Feasibility study sustainable emission reduction at the existing landfills Kragge and Wieringermeer in the Netherlands

Specific report: Current status of landfill Wieringermeer

Dutch Sustainable Landfill Foundation

25 March 2009

Final report

9T6764

IFAS

Consultants for Waste Management

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ROYAL HASKONING

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HASKONING NEDERLAND B.V.
ENVIRONMENT

Boschveldweg 21
P.O. Box 525
's-Hertogenbosch 5201 AM
The Netherlands
+31 (0)73 687 41 11 Telephone
+31 73 6120776 Fax
info@den-bosch.royalhaskoning.com E-mail
www.royalhaskoning.com Internet
Arnhem 09122561 CoC

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Drafted by	Maartje van Meeteren, Diane Timens, Kai Uwe Heyer
Checked by	Willem van Vossen
Date/initials check	10/4/2009 ....
Approved by	Willem van Vossen
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Annexes

1 INTRODUCTION

The Dutch Sustainable Landfill Foundation (DSLF) took the initiative to evaluate the possibilities and effects of sustainable landfill-methodologies at existing landfills. The main goal of this initiative can be formulated as follows:

The full scale demonstration of sustainable emission reduction at one or more existing landfills in the Netherlands

The DSLF consider isolation and eternal aftercare not a real and sustainable solution for the mitigation of unacceptable emissions due to landfills. In 1999 they initiated a project ‘Sustainable Landfilling’ (lit. 1, generic report) to develop ways to reduce the emission potential of the waste, rather than just isolating the emission potential from the environment.

The goal of sustainable landfilling in terms of the European regulatory framework is to meet the emission thresholds for a landfill for inert waste within about 30 years as well as not to exceed the threshold values for groundwater quality.
Main conclusion of this research (lit. 1, generic report) was that, when biochemical and physical processes are allowed to complete, emission potential is reduced significantly. The project ‘Sustainable Landfilling’ however aimed at landfills, yet to be constructed and concluded with design rules for these future landfills.

The success of the project ‘Sustainable Landfilling’ led to the follow-up questions:

- *Is it possible to retrofit existing landfills in such a way, that they become more sustainable?*
- *Is it possible to stimulate the natural biochemical and geochemical processes at existing landfills?*
- *Does this also lead to a significant reduction of the potential emissions?*
- *Does this significant emission reduction also lead to admissible emission levels?*

If these questions can be answered positively, less stringent aftercare or discharge from aftercare would be possible. The DSLF is convinced that the EU Landfill Directive provides the possibility for aftercare that is tailor-made to the real risk of emissions from the waste body.

Within that framework the DSLF requested the Dutch landfill owners to submit landfills, which meet the requirements for a suitable landfill site as described in the Terms of Reference (annex 1, generic report). Finally two landfills could be selected:

- the landfill “Wieringermeer” in the province of North-Holland (NL) and owned by the landfill operator Afvalzorg;
- the landfill “Kragge” in the province of North-Brabant (NL) and owned by the landfill operator Essent Environment South.

The first step of the initiative is the execution of a feasibility study with respect to the suitability of the two selected landfills. The present current status report of the landfill Wieringermeer is a part of this feasibility study.

For more information about the technical backgrounds, European and Dutch regulatory framework, overall objectives of the feasibility study and project organization, the reader is referred to the final generic report titled "Processes in the waste body and overview enhancing technical measures" (lit. 1).

2 BASIC APPROACH OF FEASIBILITY STUDY AND DELIVERABLES

The basic approach is outlined in figure 2.1, which comprises three main parts of the feasibility study.

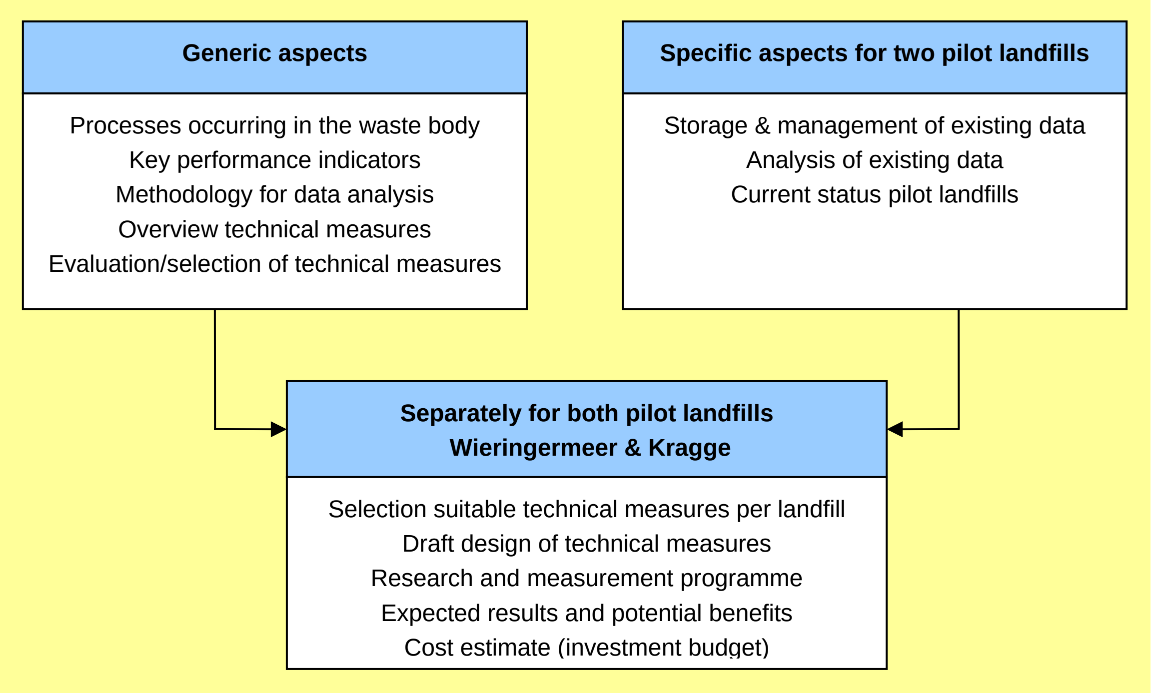

Figure 2.1: Basic approach feasibility study

These three main parts correspond to the required final deliverables, which means the following three section reports:

1. Generic report, comprising a general description of natural processes in the waste body and a general overview of technical measures to be able to enhance these processes.
2. Specific reports, separately for both demonstration landfills, comprising a description of the current status of the landfill with respect to emission potential and stabilization process (reference situation).

3. Specific reports, separately for both demonstration landfills, comprising a preliminary design of enhancing technical measures, a forecast of the achievable level of emission reduction due to autonomic and enhanced developments, and a measurement program and cost estimate.

This document represents the specific report concerning the current status of the landfill Wieringermeer.

3 OBJECTIVES

The objective is the collection of all available data on the current stabilization phase of the landfill Wieringermeer and to assess and interpret these data to predict the current status with respect to the stage of stabilization of the landfill Wieringermeer.

4 LANDILL CHARACTERISTICS

4.1 General description

Landfill the Wieringermeer is located near the town of Wieringermeer (20 km north of Hoorn) in the north-west of the Netherlands (figure 4.1). The Wieringermeer is operated by Afvalzorg. The landfill Wieringermeer is diveded in a western and eastern part. The exploitation of the western part has started in 2001. The exploitation of the eastern part of the landfill has started 1985 and ended in 2000. The height of the eastern part of the landfill is 12 meters at the upper plateau.
The surface area of the eastern part is 19 hectare divided into 6 waste cells. All compartments have a bottom liner, a leachate drainage system, a gas drainage system with gas collectors and settlement beacons. The waste compartments, leachate drainage system and gas drainage system are shown in figure 4.2. Waste cell 4 in the east has an impermeable top-liner since the early nineties. The other cells are covered with a layer of soil varying from 1 to 1.5 m.

Figure 4.1 Location and aerial photograph of the landfill Wieringermeer

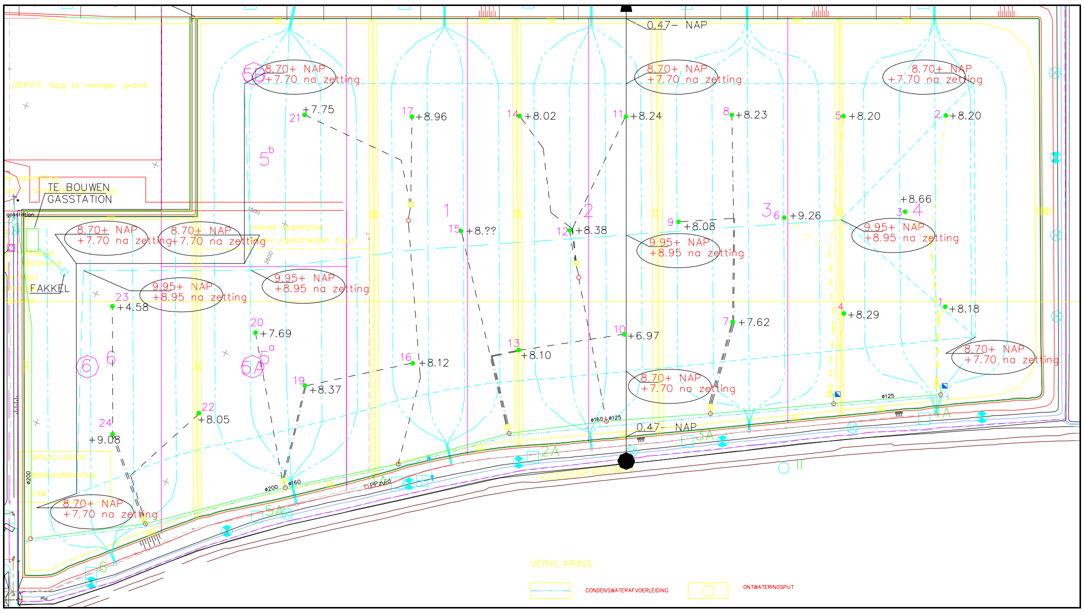

Figure 4.2 Situation of waste cells, leachate drainage system and gas wells at the landfill Wieringermeer (Afvalzorg 2000)

4.2 Selected demonstration area

In the terms of reference (TOR) to the Feasibility of Pilot Projects the minimum requirements and boundary conditions are specified for the feasibility study and for the sites suitable for a pilot project. According to the discussion with the landfill operator Afvalzorg and the expert participants, it was decided to prepare a preliminary design for the waste cell 6 in the west (see figure 4.3).

Figure 4.3 Selected waste cell 6 for demonstration project and two leachate collection pump pits

5 AVAILABLE DATA

5.1 Key performance indicators

Key performance indicators (KPI's) enable the determination of the current extent and future developments of degradation of organic matter and consequently allows the determination of the maximum feasible extent of stabilization of the landfill c.q. the maximum feasible sustainable emission reduction.

Annex 4 of the generic report (lit. 1) shows a complete list of KPI's, which have been scientifically accepted and/or have been showed to be workable in already executed large scale projects. In the list the KPI's are defined and explained and it is indicated how to be measured. The list has been subdivided in the following categories:

- General KPI's
- Leachate KPI's
- Gas KPI's

Besides the list can be subdivided into:

- primary KPI's, which can be directly related to the effects of the main process of degradation of organic waste and the overall stabilization process of the landfill.
- secondary KPI's, which are related to the performance of the necessary and required conditions for a successful degradation process.

In table 5.1 the KPI's have been summarized, in which the primary KPI's are listed bold.

Table 5.1 Primary and secondary key perfomance indicators (primary KPI's are listed bold)

General	Leachate	Gas
Temperature	**Redox (Eh)**	**Measured/calculated gas production**
Settlements	**Ammonia (NH_4)**	**CH_4/CO_2 ratio**
Waste composition	**Conductivity (Ec)**	**Gas extraction rate**
Moisture content	**Acidity (pH)**	Oxygen (O_2)
Moisture transport	**Biochemical oxygen demand (BOD)**	Inhibitors
Water balance	**Chemical oxygen demand (COD)**	
Time capsule	**COD-BOD**	
	BOD/COD ratio	
	Total organic carbon (TOC)	
	Dissolved organic carbon (DOC)	
	Benchmarking (o.a. LeachXS)	
	Chloride (Cl^-)	
	Total Volatile Fatty Acids (VFA)	
	Alkalinity	
	Nutrients	
	Sulphate (SO_4) and Sulphide (SO_2)	
	Nitrate (NO_3) and Nitrite (NO_2)	

Available data on KPI's have been collected and are presented in the chapters below, categorized into data on:

- Waste composition
- Leachate
- Gas
- Settlements

5.2 Waste composition cell 6

The production of landfill gas is strongly dependent on the available amount of carbon (C), which can be converted into biogas. The amount of carbon present in the waste body is determined by the the waste composition. Waste composition is recorded during landfilling. The landfill Wieringermeer is divided in 6 waste cells (figure 4.2). The waste composition for the entire eastern part of the landfill is shown in annex 2. In table 5.2 the waste composition and total amount of waste and carbon (both in tons) for cell 6 is summarized. The total amount of waste deposited in the selected compartment 6 is 281,083 tons, which corresponds to 28,458 tons of carbon.
The waste in cell 6 mainly consists of commercial waste (72%) and sludge and composting waste (22%). The average carbon content for cell 6 is 10.1%.

Table 5.2 – Waste composition in tons and carbon content in tons for cell 6.

Year	Soil and soil decontamination residues	Construction and demolition waste	Commercial waste	Shredder	Street cleansing waste	Coarse Household waste	Sludge and composting waste	Household waste	TOTAL
1992	0	0	23,063	0	0	0	9,632	0	**32,695**
1993	0	0	84,258	0	0	0	25,379	0	**109,637**
1994	0	0	85,701	0	0	0	25,850	0	**111,551**
1995	0	0	0	0	0	0	0	0	**0**
1996	0	0	0	0	0	0	0	0	**0**
1997	0	0	0	0	0	0	0	0	**0**
1998	6,450	8,900	8,750	650	0	2,300	150	0	**27,200**
Total waste	**6,450**	**8,900**	**201,772**	**650**	**0**	**2,300**	**61,011**	**0**	**281,083**
Total carbon	**71**	**98**	**22,397**	**88**	**0**	**313**	**5,491**	**0**	**28,458**

The carbon content has been calculated by using the relation between type of waste and the average kg of carbon (see table 5.3) as applied in the TNO-model (Hans Oonk et al, 1994) to forecast the gas production. The results of the forecast of the gas production of cell 6 is presented in the specific report with regard to the preliminary design and cost-estimate of enhancing technical measures (lit. 2).

Table 5.3 Carbon content versus types of waste

Type of waste	kg of carbon per ton of waste
Household waste	130
Coarse household waste	130
Agriculture waste	135
Commercial waste	111
Commercial sludge	111
Construction and demolition waste	11
Sewage sludge	90
Shreddar	130
Soil and ruins	11

5.3 Leachate quantity

Leachate is collected by means of drains positioned at the bottom of the waste body. Each cell has its own drainage system. Landfill Wieringermeer consists of a western and eastern part. From 1998 to 2000 leachate was only collected in the eastern part of the landfill. From 2001 to 2003 the leachate quantity is collected in the westen and eastern part. Since 2004, the collection of drainage water in the eastern part is divided in pump pit north (PPN) and pump pit south (PPZ) (figure 4.2 and 4.3). The leachate collection outline is summarized in table 5.4.

Table 5.4 – Outline of leachate quantity measurements

Year	Leachate quantity measured in
1998	Eastern part
1999	Eastern part
2000	Eastern part
2001	Eastern + western part
2002	Eastern + western part
2003	Eastern + western part
2004	Eastern (divided in PPN and PPZ) + western part
2005	Eastern (divided in PPN and PPZ) + western part
2006	Eastern (divided in PPN and PPZ) + western part
2007	Eastern (divided in PPN and PPZ) + western part

The leachate quantity in the eastern and western part of the landfill is shown in figure 5.1. The leachate quantity since the closure of the landfilling in 2000 in the eastern part varies between 38,360 m^3 and 56,451 m^3. The leachate quantity in the western part is smaller than in the eastern part. This can be explained by the smaller surface area of the western part. Since 2004 the leachate in the eastern part is collected by pump pit north (PPN) and pump pit south (PPZ) (figure 5.2). The difference in leachate quantities between PPN and PPZ are small, although the quantity in pump pit south is slightly higher. This can be explained by the fact that cell 6 only discharges to PPZ while the other cells discharge to both PPn and PPZ. The leachate quantity in PPZ and PPN is around 20,000 m^3/year.

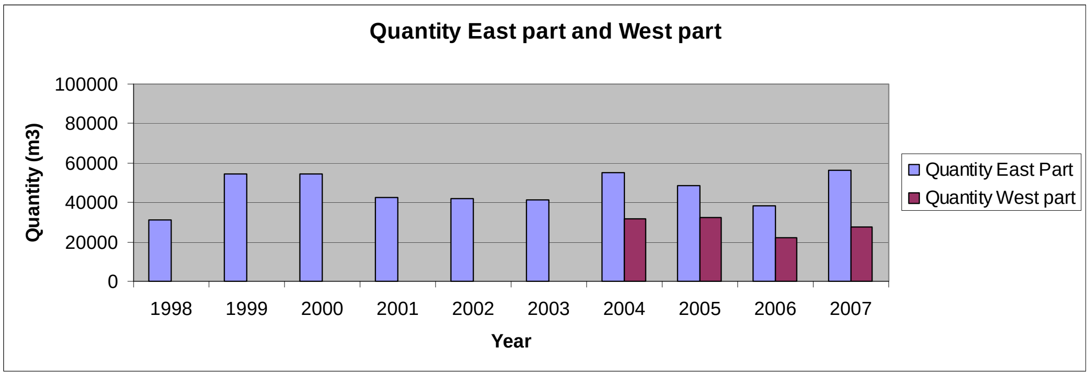

Figure 5.1 – Total leachate quantity for the western and eastern part of the landfill per year.

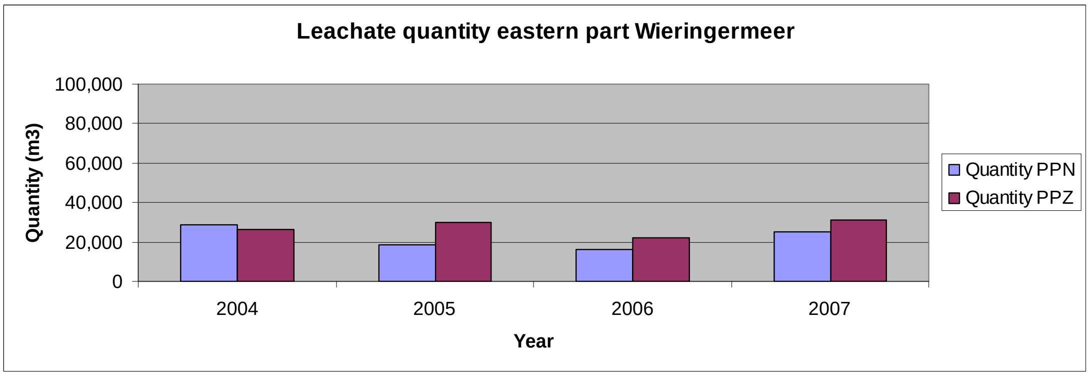

Figure 5.2 – Total leachate quantity for the eastern part divided in pump pit north and pump pit south per year.

5.4 Leachate quality

5.4.1 Macro-parameters

The emission of leachate from landfills is a potential threat to the environment. The quality of the leachate is influenced by the process of degradation of organic matter in the waste body (stabilization of the landfill). During stabilization the chemical composition of the leachate is changing. Concentrations of macro parameters can therefore be used (among other characteristics) to determine the extent of stabilization of a landfill.

The natural degradation processes are proceeding in five degradation phases (lit. 1). Each phase can be identified using Key Performance Indicators (KPI). In annex 4 of the generic report (lit. 1) a list is given of the key performance indicators (KPI's). The current status of the leachate KPI's at the Wieringermeer landfill is summarized in this paragraph.

At the Wieringermeer landfill time-series of macro and micro parameters are determined for PPN and PPZ and for cell 6 separately. All figures of PPN and PPZ are given in annex 3 and figures of cell 6 are shown in annex 4. Several characteristic figures are also shown in the text.

Besides, annex 6 shows recent results of chemical analyses on the leachate of only cell 6. These chemical analyses are especially ment as input for the LeachXS dBase (ECN), by which the actual status of stabilization of a landfill can be marked, based on comparison with other landfill data (bench-marking). However, the results of using the LeachXS dBase are not yet available.

pH and EC

The pH controls metal solubility (low pH higher metal solubility) and indicates whether processes in the landfill are in the acidogenic phase (pH 4.5 – 7.0) or methanogenic phase (7.0 – 8.2). The average pH in PPN, PPZ and cell 6 is around 7.5, indicating the methanogenic phase (figure 5.3 and 5.4).
The EC is an indicator of the dissolution of salts and leaching of salts.
In PPN and PPZ the EC varies significantly. Values from around 400 to 12,000 µS/cm are measured. In 2008 the EC in PPZ was significantly higher than in PPN.
In cell 6 the EC in 2001 to 2003 was around 1,000 µS/cm. In 2008 the EC was significantly higher 11,450 µS/cm. The high value in 2008 indicates that significant quantities of salt are still leaching form the waste body (compare EC of precipitation is around 20µS/cm). The cause of the significant increase in EC in 2008 is not known.

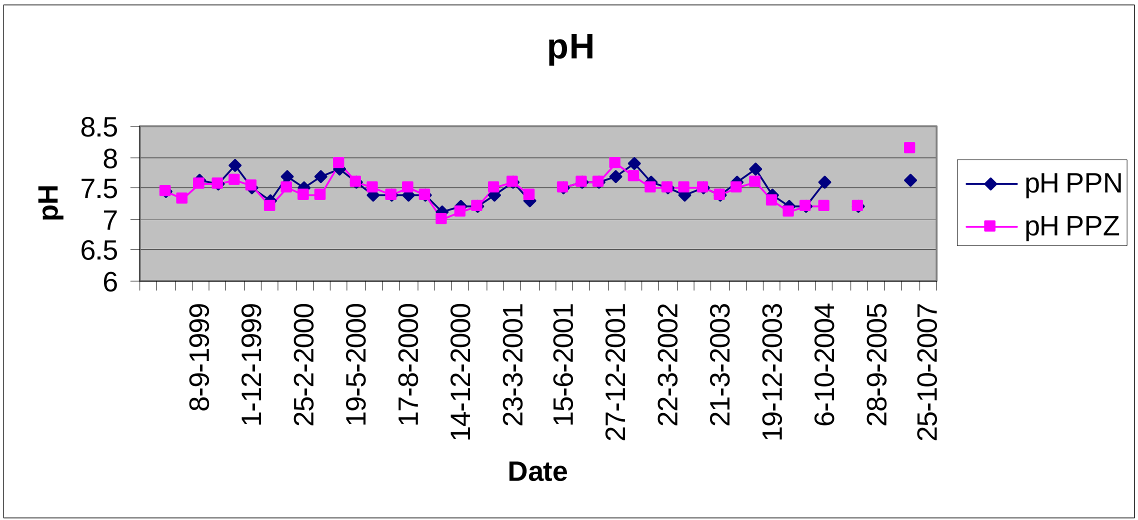

Figure 5.3 – pH in leachate water in PPN and PPZ

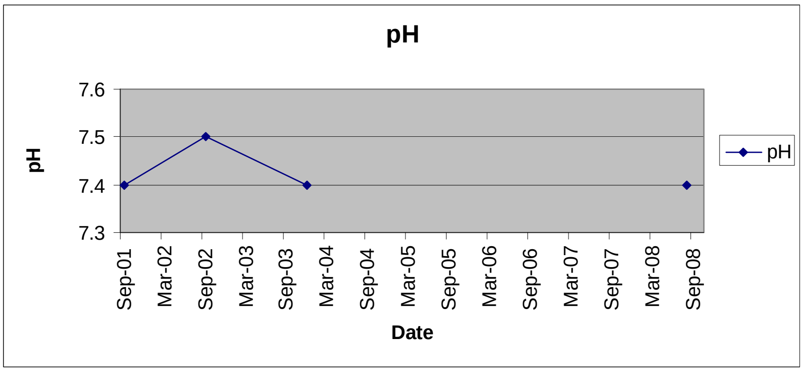

Figure 5.4 pH in leachate water cell 6.

Chlorid and bicarbonate

Chloride concentrations indicate the dissolution of salts. In PPN and PPZ the chloride concentrations show a decrease from around 1,500 mg/l in1999 to around 1,000 mg/l in 2008. In cell 6 the chloride concentrations are between 710 and 1300 mg/l., which is very well in tune with the values measured in PPN and PPZ.

In PPN and PPZ bicarbonate values show a decreasing trend from around 8,000 mg/l in 1999 to around 5,000 mg/l in 2008. In cell 6 bicarbonate values range from 4,200 to 7,100 µg/l in 2001 to 2003. This is in tune with the values measured in PPN and PPZ in this period.

Ammonium and total nitrogen

Ammonium is largely produced by hydrolysis and fermentation of the biodegradable nitrogen-containing organic compounds. Its concentration stays high, as it is not converted in the anaerobic processes. Ammonium concentrations in PPN and PPZ vary significantly, but the same trend is found in PPN and PPZ. In 2008 the ammonium concentration is around 800 mgN/l. In the leachate of cell 6 concentrations range from 493 to 830 mgN/l.

Total nitrogen is only measured in PPN and PPZ. Its concentrations vary in time. No trend is visible. In 2008 the total nitrogen concentration is around 800 mg/l like the ammonium concentration. This indicates that most nitrogen in the leachate is present as ammonium.

Sulphate

In general the transition from acidogenic to methanogenic redox conditions show a drop of sulphate concentration, caused by the reduction of sulphate to sulphide. Such a drop indictates the presence of sulphate-reducing bacteria. In PPN and PPZ sulphate concentration are measured only twice: in 2000 and 2007. In 2000 the sulphate concentration in PPN was significantly higer than in PPZ. In 2007, sulphate concentrations are around 10 mg/l. This could indicate the reduction of sulphate to sulphide (the sulphide concentrations are not known). The low sulphate concentrations indicate that the landfill is in the methanogenic phase.

BOD and COD

The BOD concentration in the leachate indicates the presence of easily degradable organic matter. The COD concentration in the leachate indicates the presence of easily as well as difficult degradable organic matter. The BOD/COD ratio is commonly used as an indicator to distinguish acidogenic and methanogenic leachate. As leachate develops from acidogenic to methanogenic, the BOD/COD ratio is expected to drop to reflect the reduction in its biodegradability. Ratio of 0.7 for a raw young leachate to 0.1 for a well-stabilised methanogenic leachate. According to Kruse (1994) three characteristic periods can be distinguished:

- acid phase: BOD/COD > 0.4
- intermediate phase: 0.4 > BOD/COD > 0.2
- methanogenic phase: BOD/COD < 0.2

In PPN and PPZ the COD concentrations are around 1,200 mg/l and the BOD concentrations are around 65 mg/l. The ratio is around 0.05 (figure 5.5). This means that the leachate is in the methanogenic phase.

In cell 6 BOD and COD concentrations were measured only in august 2008 (annex 6 and table 5.5). The BOD and COD concentration are in good agreement with the values measured in PPN and PPZ. The leachate is also in the methanogenic phase.

Table 5.5 – BOD en COD concentrations in cell 6.

Cell 6 -august 2008	mg/l
BOD	78
COD	1120
Ratio BOD/COD	0.07

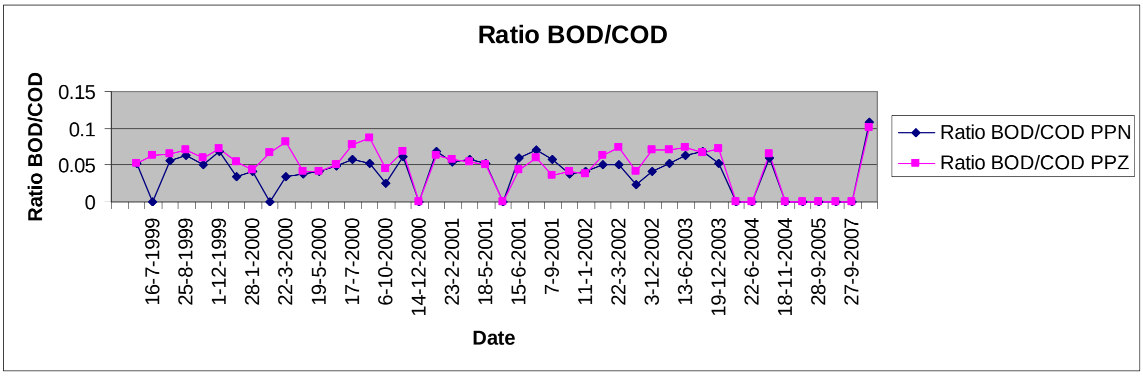

Figure 5.5 Ratio of BOD and COD in the PPN and PPZ

5.4.2 Micro-paramaters

Time series of various micro parameters are presented in annex 3 (PPN and PPZ) and annex 4 (cell 6). From a point of view of environmental risk-based approach and just to get some feeling for the measured concentration levels, they are compared to the limit values of the Dutch "Circular on target values and remediation values for soil remediation (2008)". The so called intermediate values (T-value) [1] and intervention values (I-value) [2] are also integrated in the time series in annex 3 and 4. This is illustrated for chrome in figure 5.6.

Metals: cadmium, chrome, mercury, lead and nickel

The heavy metals lead and chrome are found above the intervention value in PPN and PPZ. The concentrations of the metals cadmium, mercury and nickel are below the intermediate value.

In cell 6, the metals were measured once in august 2008 (annex 6 and table 5.6). Only the concentrations of the metals chrome and nickel are above the intervention value.

Table 5.6 Concentration metals in leachate of cell 6

Parameter	Concentration (µg/l)	> Intermediate value?	> intervention value?
Chrome	57	yes	yes
Nickel	76	yes	yes

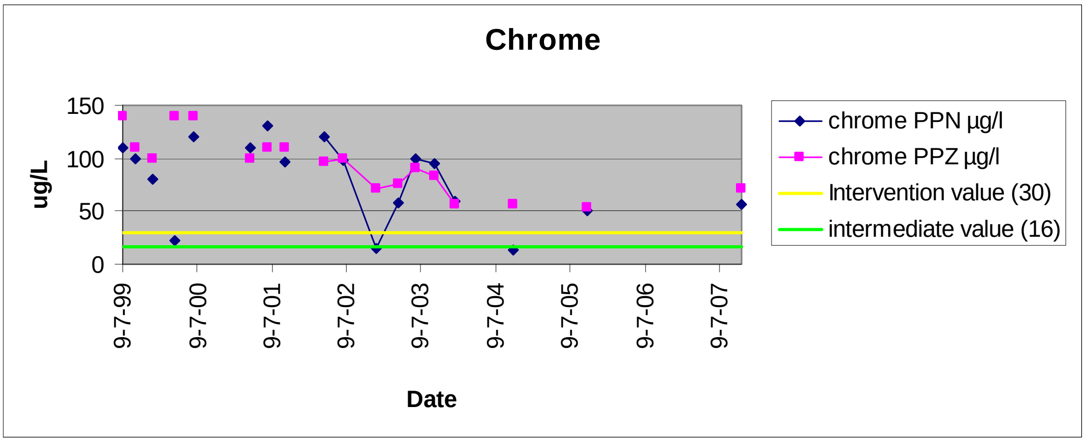

Figure 5.6 Total chrome in the PPN and PPZ

The absence of high concentrations of heavy metals (only chrome and nickel) corresponds to the relative low DOC-concentration (450 mg/l) as measured in cell 6.

Xylenes, mineral oil, Polycyclic aromatic hydrocarbons (PAH)

The intervention value for xylenes was occasionally exceeded in 2000 and 2001 in PPN and PPZ. From 2002 to 2007 the xylenes concentration was below the intervention value. In cell 6 the xylenens concentration is also below the intervention value.

[1] See chapter 6.7.1 of the generic report (lit. 1)

[2] See chapter 6.7.1 of generic report (lit. 1)

Mineral oil was only measured in PPN and PPZ. The latest years concentrations are below the detection limit.

In PPN and PPZ, the intervention value for PAH is only exceeded for Chrysene. Most of the time concentrations are below the intermediate value or detection limit. In april 2004 concentrations of benzo(a)pyrene, benzo(ghi)perylene, benzo(k)fluorathene and indeno(1,2,3cd)pyrene are above the intervention value. These data are considered as outliers. In cell 6. the concentration naphthalene is below the intermediate value since 2002. Other PAH were measured once in 2008 (table 5.6). Concentrations are below the intervention value.

Table 5.6 – PAH concentration in august 2008 in cell 6

parameter	Concentration (µg/l)	> intermediate value?	> intervention value?
Phenanthrene	3.4	yes	no
Chrysene	<0.3	-	-
Benzo(ghi)perylene	<0.09	-	-

VOC's
In PPN and PPZ the concentration 1,2-dichloorethene is below the detection limit. In cell 6 no VOC's were determined.

5.4.3 Conclusions

In general the concentrations macro and micro parameters show the same trend. The concentrations in cell 6 fit well within the concentrations found in PPN and PPZ.
Time series in PPN and PPZ are long enough to see a decreasing trend in concentrations for chloride, bicarbonate, nickel and chrome. This indicates the stabilization of the landfill and the occurrence of NA-processes.
Concentrations of lead and chrome are above the intervention value. Concentrations of other micro parameters rarely exceed the intermediate value and are often below the detection limit. This indicates that the landfill is in a more advanced stage of stabilization

The pH of 7.5, the low sulphate concentrations, the BOD/COD ratio of 0.05 and the decreasing concentrations or absence of micro parameters indicate that the landfill is in the (advanced stage of) methanogenic phase.

5.5 Gas

At the eastern part of the landfill Wieringermeer gas is collected since 1996. Landfill gas is collected by eight clusters of gas wells (figure 4.2).
Since 2007 gas is also collected at the western part. This is flared in a mobile flare and completely separated from the gas collection at the eastern part. It therefore does not interfere with the data collected at the eastern part.

5.5.1 Gas quantity

The gas quantity that is collected by the gas collectors is registered. The gas quantity in m^3/hour of the total eastern part is given in figure 5.7. From figure 5.7 it is clear that the collected gas quantity is decreasing.

This means that a lot of carbon has already been degraded and less carbon is left for profitable gas collection. In 2007 the gas collection is around 170 m^3/hr. This indicates that the landfill is in an advanced methanogenic phase.

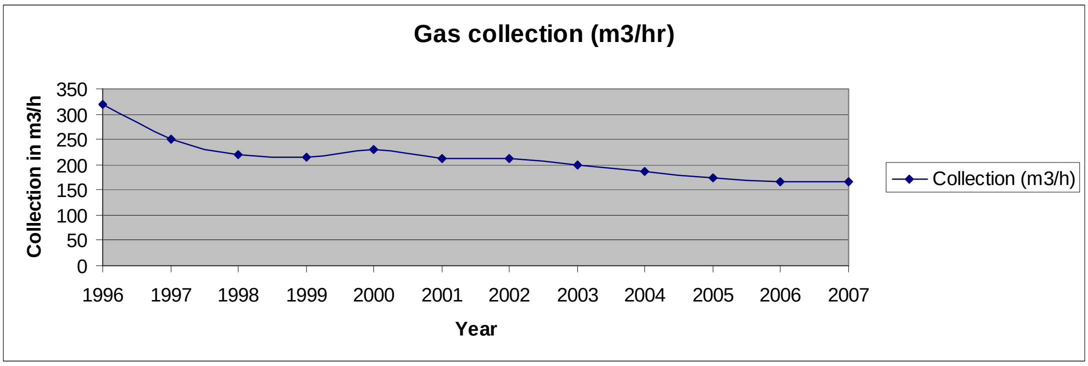

Figure 5.7 – Gas collection total eastern part in m^3/hr from 1996 to 2007

5.5.2 Gas quality

The gas quality has not been registered. The collected gas is used to fire a gas engine producing electriciy. The quality is controlled to meet the demands of the gas engine. It can safely be assumed that the collected gas contains an average of 50% methane.

5.6 Settlements

The settlement of the waste cells is monitored by settlement beacons (figure 5.8). The height of the eastern part of the waste body (NAP-level) was measured at least once a year in the period from 2001 to 2008.

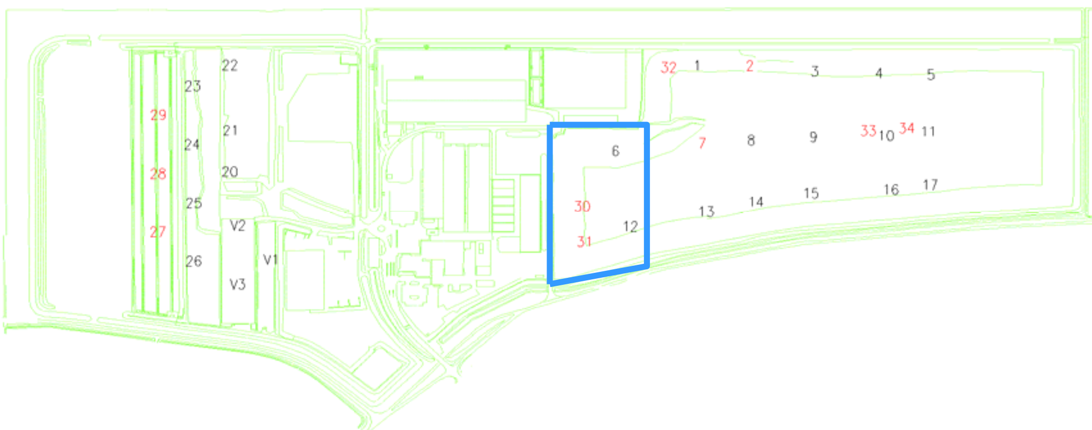

Figure 5.8 Position of settlement beacons (red numbered beacons have disappeared)

Complete time series of the individual settlement beacons in the eastern part of the landfill is shown in annex 5. Settlement beacons 6 and 12 are present in cell 6.

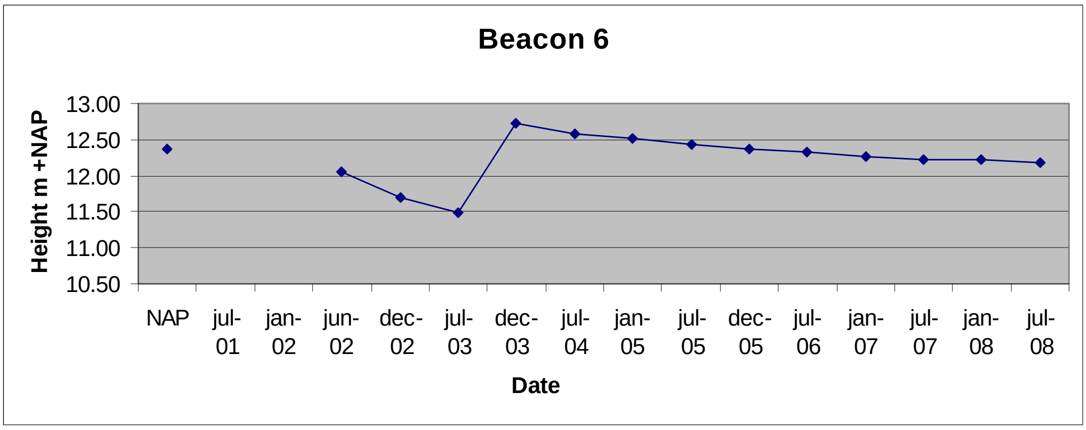

Figure 5.9 – Settlement beacon 6 in cell 6

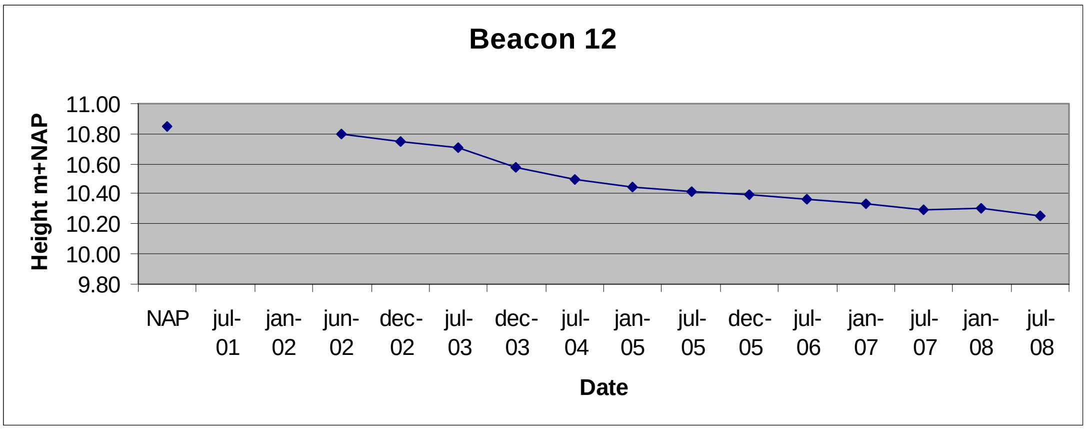

Figure 5.10 – Settlement beacon 12 in cell 6

The settlement for beacon 6 has been 54 cm since dec 2003 (figure 5.9). For beacon 12 this was 33 cm (figure 5.10). This means that the average settlement in cell 6 has been 9 cm per year in the past five years. The average settlement of the whole easter part of the landfill is 6 cm per year in the past five years. The ongoing settlement indicates that the stabilization processes are still going on. However the settlement is relatively small, which indicates an advanced stage of the methanogenic phase.

6 SUMMARY AND CONCLUSIONS

The total amount of waste deposited in the selected compartment 6 is 281,083 tons, which corresponds to 28,458 tons of carbon. The waste in cell 6 mainly consists of commercial waste (72%) and sludge and composting waste (22%). The average carbon content for cell 6 is about 10%. Landfilling in cell 6 started in 1992 and ended in 1998.

A decreasing trend in chloride, bicarbonate, nickel and chrome concentrations was found in PPN and PPZ. This indicates the stabilization of the landfill and the occurrence of NA-processes.
Concentrations of lead and chrome are above the intervention value. Concentrations of other micro parameters rarely exceed the intermediate value and are often below the detection limit. This indicates that the landfill is an advanced stage of stabilization.
The pH of 7.5, the low sulphate concentrations, the BOD/COD ratio of 0.05 and the decreasing concentrations or absence of micro parameters indicate that the landfill is in the (advanced stage of the) methanogenic phase.

The collected gas quantity is decreasing since 1996. This means that a lot of carbon has already been degraded and less carbon is left for profitable gas collection. In 2007 the gas collection is around 170 m^3/hr. This indicates that the landfill is in an advanced methanogenic phase. The collected gas is used to fire a gas engine producing electriciy. The quality is controlled to meet the demands of the gas engine. It can safely be assumed that the collected gas contains an average of 50% methane.

The settlement of the eastern part of the landfill has been 6 cm per year in the past 5 years. In cell 6 settlement is slightly higher: 9 cm/year. The ongoing settlement indicates the stabilization of the landfill. However the settlement is relatively small, which indicates an advanced methanogenic stage.

Based on the available KPI data it is very likely that the landfill Wieringermeer is in an advanced methanogenic phase. This means that the anaerobic degradation processes are almost extinguished and the added value and effectiveness of enhancing the anaerobic processes in the waste body by means of recirculation of leachate should be questioned. So it should strongly be taken into consideration to start directly with the aerobic in situ stabilization measures by means of aeration. The final decision to this should be substantiated by the results of the proposed pré-investigation.

The overall conclusion on the current status based on the assessment of the available data is summarised in table 6.1.

Table 6.1 Characteristics with respect to the current status and emission behaviour of cell 6.

Age of waste	90% from period 1992-1994, 10% from 1998	
Waste composition	Commercial waste: 75% (representing 79% of the total carbon content) Sludge: 22% (representing 19% of the total carbon content)	
Waste quantities	Waste: 281,031 ton	Carbon: 28,485 ton
Leachate: macro parameters	pH = 7.5 → methanogenic phase	
	SO4 very low → advanced methanogenic phase	
	COD low → advanced methanogenic phase	
	BOD/COD < 0.1 → advanced methanogenic phase	
	DOC low → advanced methanogenic phase	
	COD – BOD low → advanced methanogenic phase	
Leachate: microparameters	Absence of high concentrations, only Cr and Pb . → indicates advanced methanogenic phase (NA)	
Gas collection (of total eastern part)	From 325 m3/hr (1995) to 170 m3/ht (2007) → decrease → advanced methanogenic phase. This indicates that a lot of carbon has already been degraded and less carbon is left for autonomic gas production / for profitable gas utilization.	
Gas quality	No data available	
Settlement	< 20 cm in the last 3 years (ca. 6 cm per year) → relatively less settlement, but still due to anaerobic degradation of carbon → advanced methanogenic phase.	
Overall conclusion	**Landfill is in an advanced stage of the methanogenic phase, less anaerobic degradable organic matter is left.**	

7 RECOMMENDATIONS

The current available data versus the required data on the KPI's is summarized in table 7.1. The white cells indicate the data that are currently not available. It is recommended that data on all KPI's is collected during the execution of the pre-investigation program. In this way the preliminary conclusion that the current status of the landfill Wieringermeer is in the advanced methanogenic phase can be verified.

An elaborate description of the KPI's can be found in annex 4 of the generic report (lit. 1). The preliminary design of the monitoring program is outlined in the preliminary design and cost estimate report (2).

Table 7.1 Current available data (green shaded) versus required KPI's

General KPI's								
Temperature	Settlements	Waste composition	Moisture content	Moisture transport	Water balance	Time capsule	Bulk electrical conductivity	Density distribution
Leachate KPI's								
Redox condition (Eh)	Ammonia (NH4)	Conductivity (EC)	Acidity (pH)	Biochemical oxygen demand (BOD)	Chemical oxygen demand (COD)	COD - BOD	BOD/COD ratio	Dissolved organic carbon (DOC)
Fractionation of DOM	Bench marking	Total organic carbon (TOC)	Chloride(Cl^-)	Total VFA	Alkalinity	Nutrients (incl. NA parameters)	Sulphate (SO_4) Sulphide (SO_2)	Nitrate (NO_3) and Nitrite (NO_2)
Metals & other macro parameters								
Gas KPI's								
Comparison measured and calculated gas production	Ratio of methane (CH_4) and Carbon dioxide (CO_2)	Gas extraction rate	Oxygen (O_2)	Nitrogen	Inhibitors			

8 LITERATURE

1. "Feasibility study sustainable emission reduction at he existing landfills Kragge and Wieringermeer in the Netherlands, generic report: Processes in the waste body and overview enhancing technical measures", Royal Haskoning/IFAS, Final report, 20 March 2009.
2. "Feasibility study pilot project sustainable emission reduction at the existing landfills Kragge and Wieringermeer in the Netherlands, preliminary design and cost-estimate of the technical measures infiltration and aeration to enhance stabilization at the landfill Wieringermeer, final report, Royal Haskoning/IFAS, 30 March 2009.

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Annex 1
Photographs of landfill and infrastructure

Entrance to cell 6

View cell 6

View cell 6

View cell 6

Plateau of cell 6 and gas well

Settlement beacon

Gas well

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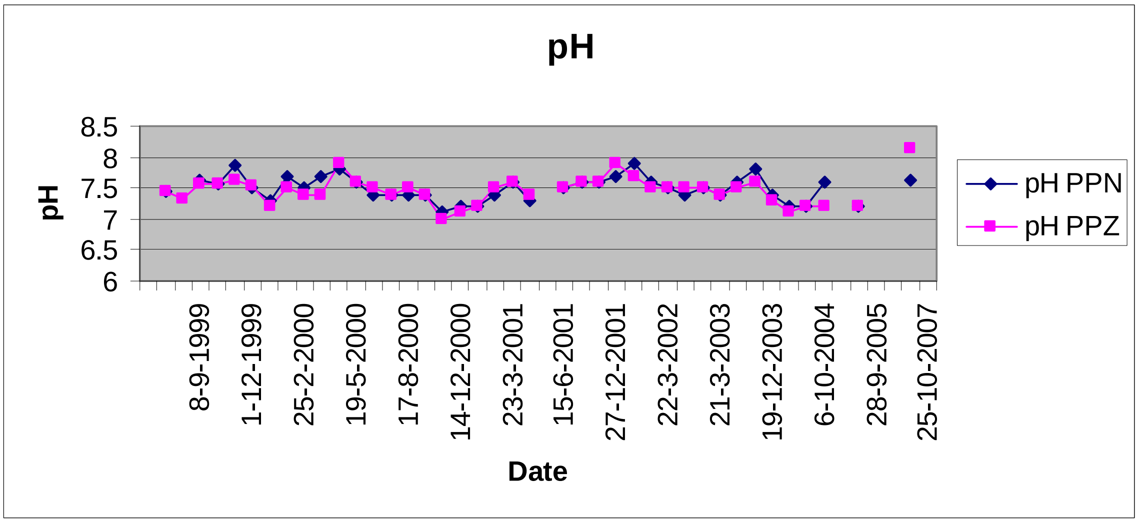
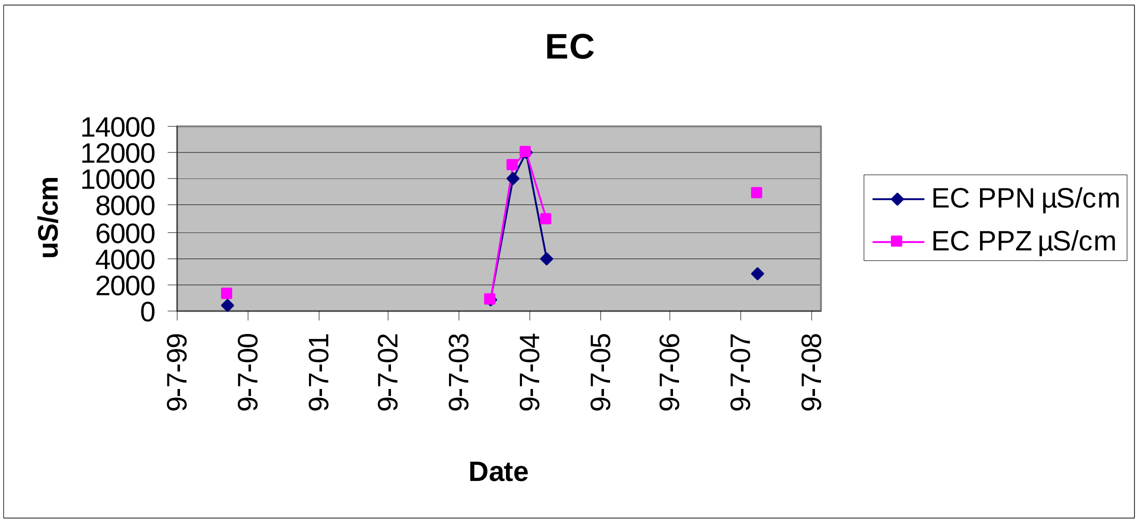
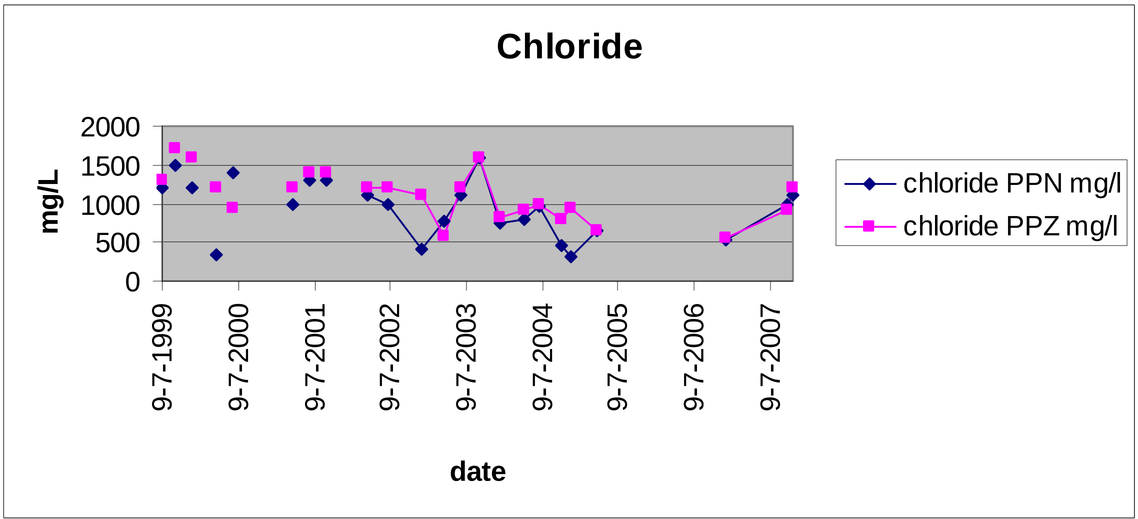
Annex 2
Waste composition eastern part landfill

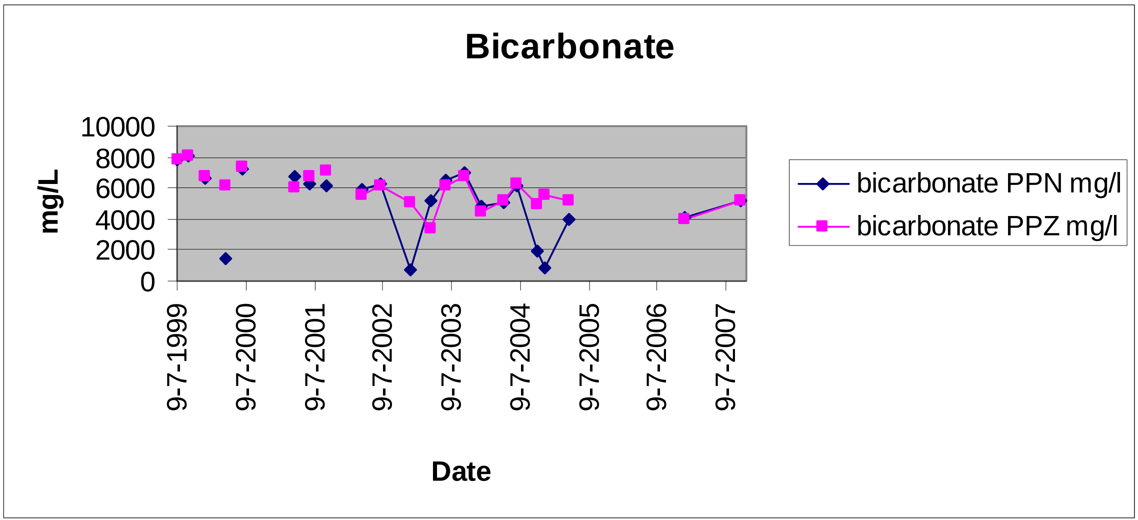
Year	Soil and soil decontami-nation residues	Construction and demolition waste	Commercial waste	Shredder	Street cleansing waste	Coarse Household waste	Sludge and composting waste	Household waste	TOTAL
1985	0	0	68.552	0	0	0	0	0	68.552
1986	0	0	72.382	0	0	0	0	0	72.382
1987	0	0	65.873	0	0	0	5.500	0	71.373
1988	0	0	84.794	0	0	0	10.900	0	95.694
1989	0	0	166.653	0	0	0	13.475	0	180.128
1990	0	0	152.553	0	0	0	37.175	0	189.728
1991	0	0	133.748	0	0	0	48.884	0	182.632
1992	0	0	138.378	0	0	0	57.790	0	196.168
1993	0	0	84.258	0	0	0	25.379	0	109.637
1994	0	0	85.701	0	0	0	25.850	0	111.551
1995	22.200	30.600	30.100	2.200	0	7.900	600	0	93.600
1996	17.900	24.700	24.300	1.800	0	6.400	500	0	75.600
1997	11.700	16.200	15.900	1.200	0	4.200	300	0	49.500
1998	12.900	17.800	17.500	1.300	0	4.600	300	0	54.400
1999	10.835	23.498	19.026	5.388	374	0	240	5.264	64.625
2000	137.577	15.158	18.561	4.041	118	1.709	526	728	178.418
Totals	213.112	127.112	1.178.279	15.929	492	24.809	227.419	5.992	1.793.988
Carbon	2.344	1.408	130.789	2.166	63	3.374	20.468	815	161.427

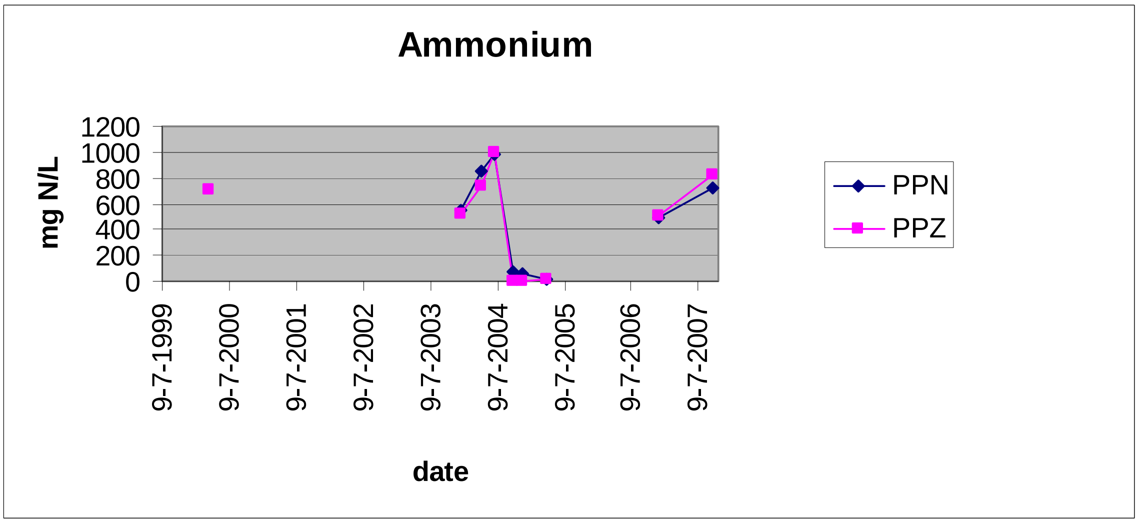
Annex 3
Leachate quality pump pit north and pump pit south

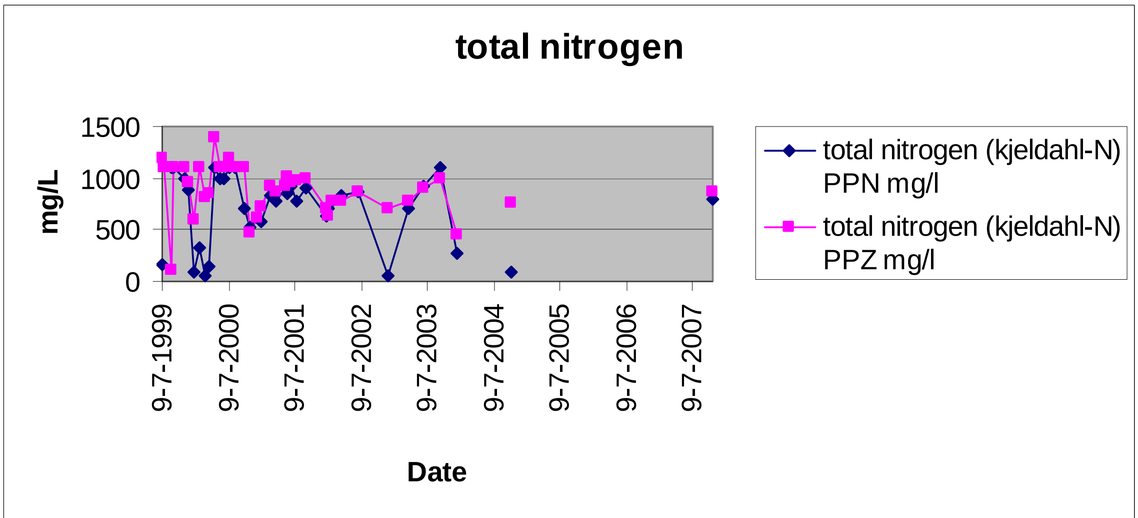

pH
8.5
8
7.5
7
6.5
6
pH
8-9-1999
1-12-1999
25-2-2000
19-5-2000
17-8-2000
14-12-2000
23-3-2001
15-6-2001
27-12-2001
22-3-2002
21-3-2003
19-12-2003
6-10-2004
28-9-2005
25-10-2007
Date
pH PPN
pH PPZ

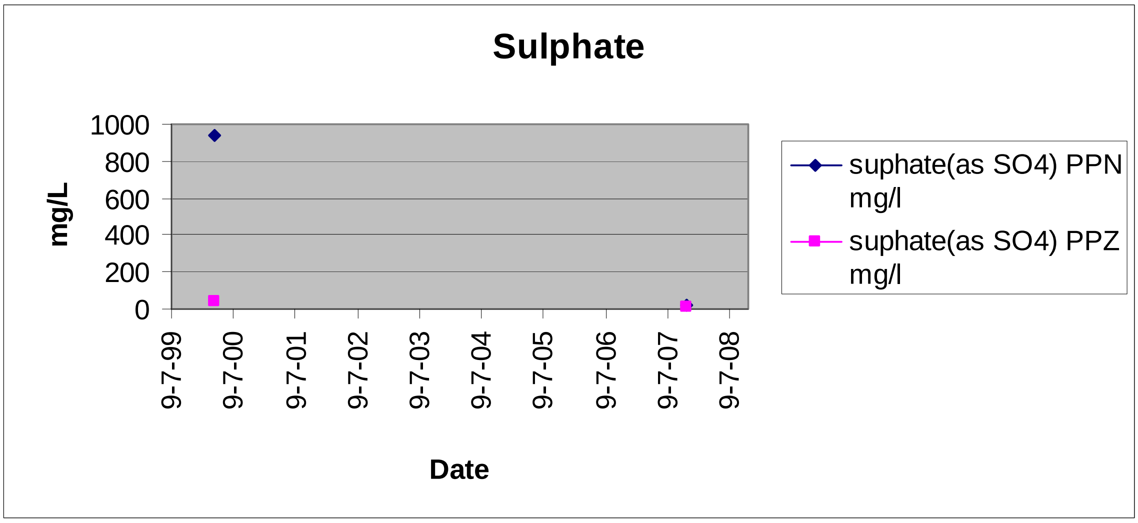

EC
14000
12000
10000
8000
6000
4000
2000
0
uS/cm
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
9-7-08
Date
EC PPN µS/cm
EC PPZ µS/cm

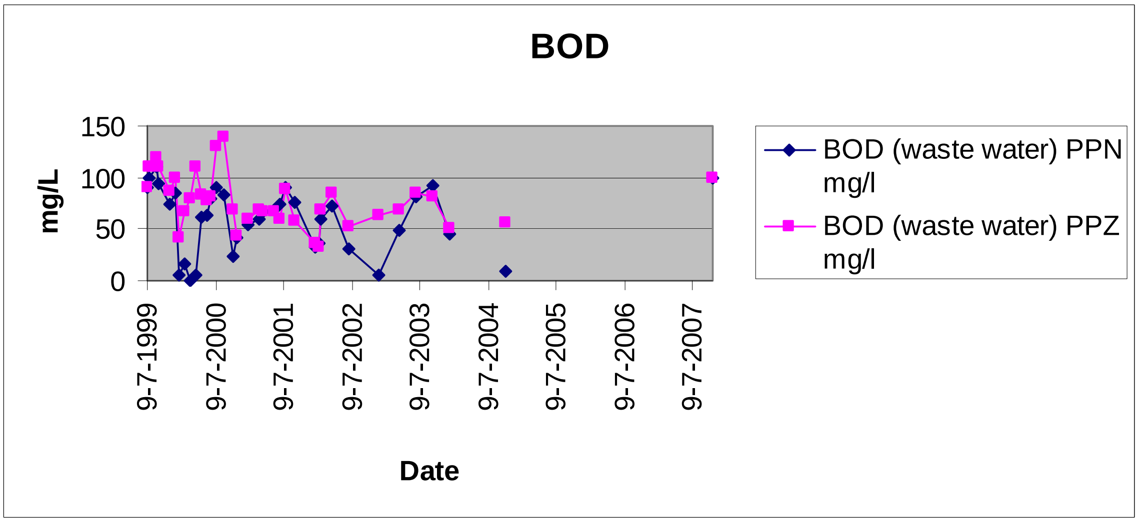

Chloride
2000
1500
1000
500
0
mg/L
9-7-1999
9-7-2000
9-7-2001
9-7-2002
9-7-2003
9-7-2004
9-7-2005
9-7-2006
9-7-2007
date
chloride PPN mg/l
chloride PPZ mg/l

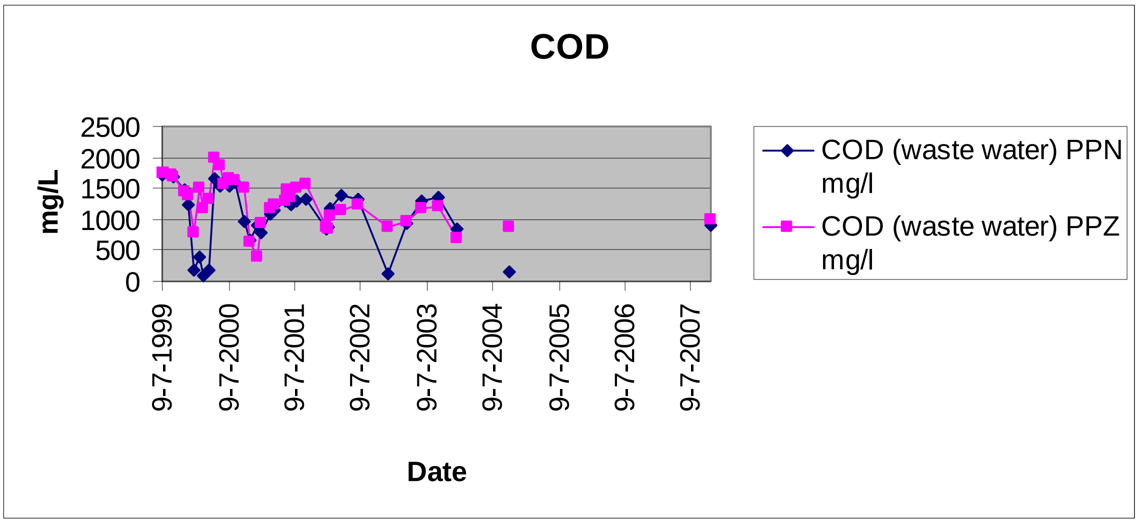

Bicarbonate
mg/L
10000
8000
6000
4000
2000
0
9-7-1999
9-7-2000
9-7-2001
9-7-2002
9-7-2003
9-7-2004
9-7-2005
9-7-2006
9-7-2007
Date
bicarbonate PPN mg/l
bicarbonate PPZ mg/l

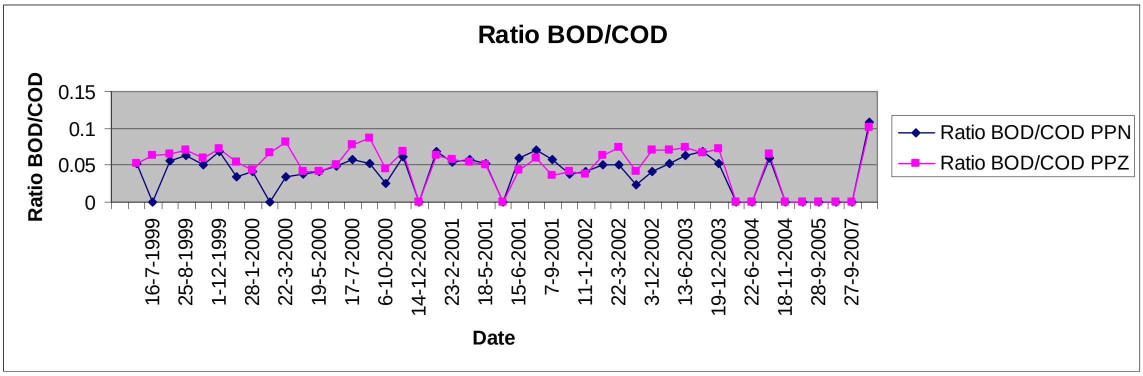

Ammonium
mg N/L
1200
1000
800
600
400
200
0
9-7-1999
9-7-2000
9-7-2001
9-7-2002
9-7-2003
9-7-2004
9-7-2005
9-7-2006
9-7-2007
date
PPN
PPZ


total nitrogen
mg/L
1500
1000
500
0
9-7-1999
9-7-2000
9-7-2001
9-7-2002
9-7-2003
9-7-2004
9-7-2005
9-7-2006
9-7-2007
Date
total nitrogen (kjeldahl-N) PPN mg/l
total nitrogen (kjeldahl-N) PPZ mg/l


Sulphate
mg/L
1000
800
600
400
200
0
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
9-7-08
Date
suphate(as SO4) PPN mg/l
suphate(as SO4) PPZ mg/l


BOD
mg/L
150
100
50
0
9-7-1999
9-7-2000
9-7-2001
9-7-2002
9-7-2003
9-7-2004
9-7-2005
9-7-2006
9-7-2007
Date
BOD (waste water) PPN mg/l
BOD (waste water) PPZ mg/l


COD
mg/L
2500
2000
1500
1000
500
0
9-7-1999
9-7-2000
9-7-2001
9-7-2002
9-7-2003
9-7-2004
9-7-2005
9-7-2006
9-7-2007
Date
COD (waste water) PPN mg/l
COD (waste water) PPZ mg/l


Ratio BOD/COD
Ratio BOD/COD
0.15
0.1
0.05
0
16-7-1999
25-8-1999
1-12-1999
28-1-2000
22-3-2000
19-5-2000
17-7-2000
6-10-2000
14-12-2000
23-2-2001
18-5-2001
15-6-2001
7-9-2001
11-1-2002
22-3-2002
3-12-2002
13-6-2003
19-12-2003
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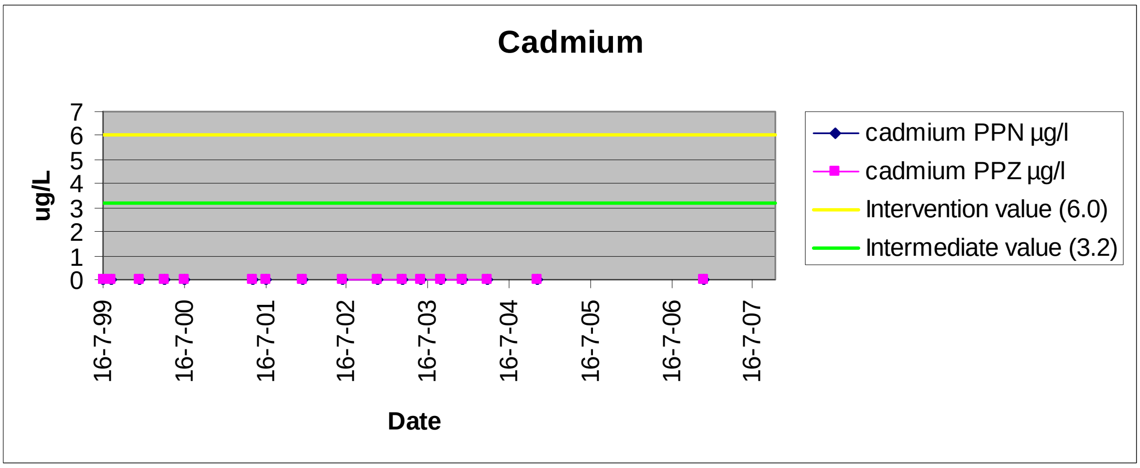
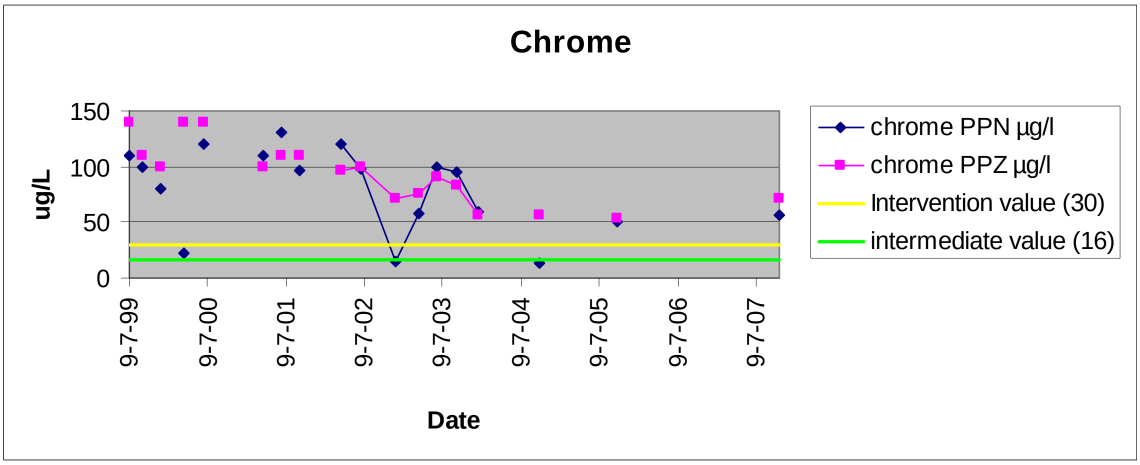
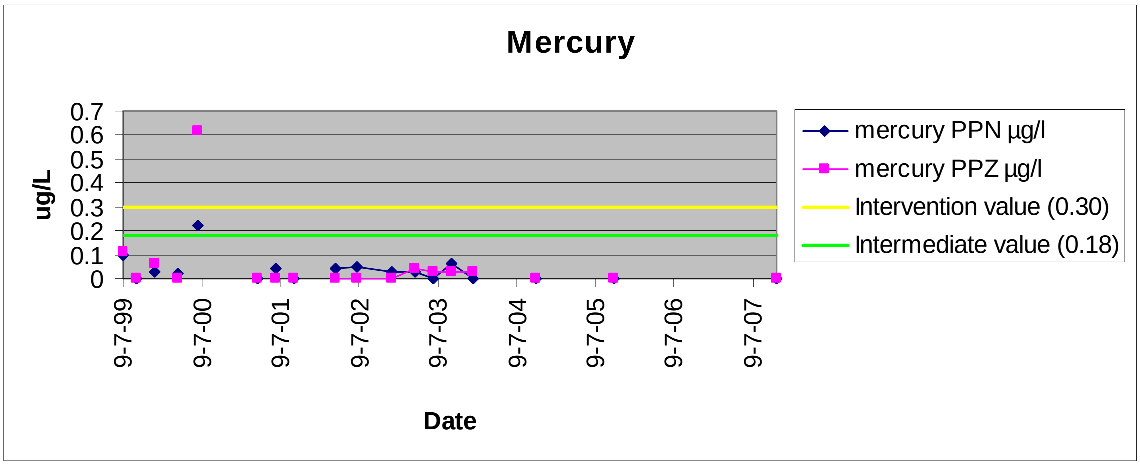
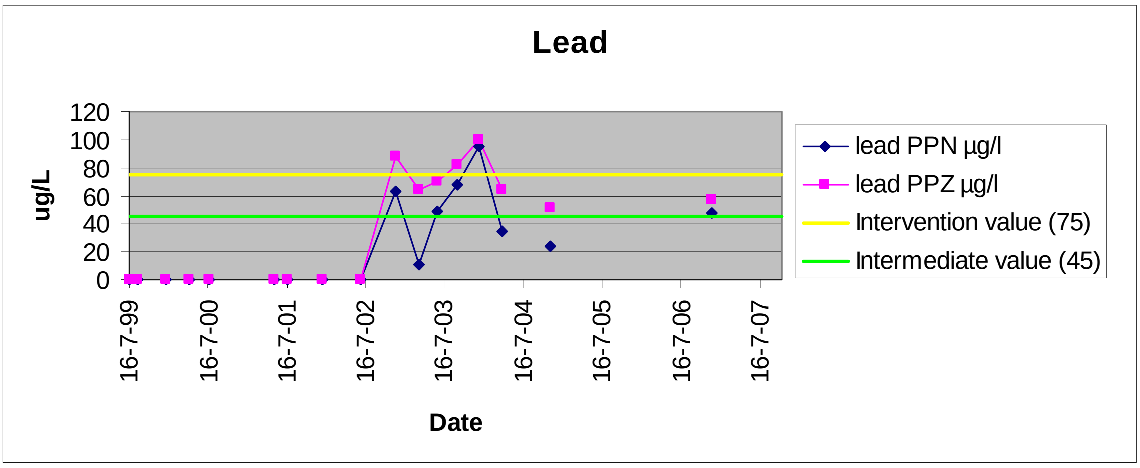
18-11-2004
28-9-2005
27-9-2007
Date
Ratio BOD/COD PPN
Ratio BOD/COD PPZ


Cadmium
ug/L
7
6
5
4
3
2
1
0
16-7-99
16-7-00
16-7-01
16-7-02
16-7-03
16-7-04
16-7-05
16-7-06
16-7-07
Date
cadmium PPN µg/l
cadmium PPZ µg/l
Intervention value (6.0)
Intermediate value (3.2)

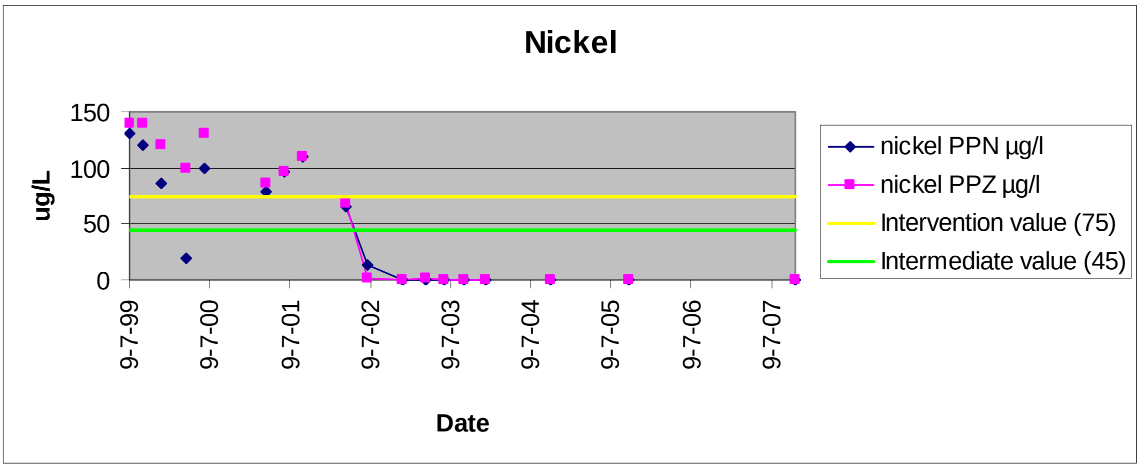

Chrome
ug/L
150
100
50
0
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
Date
chrome PPN µg/l
chrome PPZ µg/l
Intervention value (30)
intermediate value (16)



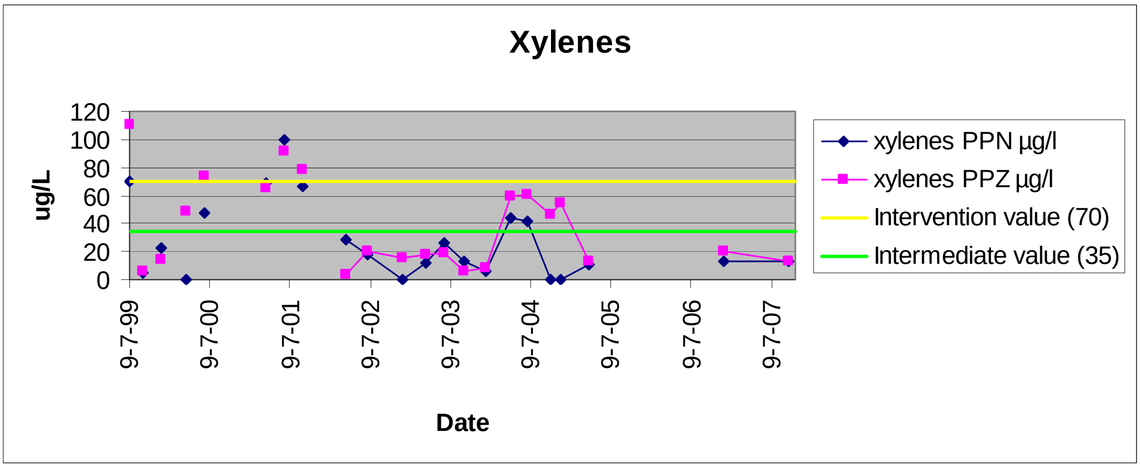
Mercury
ug/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
Date
mercury PPN µg/l
mercury PPZ µg/l
Intervention value (0.30)
Intermediate value (0.18)



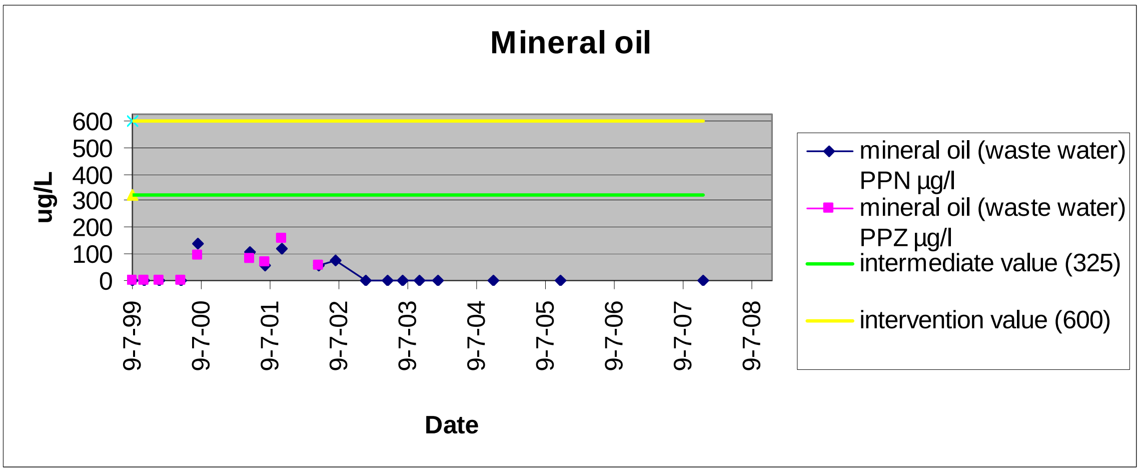
Lead
ug/L
120
100
80
60
40
20
0
16-7-99
16-7-00
16-7-01
16-7-02
16-7-03
16-7-04
16-7-05
16-7-06
16-7-07
Date
lead PPN µg/l
lead PPZ µg/l
Intervention value (75)
Intermediate value (45)



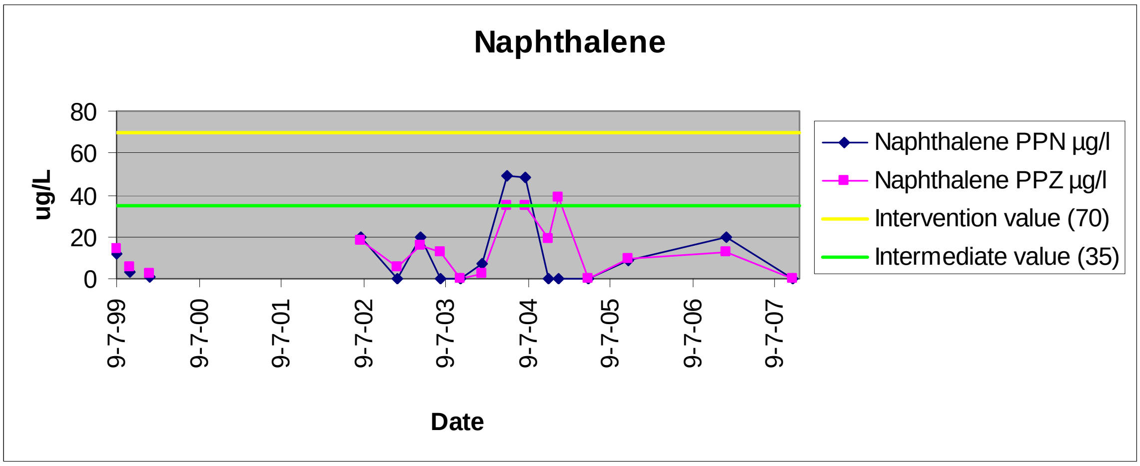
Nickel
ug/L
150
100
50
0
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
Date
nickel PPN µg/l
nickel PPZ µg/l
Intervention value (75)
Intermediate value (45)



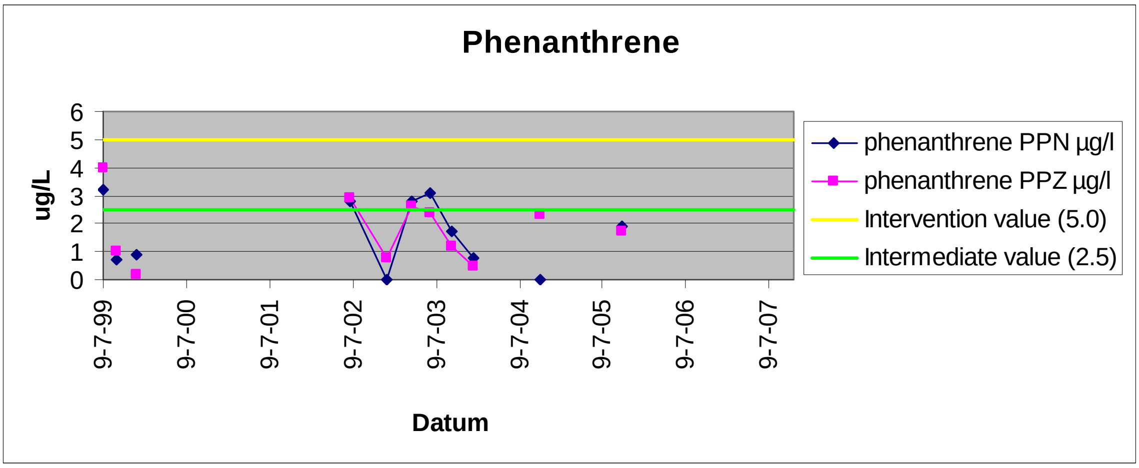
Xylenes
120
100
80
60
40
20
0
ug/L
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
Date
xylenes PPN µg/l
xylenes PPZ µg/l
Intervention value (70)
Intermediate value (35)

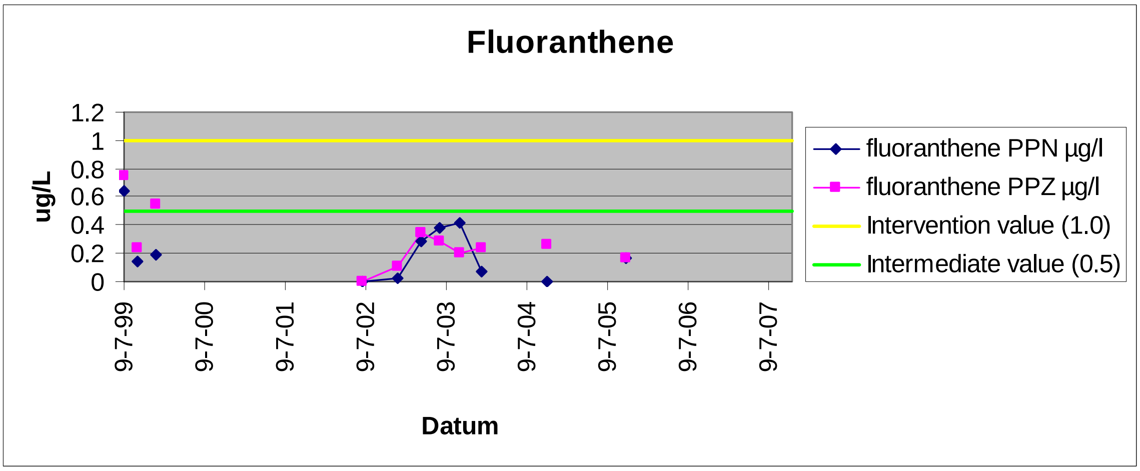


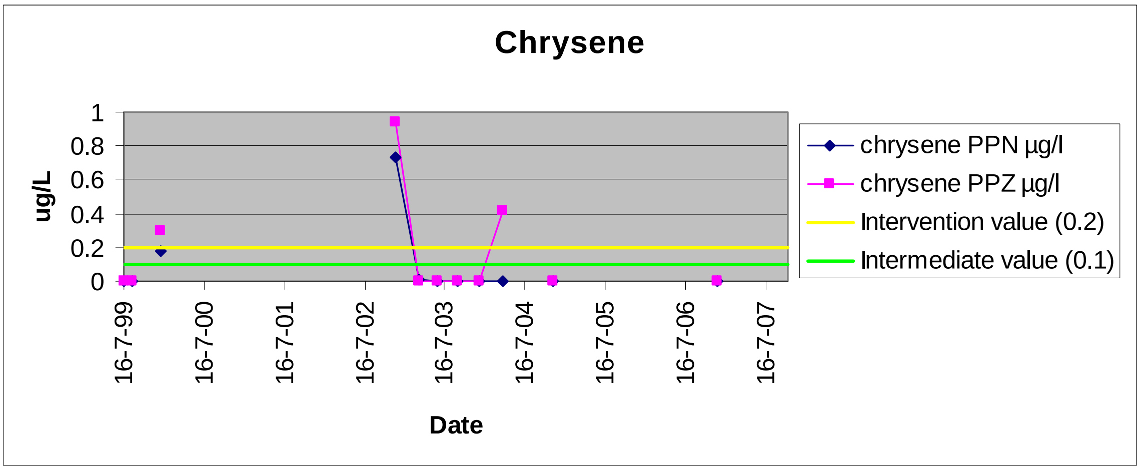
Mineral oil
600
500
400
300
200
100
0
ug/L
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
9-7-08
Date
mineral oil (waste water) PPN µg/l
mineral oil (waste water) PPZ µg/l
intermediate value (325)
intervention value (600)

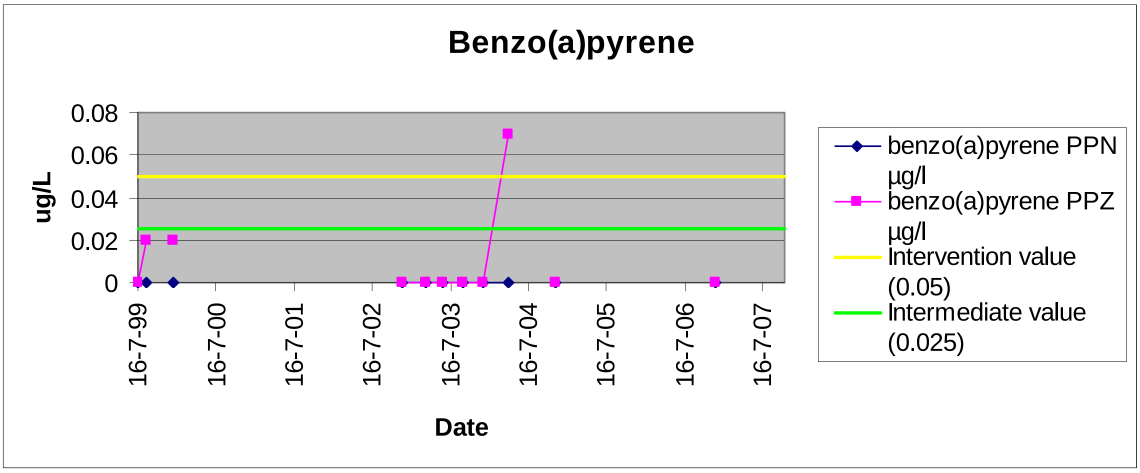


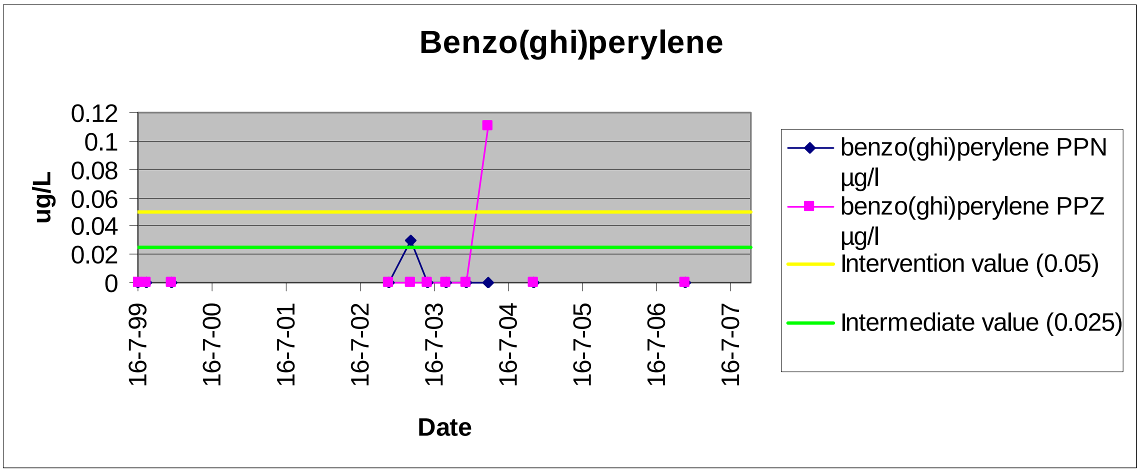
Naphthalene
80
60
40
20
0
ug/L
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
Date
Naphthalene PPN µg/l
Naphthalene PPZ µg/l
Intervention value (70)
Intermediate value (35)

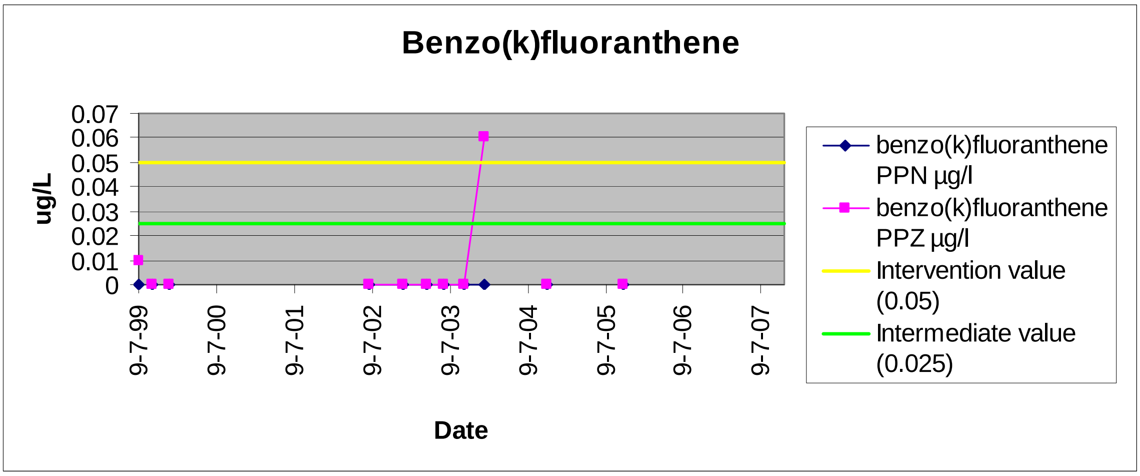

Phenanthrene
ug/L
6
5
4
3
2
1
0
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
Datum
phenanthrene PPN µg/l
phenanthrene PPZ µg/l
Intervention value (5.0)
Intermediate value (2.5)

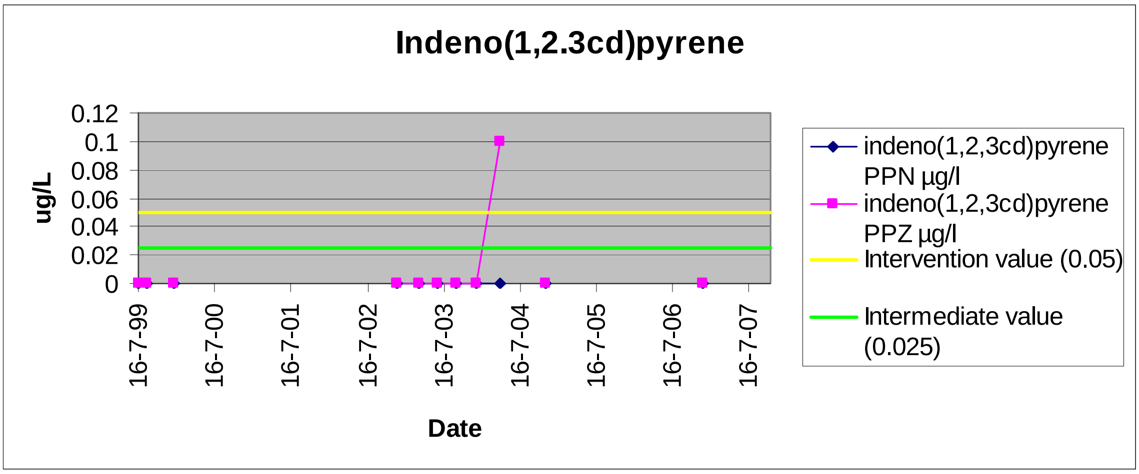

Fluoranthene
ug/L
1.2
1
0.8
0.6
0.4
0.2
0
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
Datum
fluoranthene PPN µg/l
fluoranthene PPZ µg/l
Intervention value (1.0)
Intermediate value (0.5)

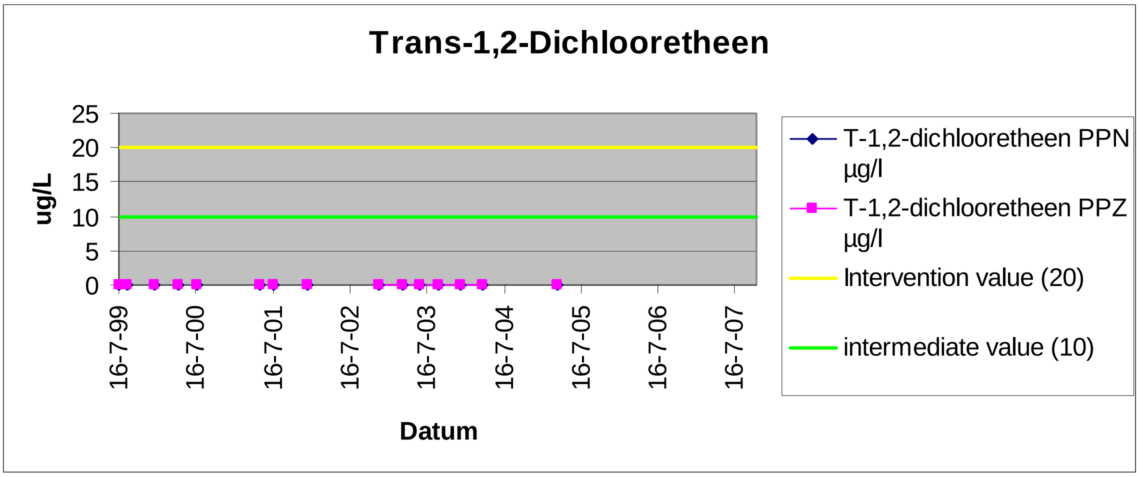

Chrysene
ug/L
1
0.8
0.6
0.4
0.2
0
16-7-99
16-7-00
16-7-01
16-7-02
16-7-03
16-7-04
16-7-05
16-7-06
16-7-07
Date
chrysene PPN µg/l
chrysene PPZ µg/l
Intervention value (0.2)
Intermediate value (0.1)

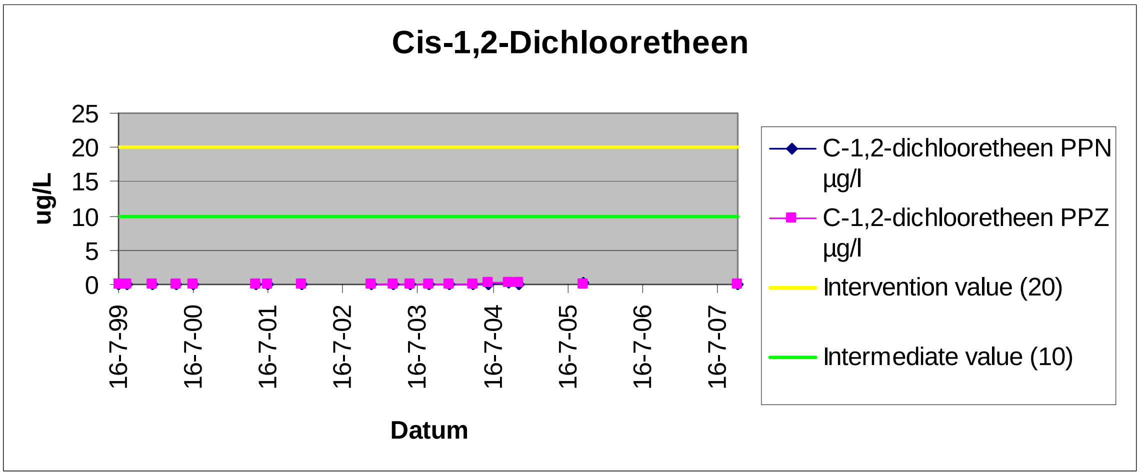

Benzo(a)pyrene
0.08
0.06
0.04
0.02
0
ug/L
16-7-99
16-7-00
16-7-01
16-7-02
16-7-03
16-7-04
16-7-05
16-7-06
16-7-07
Date
benzo(a)pyrene PPN µg/l
benzo(a)pyrene PPZ µg/l
Intervention value (0.05)
Intermediate value (0.025)


Benzo(ghi)perylene
0.12
0.1
0.08
0.06
0.04
0.02
0
ug/L
16-7-99
16-7-00
16-7-01
16-7-02
16-7-03
16-7-04
16-7-05
16-7-06
16-7-07
Date
benzo(ghi)perylene PPN µg/l
benzo(ghi)perylene PPZ µg/l
Intervention value (0.05)
Intermediate value (0.025)


Benzo(k)fluoranthene
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
ug/L
9-7-99
9-7-00
9-7-01
9-7-02
9-7-03
9-7-04
9-7-05
9-7-06
9-7-07
Date
benzo(k)fluoranthene PPN µg/l
benzo(k)fluoranthene PPZ µg/l
Intervention value (0.05)
Intermediate value (0.025)


Indeno(1,2.3cd)pyrene
ug/L
0.12
0.1
0.08
0.06
0.04
0.02
0
16-7-99
16-7-00
16-7-01
16-7-02
16-7-03
16-7-04
16-7-05
16-7-06
16-7-07
Date
indeno(1,2,3cd)pyrene PPN µg/l
indeno(1,2,3cd)pyrene PPZ µg/l
Intervention value (0.05)
Intermediate value (0.025)


Trans-1,2-Dichlooretheen
ug/L
25
20
15
10
5
0
16-7-99
16-7-00
16-7-01
16-7-02
16-7-03
16-7-04
16-7-05
16-7-06
16-7-07
Datum
T-1,2-dichlooretheen PPN µg/l
T-1,2-dichlooretheen PPZ µg/l
Intervention value (20)
intermediate value (10)


Cis-1,2-Dichlooretheen
ug/L
25
20
15
10
5
0
16-7-99
16-7-00
16-7-01
16-7-02
16-7-03
16-7-04
16-7-05
16-7-06
16-7-07
Datum
C-1,2-dichlooretheen PPN µg/l
C-1,2-dichlooretheen PPZ µg/l
Intervention value (20)
Intermediate value (10)

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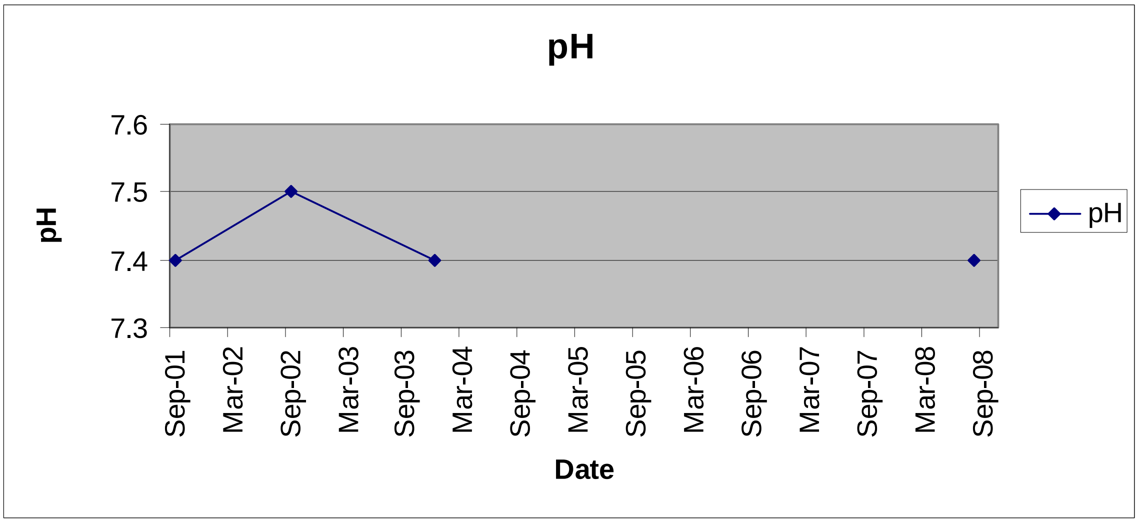
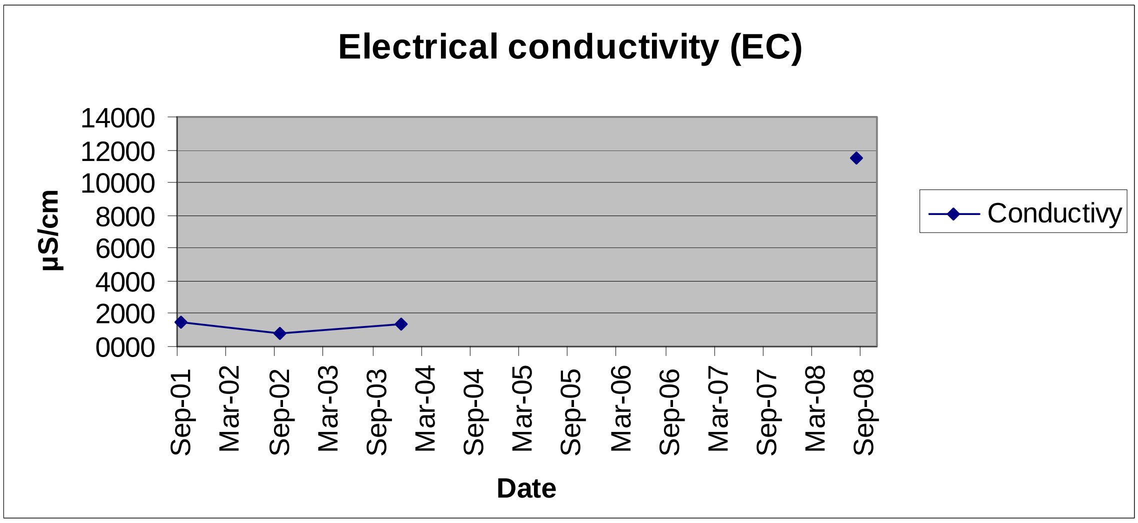
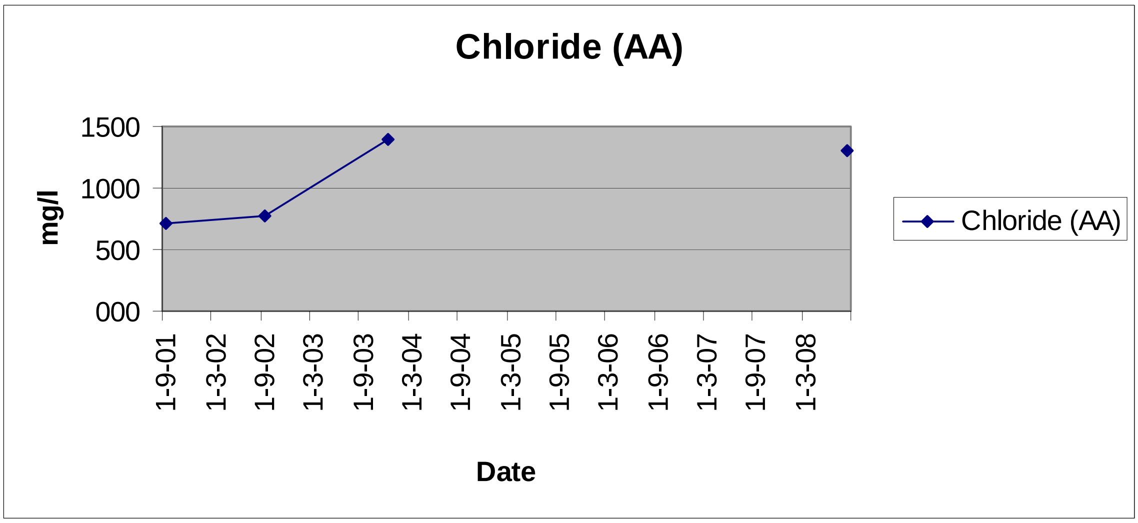
Annex 4
Leachate quality cell 6



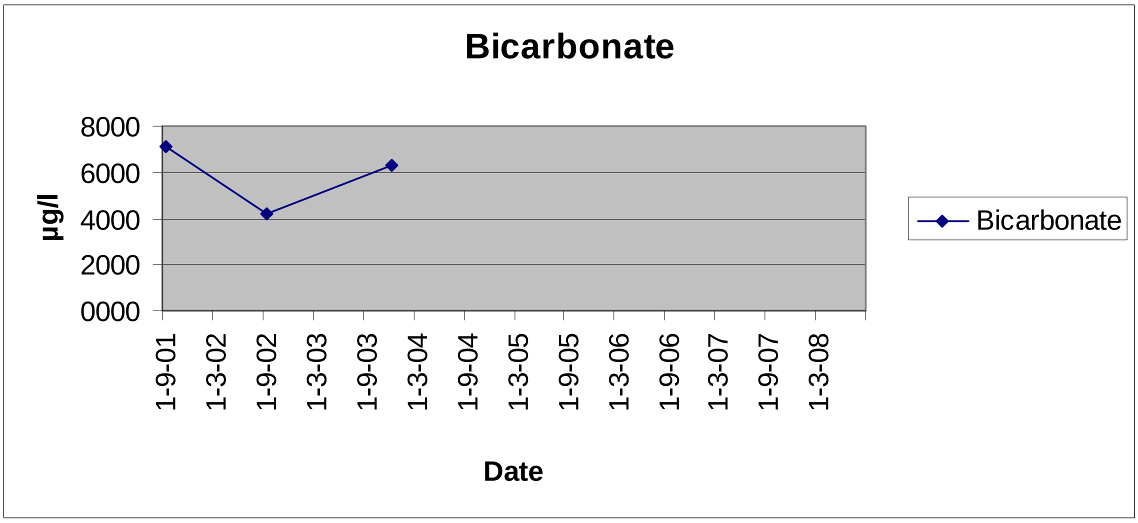
pH
pH
7.6
7.5
7.4
7.3
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Sep-05
Mar-06
Sep-06
Mar-07
Sep-07
Mar-08
Sep-08
Date
pH

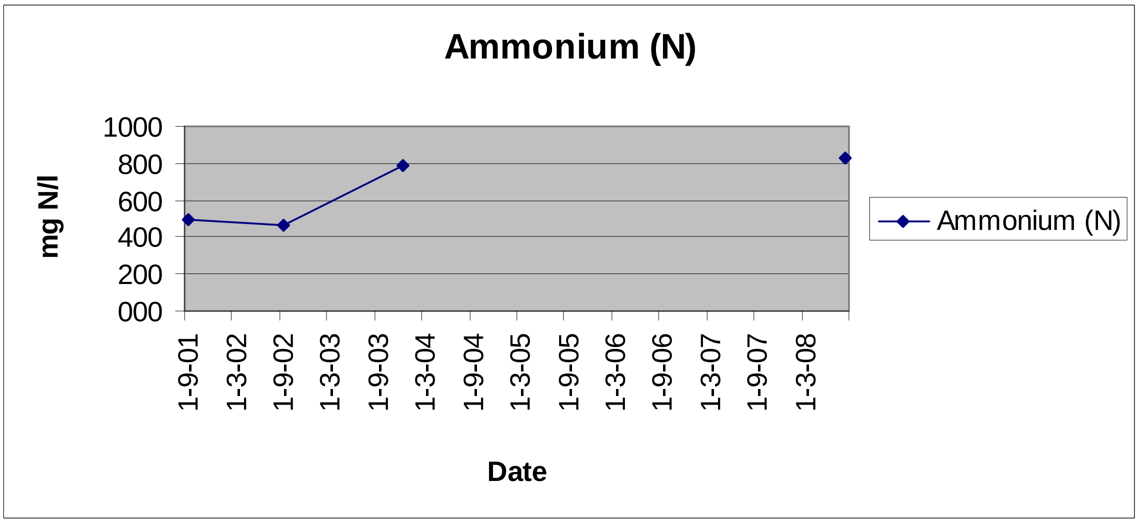


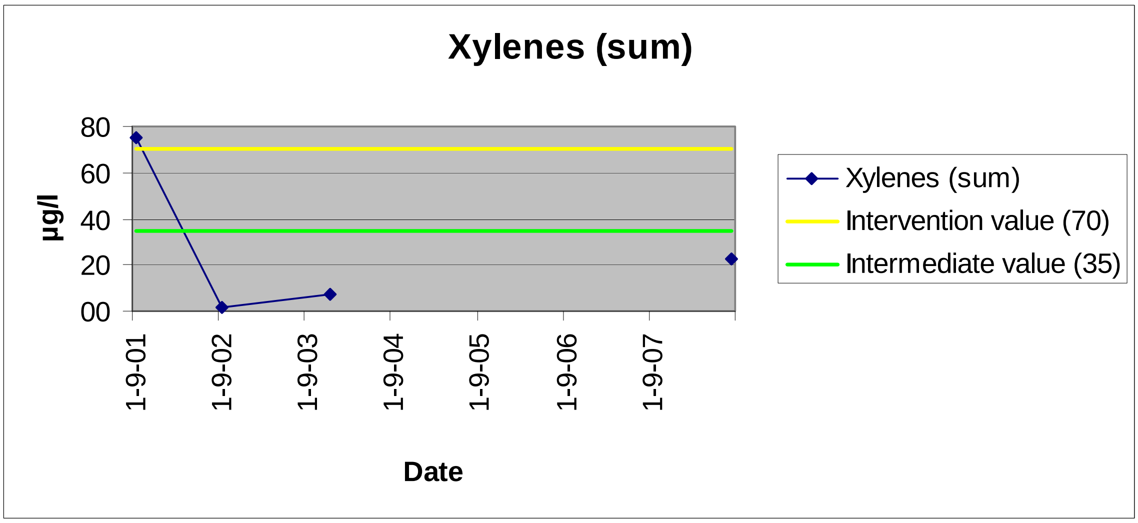
Electrical conductivity (EC)
µS/cm
14000
12000
10000
8000
6000
4000
2000
0000
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Sep-05
Mar-06
Sep-06
Mar-07
Sep-07
Mar-08
Sep-08
Date
Conductivy

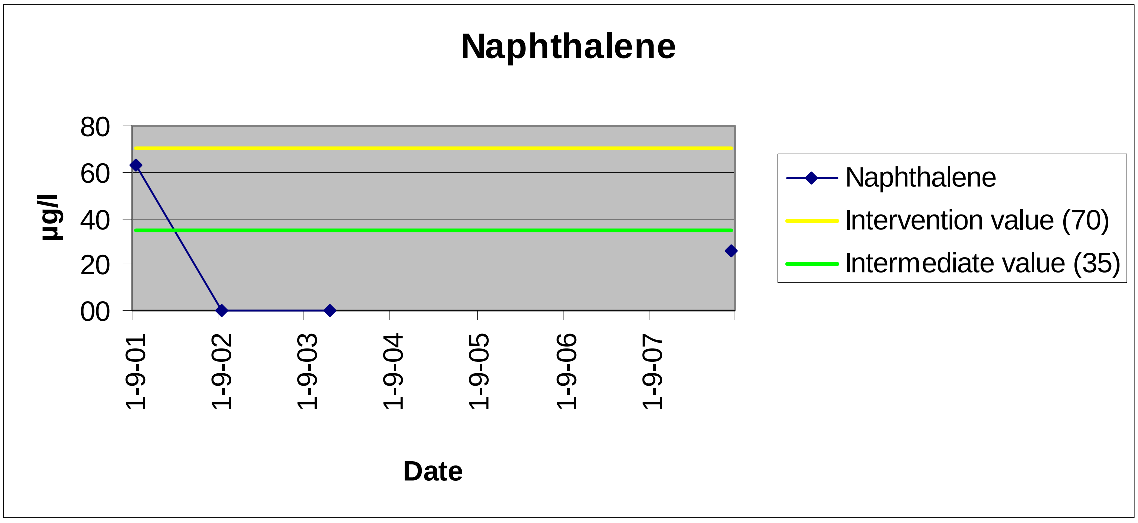


Chloride (AA)
mg/l
1500
1000
500
000
1-9-01
1-3-02
1-9-02
1-3-03
1-9-03
1-3-04
1-9-04
1-3-05
1-9-05
1-3-06
1-9-06
1-3-07
1-9-07
1-3-08
Date
Chloride (AA)

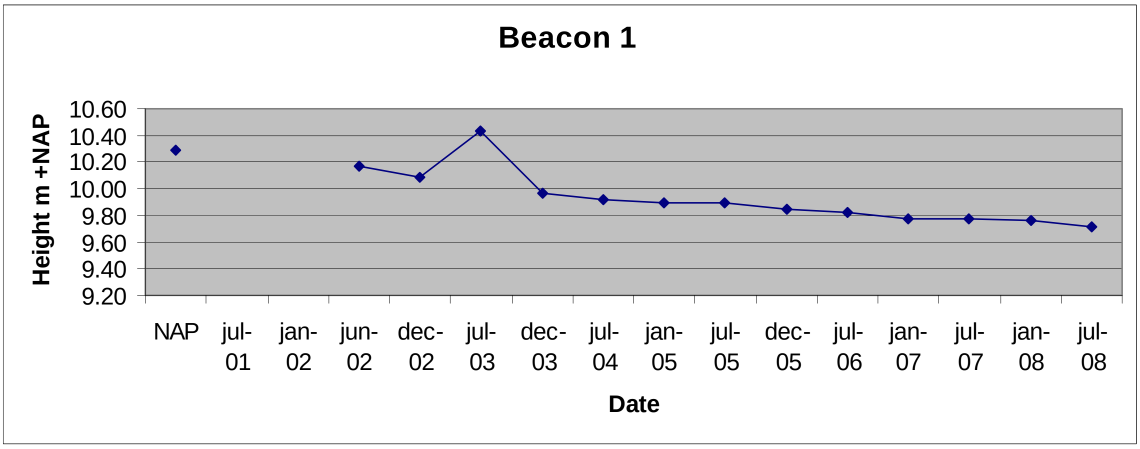

Bicarbonate
8000
6000
4000
2000
0000
µg/l
1-9-01
1-3-02
1-9-02
1-3-03
1-9-03
1-3-04
1-9-04
1-3-05
1-9-05
1-3-06
1-9-06
1-3-07
1-9-07
1-3-08
Date
Bicarbonate

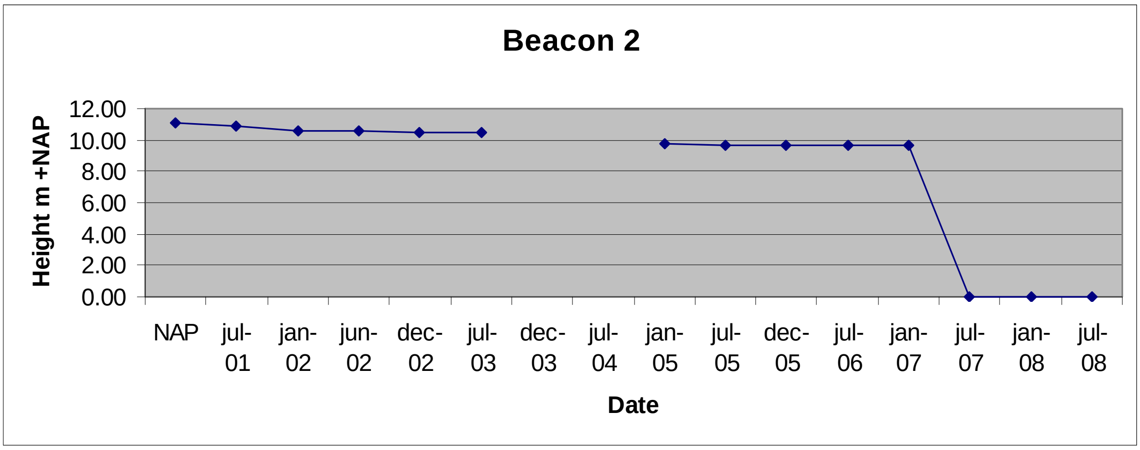

Ammonium (N)
1000
800
600
400
200
000
mg N/l
1-9-01
1-3-02
1-9-02
1-3-03
1-9-03
1-3-04
1-9-04
1-3-05
1-9-05
1-3-06
1-9-06
1-3-07
1-9-07
1-3-08
Date
Ammonium (N)

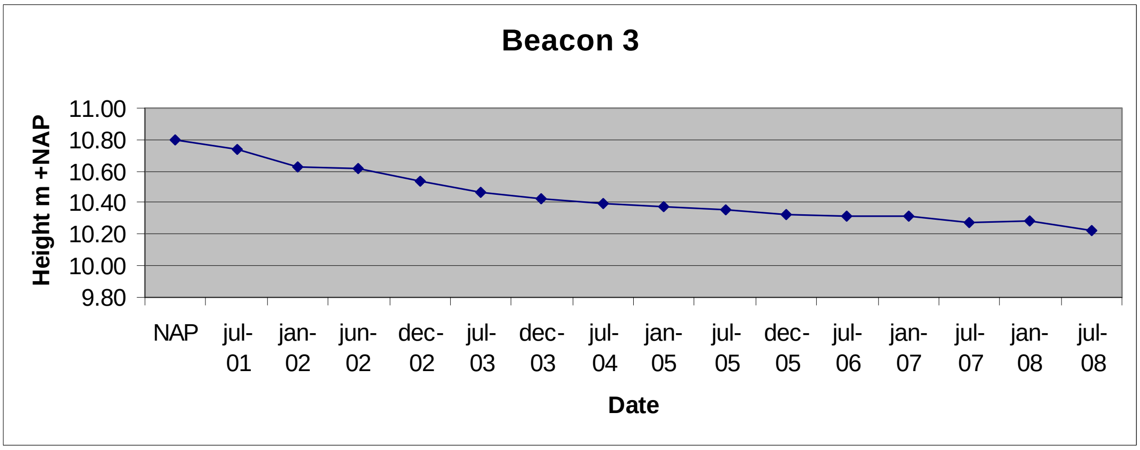

Xylenes (sum)
80
60
40
20
00
µg/l
1-9-01
1-9-02
1-9-03
1-9-04
1-9-05
1-9-06
1-9-07
Date
Xylenes (sum)
Intervention value (70)
Intermediate value (35)

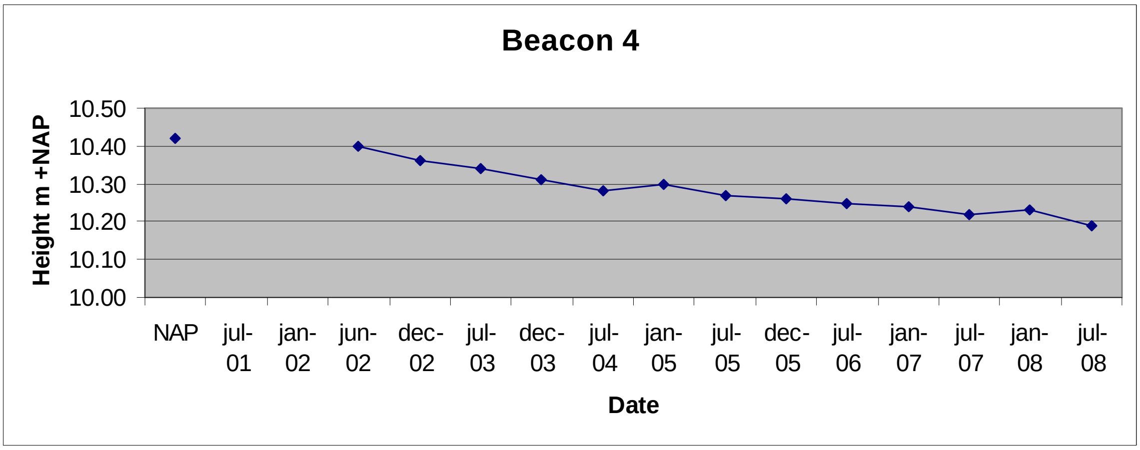

Naphthalene
80
60
40
20
00
µg/l
1-9-01
1-9-02
1-9-03
1-9-04
1-9-05
1-9-06
1-9-07
Date
Naphthalene
Intervention value (70)
Intermediate value (35)

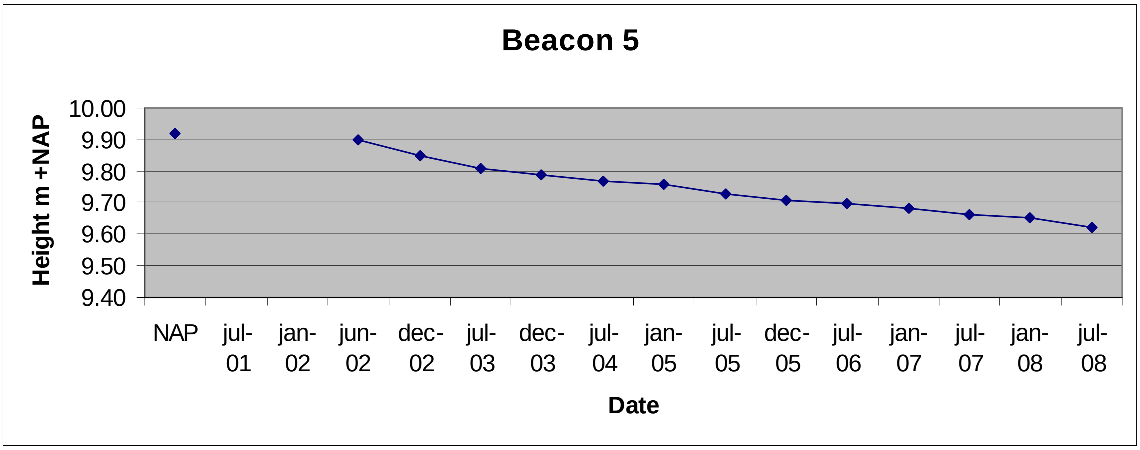
Annex 5
Time series settlement beacons

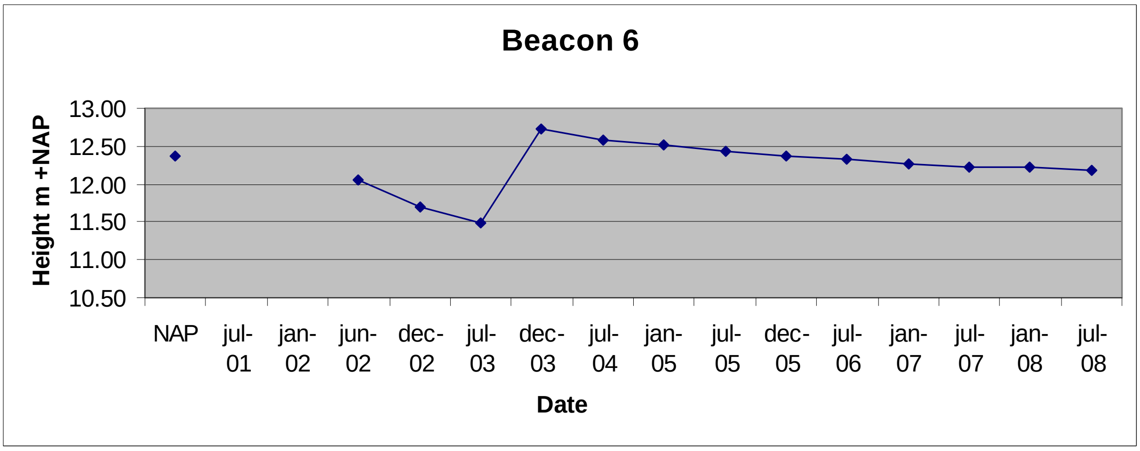

Beacon 1
Height m +NAP
10.60
10.40
10.20
10.00
9.80
9.60
9.40
9.20
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

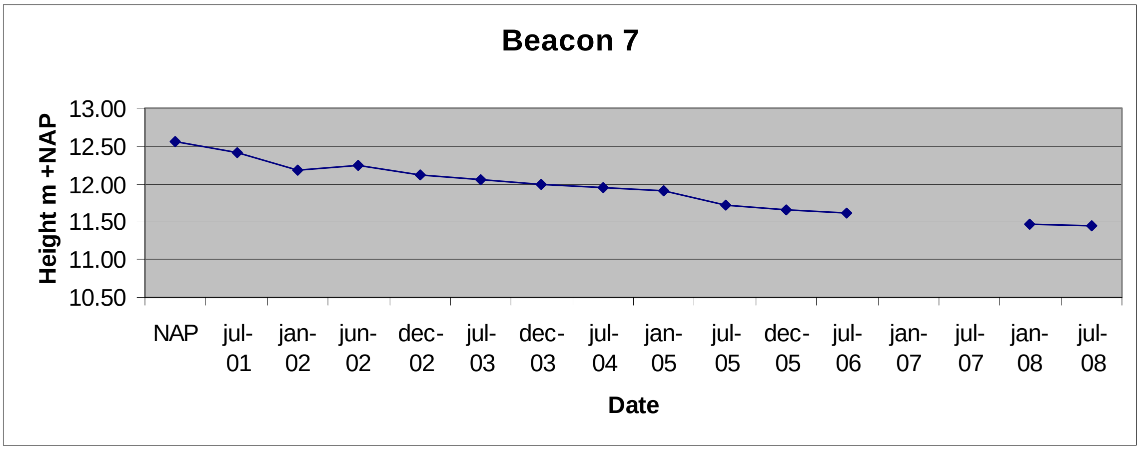

Beacon 2
Height m +NAP
12.00
10.00
8.00
6.00
4.00
2.00
0.00
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date


Beacon 3
Height m +NAP
11.00
10.80
10.60
10.40
10.20
10.00
9.80
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

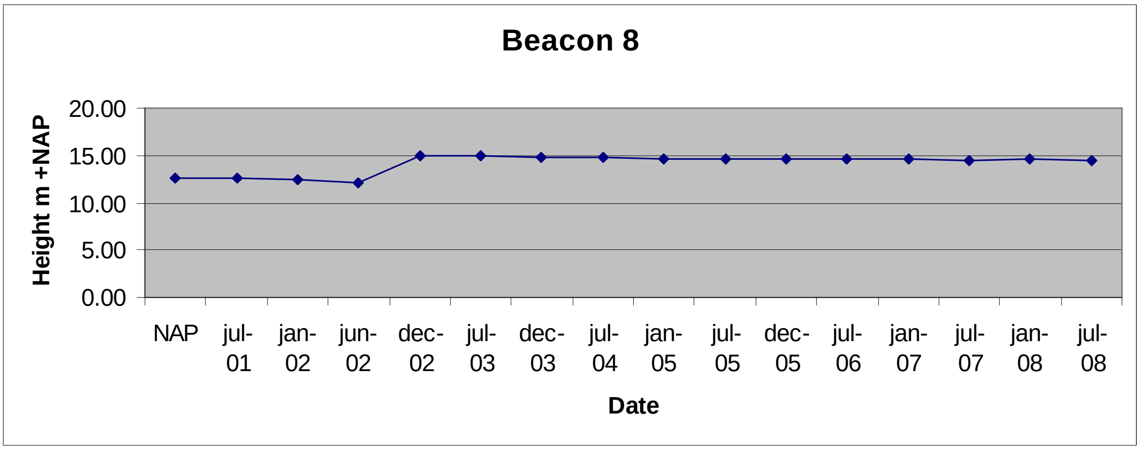

Beacon 4
Height m +NAP
10.50
10.40
10.30
10.20
10.10
10.00
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date


Beacon 5
Height m +NAP
10.00
9.90
9.80
9.70
9.60
9.50
9.40
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

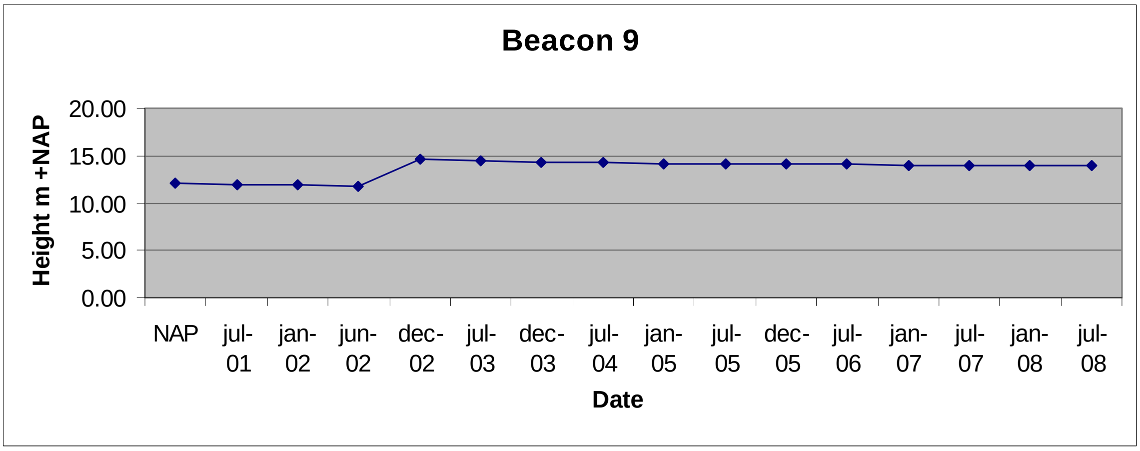

Beacon 6
Height m +NAP
13.00
12.50
12.00
11.50
11.00
10.50
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date



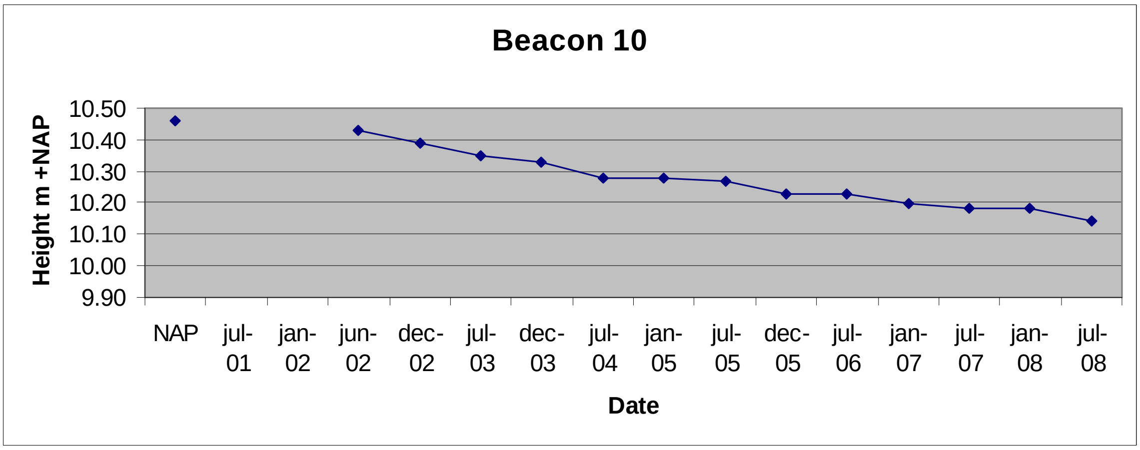
Beacon 7
Height m +NAP
13.00
12.50
12.00
11.50
11.00
10.50
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

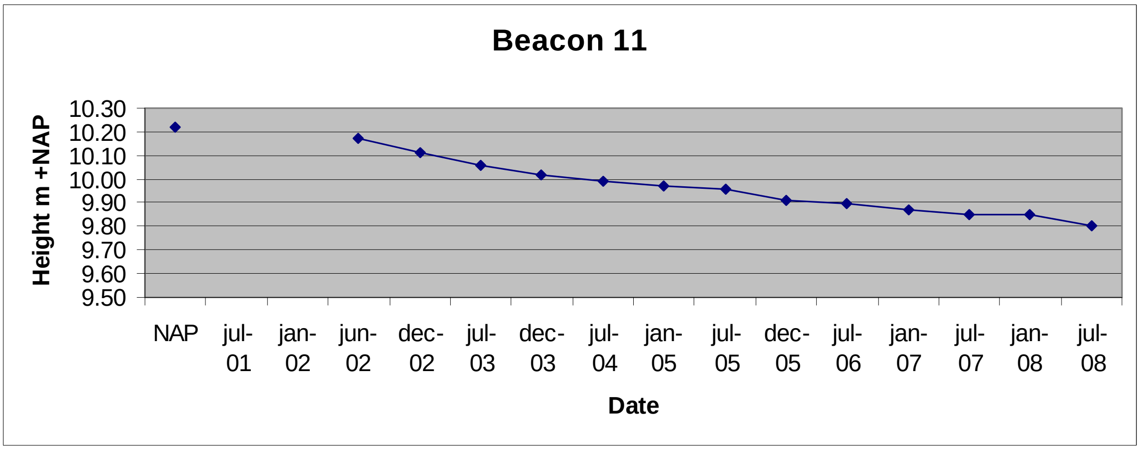


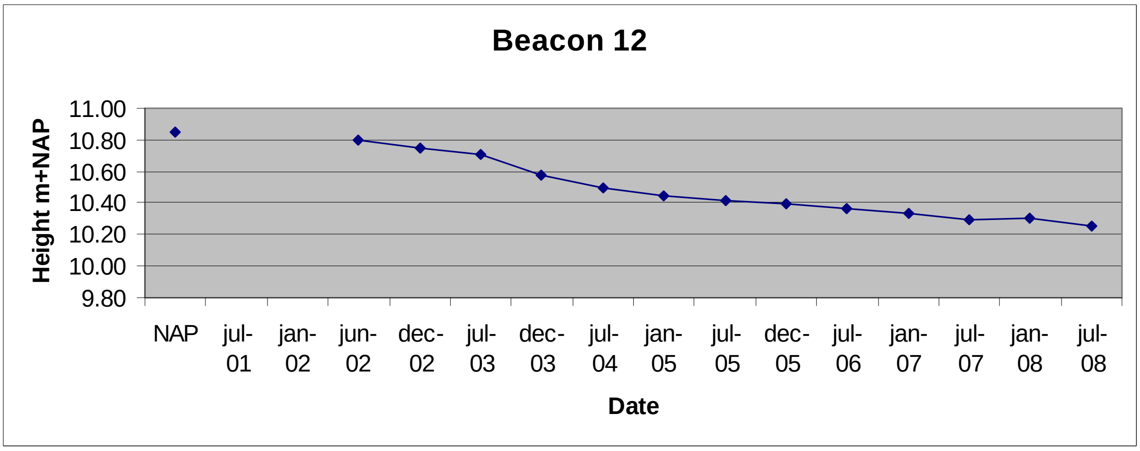
Beacon 8
Height m +NAP
20.00
15.00
10.00
5.00
0.00
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

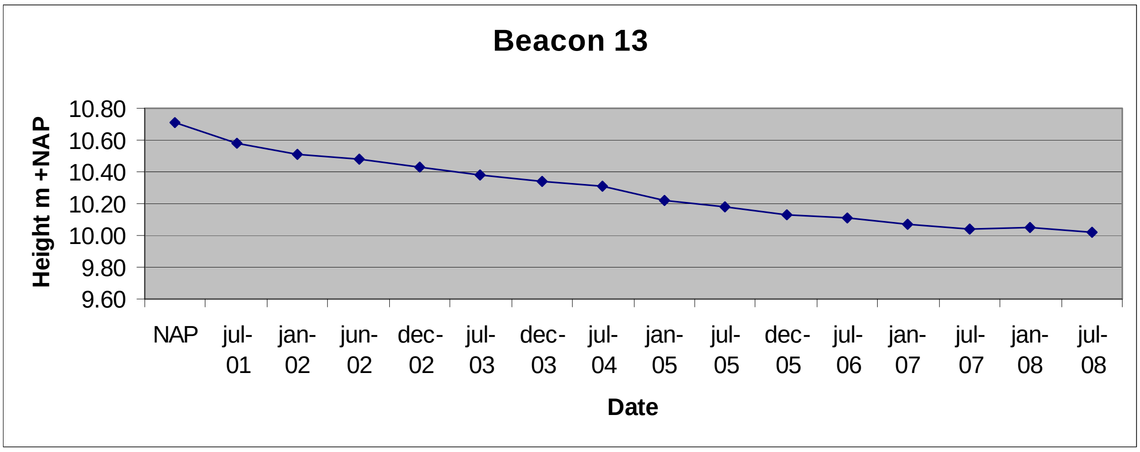


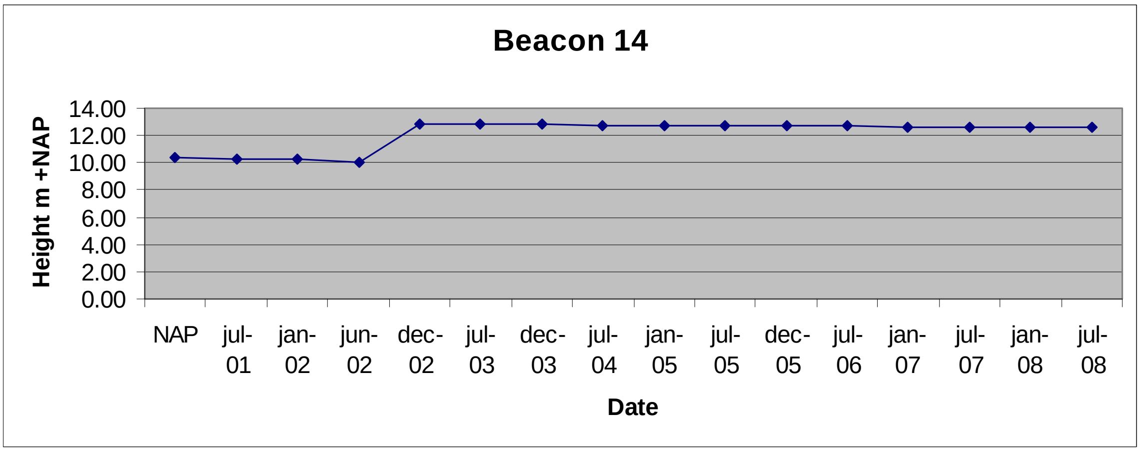
Beacon 9
Height m +NAP
20.00
15.00
10.00
5.00
0.00
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

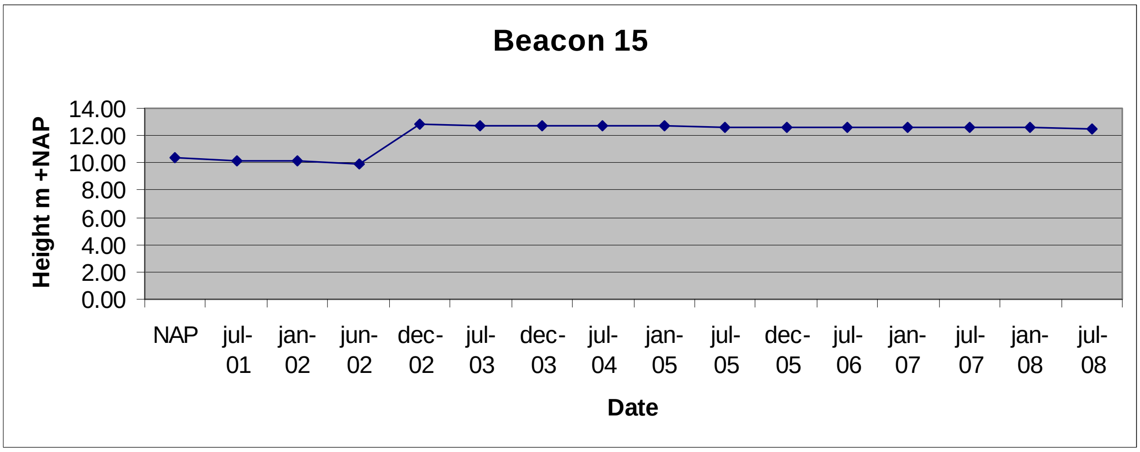

Beacon 10
Height m +NAP
10.50
10.40
10.30
10.20
10.10
10.00
9.90
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

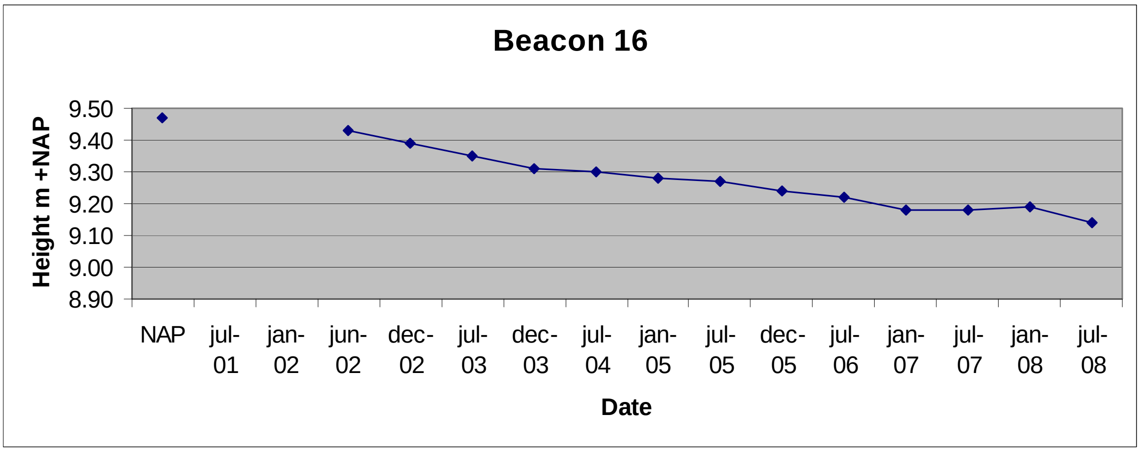

Beacon 11
Height m +NAP
10.30
10.20
10.10
10.00
9.90
9.80
9.70
9.60
9.50
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

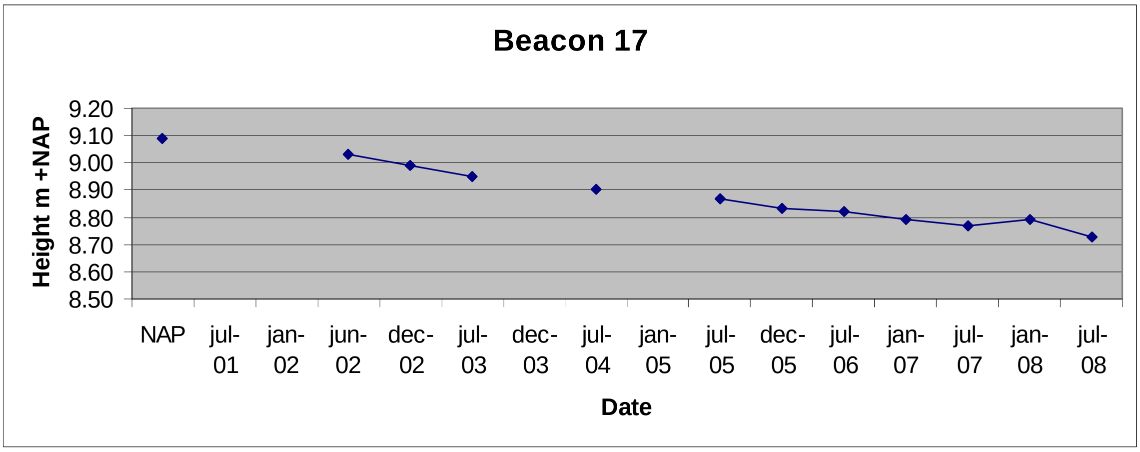

Beacon 12
Height m+NAP
11.00
10.80
10.60
10.40
10.20
10.00
9.80
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date


Beacon 13
Height m +NAP
10.80
10.60
10.40
10.20
10.00
9.80
9.60
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date


Beacon 14
Height m +NAP
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date


Beacon 15
Height m +NAP
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date


Beacon 16
Height m +NAP
9.50
9.40
9.30
9.20
9.10
9.00
8.90
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date


Beacon 17
Height m +NAP
9.20
9.10
9.00
8.90
8.80
8.70
8.60
8.50
NAP
jul-01
jan-02
jun-02
dec-02
jul-03
dec-03
jul-04
jan-05
jul-05
dec-05
jul-06
jan-07
jul-07
jan-08
jul-08
Date

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Annex 6
Chemical analyses leachate cell 6 as input for the ECN LeachXS dBase

Chemical analyses leachate cell 6 as input for the ECN LeachXS dBase (sampling date 13-08-2008)

Component	Unity	Value		Component	Unity	Value
Zirkonium (Zr)	µg/l	13		PAK 10 VROM	µg/l	22
Temperatuur	°C	17		PAK 6 Borneff (berekend)	µg/l	0,31
Zuurgraad (pH)	-	7,4		PAK 16 EPA	µg/l	29
Geleidbaarheid	µS/cm	11450		Fenol-index	µg/l	28
BZV-5	mg/l	78		Benzeen	µg/l	5,8
CZV	mg/l	1120		Tolueen	µg/l	0,8
Ammonium (als N)	mg N/l	830		Ethylbenzeen	µg/l	9,6
Nitraat (als N)	mg N/l	<0,05		Xylenen (som)	µg/l	23
Stikstof (N; vlgs Kjeldahl)	mg N/l	910		Aromaten (som)	µg/l	39
Fosfaat (opgelost)	mg/l	2,2		Minerale olie (totaal)	µg/l	<50
Chloride	mg/l	1300		EOX	µg/l	10
Sulfaat (als SO4)	mg/l	2		DOC	mg C/l	450
Arseen [As]	µg/l	14		Beryllium (Be)	µg/l	<60
Cadmium [Cd]	µg/l	<0,6		Bismut (Bi)	µg/l	<8
Chroom (VI)	µg/l	57		Borium (B)	µg/l	2900
Koper [Cu]	µg/l	10		Broom (Br)	µg/l	6400
Kwik [Hg]	µg/l	<4		Cerium (Ce)	µg/l	<4
Nikkel [Ni]	µg/l	76		Cesium (Cs)	µg/l	<4
Lood [Pb]	µg/l	<4		Dysprosium (Dy)	µg/l	<0,8
Zink [Zn]	µg/l	71		Erbium (Er)	µg/l	<0,8
som 3 metalen (As,Cd,Hg) (berekend)	µg/l	14		Europium (Eu)	µg/l	<0,8
Aluminium [Al]	µg/l	150		Gadolinium (Gd)	µg/l	<0,8
Barium [Ba]	µg/l	420		Germanium (Ge)	µg/l	<4
Antimoon [Sb]	µg/l	<4		Hafnium (Hf)	µg/l	<4
Calcium [Ca]	mg/l	210		Holmium (Ho)	µg/l	<0,8
Cobalt [Co]	µg/l	28		Jodium (I)	µg/l	1500
Kalium [K]	µg/l	690000		Lanthaan (La)	µg/l	<4
Magnesium [Mg]	µg/l	160000		Lithium (Li)	µg/l	210
Mangaan [Mn]	µg/l	620		Lutetium (Lu)	µg/l	<0,8
Natrium [Na]	µg/l	810000		Neodymium (Nd)	µg/l	<4
Molybdeen [Mb]	µg/l	<8		Niobium (Nb)	µg/l	<4
Strontium [Sr]	µg/l	1500		Palladium (Pd)	µg/l	<4
IJzer [Fe]	mg/l	13		platina (Pt)	µg/l	<4
Tin [Sn]	µg/l	8		Praseodymium (Pr)	µg/l	<0,8
Vanadium [V]	µg/l	22		Rhodium (Rh)	µg/l	<4
Naftaleen	µg/l	26		Rubidium (Rb)	µg/l	430
Anthraceen	µg/l	0,29		Ruthenium (Ru)	µg/l	<4
Fenanthreen	µg/l	3,4		Samarium (Sa)	µg/l	<0,8
Fluorantheen	µg/l	0,31		Seleen (Se)	µg/l	<10
Benzo(a)anthraceen	µg/l	<0,05		Silicium (Si)	µg/l	4000
Chryseen	µg/l	<0,3		Tellurium (Te)	µg/l	<10
Benzo(a)pyreen	µg/l	<0,02		Terbium (Tb)	µg/l	<0,8
Benzo(g,h,i)peryleen	µg/l	<0,09		Thallium (Tl)	µg/l	1,8
Benzo(k)fluorantheen	µg/l	<0,02		Thorium (Th)	µg/l	<0,8
Indeno-(1,2,3-c,d)pyreen	µg/l	<0,14		Thulium (Tm)	µg/l	<0,8
Acenaftyleen	µg/l	<0,25		Titaan (Ti)	µg/l	51

Component	Unity	Value		Component	Unity	Value
Acenafteen	µg/l	3,3		Uranium (U)	µg/l	<2
Fluoreen	µg/l	2,7		Ytterbium (Yb)	µg/l	<4
Pyreen	µg/l	0,17		Yttrium (Y)	µg/l	<0,8
Benzo(b)fluorantheen	µg/l	<0,06		Zilver (Ag)	µg/l	<4
Dibenzo(a,h)anthraceen	µg/l	<0,03				