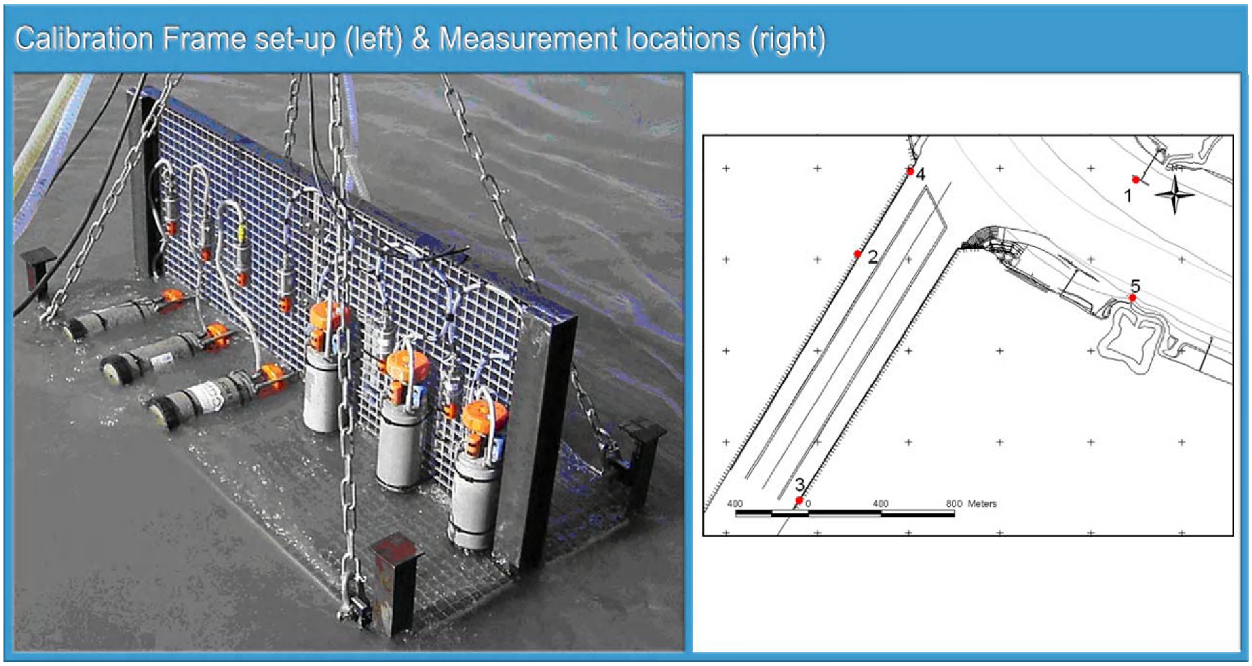
VLAAMSE OVERHEID
DEPARTEMENT MOBILITEIT EN OPENBARE WERKEN

WATERBOUWKUNDIG LABORATORIUM

Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing

Bestek 16EB/05/04



Deelrapport 2.34: Calibratie stationaire en mobiele toestellen Herfst
27 – 28 oktober 2008
Report 2.34: Calibration stationary an mobile equipment Autumn
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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)'.

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. The project term was prolonged with an extra year from April 2007 till March 2008, 'Opvolging aanslibbing Deurganckdok'.

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, i.e. 04/2007 – 03/2008
- 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 focuses 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 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 river Scheldt.

1.3. Overview of the study

1.3.1. Reports

Reports of the project ‘Opvolging aanslibbing Deurganckdok’ between April 2008 till March 2009 are summarized in Table 1-1. An overview of the HCBS2 and ‘Opvolging aanslibbing Deurganckdok’ (between April 2006 till March 2008) reports are given in APPENDIX A.

This report 2.34, describes the calibration campaign performed during the autumn of 2008.

Table 1-1: Overview of Deurganckdok Reports

Report	Description
Sediment Balance: Bathymetry surveys, Density measurements, Maintenance and construction dredging activities	
1.20	Sediment Balance: Three monthly report 1/4/2008 - 30/6/2008 (I/RA/11283/08.076/MSA)
1.21	Sediment Balance: Three monthly report 1/7/2008 – 30/9/2008 (I/RA/11283/08.077/MSA)
1.22	Sediment Balance: Three monthly report 1/10/2008 – 31/12/2008 (I/RA/11283/08.078/MSA)
1.23	Sediment Balance: Three monthly report 1/1/2009 – 31/03/2009 (I/RA/11283/08.079/MSA)
1.24	Annual Sediment Balance (I/RA/11283/08,080/MSA)
Factors contributing to salt and sediment distribution in Deurganckdok: Salt-Silt (OBS3A) & Frame measurements, Through tide measurements (SiltProfiling & ADCP) & Calibrations	
2.20	Through tide measurement Sediview DGD during average tide Spring 2008 – 19 June 2008 (I/RA/11283/08.081/MSA)
2.21	Through tide measurement Sediview DGD during average tide Spring 2008 –26 June 2008 (I/RA/11283/08.082/MSA)
2.22	Through tide measurement Sediview DGD during neap tide Summer 2008 – 24 September 2008 (I/RA/11283/08.083/MSA)
2.23	Through tide measurement Sediview DGD during spring tide Summer 2008 – 30 September 2008 (I/RA/11283/08.084/MSA)
2.24	Through tide measurement Sediview DGD during neap tide Autumn 2008 (I/RA/11283/08.085/MSA)
2.25	Through tide measurement Sediview DGD during spring tide Autumn 2008 (I/RA/11283/08.086/MSA)
2.26	Through tide measurement Sediview DGD during neap tide Winter 2009 (I/RA/11283/08.087/MSA)

Report	Description
2.27	Through tide measurement Sediview DGD during spring tide Winter 2009 (I/RA/11283/08.088/MSA)
2.28	Through tide measurement ADCP eddy DGD Summer 2008 – 1 October 2008 (I/RA/11283/08.089/MSA)
2.29	Through tide measurement Siltprofiler DGD Summer 2008 – 29 September 2008 (I/RA/11283/08.090/MSA)
2.30	Through tide measurement Siltprofiler DGD Winter 2009 (I/RA/11283/08.091/MSA)
2.31	Through tide measurement Salinity Profiling DGD Winter 2009 (I/RA/11283/08.092/MSA)
2.32	Salt-Silt distribution Deurganckdok: Six monthly report 1/4/2008 - 30/9/2008 (I/RA/11283/08.093/MSA)
2.33	Salt-Silt distribution Deurganckdok: Six monthly report 1/10/2008 – 31/3/2009 (I/RA/11283/08.094/MSA)
2.34	Calibration stationary & mobile equipment Autumn 2008 (I/RA/11283/08.095/MSA)
Boundary Conditions: Upriver Discharge, Salt concentration Scheldt, Bathymetric evolution in access channels, dredging activities in Lower Sea Scheldt and access channels	
3.20	Boundary conditions: Six monthly report 1/4/2008 – 30/09/2008 (I/RA/11283/08.096/MSA)
3.21	Boundary conditions: Six monthly report 1/10/2008 – 31/03/2009 (I/RA/11283/08.097/MSA)
Analysis	
4.20	Analysis of Siltation Processes and Factors 04/06 – 03/09 (I/RA/11283/08.098/MSA)

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, Zandvliet 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, a description can be found in IMDC (2006a; 2007a; 2008a & 2008b).

1.4. Structure of the report

This report is the factual data report of autumn calibration measurements on 2008, October 27th and 28th. 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 measurement results and processed data are presented in Chapter 4, whereas chapter 5 gives the conclusion of this calibration campaign.

2. THE MEASUREMENT CAMPAIGN

2.1. Calibration Strategy

2.1.1. Suspended Sediment Concentration

A calibration strategy for the Siltation Study in Deurganckdok for the measurement of Suspended Sediment Concentration (SSC) and Salinity was set up.

Table 2-1 gives an overview of all the instruments used for measurement of SSC in long term and through tide measurement campaigns.

Table 2-1: Overview of instruments measuring SS concentration

Instrument	***Quantity***	***Principle***	***Long term (LT) /Through Tide (TT)***
D&A Instruments OBS 3A*	11	Turbidity Backscatter Sensor	TT / LT
Siltprofiler* (Extinction Sensors)	2	Turbidity Extinction sensor	TT
SiltProfiler* (Seapoint Sensor)	1	Turbidity Backscatter Sensor	TT
Aanderaa RCM-9* (0-500 NTU)	13	Turbidity Backscatter Sensor	LT
Aanderaa RCM-9* (seapoint sensor)	1	Turbidity Backscatter Sensor	LT

**These instruments also contain conductivity sensors*

This overview shows that all instruments measure turbidity. Therefore these instruments had to be calibrated to link turbidity to SSC.

This can be done in 2 ways:

- Laboratory calibration
- In Situ calibration

Both methods have advantages and disadvantages. In a laboratory all conditions (concentration, circulation, siltation) are controllable but not identical to the situation in the field. An in situ calibration is more representative of the actual measurement conditions but less controllable. Lab calibrations almost guarantee to cover the whole measurement range of the instrument (very low to very high SSC), which is more difficult to guarantee during field calibrations.

In situ conditions allow all instruments to be calibrated simultaneously and in the same calibration mixture. This is almost unachievable in a laboratory condition.

A good knowledge of the study area can enhance the measurement range that could be attained in an in situ calibration. Knowing where and when certain concentrations are occurring is vital in order to cover a wide range of concentrations. For this reason a preliminary SSC survey was foreseen in Deurganckdok.

2.1.2. Salinity

Salinity is not measured directly but calculated using a UNESCO formula that incorporates conductivity, temperature and depth measurements (Unesco, 1991, see APPENDIX B). All sensors, which measure conductivity and temperature, have also been cross-checked with each other. This means that simultaneous measurements of conductivity and temperature are compared in brackish Scheldt water during the calibration.

2.2. Calibration set up

2.2.1. Frame set-up

A special frame was used to calibrate all stationary and mobile equipment. A rectangular frame, measuring 2 meters by 1 meter, is covered with a wire mesh. In the middle there is a vertical mesh wire wall that divides the frame in 2 parts (2*0.5m), which was used to line up all turbidity sensors to measure at the same vertical level on the frame. All the turbidity sensors were aligned to measure in a horizontal orientation. To avoid interference between backscatter turbidity sensors, a minimum distance between sensors of the same type was respected.

Figure 2-1: Calibration frame with double pump set-up

Because of the amount of sensors 2 calibration days were required, therefore the next set up was realised. In both set ups 1 pump has been used to calibrate the turbidity sensors. Pump discharge velocities have been tested in advance with dye (coffee).

Table 2-2: Set up for calibration both days

Calibration day 1 27/10/2008	***Calibration day 2 28/10/2008***
1 pump	1 pump
11 OBS 3A (IMDC) 1 SiltProfiler (IMDC) 13 RCM-9: 5 WL (0-500 NTU) 7 IMDC (0-500 NTU) 1 IMDC (seapoint + 0-500 NTU)	11 OBS 3A (IMDC) 8 CTD-diver (IMDC)

2.2.2. Measurement locations

Previous measurement campaigns in the Lower Sea Scheldt demonstrate what concentration ranges can be expected at certain locations, depths and tidal phases. It was decided to measure during incoming tide and at places with high gradients in suspended sediment concentrations between Deurganckdok (downstream) and Liefkenshoek (upstream).

2.2.3. Calibration protocol

The aim was to calibrate the turbidity sensors at 8 predetermined SS concentrations.

25 – 50 – 100 - 200 – 400 – 800 – 1200 – 1600 mg/l.

During the survey one instrument which has already been used in previous surveys and which as such can be considered as pre-calibrated had real time read-out facilities, so that the frame could be positioned in the appropriate SSC environment as mentioned above. One OBS 3A was used for this purpose.

When the instruments are positioned in the layer with the required SSC, 1 liter water samples were taken from each pump sampler for laboratory analysis. This procedure was carried out twice for each concentration.

2.2.4. Sample analysis

The NEN 6484 standard for total suspended sediment analysis was used for all water samples.

2.2.5. Validation, Drifting and extra Sensors

It has to be mentioned that the SiltProfiler has been calibrated in a laboratory set up by the manufacturer using wet mud of the measurement location (Lower Sea Scheldt). The calibration mixtures were analysed using the NEN 6484 standard.

The SiltProfiler has a high concentration range and is difficult to calibrate in situ, therefore this instruments was not be calibrated as such, but was only be validated by the calibration procedure described above.

Long term measuring equipment (i.e. RCM-9; OBS 3A) will be tested for drifting by IMDC at each redeployment, by performing a zeroing measurement in clean tap water.

2.3. Instruments

2.3.1. D & A OBS 3A

D&A Instruments type OBS-3A were calibrated. Measured parameters by the OBS 3A sensor:

- temperature (°C),
- conductivity (µS/cm)
- turbidity (counts/FTU)
- absolute depth (m)

IMDC (2006a) gives more technical details on the OBS 3A sensors.

2.3.2. SiltProfiler

For the HCBS measurements on the river Scheldt a new instrument has been developed, the SiltProfiler.

The SiltProfiler has the following general specifications. The data collection is executed locally (i.e. on the profiler) by an integrated data logger. Sensor cables are kept very short and connect to the interfacing electronics of the data logger. The data logger collects the sensor signals and records the same in internal memory. Simultaneously the data are transmitted via a serial communication cable (if connected). Emphasis is on fast data collection and less on the absolute accuracy of the sensors.

In case the communication cable is not connected, the data can be retrieved upon recovery of the profiler via a short range wireless connection. As soon as the profiler breaks the water surface the data can be accessed and transferred to the operator's PC, whereupon the profiler is ready for a new profiling session. The retrieved profile data are visualised immediately in depth profile graphs. This operational mode requires no electrical cables to be attached to the profiler. However, a small box (diameter in the order of 20 cm) with electronics, data logger and batteries is attached to the profiler. The hoisting cable is attached to sturdy structure above the electronics box.

Figure 2-2: High Resolution SiltProfiler

The sensors are:

- one Conductivity and Temperature sensor with measuring ranges adequate for use in seawater.
- multiple turbidity sensors to cover the entire range of 0 to 35 000 mg/L suspended solids: 2 transmittance sensors (type FOSLIM) are used, in combination with a Seapoint turbidity sensor (0-400 mg/l).
- one pressure sensor.

As such the SiltProfiler is anticipated to rapidly profile the suspended sediment concentration as well as the salinity structure. The SiltProfiler can measure at variable speed up to 100 measurements per second (100 Hz).

The data collection rate is adjustable to optimise for the required vertical / temporal resolution. Further, the data acquisition rate will be depth dependent in such a way that the rate is low in the upper section of the profile and higher in de lower section. Both rates and the changeover depth are user adjustable. The duration of data retrieval depends upon the amount of collected data and the effective data transfer rate.

2.3.3. Aanderaa RCM-9

The Aanderaa Recording Current Meter RCM-9 MkII is a multi-parameter instrument that consists of a CTD probe, Doppler Current Sensors and a Turbidity Sensor. This instrument is used in a moored set up for long term measurements in this project. IMDC (2006a) gives more details on the RCM-9. 5 Instruments are from Waterbouwkundig Laboratorium (WL) and 8 are from IMDC. The RCM 9 with serial number 1225 (IMDC) is equipped with an additional seapoint sensor (0-750 NTU).

2.3.4. CTD-Diver datalogger

CTD-Diver dataloggers were used.

Measured parameters by the CTD-Diver datalogger are:

- temperature (°C),
- conductivity (µS/cm)
- absolute depth (m)

IMDC (2008a) gives more details on the CTD-Diver datalogger.

2.3.5. 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.

3. COURSE OF THE MEASUREMENTS

3.1. Hydrometeorological conditions

Measurements were conducted during flood. The vertical tide is given for the tidal gauge at Liefkenshoek (see Table 3-1).

Table 3-1: High and Low Tide at Liefkenshoek Tidal Gauge on 27/10/2008 & 28/10/2008

Liefkenshoek Tidal Gauge				
	27 October 2008		28 October 2008	
	Time [MET]	Water level [m TAW]	Time [MET]	Water level [m TAW]
HW (1)	2:10	5.53	2:40	5.73
LW (2)	8:30	0.35	9:20	0.30
HW (3)	14:20	5.56	15:00	5.55
LW (4)	21:20	-0.01	21:50	-0.11

Meteorological data at Deurne was obtained from the Weather Underground website (Wunderground, 2008). Information of the Royal Meteorological Institute is not yet available.

On the 27th of October, the air temperature varied between 4 and 12 °C. The wind blew at an average velocity of 6.7 km/h from WsW. There was some rain (3mm) between 0h00 and 2h00.

On the 28th of October, the air temperature varied between 2 and 9 °C. The wind blew at an average velocity of 4.5 km/h from SW. There was no rain.

3.2. Locations

On both days the same location was visited to obtain the necessary concentrations. The location is situated near de current deflecting wall at the entrance of Deurganckdok (see Figure 3-1).

Table 3-2: Coordinates Calibration locations [UTM ED50]

Name	EASTING	NORTHING
Deurganckdok Entrance	588672	5684623

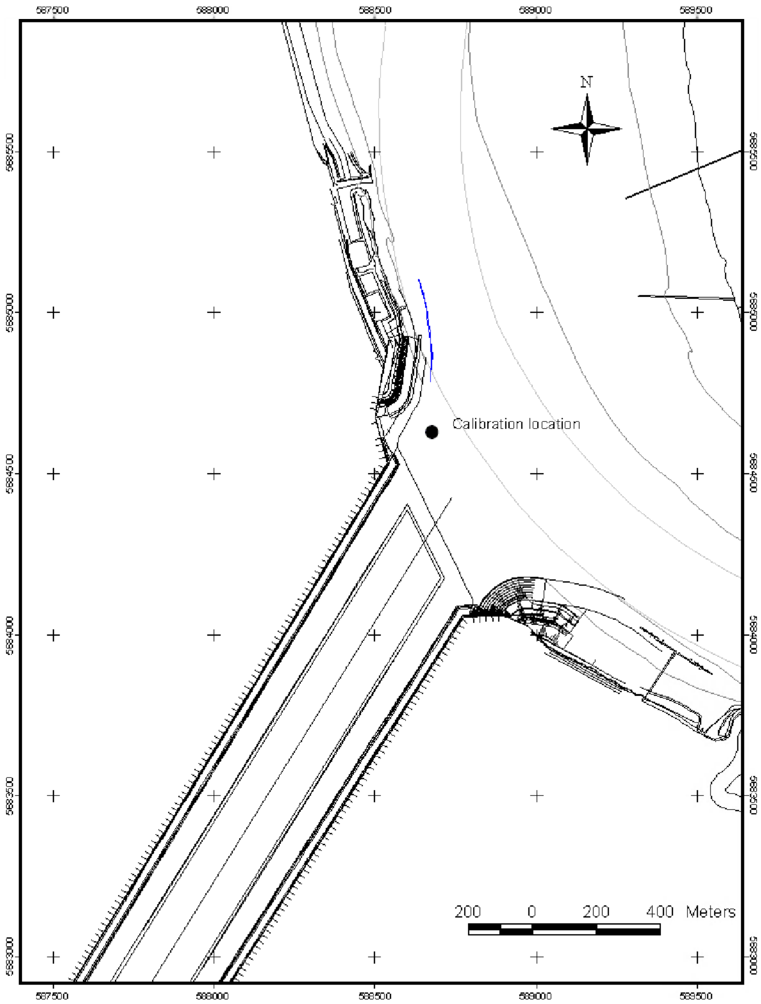


Figure 3-1: Calibration Location

3.3. Measured Concentrations

Direct read out of one of the instruments allowed to aim for the predetermined concentrations (see § 2.2.3).

The following concentration ranges were obtained:

30 – 40 – 60 – 100 - 150 – 200 – 250 – 300 – 330 mg/l.

4. PROCESSING OF DATASETS

4.1. Introduction

The SSC calibration results are given in the next paragraph (§4.2). Paragraph 4.3 covers SiltProfiler calibration checks. Conductivity and temperature comparisons are made in §4.4.

4.2. SSC Calibration results

The calibration results for all sensors are given in Table 4-1. In this table the conversion formulas are given to convert turbidity counts, NTU, FTU to SSC [mg/l]. The formulas are determined based on the data collected on both days. To verify that considering the two calibration days as two separated calibrations would not result in large differences for the conversion formulas a check up was done. It could be concluded that there are no problems when both days are considered as one calibration.

It was chosen to use second order fits to define the calibration curves. The R square value is added as well.

The calibration graphs show the suspended sediment sample concentration in mg/l on the Y-axis and the instrument readout in AD counts, or Turbidity Units (NTU/FTU) on the X-axis and can be found in APPENDIX B.

Table 4-1: Overview of Calibration Results for 04-05/02/2008 including instrument description, formulas, R^2 and RMSE values and remarks

Instrument	Serial no.	Range	Unit	Function	R^2	RMSE	Remarks
OBS3A	221	0-500	FTU	$y = 0.0121x^2 + 0.799x + 5.9306$	$R^2 = 0.8863$	27.99	IMDC
OBS3A	222	0-500	FTU	$y = 0.0022x^2 + 2.1189x – 19.269$	$R^2 = 0.9004$	26.44	IMDC
OBS3A	223	0-500	FTU	$y = 0.0094x^2 + 1.3008x – 1.0472$	$R^2 = 0.9129$	24.72	IMDC
OBS3A	224	0-2000	FTU	$y = 0.0102x^2 + 0.8544x + 12.837$	$R^2 = 0.9276$	22.54	IMDC
OBS3A	225	0-2000	FTU	$y = 0.0039x^2 + 1.6311x – 10.474$	$R^2 = 0.9078$	25.44	IMDC
OBS3A	247	0-2000	FTU	$y = 0.0089x^2 + 1.0021x + 2.2885$	$R^2 = 0.8976$	26.80	IMDC
OBS3A	261	0-500	FTU	$y = 0.0080x^2 + 1.664x - 13.120$	$R^2 = 0.8890$	27.91	IMDC
OBS3A	262	0-2000	FTU	$y = 0.0060x^2 +1.45x – 21.67$	$R^2 = 0.8677$	30.48	IMDC
OBS3A	308	0-500	FTU	$y = 0.0070x^2 +1.665x – 6.952$	$R^2 = 0.8991$	26.61	IMDC
OBS3A	313	0-2000	FTU	$y = 0.0031x^2 +2.0468x – 17.948$	$R^2 = 0.9166$	24.20	IMDC
OBS3A	314	0-2000	FTU	$y = 0.0053x^2 +1.7542x – 12.567$	$R^2 = 0.908$	25.40	IMDC
RCM-9	0149_1316	0-500	NTU	$y = 0.0026x^2 +1.9338x -18.845$	$R^2 = 0.7414$	41.86	WL
RCM-9	0152_1317	0-500	NTU	$y = -0.0093x^2 + 3.6189x – 53.04$	$R^2 = 0.9303$	55.02	WL
RCM-9	0248_232	0-500	NTU	$y = 0.0057x^2 + 1.7841x + 22.71$	$R^2 = 0.4787$	42.16	WL
RCM-9	0117_122	0-500	NTU	$y = 0.0066x^2 + 1.7637x – 11.854$	$R^2 = 0.8626$	58.13	WL
RCM-9	0579_560	0-500	NTU	$y = -0.0219x^2 + 4.7855x – 65.477$	$R^2 = 0.713$	31.29	WL
RCM-9	1165_1025	0-500	NTU	$y = 0.0199x^2 + 0.1122x + 10.259$	$R^2 = 0.8987$	29.71	IMDC

Instrument	Serial no.	Range	Unit	Function	R^2	RMSE	Remarks
RCM-9	1166_1023	0-500	NTU	$y = 0.0121x^2 + 1.323x – 11.809$	$R^2 = 0.8973$	29.92	IMDC
RCM-9	1168_1061	0-500	NTU	$y = 0.0165x^2 + 0.2103x + 17.486$	$R^2 = 0.8788$	32.50	IMDC
RCM-9	1169_1055	0-500	NTU	$y = 0.0252x^2 - 0.8158x + 42.472$	$R^2 = 0.9587$	18.97	IMDC
RCM-9	1170_1026	0-500	NTU	$y = 0.0078x^2 + 1.3251x – 16.317$	$R^2 = 0.8460$	36.64	IMDC
RCM-9	1171_1028	0-500	NTU	$y = 0.0045x^2 + 2.0586x – 39.457$	$R^2 = 0.8565$	35.37	IMDC
RCM-9	1220_1052	0-500	NTU	$y = 0.0181x^2 - 0.2227x + 25.443$	$R^2 = 0.9455$	21.80	IMDC
RCM-9	1225_1051	0-500	NTU	$y = 0.0052x^2 + 0.3902x - 1.4346$	$R^2 = 0.9117$	27.76	IMDC
RCM-9	1225_seap	0-750	FTU	$y = 34.225x – 142.51$	$R^2 = 0.8717$	33.07	IMDC
SiltProfiler	Seapoint	0-700	mg/l	comparison calibrated concentrations			
	Long Range	400-5000	mg/l	comparison calibrated concentrations			
	Short Range	4500 – 38300	mg/l	comparison calibrated concentrations			

4.3. Manufacturer's Calibration & Cross-check of Siltprofiler

4.3.1. Manufacturer's calibration of Silt Profiler

The manufacturer's calibration was done at WL|Delft Hydraulics following a procedure set forward by IMDC. This procedure is set up as follows: The sediment was sieved with a 63 µm filter. The filtrate was desalinated, and was allowed to settle and to evaporate. The resulting mud was used as base material. It was analysed for dry content, which resulted in a ratio of 0.28386 grams of dry material per gram base material.

The calibration was done in a 5 L solution of DEMI (demineralised) water in which the base material was dissolved and kept in suspension. This was done for increasing concentrations. From every calibration mixture a sample was taken to be analysed for suspended sediment concentration. 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).

This approach was chosen for its close resemblance to an in situ calibration. Manipulation of the basis material was limited.

The calibration graphs can be found in APPENDIX B.

Table 4-2: Calibration Equations as derived for both Seapoint and SiltProfiler sensors (low and high range), x=AD counts, y=sample suspended sediment concentration

Instrument	***Equation***	***R^2***
Siltprofiler – Seapoint	$Y= 0.000026x^2+ 0.594246x+1.5$	0.999
SiltProfiler – Low range	$Y = 0.000277x^2 + 0.233989x -182.9$	0.999
SiltProfiler – High range	$Y=0.0.001698x^2 + 4.429417x -332.6$	0.999

4.3.2. Cross-check of SiltProfiler

The Siltprofiler was cross-checked during the in situ calibration. Figure 4-1 shows the comparison of the Siltprofiler measurement for 27 October 2008. The X-axis shows the sample SSC, the Y-axis shows the Siltprofiler SSC (determined by the manufacturer's calibration).

Turbidity values were converted to suspended sediment concentration using the equation of the calibration curve determined at the pre-calibration done by WL|Delft. These were compared to sample concentrations. Only Seapoint measurements were used, because of the low concentrations. It can be seen that the higher the concentration the higher de deviation.

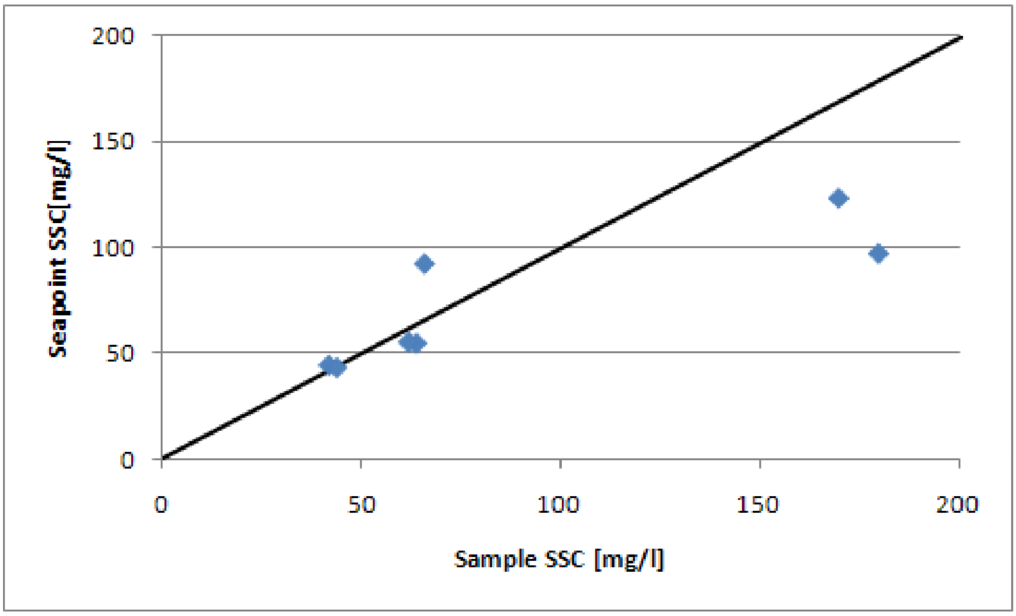


Figure 4-1:Comparison of Sample SSC to SiltProfiler SSC for 27 October 2008

4.4. Conductivity, temperature and salinity cross-check

Conductivity and temperature measurements were conducted during this measurement campaign, however it was not possible to obtain a wide range of conductivity/salinity levels in the area that was frequented for the calibration. A limited analysis will include a comparison of simultaneous conductivity and temperature measurements by the different instruments that were mounted on the frame.

The OBS3A instrument with serial number 308 was chosen as a reference, because this instrument was recently (September 2008) been sent to the manufacturer for maintenance. Both the temperature and the conductivity sensor have then been cleaned, checked and recalibrated. Therefore, it could be assumed that these sensors are most reliable and can be used as a reference to control the remaining sensors.

During analysis of the data, it appeared the conductivity measurements of the SiltProfiler were erroneous. Cross calibrating the measurements was also impossible. Usually a CTD – Diver is installed on the SiltProfiler during measurements, so conductivity values can be obtained this way.

4.4.1. Conductivity

Figure 4-2 shows the conductivity read out of all OBS 3A instruments deployed at the same level on the measurement frame. Most of the OBS 3A instrument measured significant lower conductivity values than the reference sensor. Their trend is very similar but due to pollution on the sensor, their absolute value is up to 3mS/cm less than the reference sensor. Because of these high differences, it was necessary to derive offsets for each OBS3A conductivity sensor. In further reports, conductivity values will be corrected using these offsets (see Table 4-3).

Figure 4-3 shows the corrected conductivity values for all deployed OBS3A instruments.

Table 4-3 Offsets for OBS3A conductivity

Instrument	***Offset***	***Instrument***	***Offset***
OBS3A sn 308	0.00		
OBS3A sn 221	1.00	OBS3A sn 247	0.15
OBS3A sn 222	0.87	OBS3A sn 262	2.43
OBS3A sn 223	1.40	OBS3A sn 261	2.42
OBS3A sn 224	-0.09	OBS3A SN 313	0.44
OBS3A sn 225	5.11	OBS3A SN 314	0.97

Figure 4-4 shows the conductivity read out of the RCM-9 instruments deployed at the same level on the measurement frame. One RCM-9 of WL didn't measure conductivity. All IMDC RCM-9 conductivity sensors measure similar conductivity values. Two of the RCM-9 conductivity sensors installed on the instruments of WL give a slightly higher value. Notice that the WL RCM-9's were only deployed during the first calibration day and the IMDC RCM-9's only during the second calibration day.

Figure 4-5 shows the conductivity read out of all the CTD – Divers deployed at the same level on the measurement frame. Notice that the CTD-Divers were only installed on the frame the second calibration day. All sensors measure similar conductivity values, except instrument Z055, which measures corrupt conductivity values.

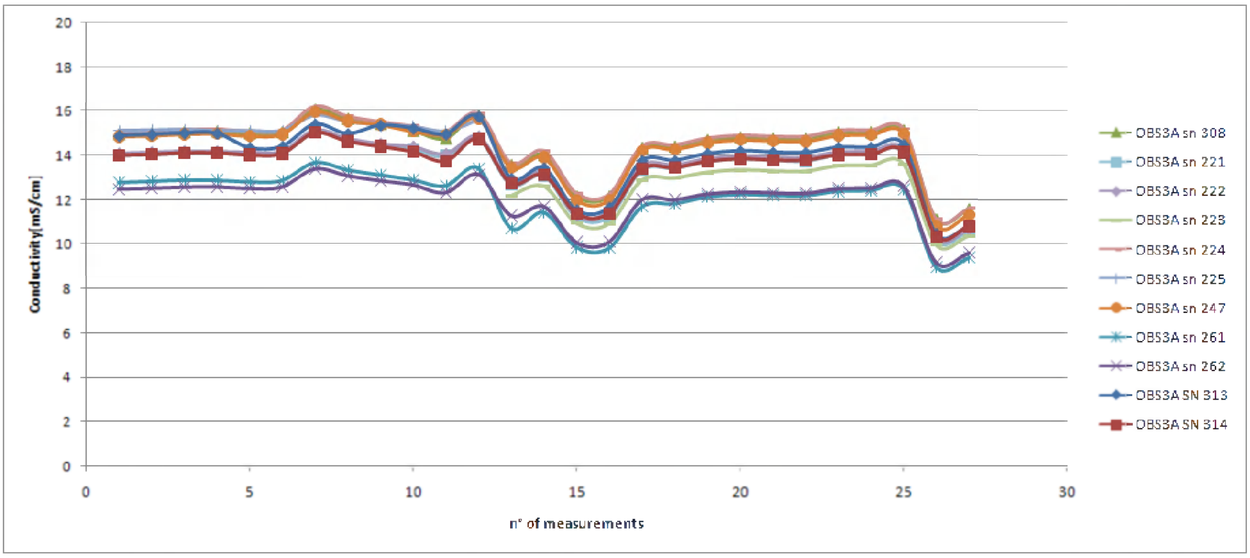


Figure 4-2: OBS 3A Conductivity Measurements 27/10/2008 & 28/10/2008

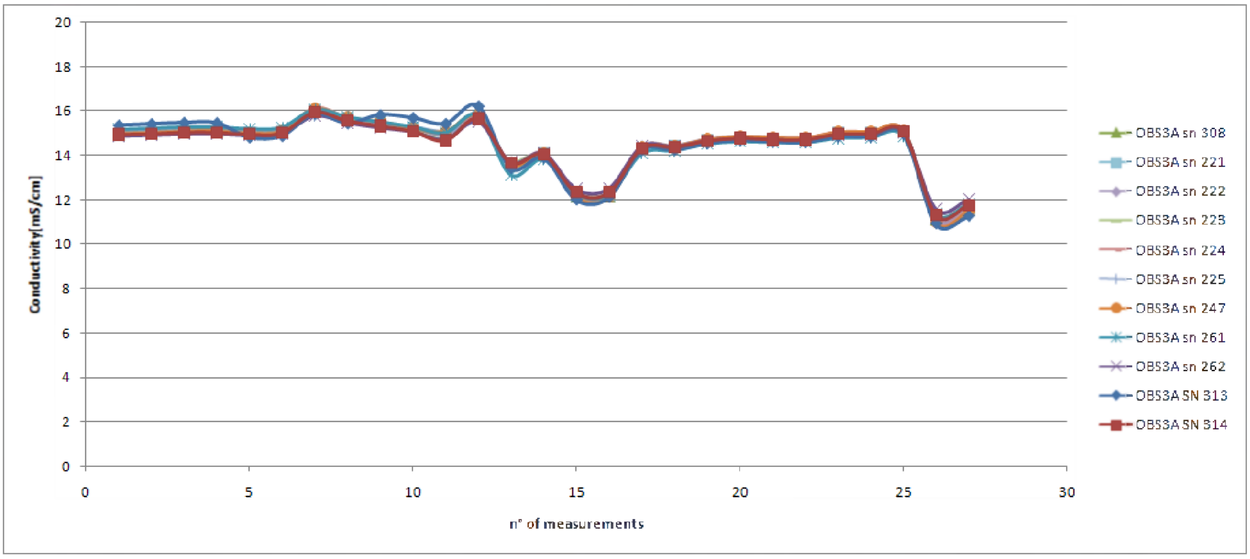


Figure 4-3: OBS 3A Corrected Conductivity Measurements 27/10/2008 & 28/10/2008

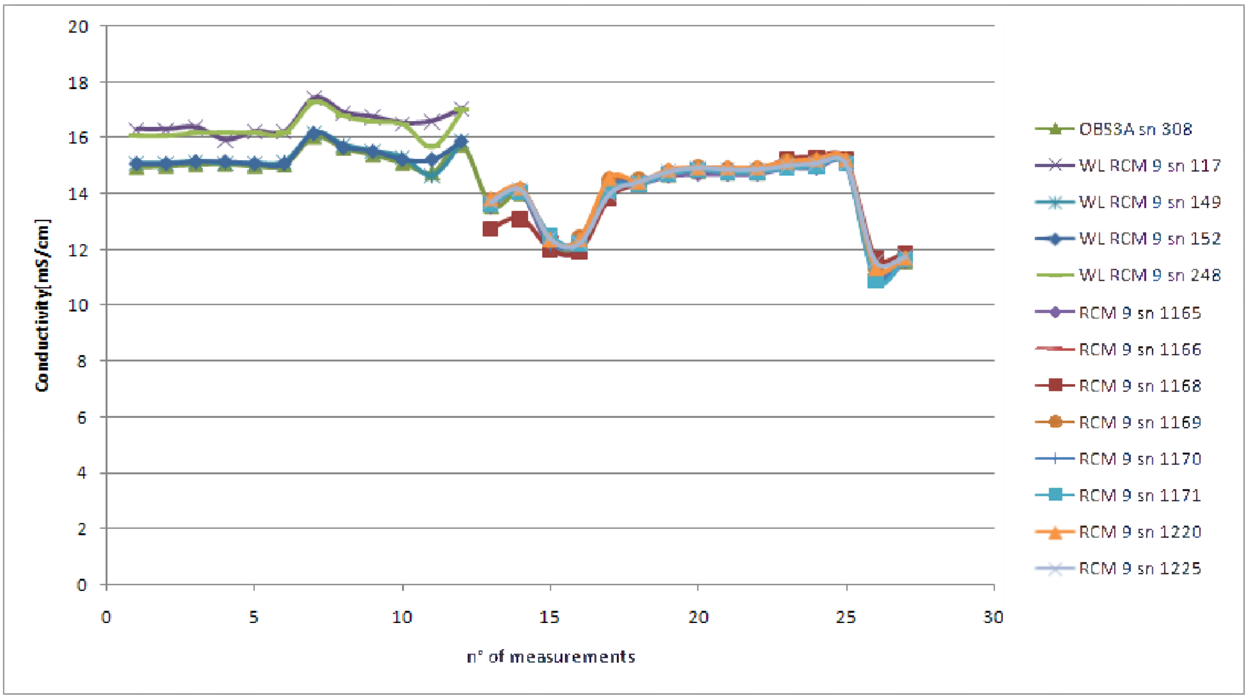


Figure 4-4: RCM-9 Conductivity Measurements 27/10/2008 & 28/10/2008

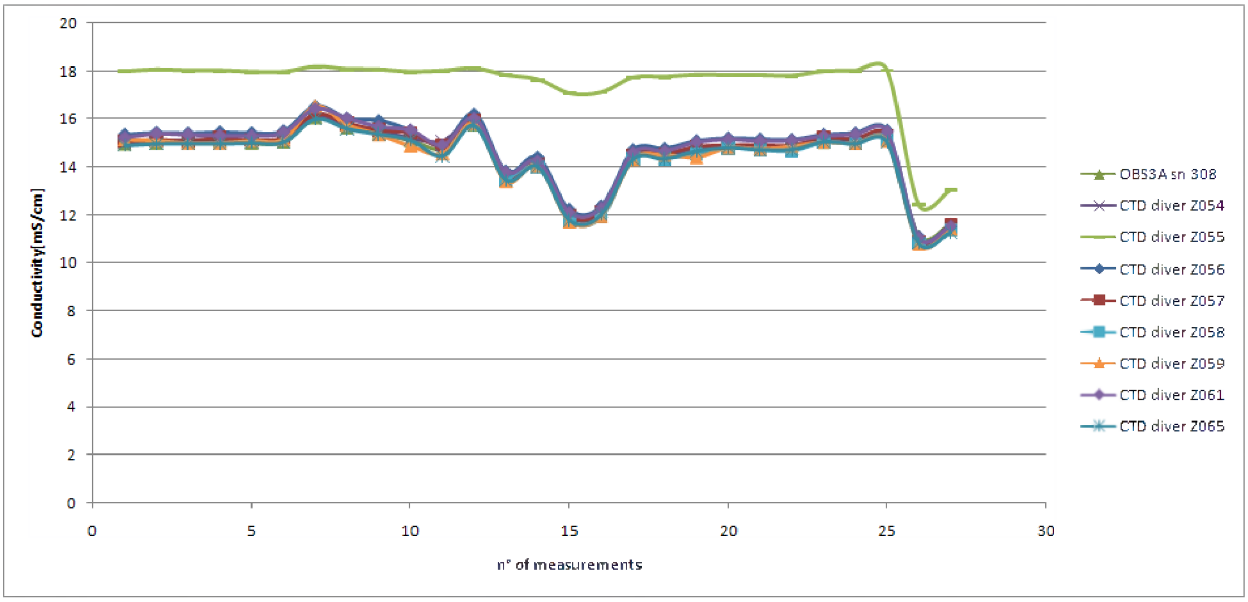


Figure 4-5: CTD-Diver Conductivity Measurements 27/10/2008 & 28/10/2008

The Root Mean Square Error (RMSE) was calculated for each correctly working instrument. The RMSE was calculated for each instrument comparing its measurement to the reference conductivity measurement (OBS3A sn 308). (see Table 4-4 & Table 4-5).

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_i - \overline{X})^2} \text{ in which}$$

X_i = measured conductivity value for a given instrument

$\overline{X}$ = OBS3A sn 308 conductivity value for each measurement

n = number of measurements

Table 4-4: RMSE values [mS/cm] for Conductivity sensors

Instrument	RMSE	Instrument	RMSE
OBS3A SN 313	0.557	RCM 9 sn 1165	0.072
OBS3A SN 314	0.973	RCM 9 sn 1166	0.124
OBS3A sn 308	0.000	RCM 9 sn 1168	0.402
OBS3A sn 262	2.432	RCM 9 sn 1169	0.147
OBS3A sn 261	2.426	RCM 9 sn 1170	0.062
OBS3A sn 247	0.154	RCM 9 sn 1171	0.129
OBS3A sn 225	5.100	RCM 9 sn 1220	0.178
OBS3A sn 224	0.113	RCM 9 sn 1225	0.179
OBS3A sn 223	1.406	CTD diver Z054	0.129
OBS3A sn 222	0.870	CTD diver Z055	3.137
OBS3A sn 221	0.995	CTD diver Z056	0.346
WL RCM 9 sn 579	0.000	CTD diver Z057	0.135
WL RCM 9 sn 152	0.159	CTD diver Z058	0.166
WL RCM 9 sn 149	0.106	CTD diver Z059	0.190
WL RCM 9 sn 117	1.320	CTD diver Z061	0.272
WL RCM 9 sn 248	1.159	CTD diver Z065	0.136

Table 4-5: RMSE values [mS/cm] for Corrected OBS3A Conductivity sensors

Instrument	RMSE	Instrument	RMSE
OBS3A sn 308	0.000		
OBS3A sn 225	0.149	OBS3A SN 313	0.295
OBS3A sn 224	0.058	OBS3A SN 314	0.088
OBS3A sn 223	0.130	OBS3A sn 262	0.188
OBS3A sn 222	0.066	OBS3A sn 261	0.206
OBS3A sn 221	0.051	OBS3A sn 247	0.074

4.4.2. Temperature

Temperature measurements were compared as well. Figure 4-6, Figure 4-7 and Figure 4-8 show the temperature measurements of the OBS 3A, the RCM-9 and the CTD-Diver instruments. The CTD-Diver temperature measurements show a spread of 0.2°C up to 0.5 °C, which is the largest but still is small. All measurements follow the same trend. RMSE values are given in

Table 4-6 and are calculated with reference to the OBS3A sn 308 temperature sensor.

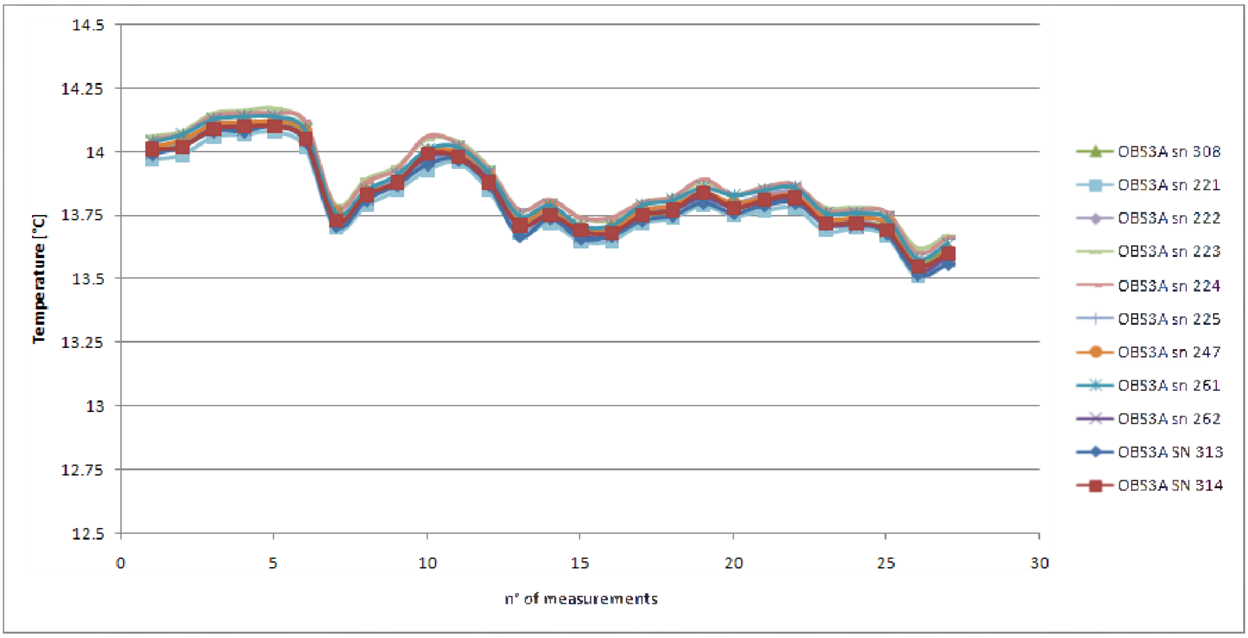


Figure 4-6: OBS 3A Temperature Measurements 27/10/2008 & 28/10/2008

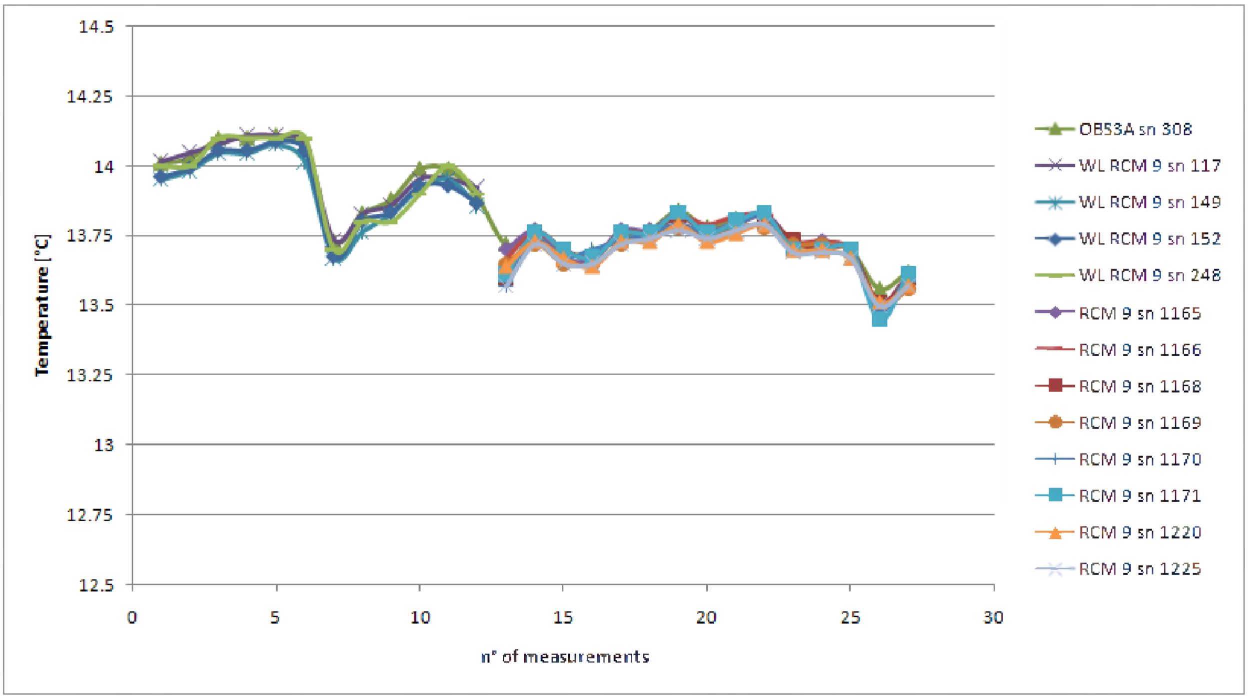


Figure 4-7: RCM-9 Temperature Measurements 27/10/2008 & 28/10/2008

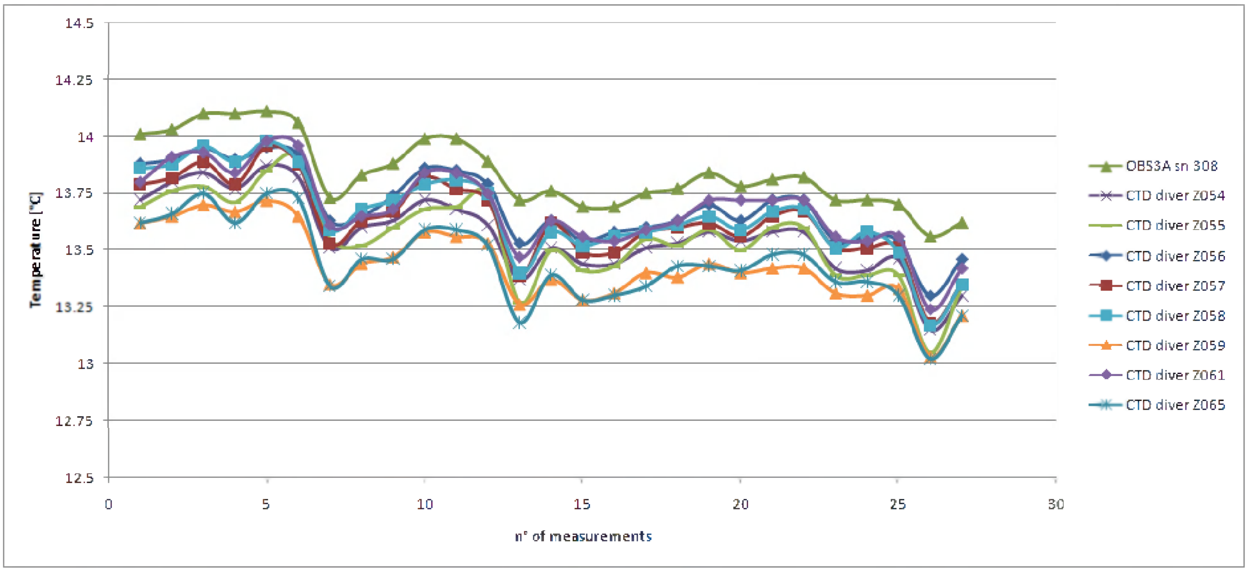


Figure 4-8: CTD-Diver Temperature Measurements 27/10/2008 & 28/10/2008

Table 4-6: RMSE values [°C] temperature sensors

Instrument	***RMSE***	***Instrument***	***RMSE***
OBS3A SN 313	0.026	RCM 9 sn 1165	0.018
OBS3A SN 314	0.007	RCM 9 sn 1166	0.021
OBS3A sn 308	0.000	RCM 9 sn 1168	0.036
OBS3A sn 262	0.013	RCM 9 sn 1169	0.041
OBS3A sn 261	0.033	RCM 9 sn 1170	0.049
OBS3A sn 247	0.015	RCM 9 sn 1171	0.042
OBS3A sn 225	0.018	RCM 9 sn 1220	0.043
OBS3A sn 224	0.049	RCM 9 sn 1225	0.056
OBS3A sn 223	0.053	CTD diver Z054	0.273
OBS3A sn 222	0.014	CTD diver Z055	0.294
OBS3A sn 221	0.038	CTD diver Z056	0.151
WL RCM 9 sn 579	0.032	CTD diver Z057	0.217
WL RCM 9 sn 152	0.043	CTD diver Z058	0.192
WL RCM 9 sn 149	0.053	CTD diver Z059	0.404
WL RCM 9 sn 117	0.021	CTD diver Z061	0.167
WL RCM 9 sn 248	0.040	CTD diver Z065	0.396

4.4.3. Salinity

Salinity is calculated according to the Unesco pps-78 formula (see APPENDIX B), using the uncorrected conductivity values. These calculated salinities are compared between the different instruments. The RMSE values are given in Table 4-7. A graph with calculated salinity values is given together with the reference salinity value in Figure 4-9, Figure 4-10 and Figure 4-11.

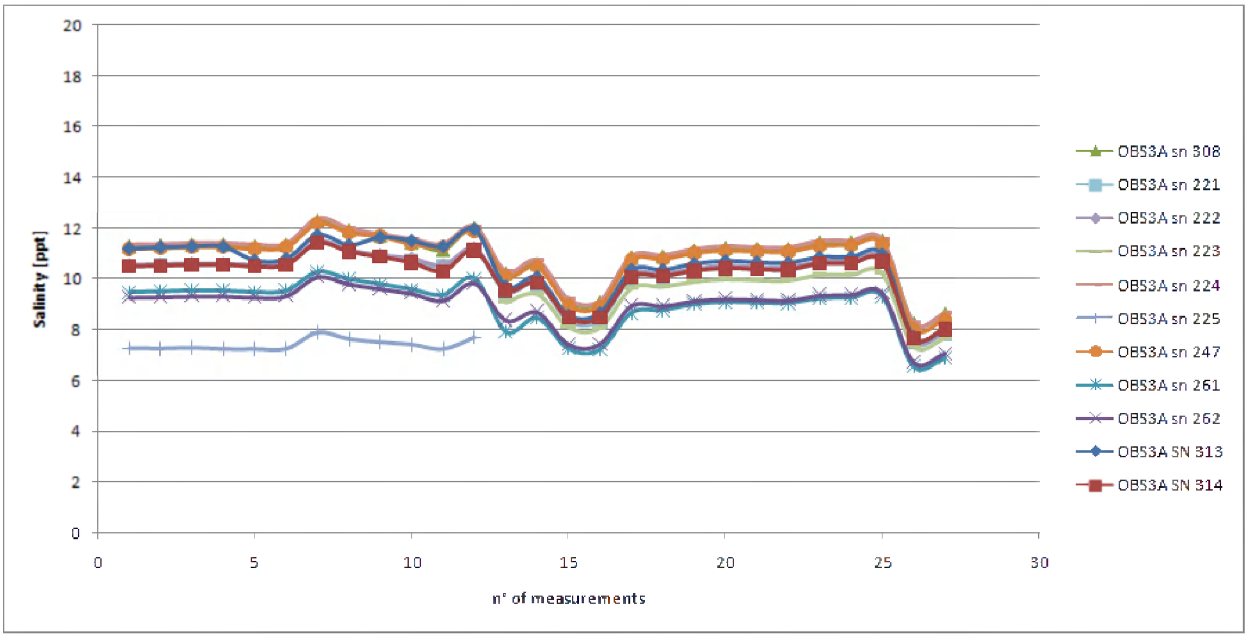


Figure 4-9: OBS 3A Salinity values 27/10/2008 & 28/10/2008

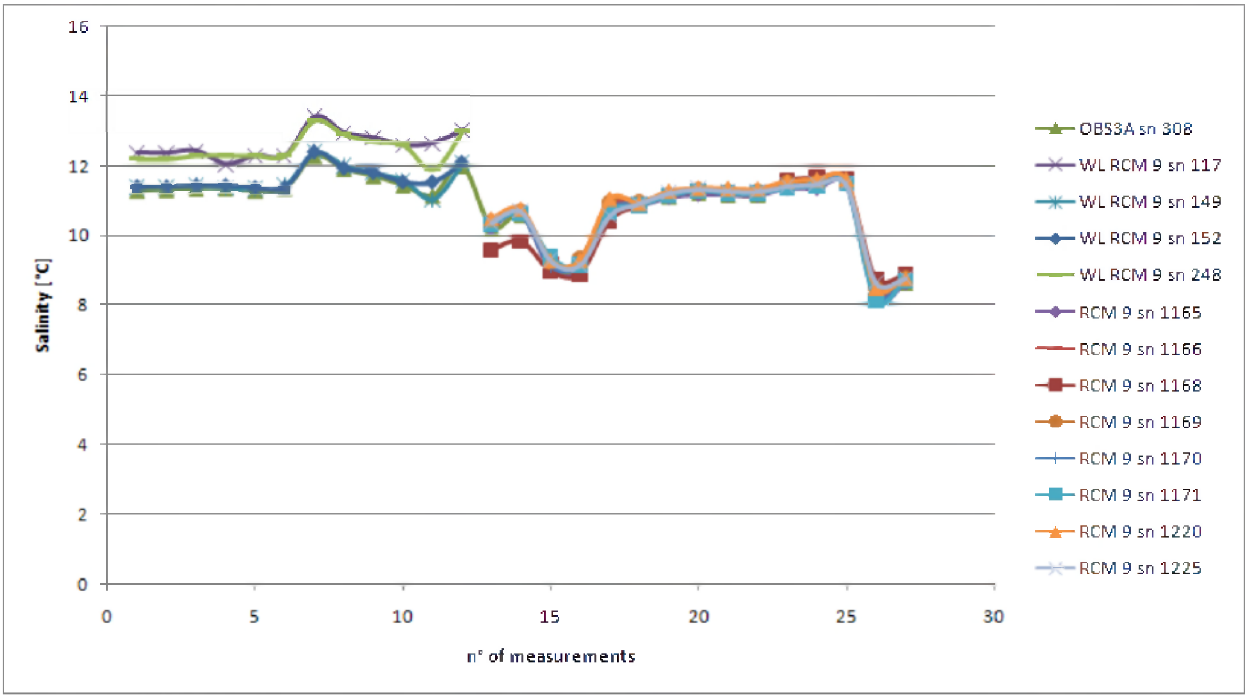


Figure 4-10: RCM 9 Salinity values 27/10/2008 & 28/10/2008

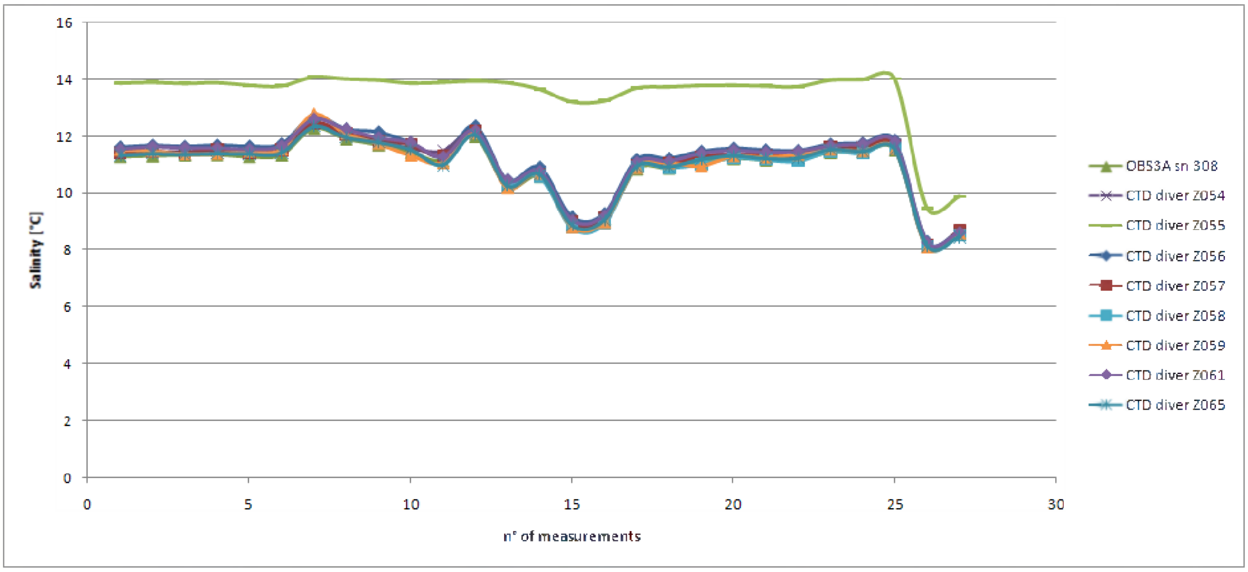


Figure 4-11 CTD diver Salinity values 27/10/2008 & 28/10/2008

Table 4-7: RMSE values [ppt] salinity

Instrument	***RMSE***	***Instrument***	***RMSE***
OBS3A SN 313	0.448	RCM 9 sn 1165	0.062
OBS3A SN 314	0.793	RCM 9 sn 1166	0.098
OBS3A sn 308	0.000	RCM 9 sn 1168	0.327
OBS3A sn 262	1.974	RCM 9 sn 1169	0.124
OBS3A sn 261	1.977	RCM 9 sn 1170	0.053
OBS3A sn 247	0.132	RCM 9 sn 1171	0.104
OBS3A sn 225	12.449	RCM 9 sn 1220	0.152
OBS3A sn 224	0.076	RCM 9 sn 1225	0.151
OBS3A sn 223	10.391	CTD diver Z054	0.145
OBS3A sn 222	0.717	CTD diver Z055	2.675
OBS3A sn 221	0.808	CTD diver Z056	0.310
WL RCM 9 sn 579	7.578	CTD diver Z057	0.140
WL RCM 9 sn 152	0.133	CTD diver Z058	0.110
WL RCM 9 sn 149	0.095	CTD diver Z059	0.164
WL RCM 9 sn 117	1.079	CTD diver Z061	0.250
WL RCM 9 sn 248	0.965	CTD diver Z065	0.094

5. CONCLUSION OF THE AUTUMN CALIBRATION 2008

The technical realization of the in situ calibration for turbidity measurements was carried out with variable success. Only low concentrations were found in the water column at various tidal phases during the incoming tide. The highest concentration sampled was 330 mg/l.

RMSE values for the SSC were rather high (from 20 to 60 mg/l). This was mainly due to the samples with the highest concentration, but deviation of the calibration graphs is not noticed for these samples. This could be due to a higher sand content of the samples with high SS concentrations. The sand content of the suspended sediment samples is negligible in general. But as mentioned before, the sand content runs up when aiming for high concentrated samples.

High concentrations can only be found near the bottom. Disturbance of the soft bottom at these depths is inevitable and therefore not recommended for calibration. For instruments with a very high turbidity range (SiltProfiler) an in situ calibration is not recommended. It is very hard to find very high concentrations in a homogenous mixture in the Lower Sea Scheldt. Only in situ cross-checks are useful in this case, with the widest range of concentrations possible.

When compared to the previous calibrations in autumn 2007 (IMDC, 2008a) and winter 2008 (imdc, 2008b) It can be seen that the calibration graphs in this calibration are very similar to autumn 2007 and both these calibrations are more linear in nature than the previous calibration, which was more parabolic. This parabolic nature implies higher SSC in the higher range of turbidity (NTU and FTU) and can be related to the higher sand content for the higher concentrations, or to different sediment characteristics between winter and autumn conditions.

The conductivity cross-check was limited due to the small range of conductivities that were measured. The conductivity comparison of the CTD-Divers and the RCM-9 instruments showed similar trends, the range of values during each measurement was about 0.5 mS/cm. The conductivity of the OBS3A instruments had more variation (about 2 to 3 mS/cm) and offsets were calculated to correct these conductivity values. Despite the variation, it can be seen in Figure 4-2, Figure 4-4 and Figure 4-5 that every instrument is quite consistent in relation to the reference sensor, except for CTD diver Z055.

Temperature measurements were also compared. No large discrepancies were found. All RMSE values for the instruments were lower than 0.15 °C. All together the temperature measurements by each instrument are acceptable.

The salinity RMSE values were a bit smaller when compared to the conductivity RMSE values. Since the corrected conductivity values will be used to calculate salinity in further reports, for the OBS3A instruments, RMSE values of the OBS3A instruments are not relevant. Of course is the salinity from CTD diver Z055 also unreliable, due to the false conductivity values of this sensor.

6. REFERENCES

ABB Instrumentation (2005) Principles of a Nephelometric Turbidity Monitor.

ARGUS UMWELT-MEATECHNIK (2005), ASM-IV-laser, ARGUS surface meter manual, 31p.

IMDC (2006a). 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), in opdracht van AWZ.

IMDC (2006b). Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slibsuspensies Deelrapport 7.4 23/3 Parel 2 – Schelle (I/RA/11291/06.097/MSA), in opdracht van AWZ.

IMDC (2007a). Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slibsuspensies Deelrapport 6.2 Summer Calibration (I/RA/11291/06.093/MSA), in opdracht van AWZ.

IMDC (2007b). Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slibsuspensies Deelrapport 12 Report concerning the presence of HCBS layers in the Scheldt river (I/RA/11291/06.109/MSA), in opdracht van AWZ.

IMDC (2008a). Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.9 Autumn Calibration (I/RA/11283/07.095/MSA)

IMDC (2008b) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.19: Calibration stationary & mobile equipment winter (I/RA/11283/07.096/MSA)

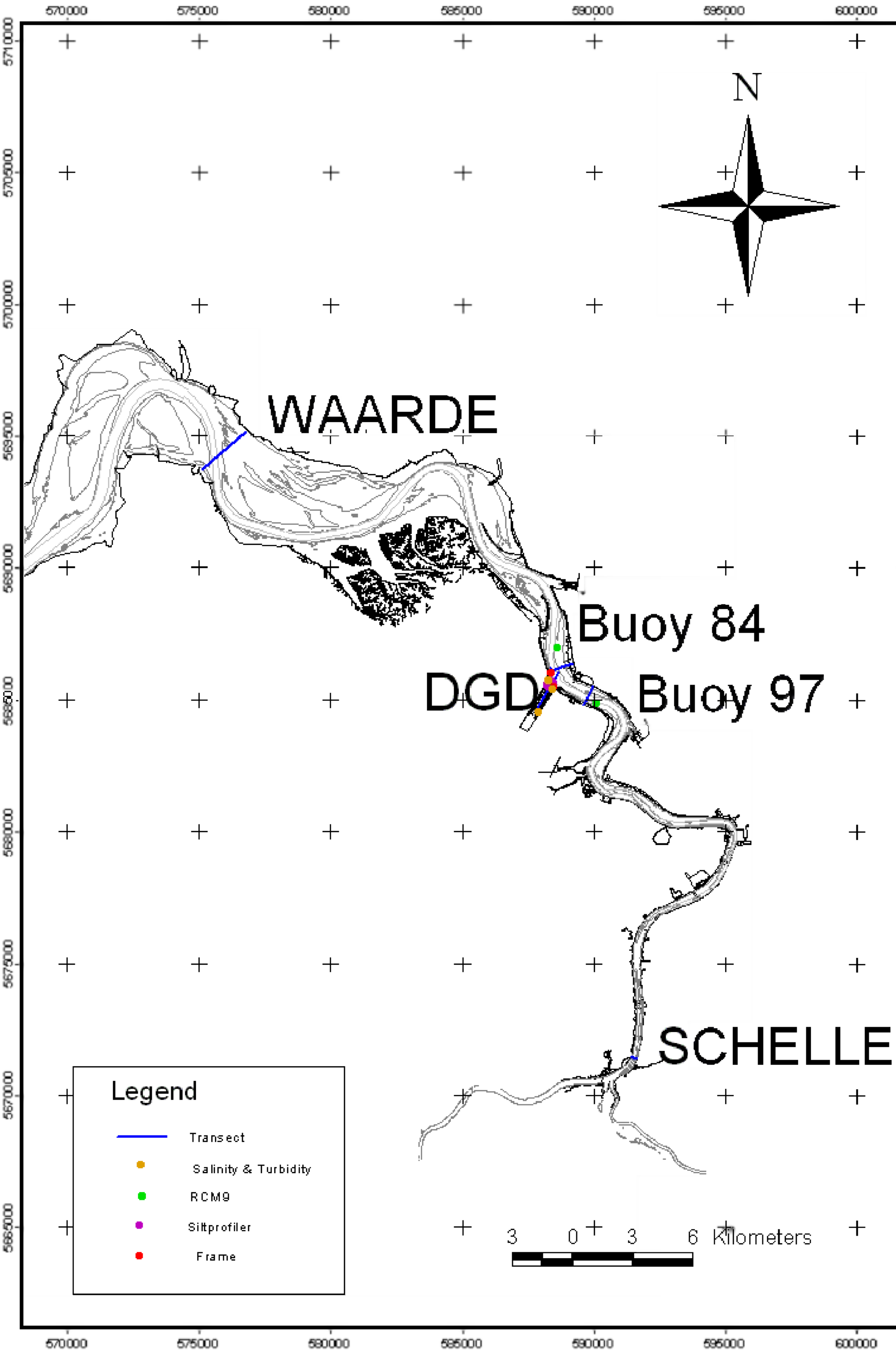
Unesco (1991). Processing of Oceanographic Station Data.

Wunderground (2007).Weather Underground: www.wunderground.com.

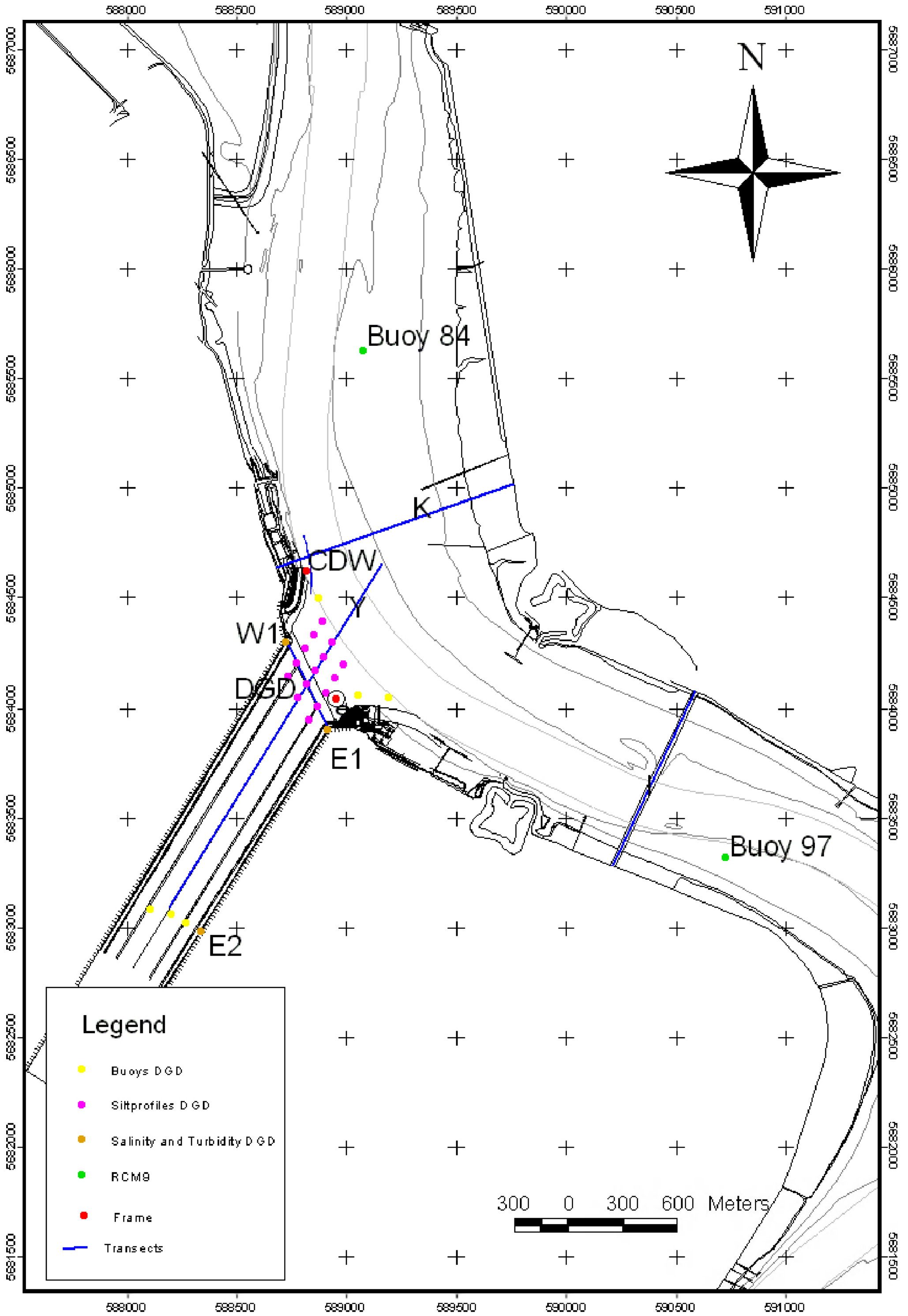
APPENDIX A.

OVERVIEW OF MEASUREMENT

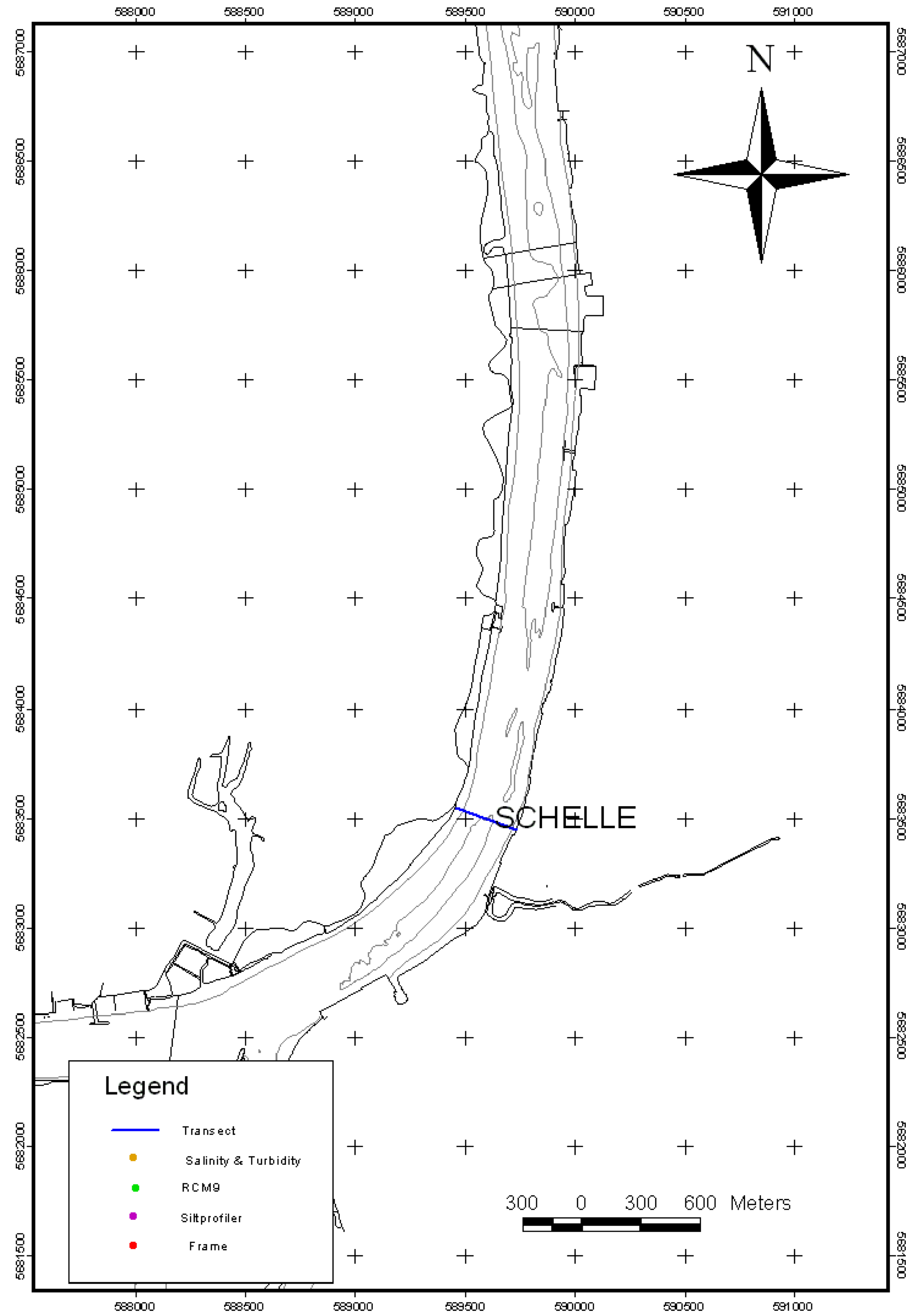
A.1 Overview of the measurement locations for the whole HCBS2 and Deurganckdok measurement campaigns



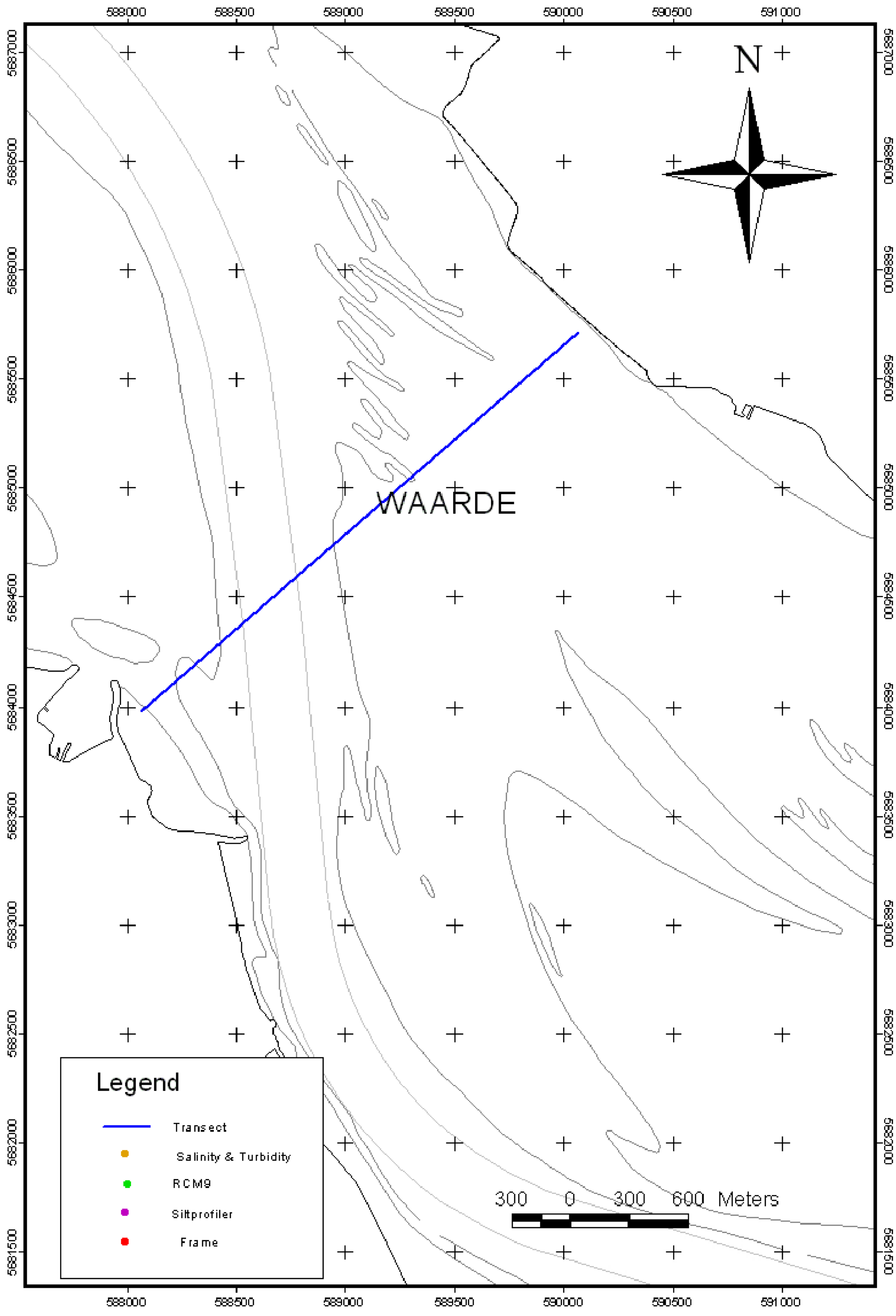
Annex Figure A-1: Overview of the measurement locations



Annex Figure A-2: Overview of the measurement locations at Deurganckdok



Annex Figure A-3: Transect S in Schelle



Annex Figure A-4: Transect W in Waarde

A.2 Overview of all measurement locations HCBS and Deurganckdok measurement campaigns

Annex Table A-1: coordinates of theoretical transects

Transect	Start Easting	Start Northing	End Easting	End Northing
I	590318.00	5683302.00	590771.00	5684257.00
K	588484.00	5684924.00	589775.00	5685384.00
SCHELLE	592645.07	5665794.06	592952.68	5665682.28
DGD	588764.88	5684056.49	588540.95	5684526.94
Y	589059.09	5684948.36	587898.76	5683076.56
WAARDE	573541.00	5696848.20	571318.00	5694932.90

Annex Table A-2: coordinates of SiltProfiler gauging locations

SP	EASTING	NORTHING
1	588737	5684638
2	588690	5684562
3	588643	5684486
4	588596	5684411
5	588549	5684335
6	588606	5684217
7	588653	5684293
8	588700	5684368
9	588747	5684444
10	588793	5684520
11	588850	5684402
12	588803	5684326
13	588756	5684250
14	588709	5684174
15	588662	5684099

APPENDIX B.

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 cond.ratio	0.0117	$R = \frac{C}{42.914 mS/cm}$
C Cond at t	**0.5**	**Input conductivity in mS/cm of sample**
t deg. C	**22.00**	**Input temperature of sample solution**
P dBar	**20**	**Input pressure at which sample is measured in decibars**
Rp	1.0020845	$R_p = 1 + \frac{p(e_1 + e_2 p + e_3 p^2)}{1 + d_1 t + d_2 t^2 + (d_3 + d_4 t)R}$
rt	1.1641102	$r_t = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + c_4 t^4$
Rt	0.0099879	$R_t = \frac{R}{R_p \times r_t}$
Delta S	-0.0010	$\text{Delta S} = \frac{(t-15)}{1+k(t-15)}(b_0 + b_1 R_t^{1/2} + b_2 R_t + b_3 R_t^{3/2} + b_4 R_t^2 + b_5 R_t^{5/2})$
S = Salinity	**0.257**	$S = a_0 + a_1 R_t^{1/2} + a_2 R_t + a_3 R_t^{3/2} + a_4 R_t^2 + a_5 R_t^{5/2} + \text{delta S}$

a0	0.0080	b0	0.0005	c0	0.6766097	d1	3.426E-02	e1	2.070E-04
a1	-0.1692	b1	-0.0056	c1	2.00564E-02	d2	4.464E-04	e2	-6.370E-08
a2	25.3851	b2	-0.0066	c2	1.104259E-04	d3	4.215E-01	e3	3.989E-12
a3	14.0941	b3	-0.0375	c3	-6.9698E-07	d4	-3.107E-03		
a4	-7.0261	b4	0.0636	c4	1.0031E-09				
a5	2.7081	b5	-0.0144						
		k	0.0162						

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 = Rt x Rp x rt

R = C(S,t,p)/C(35,15,0)

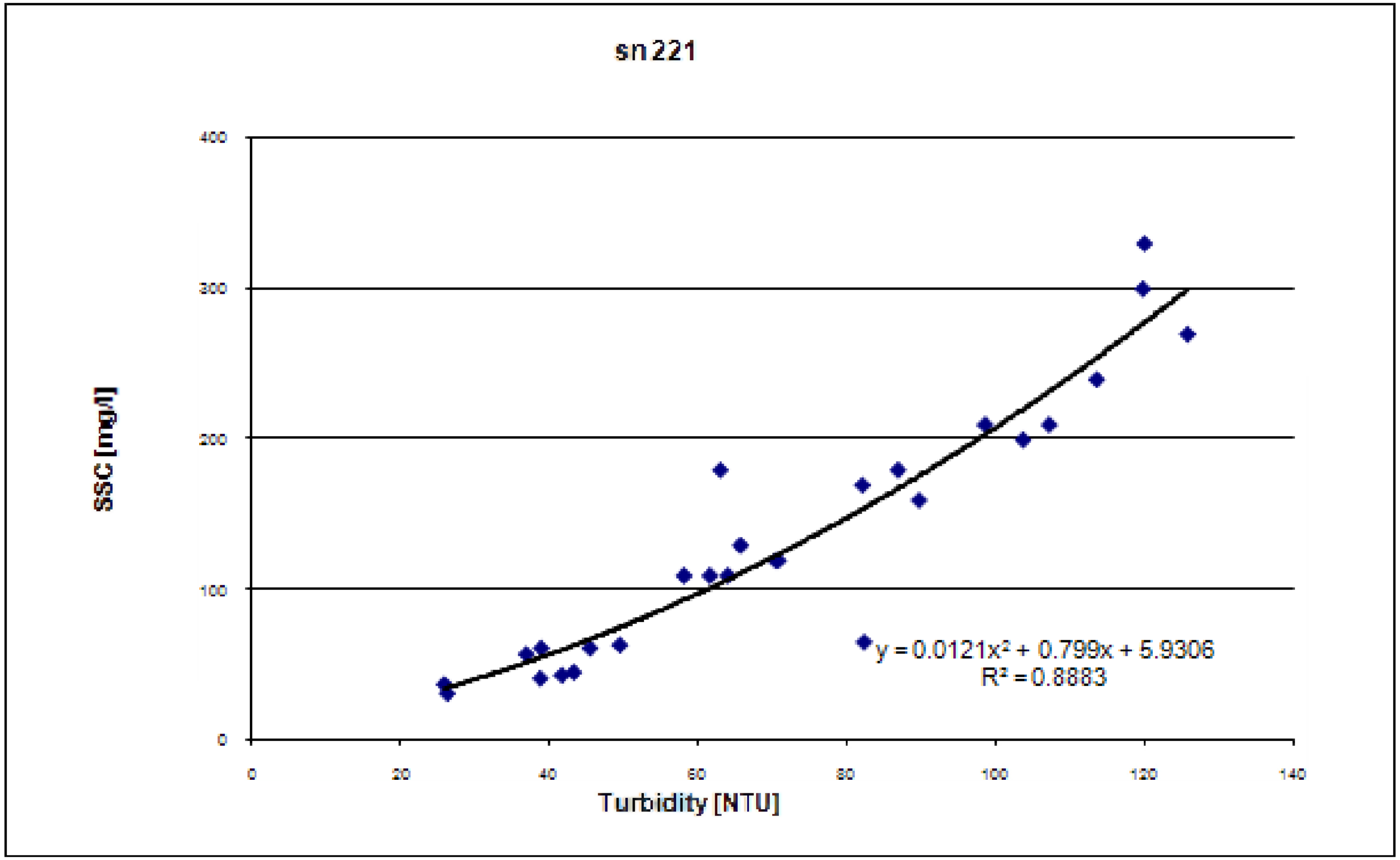
C = 42.914 mS/cm at 15 deg C and 0 dbar pressure ie C(35,15,0) where 35 is the salinity

Ocean pressure is usually measured in decibars. 1 dbar = 10^-1 bar = 10^5 dyne/cm^2 = 10^4 Pascal.

APPENDIX C. CALIBRATION GRAPHS

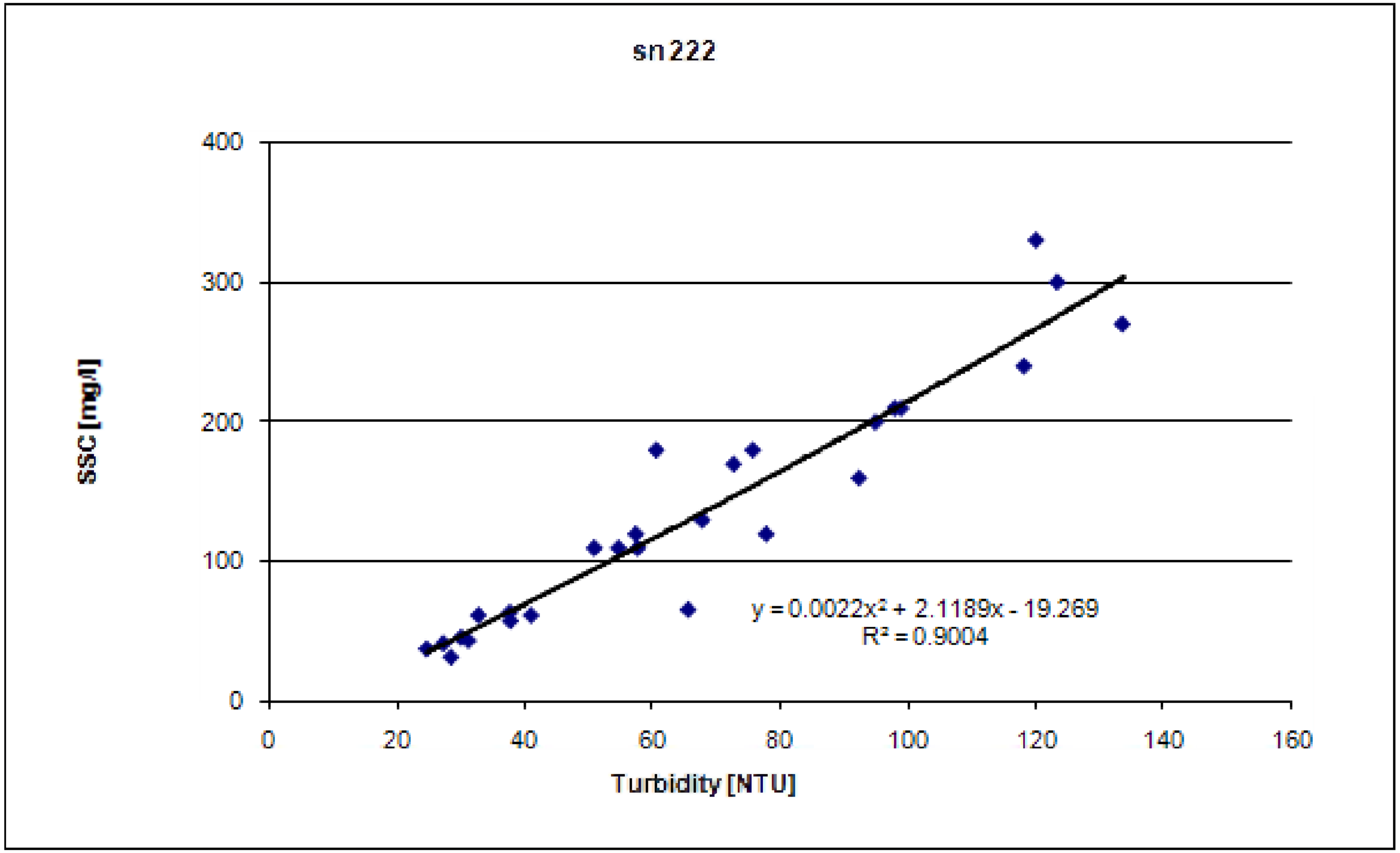
C.1 In situ Calibration Graphs

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 221		*Data processed by:* IMDC
Location: Lower Sea Scheldt	Date: 27/10/08 & 28/10/08	*In association with:* WL | delft hydraulics
		I/RA/11283/08.095/MSA

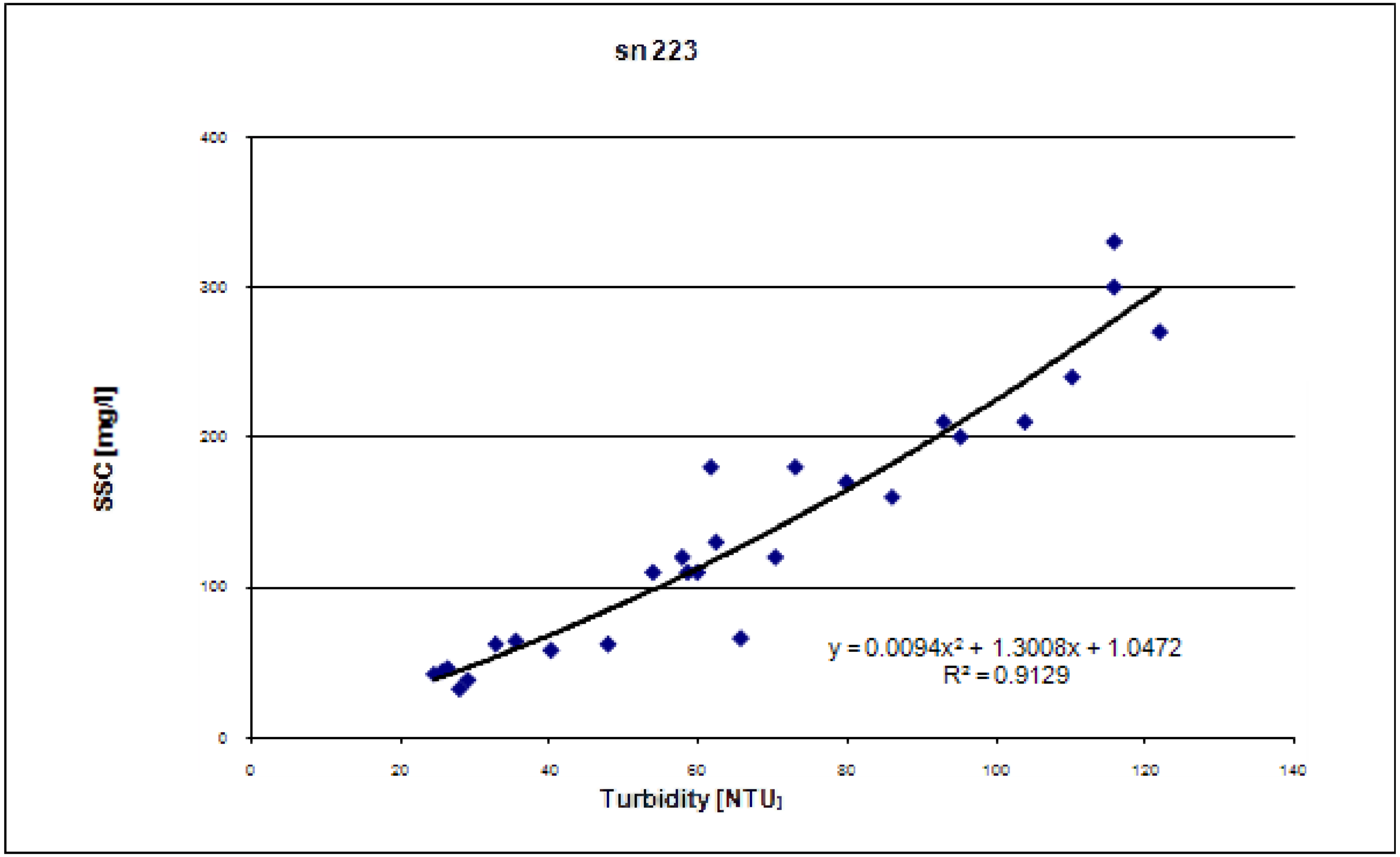
11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 222

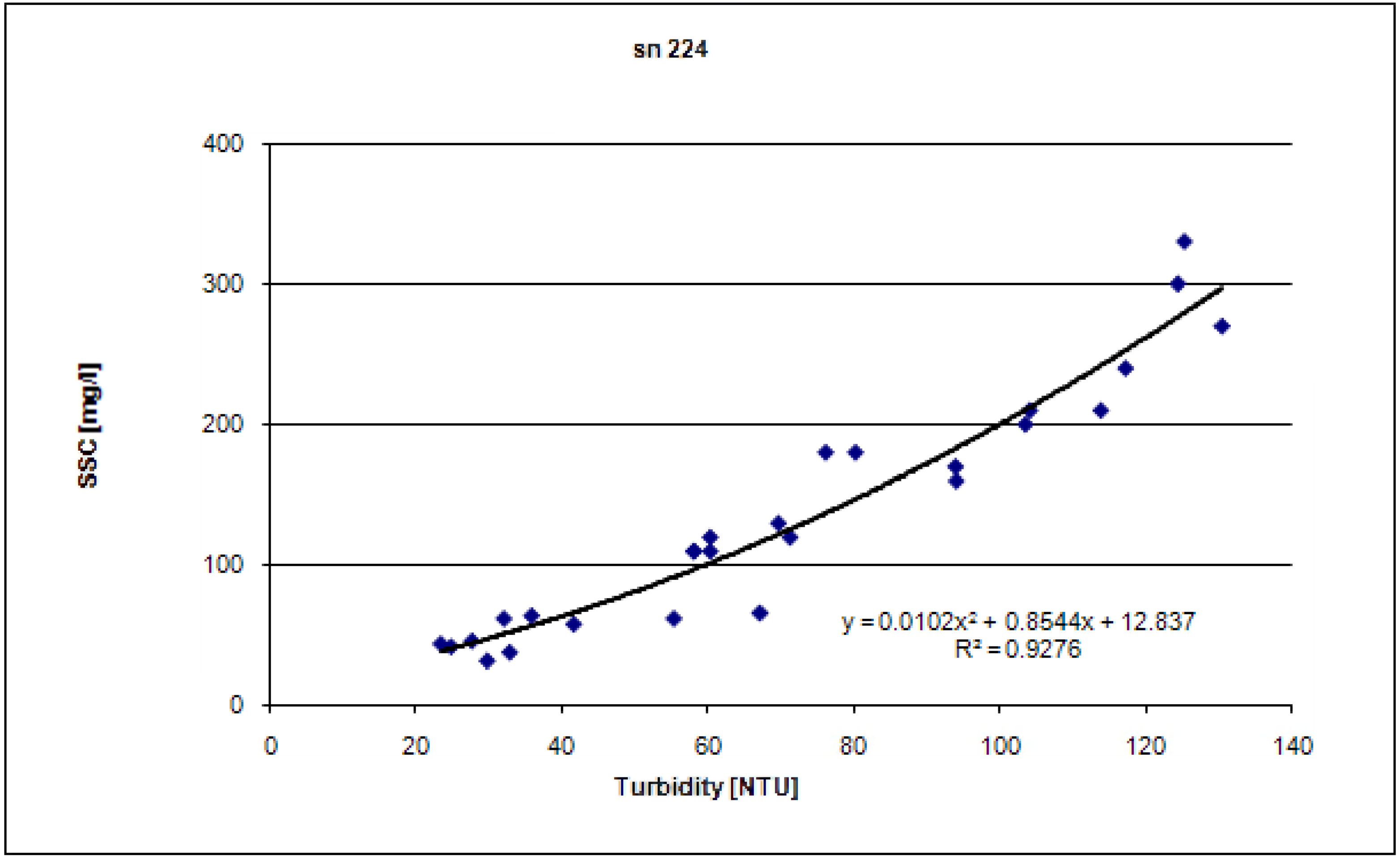
Location: Lower Sea Scheldt	Date: 27/10/08 & 28/10/08	*Data processed by:* IMDC *In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*

11283 DGD2 – CALIBRATION AUTUMN



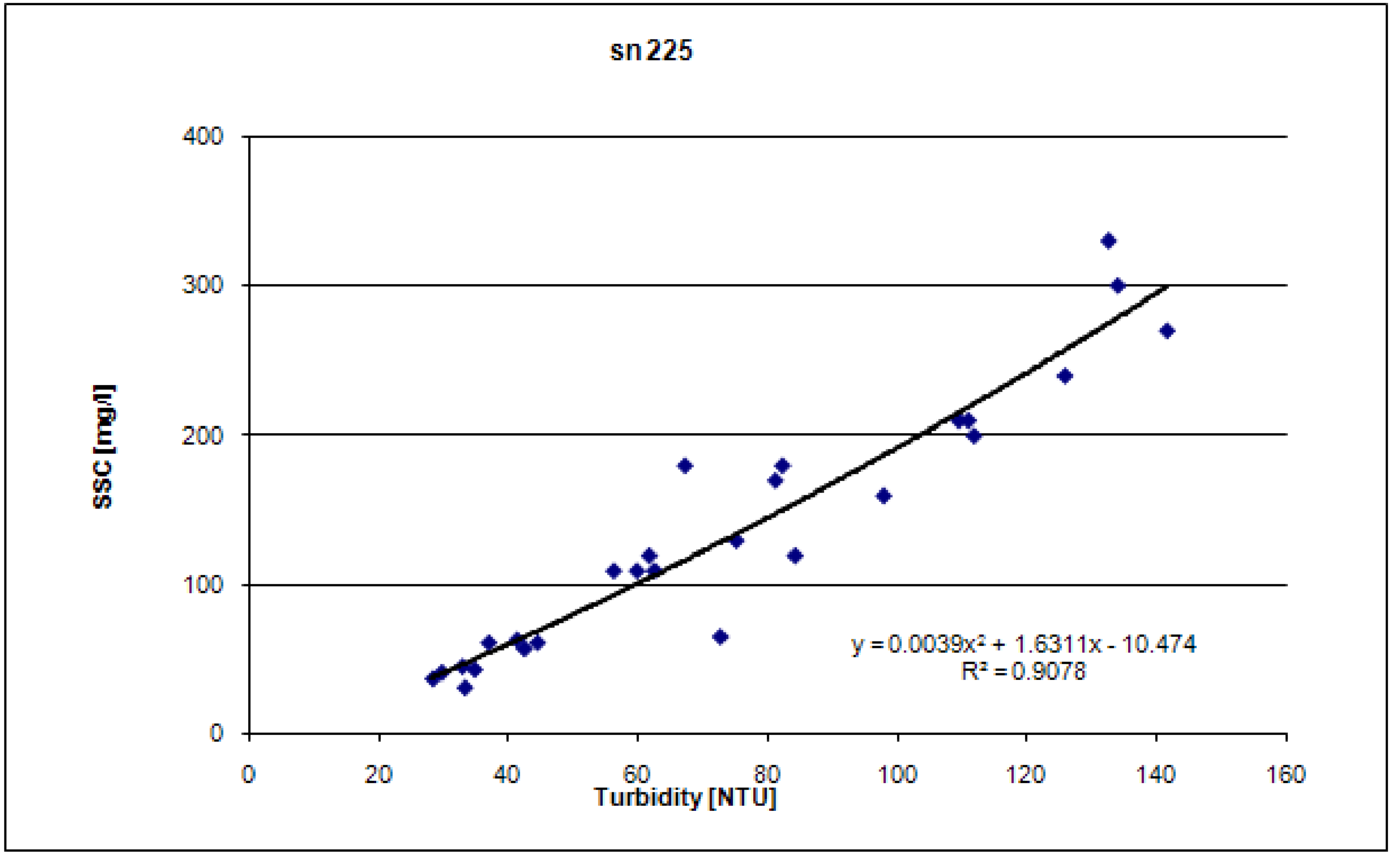
Calibration Graph of OBS3A s/n 223		*Data processed by:* IMDC
Location: Lower Sea Scheldt	Date: 27/10/08 & 28/10/08	*In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 224		Data processed by: IMDC
Location: Lower Sea Scheldt	Date: 27/10/08 & 28/10/08	In association with: wl | delft hydraulics I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 225

Location:
Lower Sea Scheldt

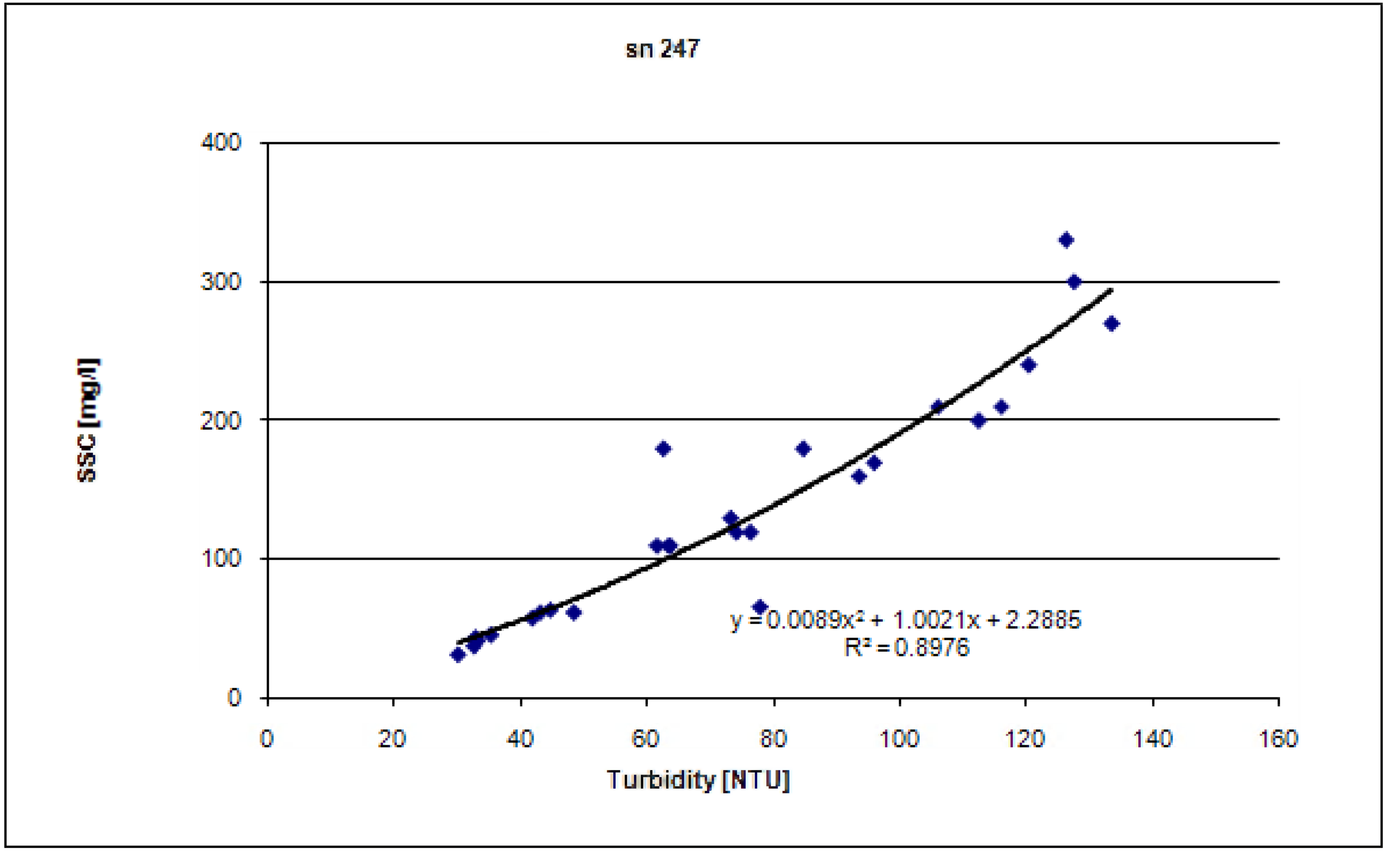
Date:
27/10/08 & 28/10/08

Data processed by: IMDC International Marine & Dredging Consultants

In association with: WL | delft hydraulics

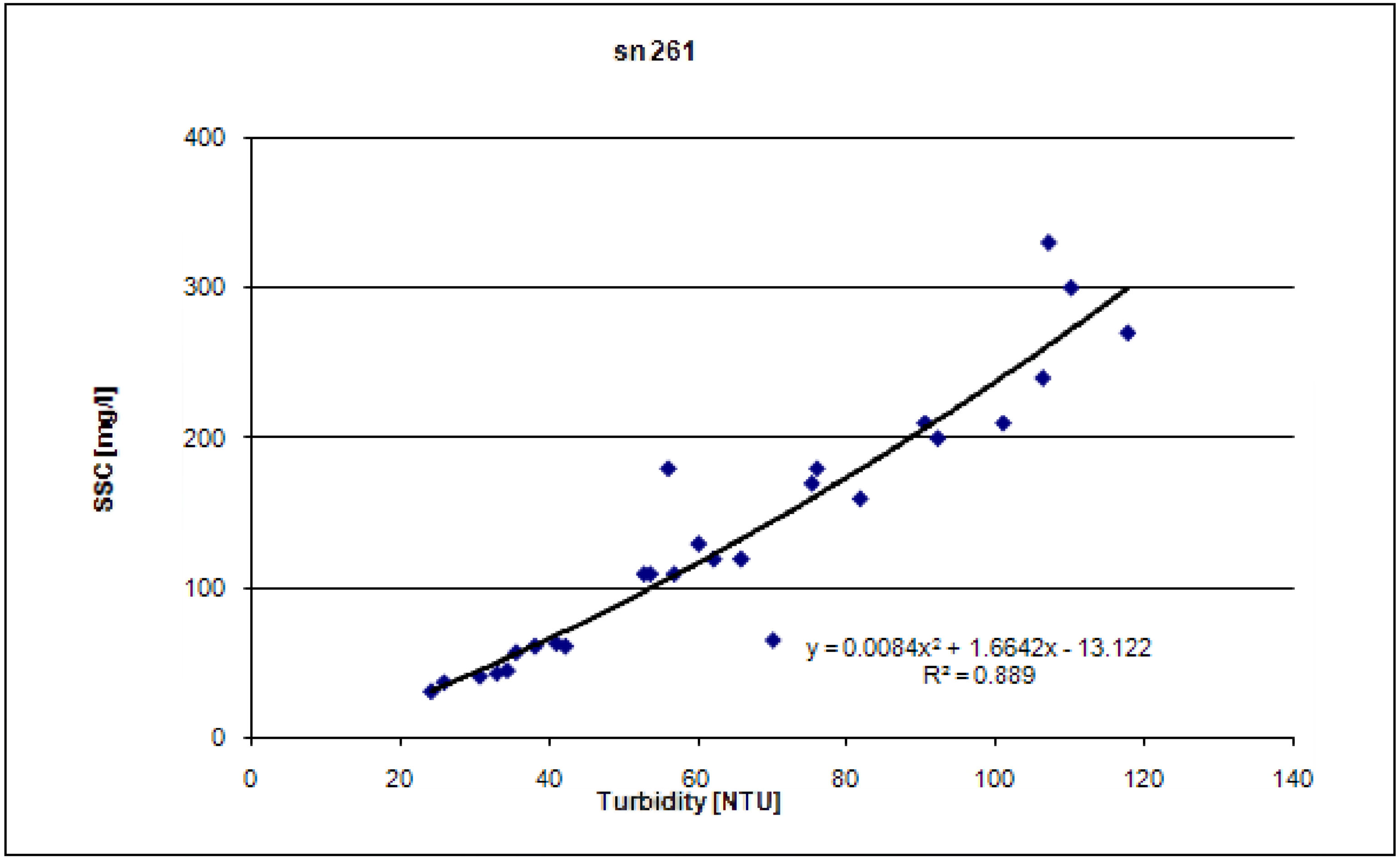
I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



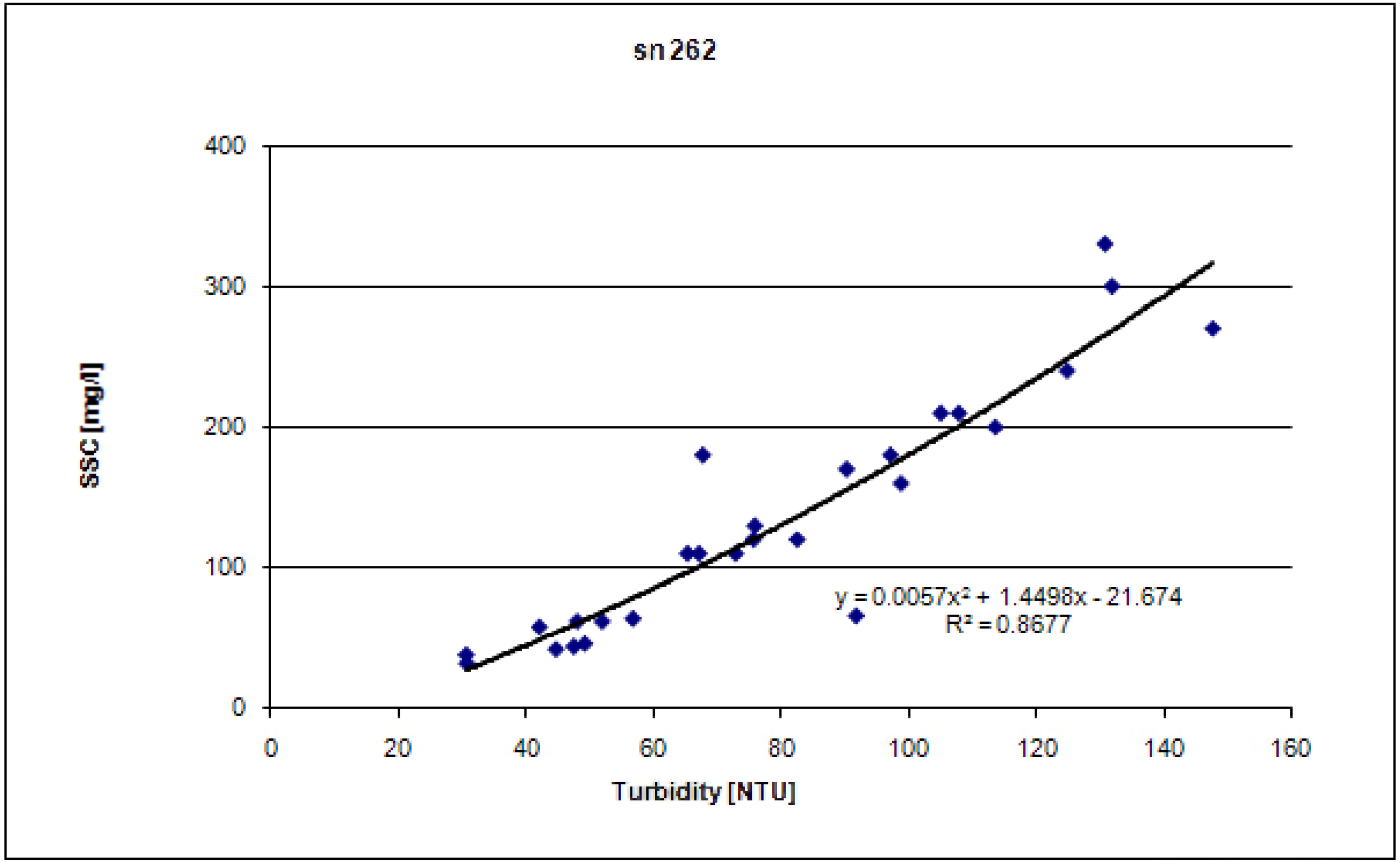
Calibration Graph of OBS 3A s/n 247		*Data processed by:* IMDC
Location: Lower Sea Scheldt	Date: 27/10/08 & 28/10/08	*In association with:* wl | delft hydraulics
		I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 261		*Data processed by:* IMDC International Marine & Dredging Consultants
Location: Lower Sea Scheldt	Date: 27/10/08 & 28/10/08	*In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*

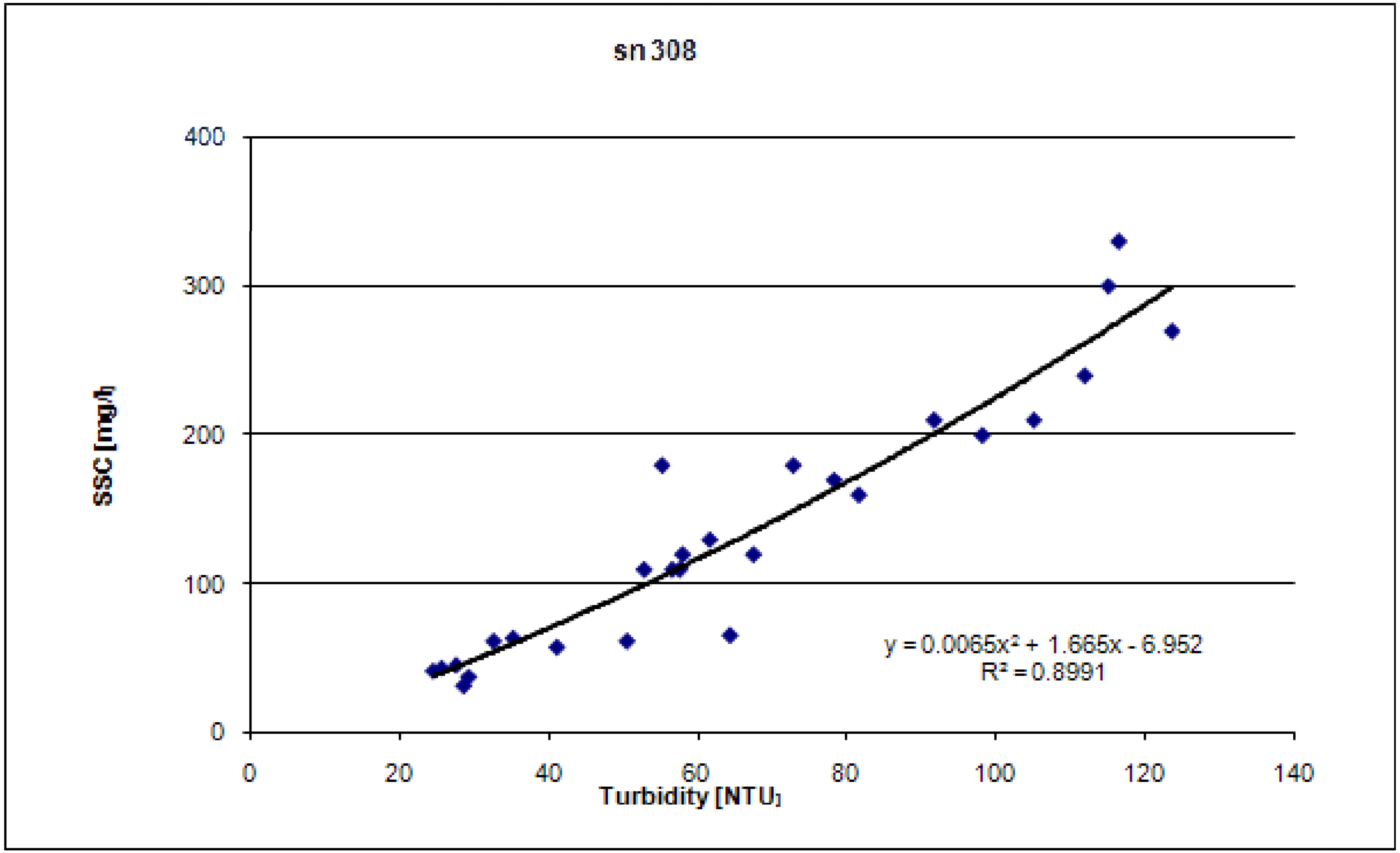
11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 262

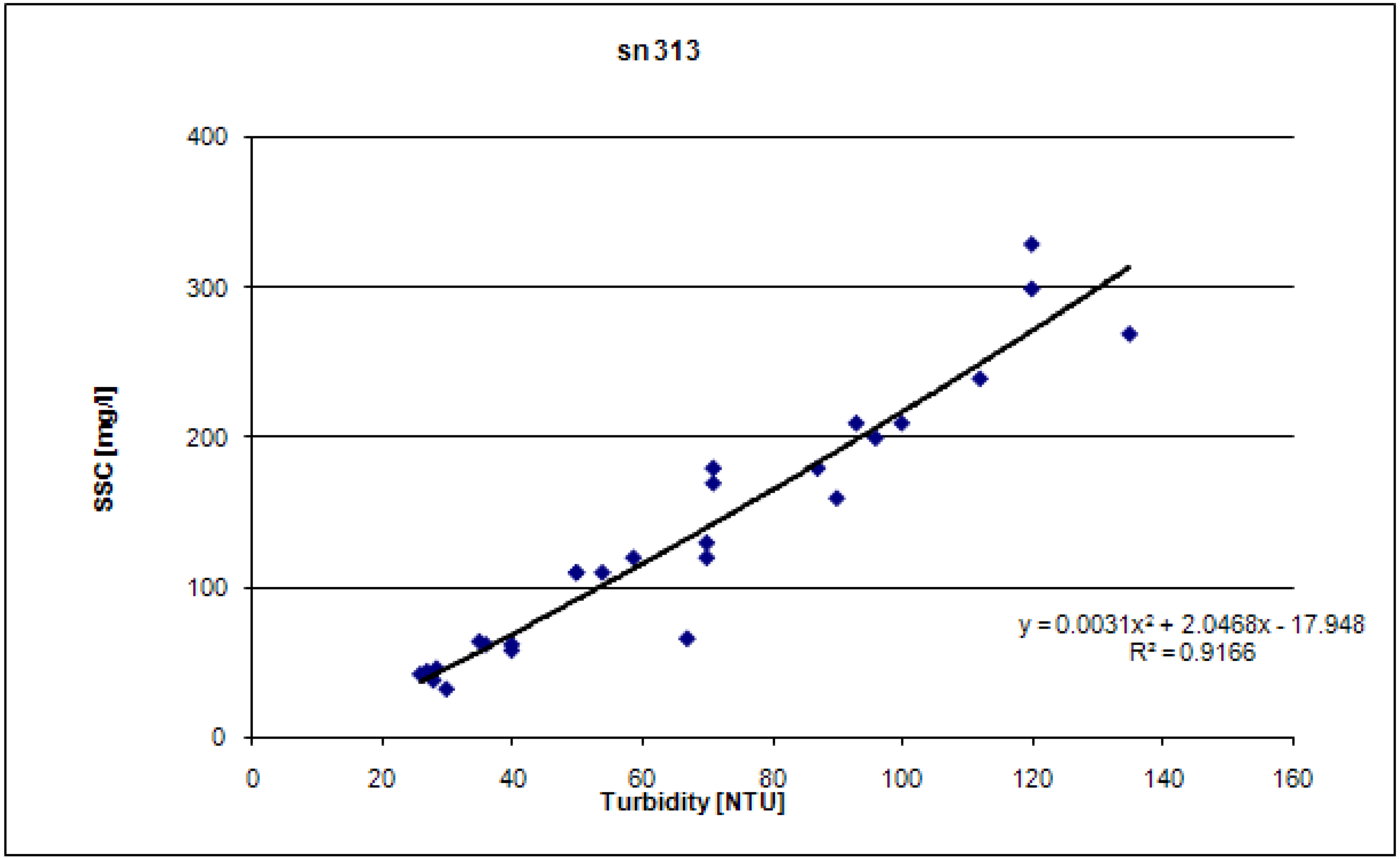
Location: Lower Sea Scheldt	Date: 27/10/08 & 28/10/08	*Data processed by:* IMDC *In association with:* WL delft hydraulics *I/RA/11283/08.095/MSA*

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 308	*Data processed by:* IMDC
Location: Lower Sea Scheldt / Date: 27/10/08 & 28/10/08	*In association with:* wl | delft hydraulics
	I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 313

Data processed by:

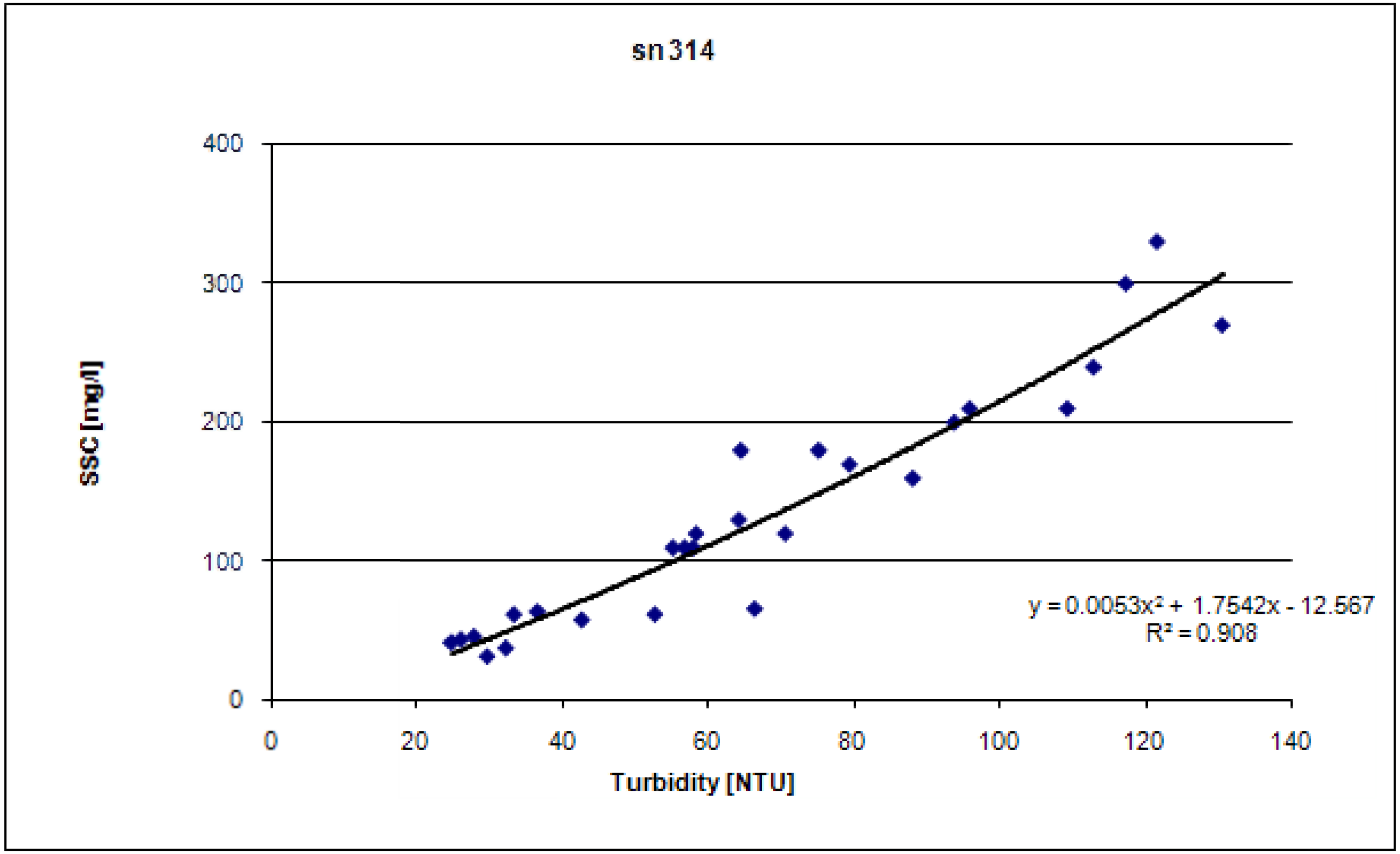
In association with:

Location:
Lower Sea Scheldt

Date:
27/10/08 & 28/10/08

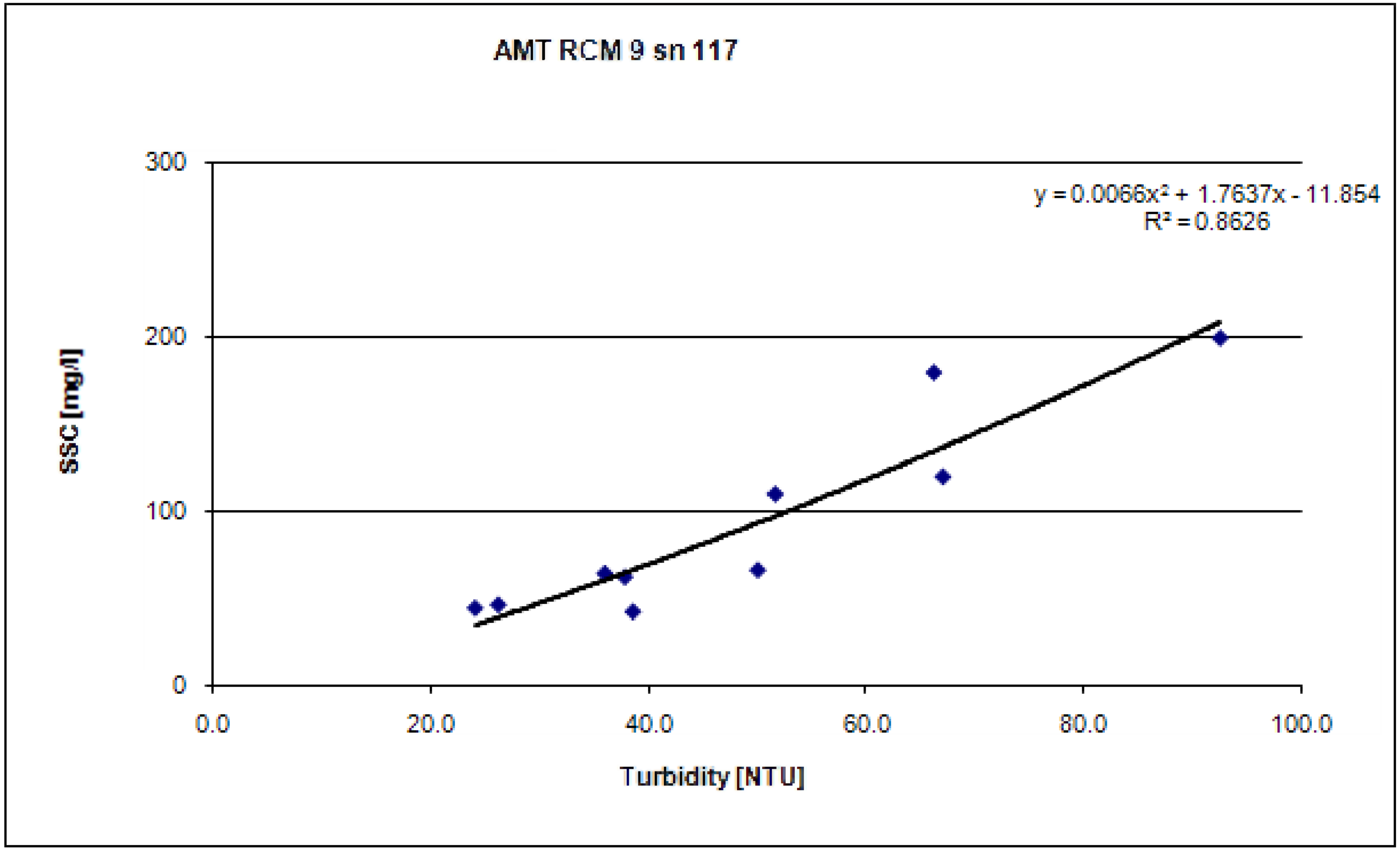
I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of OBS 3A s/n 314	*Data processed by:* IMDC
Location: Lower Sea Scheldt / Date: 27/10/08 & 28/10/08	*In association with:* wl | delft hydraulics
	I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 117-122

Data processed by: IMDC

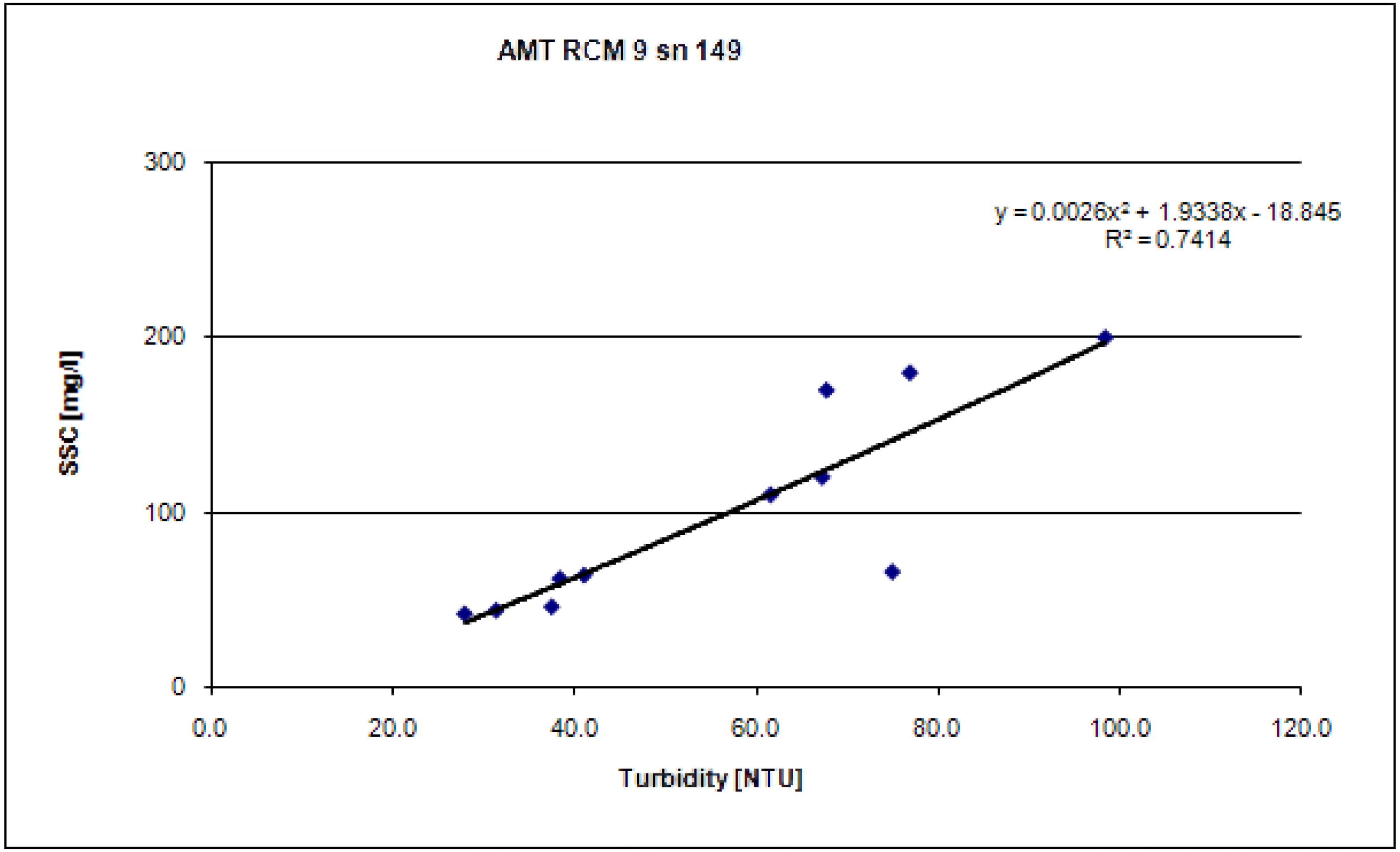
In association with: WL | delft hydraulics

Location: Lower Sea Scheldt

Date: 27/10/08

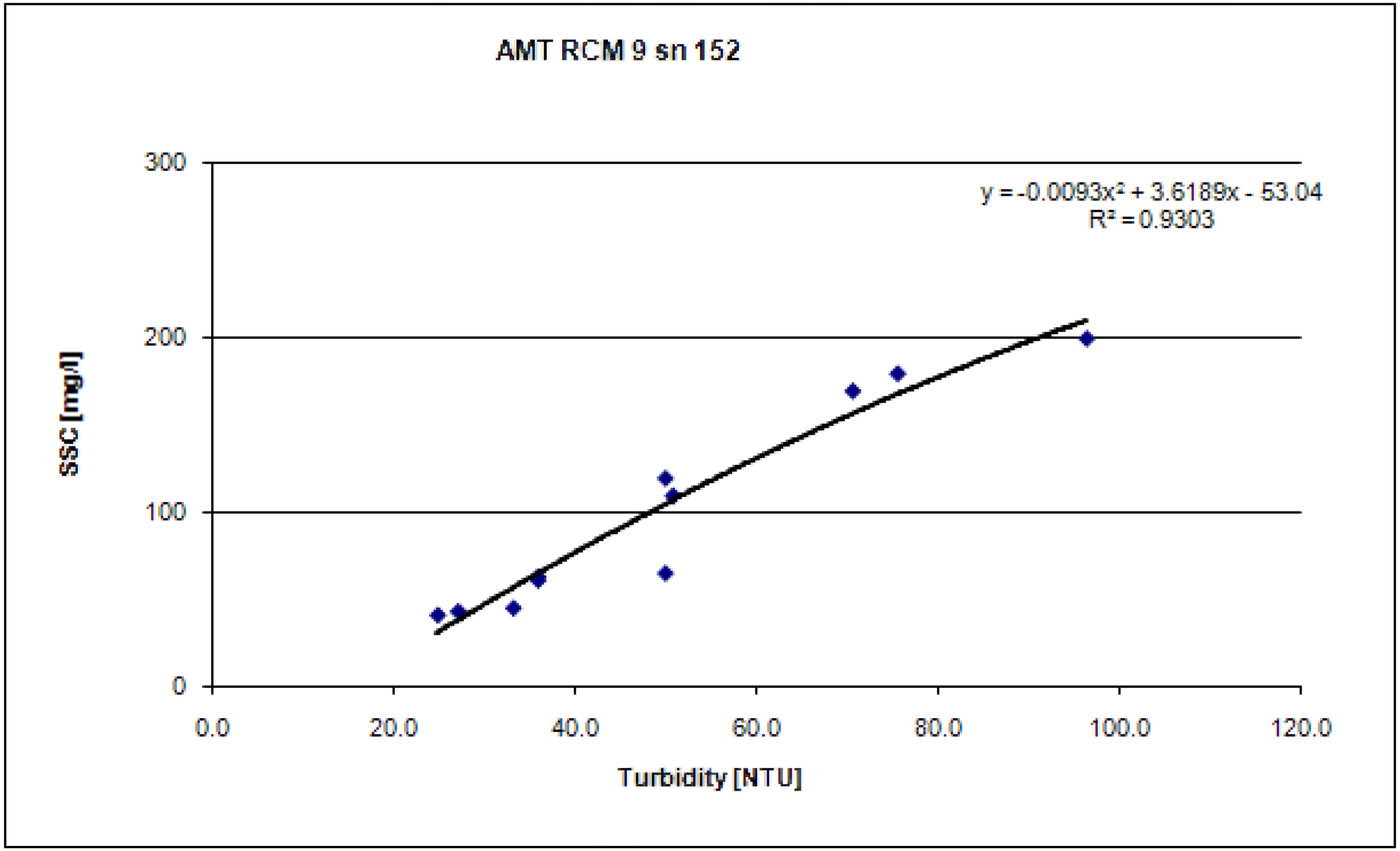
I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



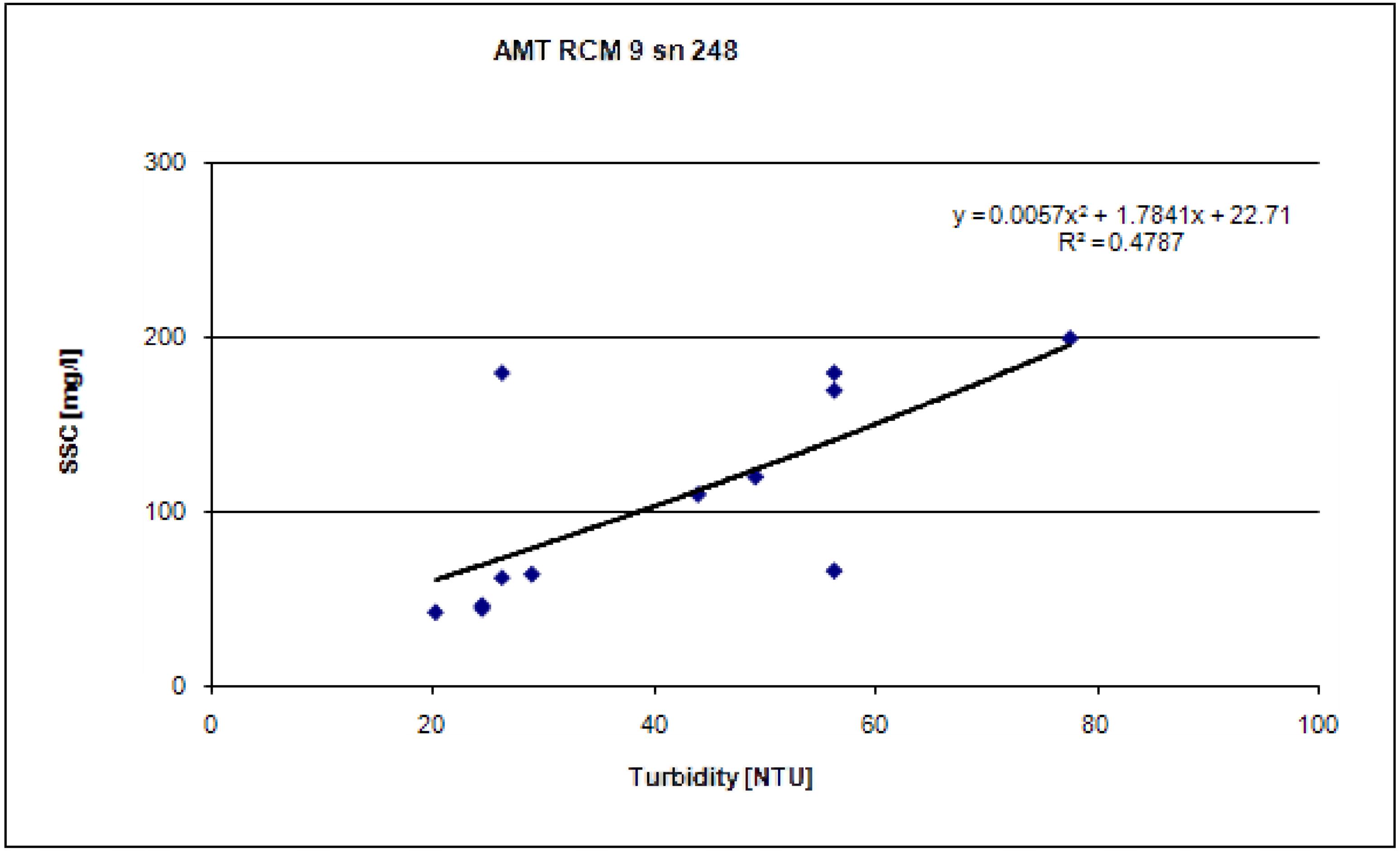
Calibration Graph of RCM-9 149-1316		*Data processed by:* IMDC
Location: Lower Sea Scheldt	Date: 27/10/08	*In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 152-1317		*Data processed by:* IMDC
Location: Lower Sea Scheldt	Date: 27/10/08	*In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 248-232

Data processed by: IMDC

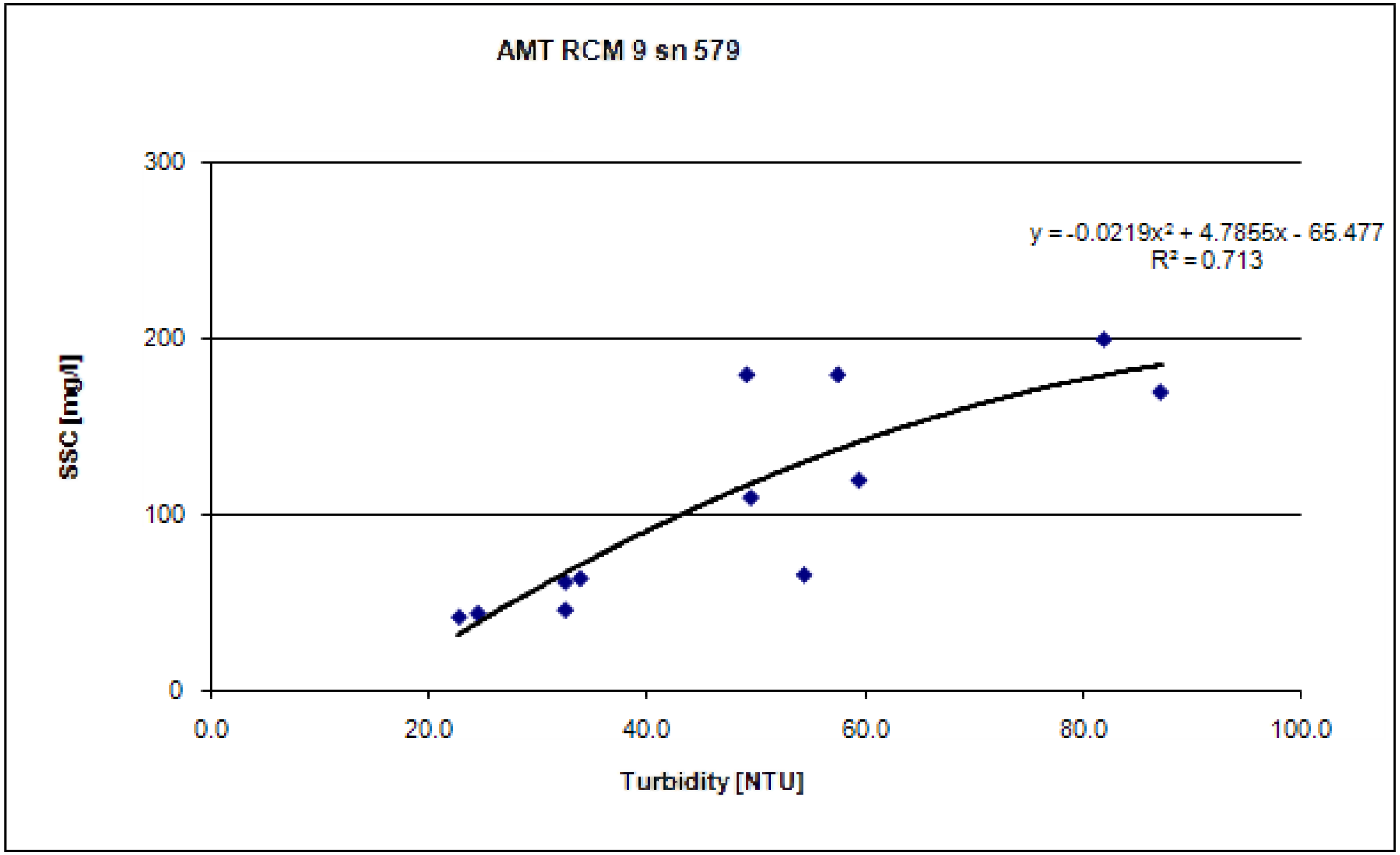
In association with: wl | delft hydraulics

Location: Lower Sea Scheldt

Date: 27/10/08

I/RA/11283/08.095/MSA

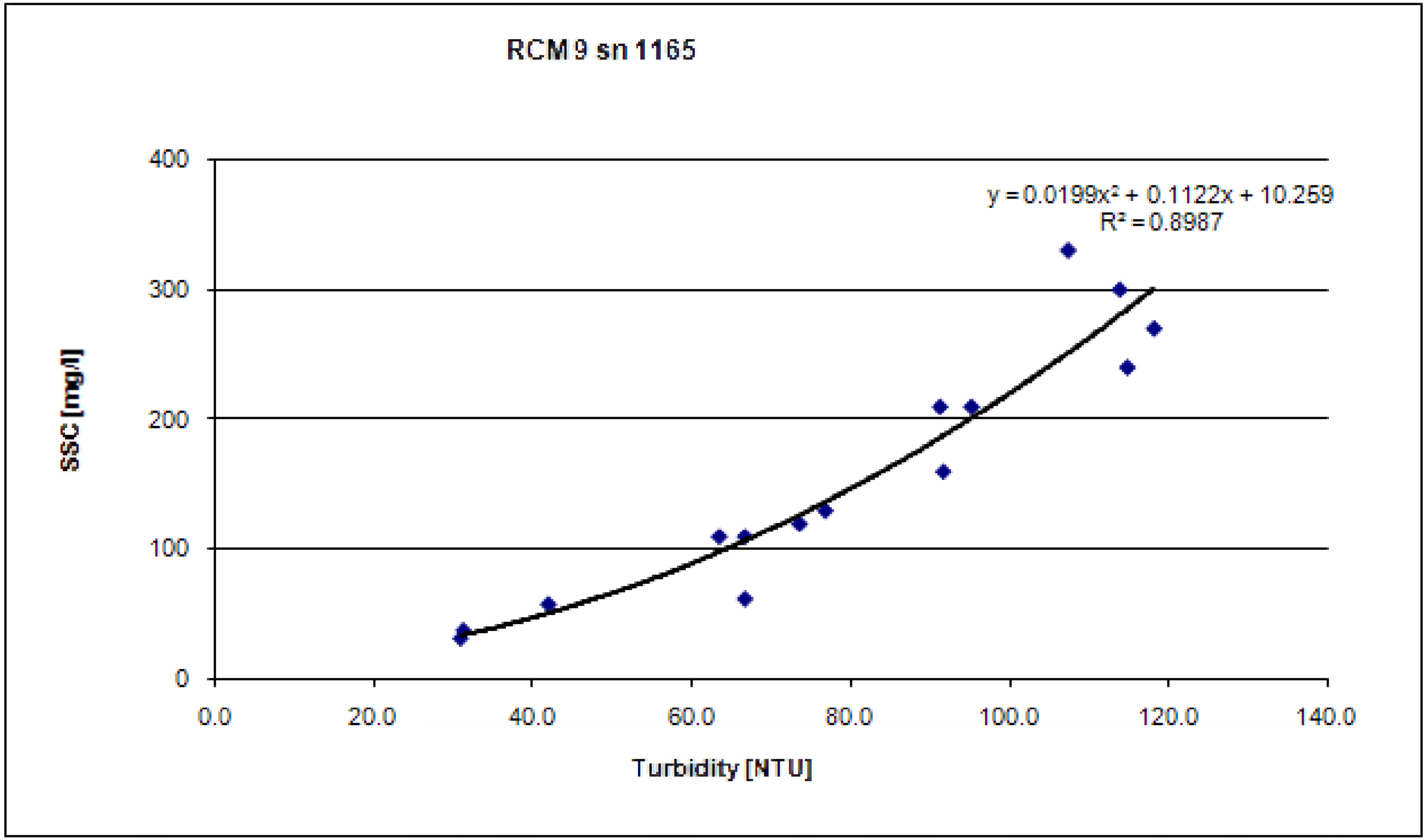
11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 579-560

Location:	Date:	*Data processed by:*
Lower Sea Scheldt	27/10/08	*In association with:*
		I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 1165-1025

Location:
Lower Sea Scheldt

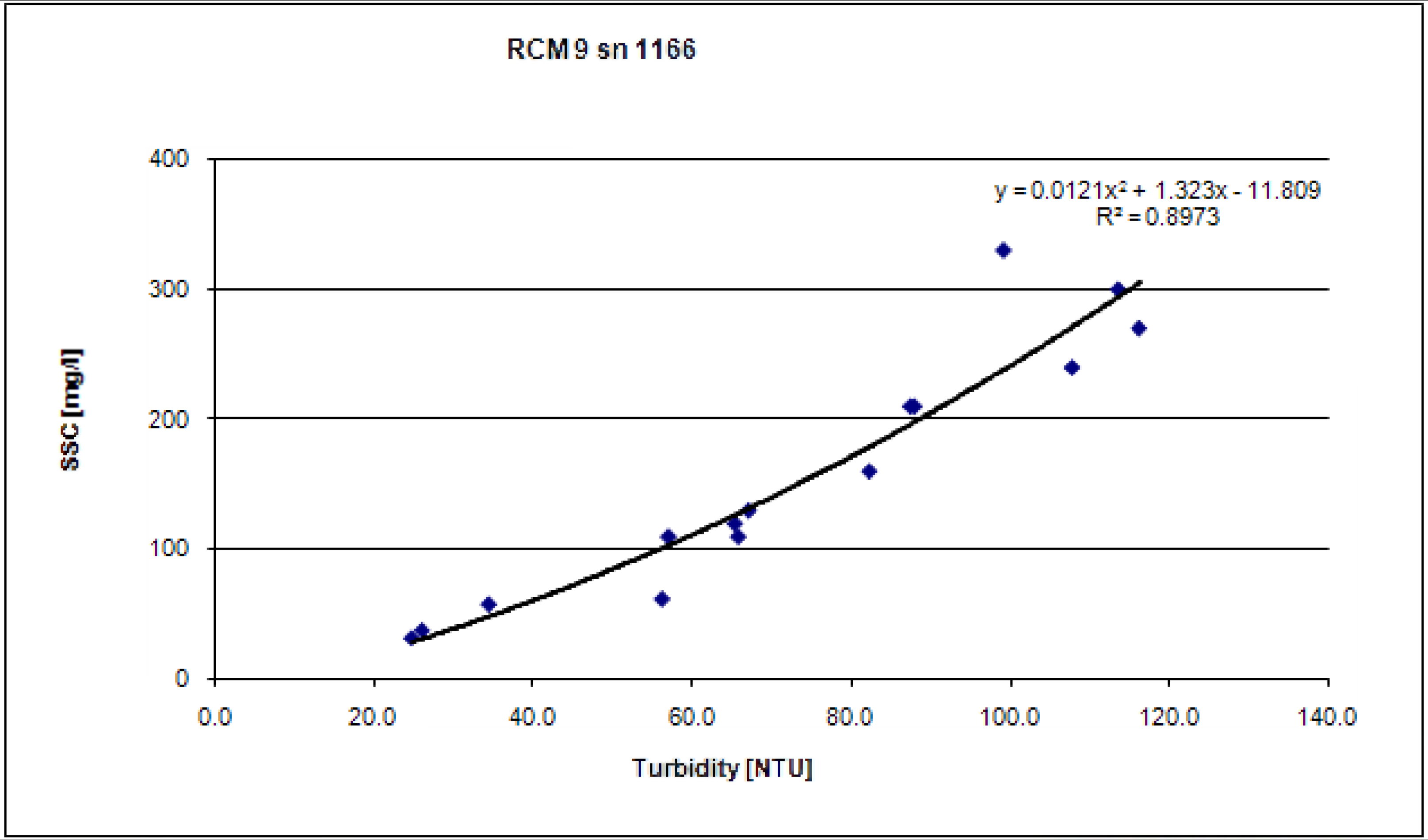
Date:
28/10/08

Data processed by: IMDC

In association with: wl | delft hydraulics

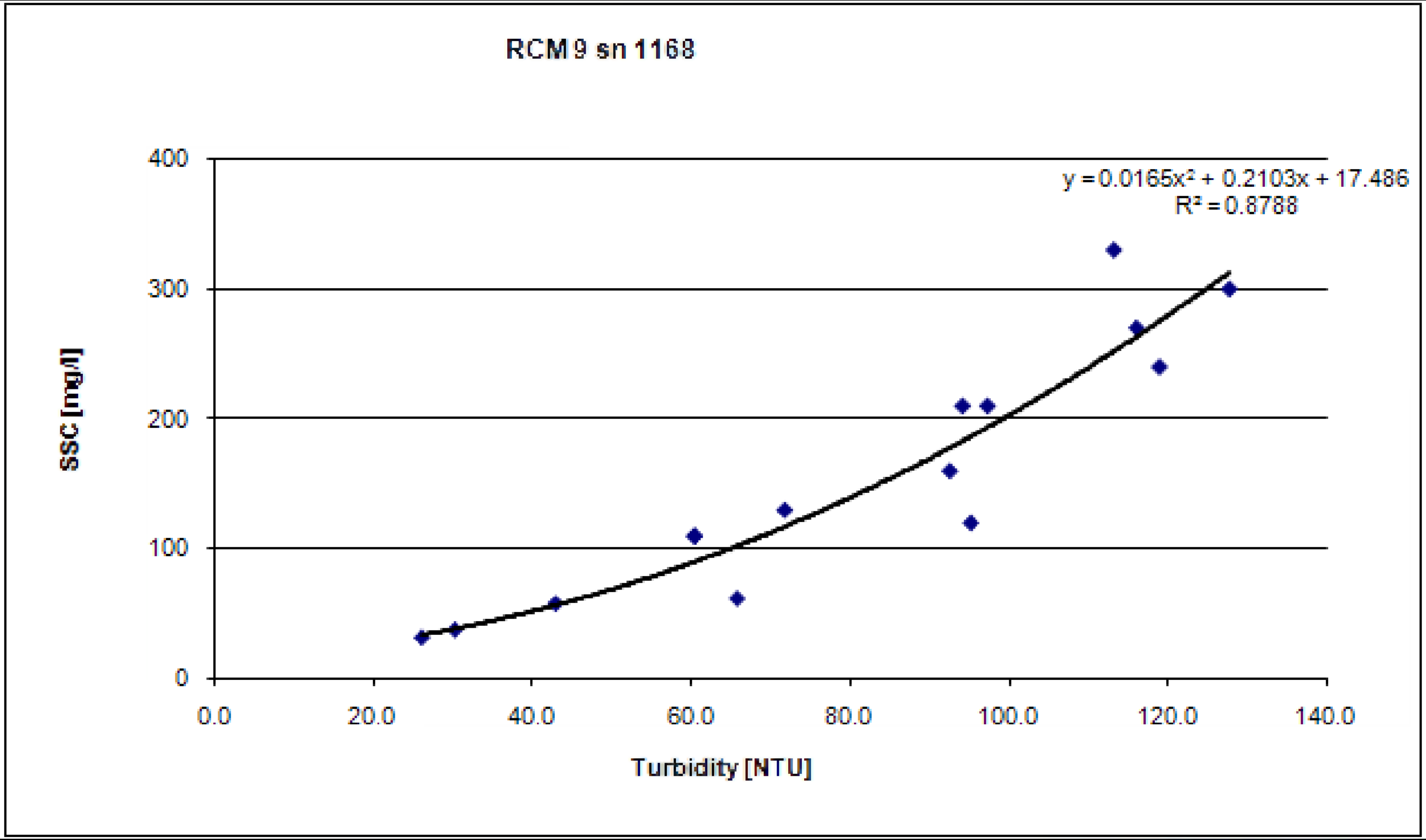
I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



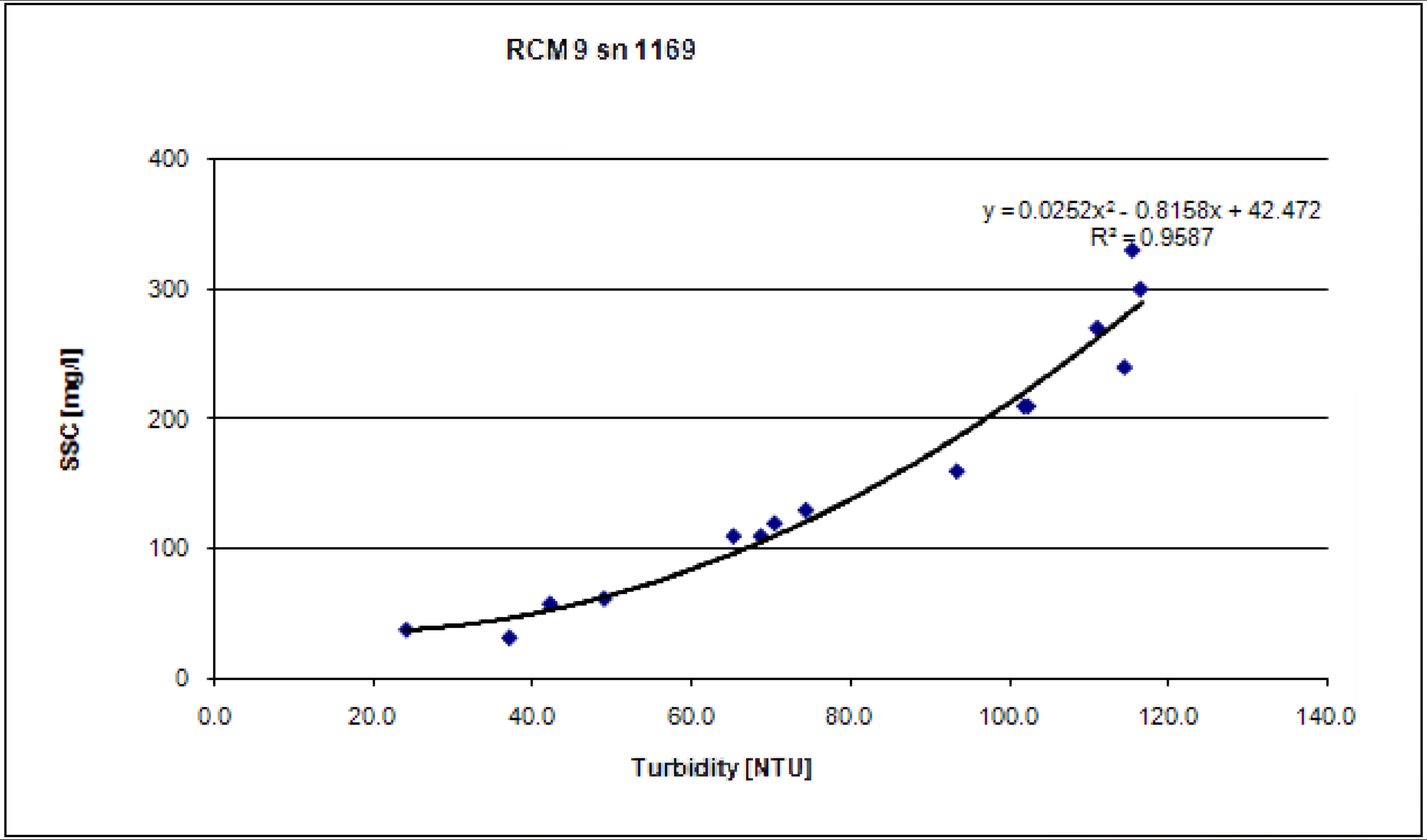
Calibration Graph of RCM-9 1166-1023		*Data processed by:* IMDC
Location: Lower Sea Scheldt	Date: 28/10/08	*In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 1168-1061		Data processed by: IMDC
Location: Lower Sea Scheldt	Date: 28/10/08	*In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 1169-1055

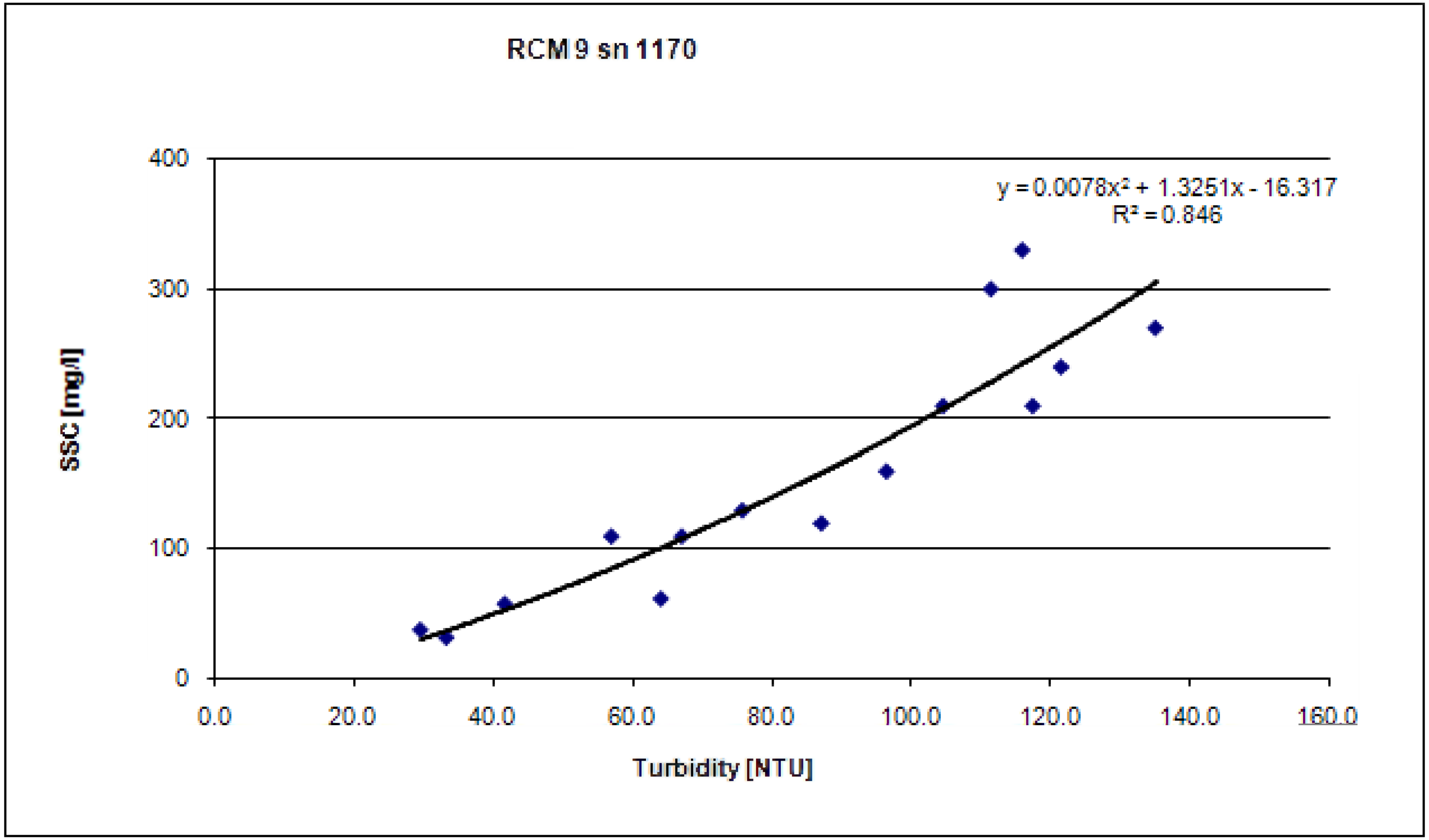
Data processed by: IMDC

In association with: WL | delft hydraulics

Location:	Date:
Lower Sea Scheldt	28/10/08

I/RA/11283/08.095/MSA

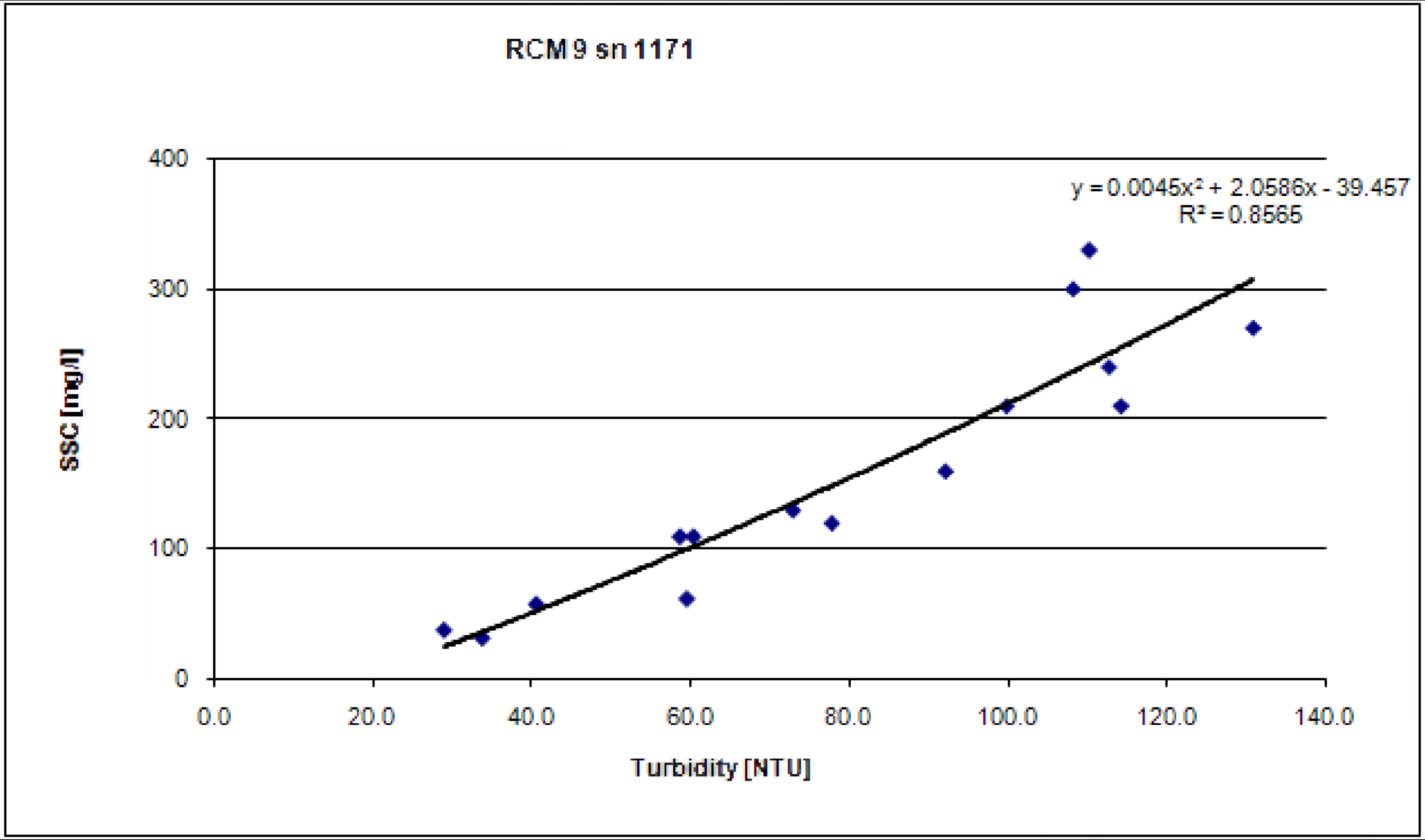
11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 1170-1026	*Data processed by:* IMDC
Location: Lower Sea Scheldt / Date: 28/10/08	*In association with:* wl | delft hydraulics

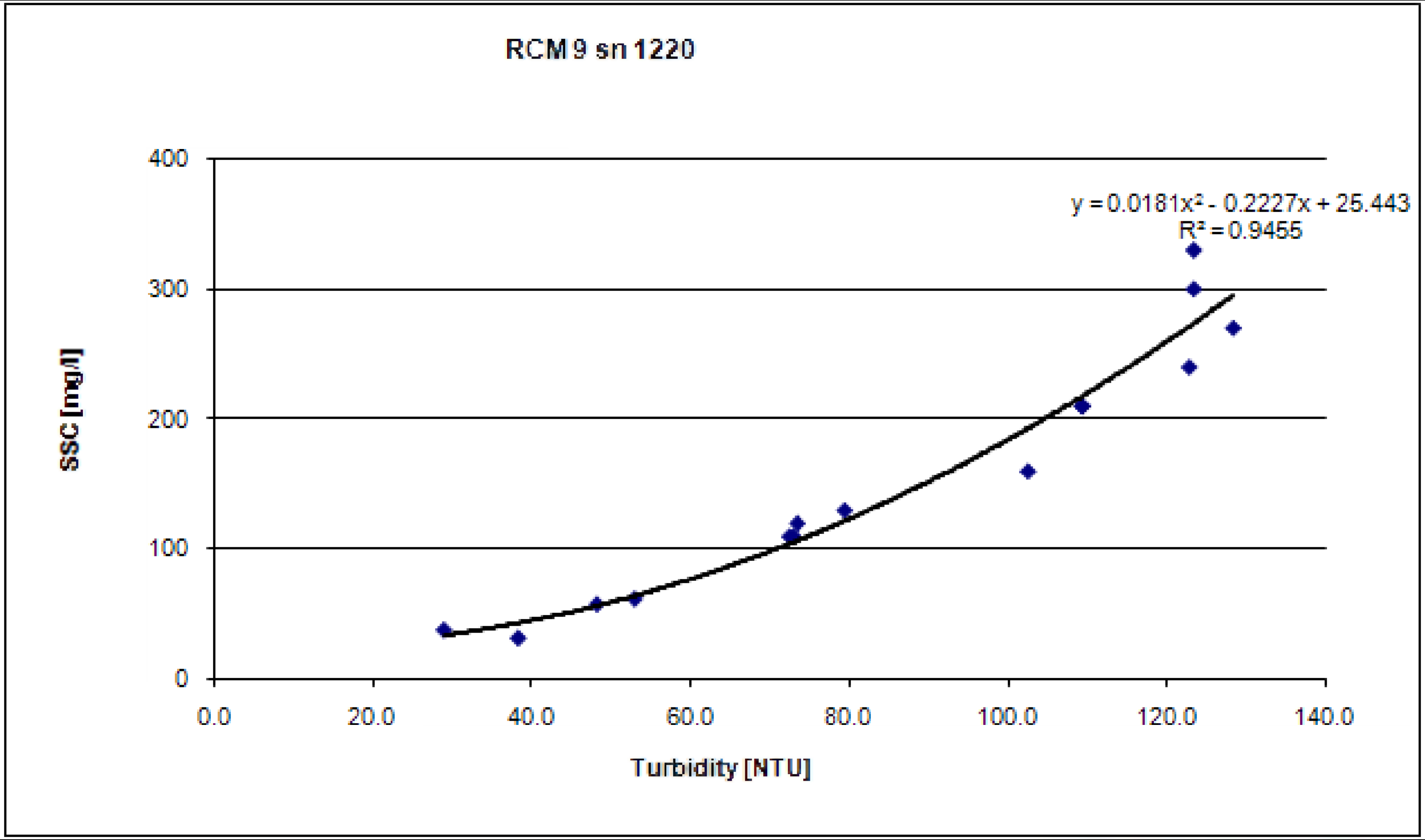
I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 1171-1028		*Data processed by:* IMDC
Location: Lower Sea Scheldt	Date: 28/10/08	*In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*

11283 DGD2 – CALIBRATION AUTUMN

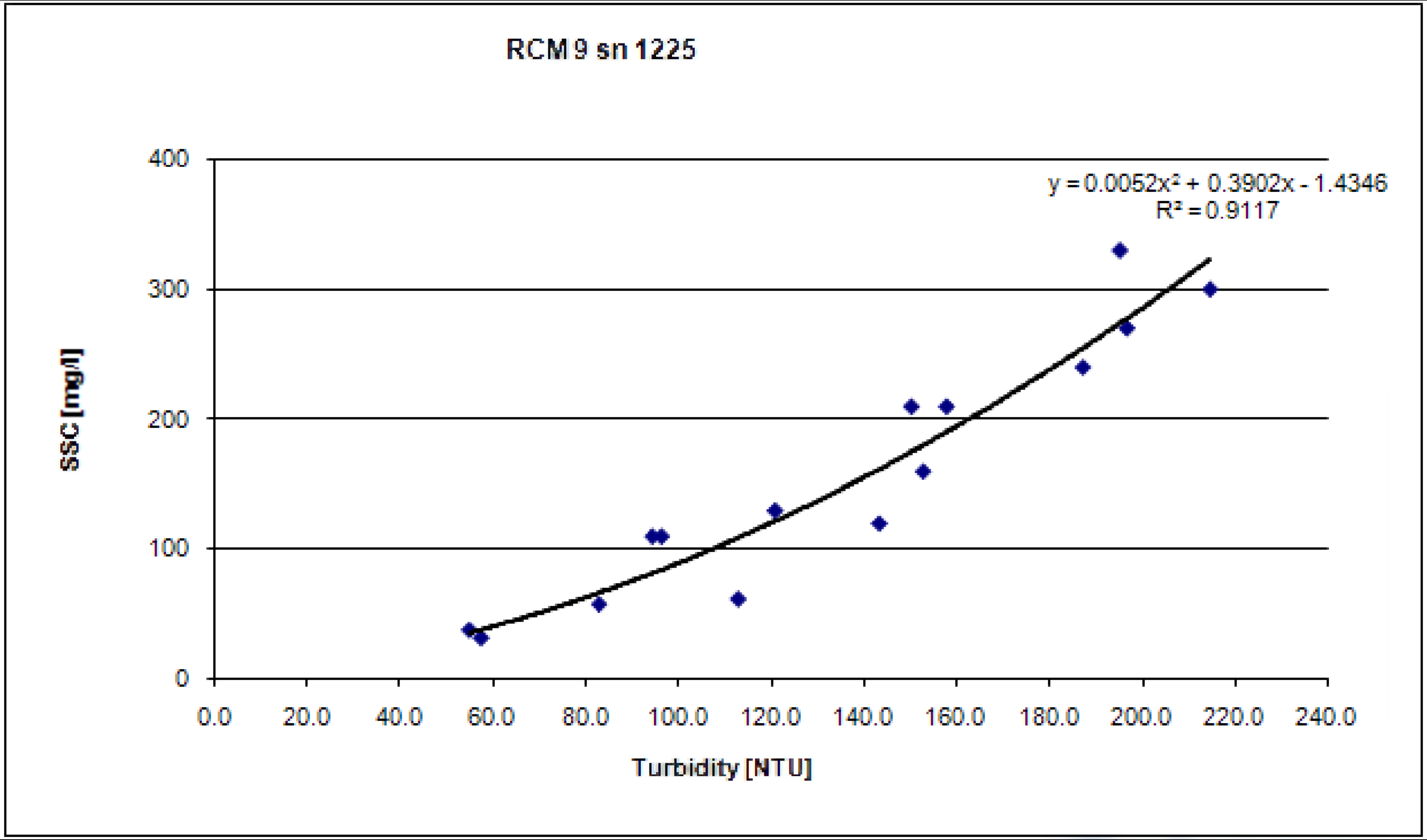


Calibration Graph of RCM-9 1220-1052

Location: Lower Sea Scheldt	Date: 28/10/08	Data processed by: IMDC In association with: wl | delft hydraulics

I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 1225-1051

Data processed by: IMDC

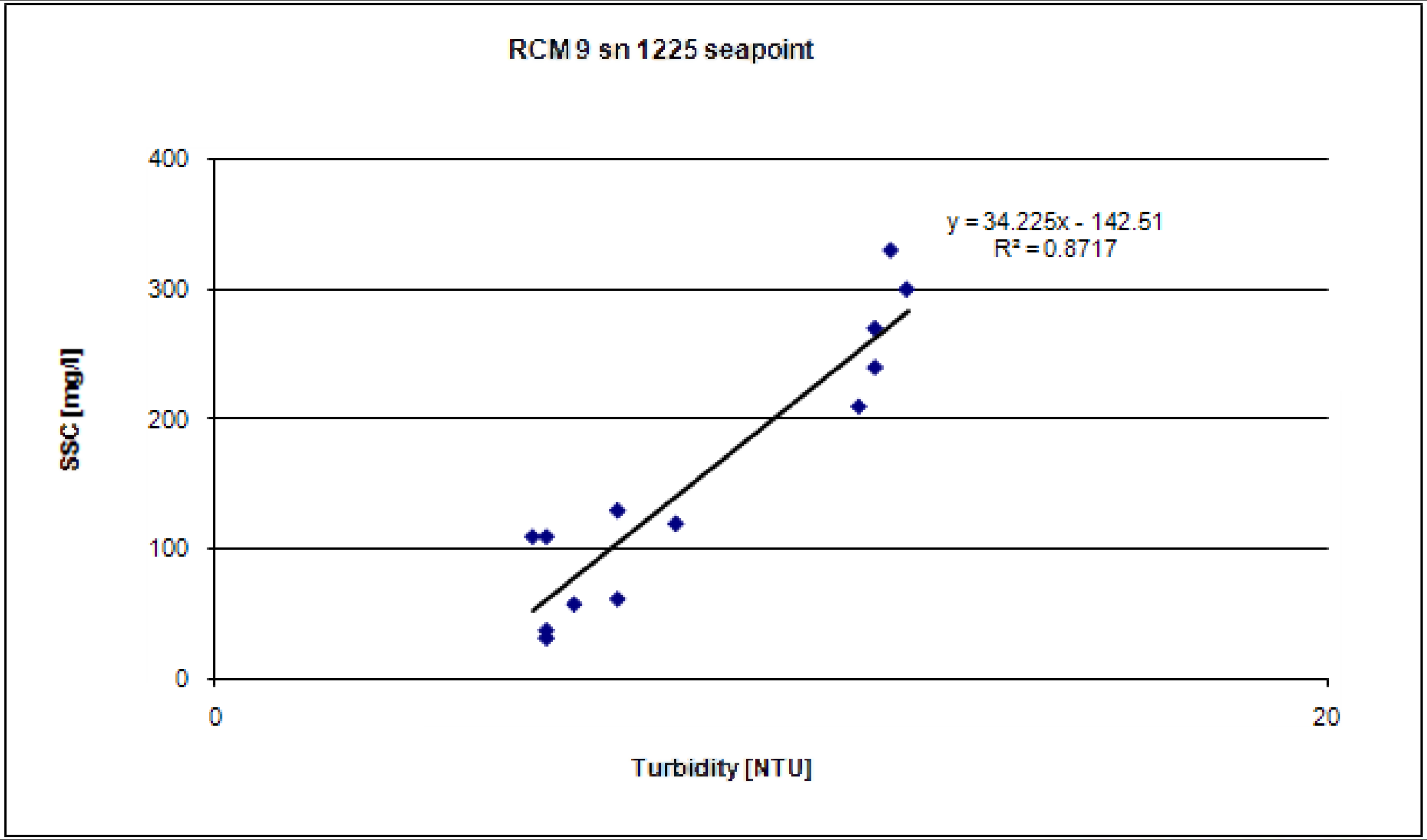
In association with: WL | delft hydraulics

Location: Lower Sea Scheldt

Date: 28/10/08

I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of RCM-9 1225-Seapoint

Location:
Lower Sea Scheldt

Date:
28/10/08

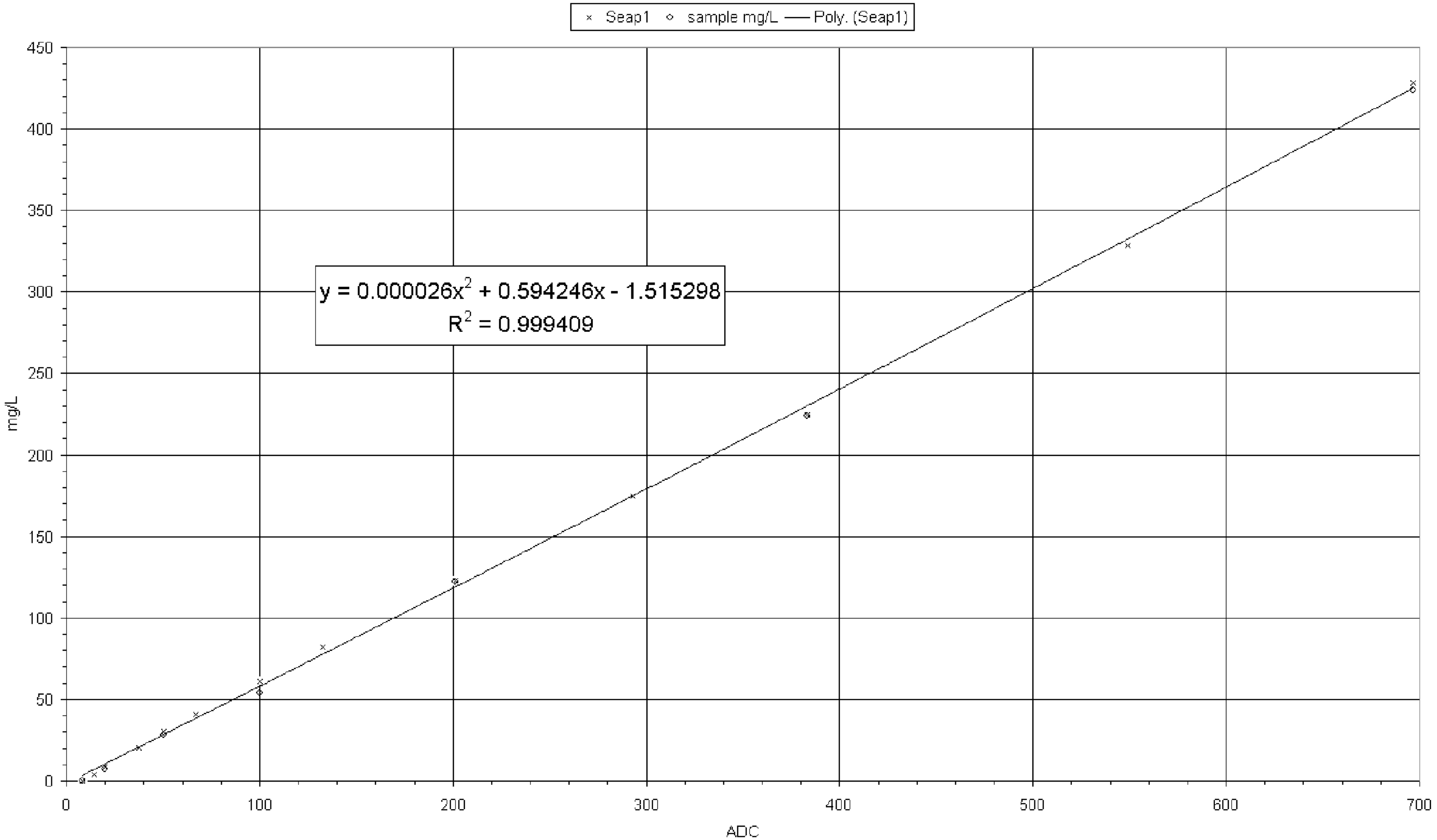
Data processed by: IMDC

In association with: wl | delft hydraulics

I/RA/11283/08.095/MSA

C.2 Manufacturers Calibration

11283 DGD2 – CALIBRATION AUTUMN

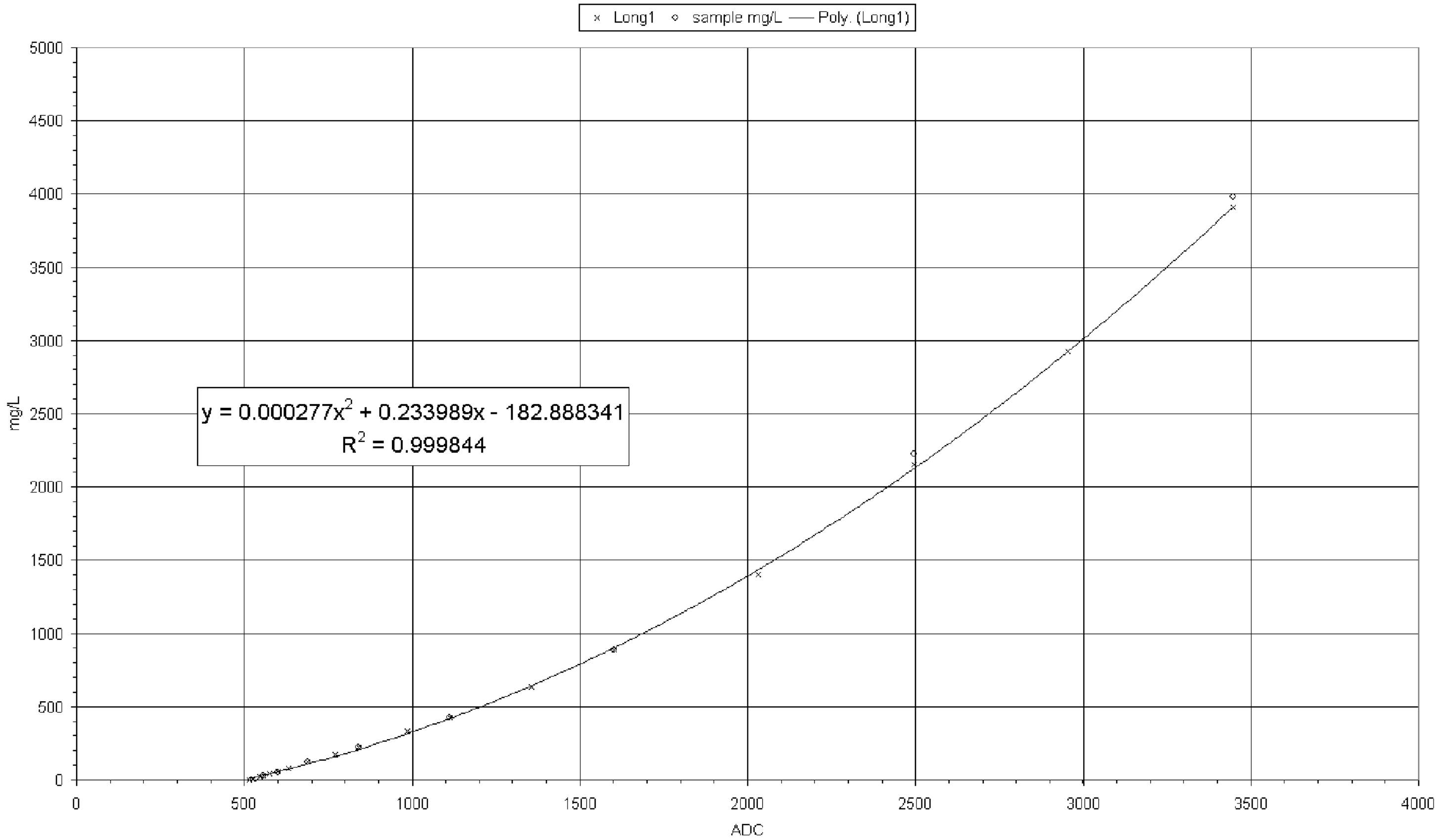


Calibration Graph of Siltprofiler - Seapoint

Location: WL|Delft Hydraulics	Date: 10/01/2007	*Data processed by:* IMDC *In association with:* WL | delft hydraulics

I/RA/11283/08.095/MSA

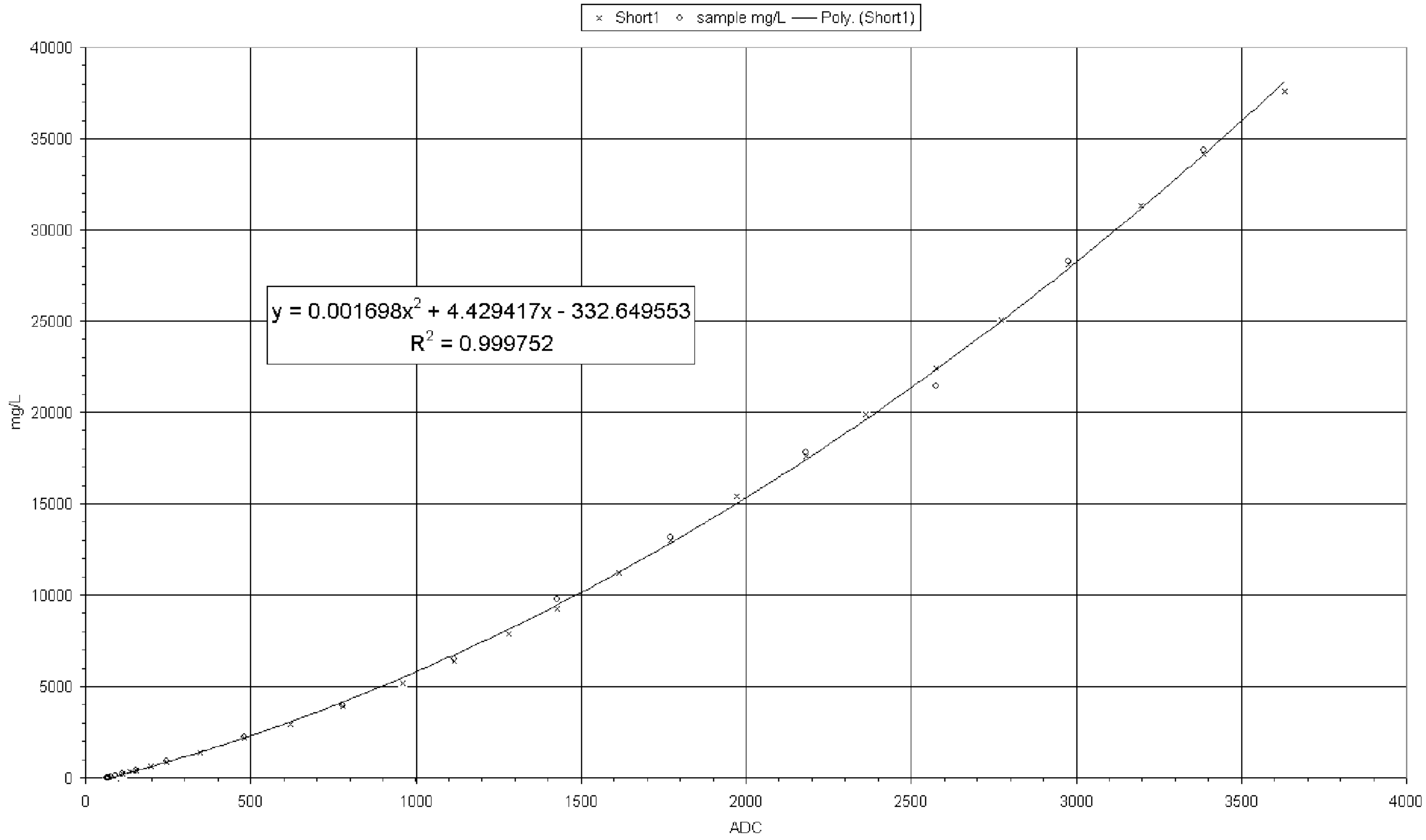
11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of Siltprofiler – Long Range	*Data processed by:* IMDC
Location: WL|Delft Hydraulics — Date: 10/01/2007	*In association with:* WL | delft hydraulics

I/RA/11283/08.095/MSA

11283 DGD2 – CALIBRATION AUTUMN



Calibration Graph of Siltprofiler – Short Range		*Data processed by:* IMDC
Location: WL|Delft Hydraulics	Date: 10/01/2007	*In association with:* wl | delft hydraulics *I/RA/11283/08.095/MSA*