time after HW [HH:MM]
-1:28

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with:
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6068DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
16:59 - 17:02

Time after HW [HH:MM]
-0:59

Data Processed by:
In association with:  F

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6068DGDT_sub.csv

Location:
Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/sm²)

Projected distance [m]

Date / Time [MET] :
27-Sep-2006
16:59 - 17:02

Time after HW [HH:MM]
-0:59

Data Processed by:
In association with :  F
fl/RA/11283/06.119/MSA

Tidal Elevation 27-Sep-2006

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile: 
6071DGDt_sub.csv

Location: 
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
17:33 - 17:37

Time after HW [HH:MM]
-0:24

Data Processed by:
In association with: F

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6071DGDt_sub.csv

Location:
Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/sm²)

Tidal Elevation 27-Sep-2006

- 27-Sep-2006
  17:33 - 17:37
- Time after HW [HH:MM]
  -0:24

HW/LW:
  05:50: h = 5.31 m+TAW
  12:30: h = 0.05 m+TAW
  18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

Equipment(s):
- ADCP

Sourcefile: 6074DGDt_sub.csv
Location: Transect DGD

- Parallel Current Velocity [m/s]
- Perpendicular Current Velocity [m/s]
- Depth Averaged Velocity [m/s]

Date / Time [MET]:
27-Sep-2006
18:09 - 18:13

Tidal Elevation 27-Sep-2006:
HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Time after HW [HH:MM]:
0:11

Data Processed by:
In association with:
I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6074DGDt_sub.csv

Location:
Transect DGD

Suspended Sediment Concentration (mg/l)

Tidal Elevation 27-Sep-2006

Date / Time [MET] :
27-Sep-2006
18:09 - 18:13

Time after HW [HH:MM]
0:11

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

Data Processed by:
In association with :  F
fl/RA/11283/06.119/MSA

CEJVS

In association with :  F
fl/RA/11283/06.119/MSA

Aanslibbing Deurgankdok

11283

Equipment(s):
ADCP

Sourcefile:
6077DGDt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
18:29 - 18:33

Time after HW [HH:MM]
0:31

Data Processed by:
In association with:  F

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW

I/RA/11283/06.119/MSA
Data Processed by: IMDC
In association with: I/RA/11283/06.119/MSA
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Sourcefile:
6080DGt_sub.csv

Location:
Transect DGD

Parallel Current Velocity [m/s]

Perpendicular Current Velocity [m/s]

Depth Averaged Velocity [m/s]

Tidal Elevation 27-Sep-2006

Date / Time [MET]:
27-Sep-2006
18:59 - 19:03

Time after HW [HH:MM]
1:01

Data Processed by:
In association with: F/LRA/11283/06.119/MSA

HW/LW: 05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
Aanslibbing Deurganckdok

11283

Sourcefile: 6080DGt_sub.csv

Equipment(s): ADCP

Location: Transect DGD

Suspended Sediment Concentration (mg/l)

Sediment Flux (g/sm²)

Projected distance [m]

Date / Time [MET]:
27-Sep-2006
18:59 - 19:03

Time after HW [HH:MM]
1:01

Data Processed by:
In association with:  
I/RA/11283/06.119/MSA

HW/LW:
05:50: h = 5.31 m+TAW
12:30: h = 0.05 m+TAW
18:00: h = 5.29 m+TAW
APPENDIX G. DISCHARGE AND SEDIMENT FLUX FOR THE TOTAL CROSS-SECTION
Discharge distribution over the cross section: positive is from dock to river

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Discharge distribution over the cross section: positive is from dock to river

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Concentration distribution over the cross section.

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APPENDIX H.

TEMPORAL VARIATION OF TOTAL FLUX AND TOTAL DISCHARGE
Aanslibbing Deurganckdok

11283

Equipment(s):
ADCP

Location:
Transect DGD

Total discharge through the measured cross section, positive is from dock to river
### Aanslibbing Deurganckdok

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<tr>
<th>Location</th>
<th>Equipment(s):</th>
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<td>Transect DGD</td>
<td>ADCP</td>
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**Total flux through the measured cross section, positive is from dock to river**
APPENDIX I. HCBS2 REPORTS
<table>
<thead>
<tr>
<th>Report</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Ambient Conditions Lower Sea Scheldt</strong></td>
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<tr>
<td>5.3</td>
<td>Overview of ambient conditions in the river Scheldt – January-June 2006 (l/RA/11291/06.088/MSA)</td>
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<td>5.4</td>
<td>Overview of ambient conditions in the river Scheldt – July-December 2006 (l/RA/11291/06.089/MSA)</td>
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<td>5.5</td>
<td>Overview of ambient conditions in the river Scheldt: RCM-9 buoy 84 &amp; 97 (1/1/2007 -31/3/2007) (l/RA/11291/06.090/MSA)</td>
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<td>5.6</td>
<td>Analysis of ambient conditions during 2006 (l/RA/11291/06.091/MSA)</td>
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<tr>
<td><strong>Calibration</strong></td>
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<tr>
<td>6.1</td>
<td>Winter Calibration (l/RA/11291/06.092/MSA)</td>
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<tr>
<td>6.2</td>
<td>Summer Calibration and Final Report (l/RA/11291/06.093/MSA)</td>
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<td><strong>Through tide Measurements Winter 2006</strong></td>
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<td>7.1</td>
<td>21/3 Scheldewacht – Deurganckdok – Salinity Distribution (l/RA/11291/06.094/MSA)</td>
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<tr>
<td>7.2</td>
<td>22/3 Parel 2 – Deurganckdok (l/RA/11291/06.095/MSA)</td>
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<td>7.3</td>
<td>22/3 Laure Marie – Liefkenshoek (l/RA/11291/06.096/MSA)</td>
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<td>7.4</td>
<td>23/3 Parel 2 – Schelle (l/RA/11291/06.097/MSA)</td>
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<td>7.6</td>
<td>23/3 Veremans Waarde (l/RA/11291/06.099/MSA)</td>
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<td><strong>HCBS Near bed continuous monitoring (Frames)</strong></td>
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<td>Near bed continuous monitoring winter 2006 (l/RA/11291/06.100/MSA)</td>
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<td><strong>INSSEV</strong></td>
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<td><strong>Cohesive Sediment</strong></td>
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<td>Cohesive sediment properties summer 2006 (l/RA/11291/06.103/MSA)</td>
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<td><strong>Through tide Measurements Summer 2006</strong></td>
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<td>11.1</td>
<td>Through Tide Measurement Sedview and Siltoprofiler 27/9 Stream - Liefkenshoek (l/RA/11291/06.104/MSA)</td>
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<td>Through Tide Measurement Sedview and Siltoprofiler 28/9 Stream - Raai K (l/RA/11291/06.106/MSA)</td>
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<td>Through Tide Measurement Sedview 28/9 Veremans - Waarde(l/RA/11291/06.107/MSA)</td>
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<td>Through Tide Measurements Sedview 28/9 Parel 2 - Schelle (l/RA/11291/06.108/MSA)</td>
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<td>Through tide measurement 26/9 Scheldewacht – Deurganckdok – Salinity Distribution (l/RA/11291/06.161/MSA)</td>
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<td>Analysis</td>
<td>Report concerning the presence of HCBS layers in the Scheldt river (I/RA/11291/06.109/MSA)</td>
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