



HELCOM Guidelines for
the annual and periodical
compilation and reporting of
waterborne pollution
inputs to the Baltic Sea
(PLC-Water)


Baltic Marine Environment
Protection Commission

Monitoring & assessment



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1. Introduction

Since the establishment of the Convention for the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention) in 1974, the Commission for the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Commission or HELCOM for short) has been working to reduce the inputs of nutrients to the sea. Through coordinated monitoring, HELCOM has, since the mid-1980s been compiling information about the magnitude and sources of nutrient inputs into the Baltic Sea. By regularly compiling and reporting data on pollution inputs, HELCOM is able to follow the progress towards reaching politically agreed nutrient reduction input goals.

In 2007, the HELCOM Baltic Sea Action Plan (BSAP) was adopted by the Baltic Sea coastal countries and the European Union (HELCOM 2007). The BSAP has the overall objective of reaching good environmental status in the Baltic Sea by 2021, by addressing eutrophication, hazardous substances, biodiversity and maritime activities. The BSAP included for the first time ever a nutrient reduction scheme based on maximum allowable inputs (MAI) of nutrients to achieve good status in terms of eutrophication derived through modelled calculations by the Baltic Nest Institute (BNI) – Sweden. The plan also adopted provisional country-wise allocation of reduction targets (CARTs) to fulfil MAI.

The 2013 HELCOM Copenhagen Ministerial Declaration (HELCOM 2013) agreed on revised MAI and new CARTs that were calculated based on improved eutrophication targets and models, more complete data on nutrient inputs (produced by the PLC-5.5 project) and revised allocation principles. HELCOM Brussels Ministerial Declaration 2018 called HELCOM member states to act further to achieve national reduction requirements based on Maximum Allowable Inputs of nutrients to the Baltic Sea sub-basins.

The present document contains a revised and updated version of the guidelines that was prepared as part of the project *Seventh Baltic Sea Pollution Load Compilation (PLC-7)* covering waterborne input data during 1995-2017 and should serve to guide the Contracting Parties of the Helsinki Commission in their national monitoring and reporting of pollution inputs in order to allow for compilation of harmonized data for producing region-wide PLC assessments, and providing data for the follow-up of implementation of the HELCOM Nutrient Input Reduction Scheme. The guidelines are aligned with EU quality assurance standards and OSPAR methodologies.

Although, the PLC assessment will cover total inputs to the Baltic Sea, including inputs to the sea via the atmosphere, these guidelines focus on compilation of waterborne input data (atmospheric deposition within the Baltic Sea catchment area is included in the source apportionment of loads to inland surface waters). Atmospheric deposition of nitrogen, cadmium, lead and mercury to the Baltic Sea is assessed and reported regularly by EMEP (Co-operative Programme for Monitoring and Evaluation of Long-Range Transmission of Air Pollutants in Europe) to HELCOM.

A detailed description of the contents of these guidelines is in Chapter 2.

1.1. Aim of PLC assessments

In Article 3 and Article 16 of the Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1992 (Helsinki Convention), the Contracting Parties agreed to undertake measures to prevent and eliminate pollution of the marine environment of the Baltic and to provide pollution load data, as far as available. Compilations of pollution load data (PLC) have been an integral part of HELCOM assessment system since 1987, focusing on annual and periodic assessments of inputs of nutrients and selected hazardous substances.

The PLC assessments aim to follow up on the implementation of the Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention) by its Contracting Parties, in particular paragraphs 1 and 2 under Article 6 of the Convention:

- *The Contracting Parties undertake to prevent and eliminate pollution of the Baltic Sea Area from land-based sources by using, inter alia, Best Environmental Practice for all sources and Best Available Technology for point sources. The relevant measures to this end shall be taken by each Contracting Party in the catchment area of the Baltic Sea without prejudice to its sovereignty.*
- *The Contracting Parties shall implement the procedures and measures set out in Annex III. To this end they shall, inter alia, as appropriate co-operate in the development and adoption of specific programmes, guidelines, standards or regulations concerning emissions and inputs to water and air, environmental quality, and products containing harmful substances and materials and the use thereof.*

The 2013 Monitoring and Assessment Strategy and HELCOM Ministerial Declaration 2013 and 2018, specified by decisions of HELCOM Heads of Delegations created demands for a number of PLC products:

- HELCOM core pressure indicator on progress towards fulfilment of Maximum Allowable Inputs of nutrients (MAI);
- assessment of progress towards implementation of National Nutrient Input Ceilings;
- quantification of sources and pathways of nutrients to the Baltic Sea;
- assessment of nutrients input by major rivers;
- assessment of effectiveness of measures to reduce input of nutrients;
- assessment of input of selected hazardous substances.

The PLC products serve to follow up implementation of HELCOM BSAP and other agreements but also those Contracting Parties that are EU Member States for their river basin management plans under WFD and programmes of measures under MSFD.

The PLC utilizes monitoring data obtained in accordance with the requirements of the HELCOM Recommendations on waterborne pollution input assessment and on monitoring of airborne pollution input. It also integrates the data reported by the Contracting Parties under the Convention on Long-range Transboundary Air Pollution and its protocols as well as data obtained in the frame of the EU and national monitoring programmes.

Contracting Parties to the Helsinki Convention report data on input of nutrients into the Baltic Sea annually and periodically. Annually reported data are mainly utilized to assess nutrient load on sub-basins of the Baltic Sea and progress towards Maximum Allowable Inputs of nutrients (MAI). The data on input of selected hazardous substances are used to update Baltic Sea Fact Sheets. They might also be a part of indicators of pollution of the Baltic Sea by hazardous substances.

Periodically reported data are used for the assessment of progress towards implementation of National Nutrient Input Ceilings; apportionment of sources and pathways of nutrients; assessment of nutrients input by major rivers.

The objectives of annual and periodic waterborne pollution input compilations (PLC-Water) are to:

- Compile information on the waterborne inputs of nutrients via rivers and direct discharges to the Baltic Sea as well as from different sources in the Baltic Sea catchment area on the basis of harmonized monitoring and modelling methods;
- Compile information on the waterborne inputs of selected hazardous substances via rivers and direct discharges to the Baltic Sea;
- Follow-up the long-term changes in the pollution input from various sources by normalizing data and making trend analysis with standardized methodologies;
- Identify the main sources of pollution to the Baltic Sea in order to support prioritization of measures;
- Assess overall the effectiveness of measures taken to reduce the pollution inputs into the Baltic Sea catchment area;
- Assess total nutrient inputs from different countries to the different Baltic Sea sub-basins to identify progress towards national input ceilings;

Evaluation of effectiveness of measures requires specific reporting which is not a part of the current Guideline.

National data on inputs of nutrients are stored in the HELCOM PLC water database and publicly available after quality assurance, in accordance with HELCOM information policy.

1.2. Aims of the PLC guidelines

The aims of these guidelines are to:

- Provide a framework and serve as a tool for HELCOM Contracting Parties in national monitoring, quantification and reporting on total waterborne inputs of nitrogen, phosphorus and selected hazardous substances and their sources to the Baltic Sea to obtain a harmonized and comparable dataset covering the whole Baltic Sea region.
- Enhance the comparability, consistency and quality of the PLC data and, to the extent possible ensure harmonized practices between Contracting Parties when carrying out PLCs and when assessing PLC data for source quantification.
- Provide guidance in cases where there is a choice of methods.
- Ensure transparency, so that any differences in methods are easy to detect. This concerns cases where harmonization of practices cannot be obtained due to climatic, topographical, hydrological or other differences between Contracting Parties.
- Include contents of the annual and periodic reporting templates and detailed explanation on how to fill in templates, upload and inserted data in the PLC database and how to perform and follow-up quality assurance of inserted data.

To fulfil the evolving data requirements of HELCOM and its Contracting Parties, these guidelines according to HELCOM Recommendation 37-38/1 (2016a) should be regularly evaluated and updated by experts and adopted by the responsible subsidiary body of HELCOM.

1.3. PLC data reporting requirements

The PLC monitoring and reporting requirements reflect the data needs of HELCOM for supporting the implementation of the Helsinki Convention and the Baltic Sea Action Plan (HELCOM 2007 and HELCOM 2013), while bearing in mind also the monitoring and reporting needs of those HELCOM Contracting Parties that are also EU Member States.

According to **HELCOM Recommendation 37-38/1** “Waterborne pollution input assessment (PLC-WATER)” (HELCOM, 2016) data is to be reported by Contracting Parties to the Commission both on an annual and periodical basis:

- Annually, total inputs of nutrients and hazardous substances to the sea should be reported by quantifying inputs from monitored rivers, unmonitored areas, and point sources discharging directly to the sea (**Table 1.1**).
- Periodically (every six years unless otherwise decided by HELCOM), comprehensive waterborne pollution input assessment should be carried out to quantify, in addition to the total inputs to the sea (annual reporting), also waterborne discharges from point sources, losses from diffuse sources as well as natural background losses into inland surface waters within the Baltic Sea catchment area located within the borders of the Contracting Parties (**Table 1.1 and 1.2**).

The parameters to be reported have been agreed upon by the Contracting Parties as either mandatory or voluntary (**Tables 1.1 and 1.2**). Further, the limits of quantification/detection (LOQ/LOD) for the different parameters are taken into account when evaluating if they must be reported. See the list of definitions in Annex 1 for explanations of the terms *measured*, *calculated* and *estimated*.

Table 1.1 lists the annual reporting obligation and **Table 1.2** the additional reporting requirement besides the annual reporting during the periodic assessment.

The annual reporting requirements are further specified in Chapter 13 and more details on the additional reporting requirements for the periodical reporting requirements are given in Chapter 14. The specific annual reporting formats are included in Annex 2 and the periodical reporting formats in Annex 3.

Table 1.1. Variables to be reported within PLC-Water (annually).

Parameters	Point sources discharging directly to the Baltic Sea ⁷			Monitored rivers*	Unmonitored areas ⁵	Transboundary at the border of the Contracting Party ¹⁰
	Municipal Effluents*	Industrial Effluents*	Aqua-culture*			
BOD₅ ³	+	+ ⁹	+	v	v	v
TOC				v		
TP	+	+	+	+	+	+
P_{PO4}	+ ⁸	v		+	+	
TN	+	+	+	+	+	+
N_{NH4}	+	v		+	+	
N_{NO2} ⁴	v	v		+	+	
N_{NO3} ⁴	v	v		+	+	
Hg ¹¹	+ ²	+ ⁹		+ ¹	+ ¹	v
Cd ¹¹	+ ²	+ ⁹		+ ¹	+ ¹	v
Zn ¹¹	+ ²	+ ⁹		v	v	v
Cu ¹¹	+ ²	+ ⁹		v	v	v
Pb ¹¹	+ ²	+ ⁹		+ ¹	+ ¹	v
Ni ¹¹	+ ²	+ ⁹		v	v	v
Cr ¹¹	+ ²	+ ⁹		v	v	v
Flow	+	+	+ ⁶	+	+	+

Footnotes:

+ mandatory

v voluntary

¹ Except for rivers where heavy metal concentrations are below the limit of quantification (LOQ). If all measurements are below LOQ, then the value should be reported as zero and information provided about number of samples below the LOQ. (Those countries who do not use LOQ should replace it with limit of detection (LOD)).

² Hazardous substances are mandatory for municipal waste water treatment plants (MWWTP) larger than 20,000 population equivalent (PE).

³ If BOD₇ is measured, it will be stored in the HELCOM PLC-Water database, and for PLC assessments a conversion factor BOD₅ = BOD₇ / 1.15 will be used for converting to BOD₅.

⁴ Can be monitored and reported as the sum of oxidized nitrogen (NO_{2,3}-N).

⁵ Diffuse sources entering directly to the sea include inputs from scattered dwellings and rainwater overflows.

⁶ For aquaculture where it is relevant (outlet for discharges).

⁷ Point sources discharging directly to the Baltic Sea should preferably be reported individually, but can be reported as a sum for every Baltic Sea sub-basin for municipal effluents, industrial effluents, and aquaculture, respectively.

⁸ Should be measured or calculated.

⁹ If monitoring of the parameter is required in the permit conditions of the industrial plant

¹⁰ Surface water retention of total nitrogen (TN) and total phosphorus (TP) on transboundary inputs in the receiving catchment should be reported if updated data/information is available compared to former reported/used data.

¹¹ Might be measured as dissolved concentration as in accordance to EU Water Framework Directive (Directive 2013/39/EU of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy), heavy metals on the list of priority substances must be determined as dissolved concentrations, i.e. the dissolved phase of a water sample obtained by filtration through a 0.45 µm filter or any equivalent pre-treatment.

* In those cases where the recorded concentrations are below the LOQ, the estimated concentration should be calculated using the equation: Estimate = ((100%-A) x LOQ)/100 where A= percentage of samples below LOQ (cf. Chapter 12.7). This is according to one of the options listed in the guidance document on monitoring adopted by EU under the IE Directive. (Those countries who do not use LOQ should replace it with LOD in the equation.)

Table 1.2. In addition to the annual reporting in Table 1.1, the following data and information are also to be reported periodically for PLC-Water every sixth year unless otherwise decided by HELCOM.

Parameters	Monitored areas			Unmonitored areas			Retention (monitored and unmonitored, respectively) ⁴
	Point sources ¹	Diffuse sources ²	Natural background	Point sources ³	Diffuse sources ²	Natural background losses	
TP	+	+	+	+	+	+	+
TN	+	+	+	+	+	+	+
Hg ⁵	v			v			
Cd ⁵	v			v			
Pb ⁵	v			v			
Flow	+			+			

Footnotes:

+ mandatory

v voluntary

¹ Reported for MWWTPs, industries and aquaculture separately.

² Nutrient losses from diffuse sources can be estimated either as the total for all sources or as losses divided by individual source/pathways.

³ The point sources from unmonitored areas are to be reported individually although they can be aggregated separately for MWWTPs, industries and aquaculture (in monitored areas point sources are to be reported individually).

⁴ Preferably a separate retention value should be estimated for each pathway, otherwise a single value can be provided. See Chapter 9 for calculation of retention.

⁵ Might be measured as dissolved concentration as in accordance to EU Water Framework Directive (WFD) (Directive 2013/39/EU of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy), heavy metals on the list of priority substances must be determined as dissolved concentrations, i.e. the dissolved phase of a water sample obtained by filtration through a 0.45 µm filter or any equivalent pre-treatment.

2. Framework and approach of waterborne pollution load compilation

2.1. Overall framework

The guidelines focus mainly on nutrients but also cover quantification of total waterborne inputs of cadmium, lead and mercury, and loads of chrome, copper, mercury, nickel and zinc selected point sources (Table 1.1).

The overall structure of the guidelines is shown in **Figure 2.1**, reflecting the general framework and approach used for quantifying total waterborne inputs to the Baltic Sea and for quantifying importance of different nutrient sources. The different topics are described in separate chapters with cross-reference to other chapters to avoid repetition of information. The reporting requirements are assigned to separate chapters on annual obligations (Chapter 13) and on periodical reporting (Chapter 14), respectively. The details related to reporting sheets can be found in Annex 2 and 3.

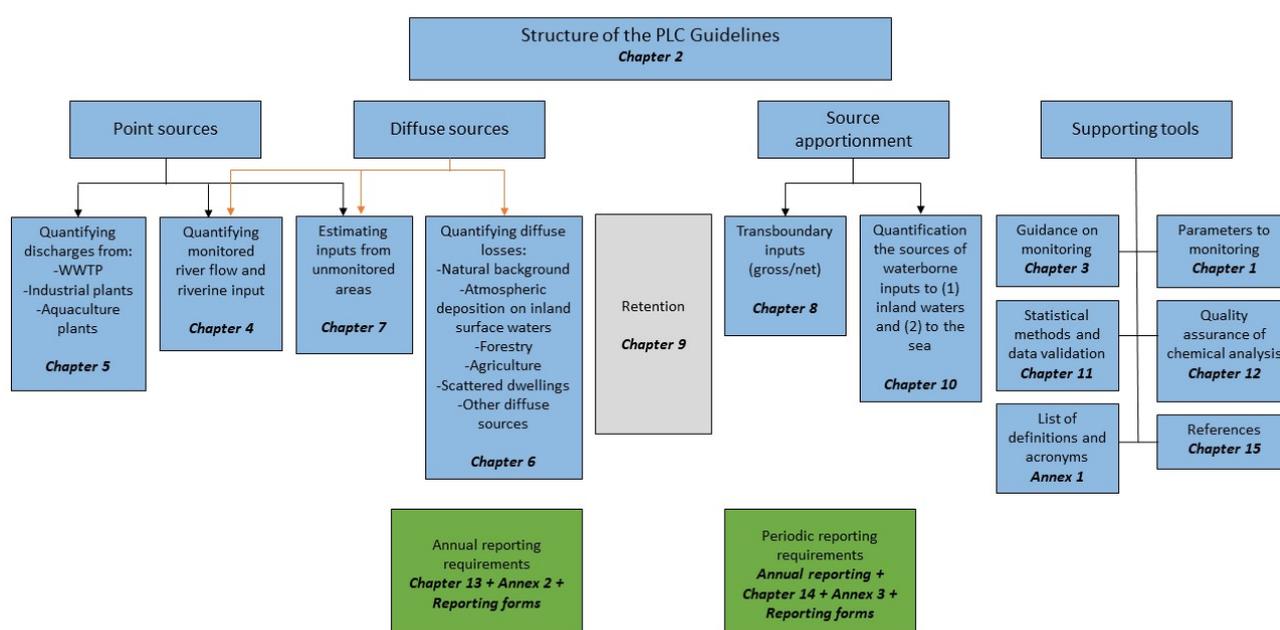


Figure 2.1. Structure of the pollution load compilation (PLC) guidelines illustrating where different topics are scrutinized. The main definitions and abbreviations used in the guidelines are listed in Annex 1.

Retention is indicated in a grey box as it is used for quantifying transboundary inputs entering the Baltic Sea, quantification of sources entering into freshwater and for source apportionment.

2.2. Quantification of total inputs to the Baltic Sea

Contracting Parties are obliged annually to quantify and report total waterborne inputs from point and diffuse sources entering to the Baltic Sea from their catchment (HELCOM **HELCOM Recommendation 37-38/1** "Waterborne pollution input assessment (PLC-WATER)", (HELCOM, 2016a). Transboundary waterborne nutrient inputs reaching the Baltic Sea should be included in the total waterborne inputs, and the transboundary part of Contracting Parties waterborne inputs should be quantified to allow for the follow up on the progress towards reaching the country-wise allocation of reduction targets (CARTs) under the nutrient reductions scheme adopted in the 2013 HELCOM Copenhagen Ministerial Declaration (HELCOM 2013).

The total waterborne input is the sum of total riverine inputs from monitored and unmonitored areas plus the input from point sources discharging directly to the Baltic Sea (also called direct discharges) and is quantified for nutrients and selected hazardous substances per Contracting Party and per Baltic Sea sub-basin as:

$$TI_x = \sum I_x \text{ monitored rivers} + \sum I_x \text{ unmonitored areas} + \sum I_x \text{ point sources discharging directly to the sea} \quad (2.1)$$

where

TI_x is total waterborne inputs (I) of the substance x from a country.

The objective is to provide estimates that are as exact as possible, of the total waterborne inputs entering the Baltic Sea sub-basins including estimates of the share of transboundary waterborne nutrient inputs entering the Baltic Sea. Further, the objectives are to quantify total inputs of selected hazardous substances.

2.3. Quantifying sources of waterborne nutrient inputs to the Baltic Sea

Contracting Parties are obliged to periodically (every six years) quantify and report nutrient discharges from point sources, and nutrient losses from natural and anthropogenic diffuse sources into inland surface waters within monitored and unmonitored catchment areas of the Baltic Sea located within their borders. Further, the Contracting Parties are obliged to periodically quantify and report the sources of the total nutrient inputs entering the Baltic Sea taking into account the retention in inland surface waters. Quantification of sources of inputs is explained in Chapters 5 and 6, and quantification of transboundary loads in Chapter 8.

Two source quantification approaches are described in Chapter 10:

- Quantifying the total gross loads from point sources, diffuse sources and natural background losses into inland surface waters within the whole Baltic Sea catchment area is important to get a comprehensive overview of the total loading originating in the Baltic Sea catchment area and the nutrient sources behind these inputs. This is called the “source oriented approach”.
- Quantifications of the sources of the total waterborne nutrient inputs to the sea are used for assessing the main sources of waterborne nutrient inputs to the sea, and to evaluate the resulting effects of land-based measures for reducing waterborne nutrient inputs (to the sea) taking into account the importance of inland surface water retention. This is called the “load oriented approach”.

Examples of different point and diffuse sources and pathways for nutrients (and heavy metals) to inland surface waters and waterborne inputs to the sea are shown in **Figure 2.2**. The Contracting Parties are not obliged to quantify all the pathways, only the (major) point and diffuse sources described in Chapters 5 and 6. **Figure 2.3** illustrates how different sources add nutrients to inland surface waters and how retention in the waters of the catchment area removes and/or retains nutrients.

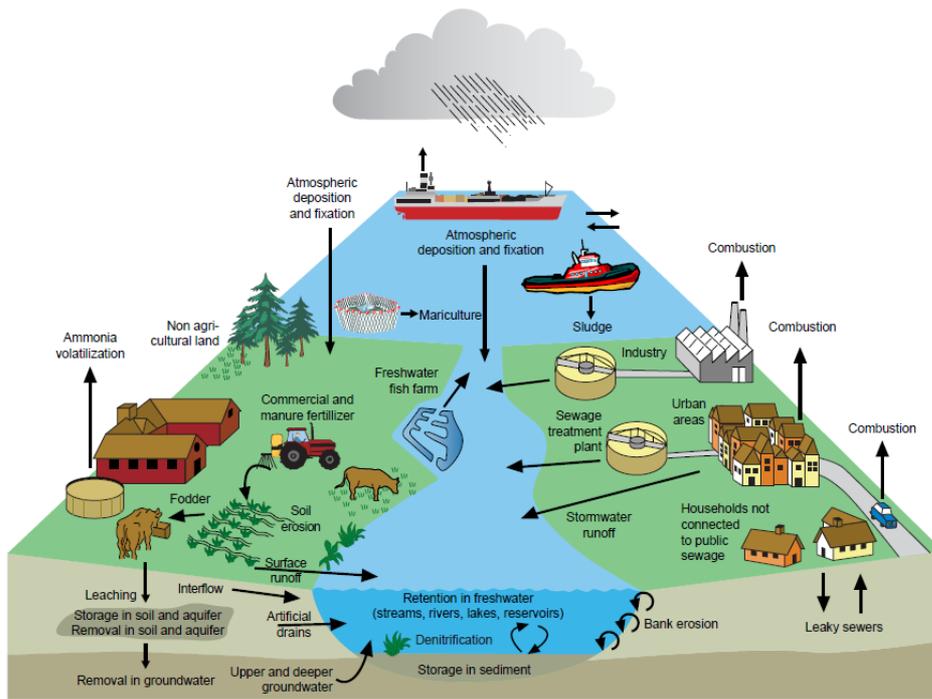


Figure 2.2. Sources and pathways of nutrients (and heavy metals) to the marine environment. Some of the arrows are only of relevance for one of the nutrients e.g. combustion and ammonia volatilization (nitrogen). For the atmospheric compartment, atmospheric deposition on surface inland waters is included in inputs from diffuse sources and only airborne inputs on inland surface waters are included in the PLC guidelines. (Airborne emissions and deposition to the sea are covered in EMEPs annual reports and fact sheets on airborne inputs, cf. Annex 7)

Retention is the removal of e.g. nutrients in surface waters of river systems including lakes, flooded riverbanks and wetlands caused by biological, chemical and physical processes (**Figure 2.3**). As a proportion of the nutrients entering inland surface water is retained or removed, retention must be taken into account when e.g. evaluating sources for total waterborne inputs to sea and quantifying net contribution of riverine transboundary inputs. Chapter 9 deals with retention in inland surface waters.

2.4. Supporting tools

The guidelines also include chapters regarding:

- An overview of the parameters to monitor (Chapter 1)
- Guidance on how to take and handle water samples in rivers, and to monitor river flow and discharge from some point sources (Chapter 3)
- Statistical methods for assessing PLC data (estimating uncertainty, normalization, trend analysis etc.) and how to handle data gaps and outliers (Chapter 11)
- Minimum quality assurance expected by the Contracting Parties, inter-laboratory comparison test, recommended limits of quantification (Chapter 12)
- List of definitions and acronyms, detailed instructions on reporting sheets and on reporting and making quality assurance using the PLC WEB-application, a short description of used methodology to quantify atmospheric deposition in the Baltic Sea etc. (Annexes 1-7).

Some of the statistical methods included in the guidelines serve as guidance for elaborating PLC assessments. They will be performed in a uniform way within the HELCOM PLC data processing framework, and Contracting Parties are not required to make these calculations (further specifications are given in Chapter 11).

2.5. Basic definitions

Figure 2.4 illustrates the definitions of catchment areas, monitored areas, unmonitored areas, direct and indirect point sources and transboundary inputs (see the list of definitions and acronyms contained in Annex 1).

Monitored areas are the catchment area upstream of the river monitoring station. The chemical monitoring decides the monitored area in cases where the locations of chemical and hydrological monitoring stations do not coincide (see Chapter 4.2).

Unmonitored areas are any part of sub-catchment(s) located downstream of the (riverine) chemical monitoring point within the catchment and further all unmonitored catchments; e.g. unmonitored part of monitored areas.

Catchment area is any area of land where precipitation collects and drains off into a common outlet such as into a river, bay or other body of water. The catchment to the Baltic Sea is divided in catchment areas to each Baltic Sea sub-basin (c.f. **Figure 2.5**) and each of these catchments are divided in several sub-catchments (cf. **Figure 2.6**)

Sub-catchment is a portion of a catchment as e.g. the corresponding catchment to each monitoring station or the unmonitored area river of a catchment.

Sub-basin are the sub-division units of the Baltic Sea: the Kattegat (KAT), The Sound (SOU), Western Baltic (WEB), Baltic Proper (BAP), Gulf of Riga (GUR), Gulf of Finland (GUF), Archipelago Sea (ARC) Bothnian Sea (BOS) and Bothnian Bay (BOB). The whole Baltic Sea is abbreviated BAS. Cf. Figure 2.5

Direct point sources are municipal wastewater treatment plants, industrial plants and aquaculture plants discharging directly into the Baltic Sea. Further, it includes marine aquaculture plants situated and discharging in marine waters.

Indirect point sources are municipal wastewater treatment plants, industrial plants and aquaculture plants discharging (defined by location of the outlet) into the monitored or unmonitored part of the catchment area thorough one or several outlets.

A river that has its outlet to the Baltic Sea at the border between two countries is considered a **border river**. For these rivers, the inputs to the Baltic Sea are divided between the countries in relation to each country's share of total load.

A transboundary river has its outlet to the sea situated in one country, but is receiving transboundary inputs from one or several upstream countries. Chapter 8 includes a list of the transboundary rivers where Contracting Parties should quantify the proportion of transboundary inputs. In some cases, a river is both border and transboundary, as shown for Nemunas in **Figure 8.1**.

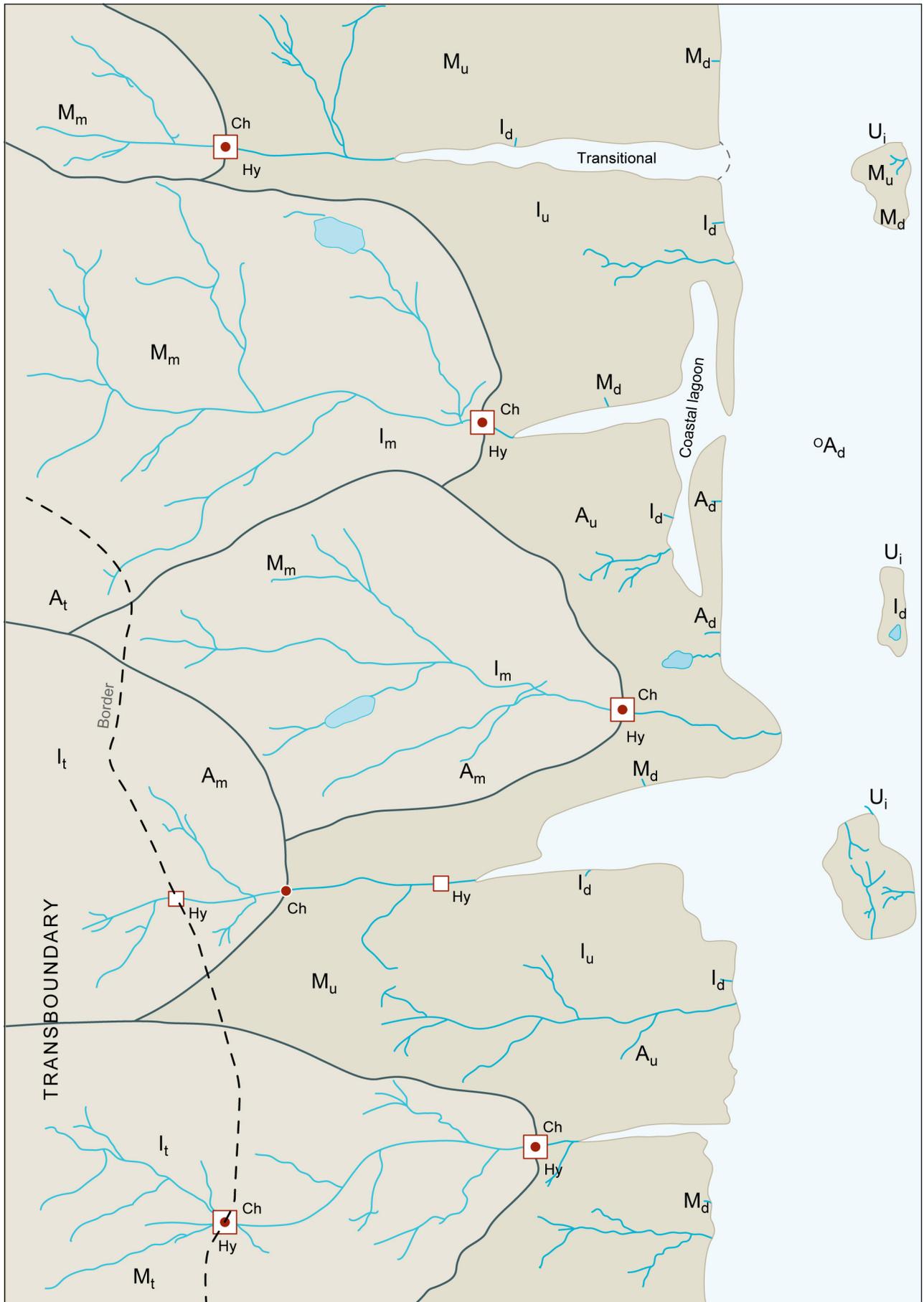


Figure 2.4. Illustration of some key definitions used in these guidelines – see also Annex 1 “List of definitions and acronyms”. Sub-catchment to monitoring stations shown with black bold curved lines. **I=Industry, M=MWWTPs municipal wastewater treatment plants, A=aquaculture, U_i = unmonitored island, Hy=hydrographic monitoring station, Ch=Chemical monitoring stations, u=unmonitored, m=monitored, t=transboundary, d= direct inputs (point sources).**

2.6. Division of the Baltic Sea catchment area

In order to take into account the harmonization process within HELCOM and the assessment products dealing with pollution inputs and their effect in the marine environment, the Baltic Sea is divided into the sub-basins listed in **Table 2.1**. An overview of the entire Baltic Sea catchment area and the catchment areas to the sub-basins of Baltic Sea are presented in **Figure 2.5**.

Table 2.1. Sub-catchment of the Baltic Sea catchment area for which data have to be reported.

No.	Sub-basins	Abbreviation
1	Bothnian Bay	BOB
2	Bothnian Sea	BOS
3	Archipelago Sea	ARC
4	Gulf of Finland	GUF
5	Gulf of Riga	GUR
6	Baltic Proper	BAP
7	Western Baltic	WEB
8	The Sound	SOU
9	The Kattegat	KAT

To enable for assessments the input figures must be collected and reported separately for the catchment to each sub-basin by each Contracting Party. A GIS shape file of the sub-basins of the Baltic Sea and sub-catchments of the Baltic Sea catchment area can be downloaded via the [HELCOM Map and Data Service](#).

In relation to assessment of the BSAP nutrient reduction scheme (e.g. of progress in fulfilling MAI and CART) the following sub-basins are reported aggregated:

- Archipelago Sea included as a part of Bothnian Sea (BOS)
- The Sound and Western Baltic as Danish Straits (DS)

The main part of the catchment to the Baltic Sea is monitored and it is mainly minor rivers and areas close to the sea that are unmonitored (**Figures 2.6 and 2.7**).

The distribution of monitored and unmonitored areas as well as spatial borders of sub-catchments might be changed in case of changing of national monitoring programmes or location of monitoring stations. Spatial data on monitored and unmonitored sub-catchments are to be updated contemporary with periodic reporting. Requirements for the spatial data are given in the Chapter 14.

Upstream parts of the catchments located within the borders of countries without the river outlet to the sea are transboundary sub-catchments (fig 2.8). There are also rivers which are borders between countries these border rivers also divide the river basin to sub-catchments (Figure 2.8).

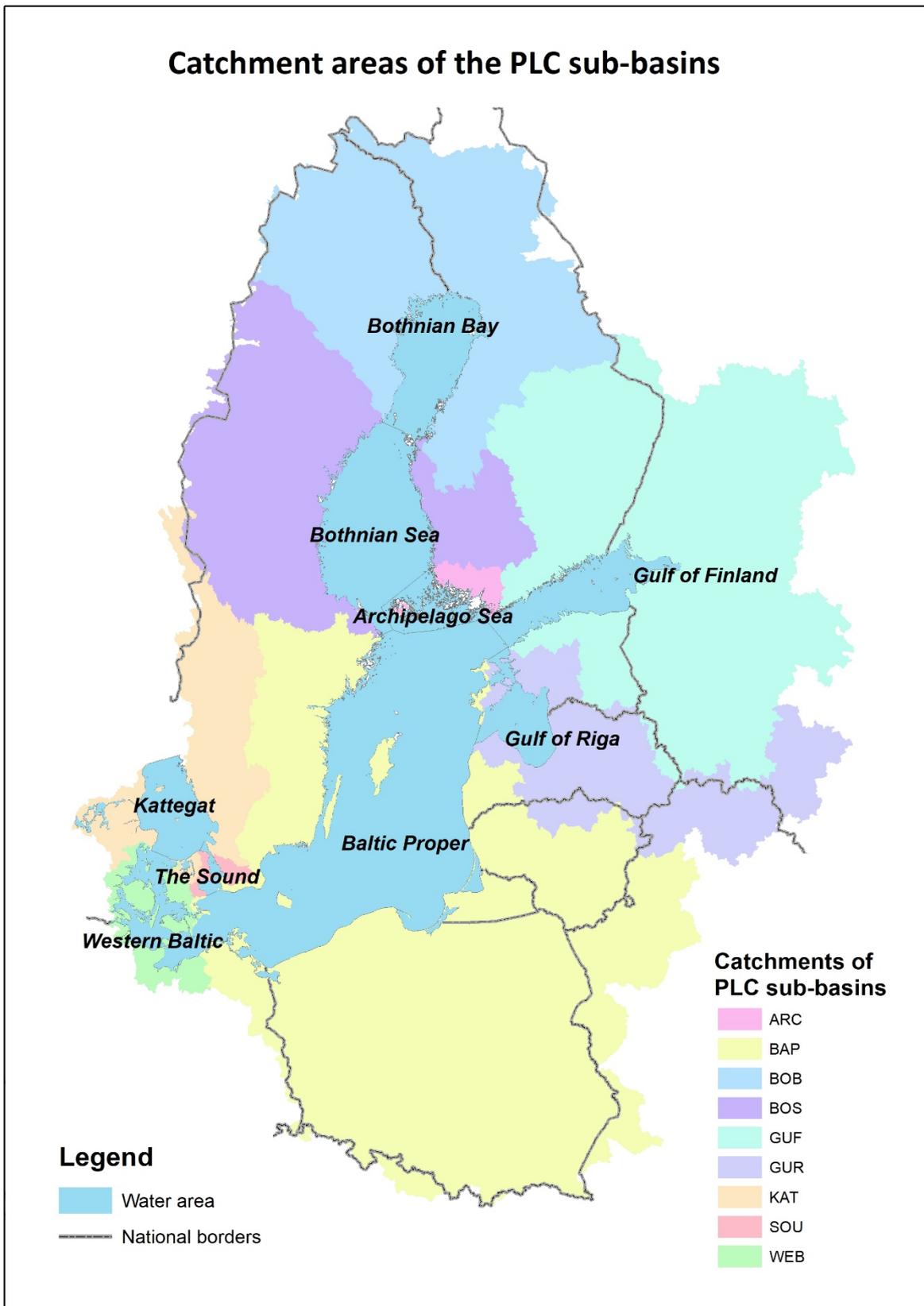


Figure 2.5. Catchment areas of the Baltic Sea sub-basins as defined for PLC-Water.

Baltic Sea catchment and PLC subcatchment

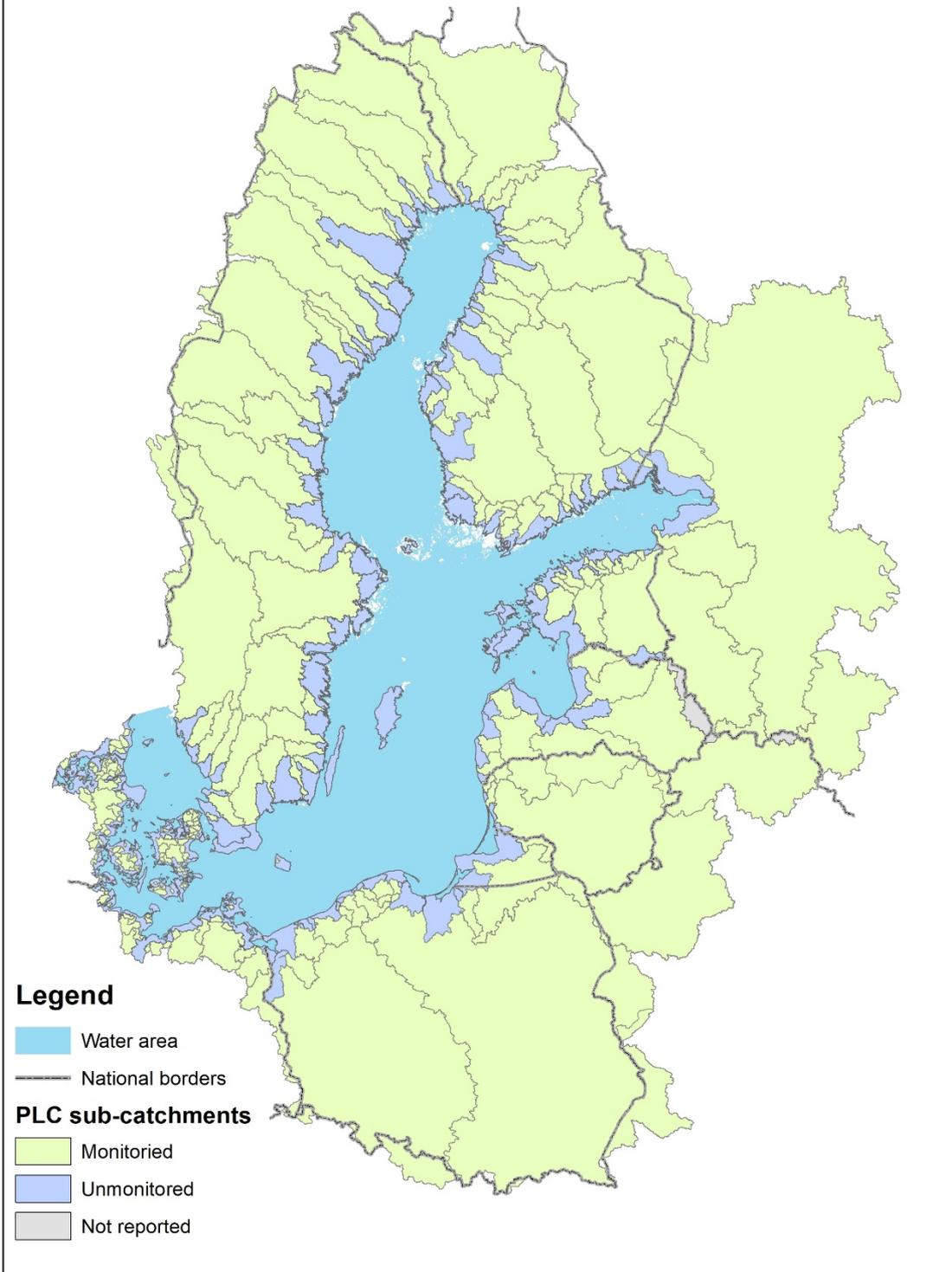


Figure 2.6. Monitored and unmonitored areas in the HELCOM countries. The figure includes transboundary catchments and the catchment area located outside the HELCOM countries.



Figure 2.7. Close up of Danish, German, western Poland and southern Swedish monitored and unmonitored areas.

Border rivers and transboundary sub-catchments

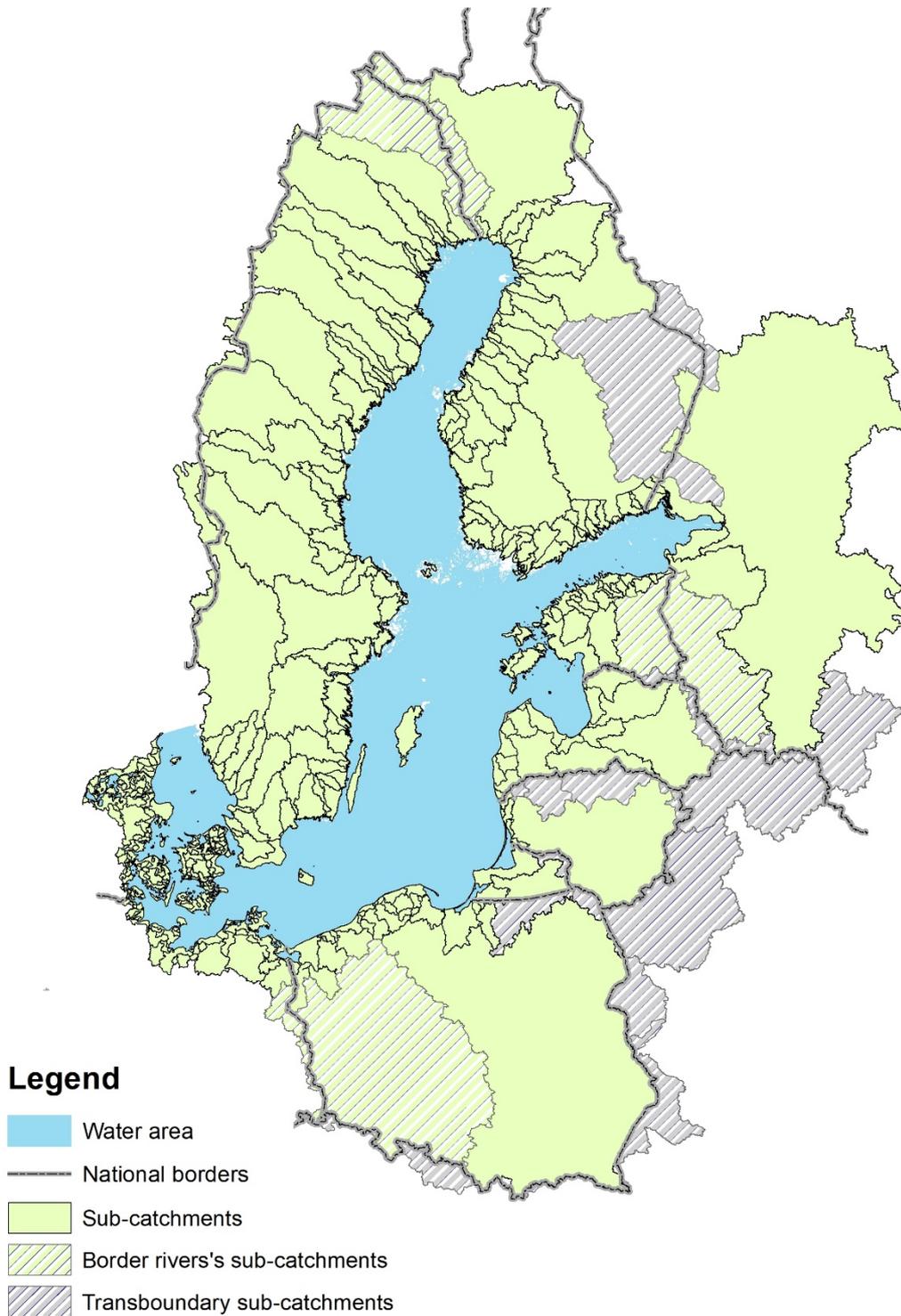


Figure 2.8. Border rivers and transboundary sub-catchments.

3. Guidance on monitoring

This chapter gives guidance on how to monitor riverine and wastewater flow as well as how to take and handle water samples in rivers, municipal wastewater treatment plants and industrial plants.

3.1. Flow measurements

3.1.1. Riverine flow measurements

For rivers with riverine water level and flow (velocity) measurements, the location of permanent hydrological stations (if any), measurement equipment, frequency of water level and flow measurement should at least follow the World Meteorological Organization (WMO) Guide to Hydrological Practices ([WMO-No. 168, 2008](#)) and national quality assurance (QA) standards. See also Chapter 3.1.2. on requirements of monitoring water flow.

Rivers with long-term mean flow rates $> 5 \text{ m}^3\text{s}^{-1}$ should be monitored regularly (at least 12 times per year). For part of the Baltic Sea catchment it is necessary also to include rivers with long-term mean flow rates $< 5 \text{ m}^3\text{s}^{-1}$ in the regularly monitoring, to reduce the proportion of unmonitored area. In general, the frequency of flow measurement should as a minimum correspond to the sampling frequency for the determination of the load and be carried out at least 12 times per year.

Preferable the discharge (or at least the water level) should be monitored continuously and close to where chemical samples are taken. If the discharges are not monitored continuously the measurements must cover low, mean and high river flow rates, i.e. they need not necessarily to be done at regular intervals, but should as a minimum reflect the main annual river flow pattern. A relation between discharge and water level should be established based on the regular discharge measurement in order to calculate daily flow in the river. Continuously controlled and regularly calibrated equipment (e.g. current meters) and carefully performed measurements together with an accurate calculation can diminish errors.

3.1.2. Wastewater flow measurements

The accuracy of the wastewater flow measurements in municipal sewage systems and industrial plants are in many cases of a considerable lower quality than can be expected. Measurement errors of more than 20% are not unusual. However, the accuracy can be improved by increasing the awareness of the types of errors, by elimination of these errors and by continuous maintenance of the measurement system and its accuracy. A relative error less than 5%, which can be achieved by most of the methods used in open and closed systems, should be the target in each case.

An open flow measurement system includes channels, flumes and weirs, e.g. Venturi- and Parshall channels/flumes and Thompson (V-notch) weirs. In closed systems the measurement takes place in pipes using different kind of flow meters, e.g. ultrasonic (Acoustic -Doppler) and electromagnetic meters. Most of these available methods are reliable if properly used and can be recommended for the wastewater flow measurement. In this chapter only some general instructions related to the flow measurement and improvement of its accuracy are presented. More detailed information can be obtained from numerous standards (e.g. ISO-/DIN-standards), guidelines and handbooks (e.g. [WMO-No. 168, 2008](#)) that deal with flow measurement methods, the theory and prerequisites of them, as well as possible sources of error, calibration methods etc.

A flow measurement system should be chosen so that continuous measurement and registration of wastewater flow can be carried out. In addition to the instant flow recorder the system should have a totalizer to give the cumulative flow. Otherwise the system should be chosen on the basis of good accuracy and reliability.

The whole flow measurement system (waterways plus measurement devices) should be planned carefully as well as built and installed exactly according to dimensions, prerequisites and guidelines of the chosen system/method. Old systems should be checked thoroughly from time to time. Observed errors should be corrected; if this is not possible, a new accurate system should be applied.

The measurement system/equipment should be calibrated on-site (in the real measurement conditions). The calibration should be carried out by using an independent method/system that is accurate (relative error preferably less than $\pm 2\%$). The accuracy of the calibration should be possible to estimate in each calibration. The calibration should be repeated from time to time e.g. once per 1-2 years. If the system is stable the calibration frequency can be reduced and vice versa.

In order to maintain continuously a good accuracy and reliability of the measurement system, waterways and devices have to be cleaned and the function of them checked regularly. For example, in the case of Venturi-channels and overflow weirs, the correctness of the water level measurement should be checked daily.

The above mentioned principles for selection of flow measurement systems, and for calibration and control of systems are valid for treated and untreated wastewater. However, the untreated wastewater outflow is often not measured with stationary measurement systems. In these cases, the flow has to be estimated, e.g. on the basis of the water consumption.

3.2. Sampling strategy for water samples: site selection and sampling frequency

3.2.1. Riverine water sampling

The sampling strategy for water samples should be designed on the basis of historical records and cover the whole flow cycle (low, mean and high river flow). It is important to cover periods of expected high river flow, if continuous monitoring is not performed. It is known that in general there is a positive (but not necessarily linear) correlation between periods of high river flow and high concentrations, especially for substances transported in connection with particles as suspended solids, e.g. some nutrient species and some heavy metals. Sampling should therefore be done at different high flow conditions as hysteresis effects may occur. For all monitored rivers a minimum of 12 samples should be collected over a year in order to estimate the annual input load (Rönback et al. 2009, Ekholm et al 1995, and Rekolainen et al. 1995). The samples do not need to be collected at regular intervals, but at a frequency that appropriately reflects the expected river flow pattern. This is particularly important if only 12 samples are taken annually and there is a marked annual variation in the flow pattern. If more samples are taken (e.g. 18, 26 or more) and/or the flow pattern does not show significant annual variation, the samples can be more evenly distributed over the year. Overall, for substances transported in connection with suspended solids, lower bias and better precision is obtained with higher sampling frequency (Kronvang & Bruhn 1996) – see also Chapter 11.4.

The monitoring site should be in the river stretch where the water is well mixed (such as at a weir or immediately downstream of a weir) and, therefore, of uniform quality. Pooled sampling strategy (i.e. several sub-samples are collected to make one pooled sample) is recommended where the concentration of sampled substances can change markedly within a short period, and these sub-samples can be taken either flow- or time-proportional. Otherwise discrete samples can be collected. The representativeness of the sampling points in the cross-section must be checked. The Standard ISO 5667-6 should be used. Guidelines for carrying out sampling are contained in Annex 4.

3.2.2. Wastewater sampling

There are several ISO-standards dealing in detail with the sampling of wastewater already applied by Contracting Parties. Therefore, in this chapter only the main principles of sampling are presented.

In order to get representative samples, they should be taken at points where the effluent has a high turbulent flow to ensure good mixing. If the water is not mixed properly the suspended solids and other substances may be unequally distributed in the water column, which may cause a remarkable error. The chosen sampling location should be regularly cleaned to avoid excess contamination by sludge, bacterial film etc. from the walls. Sampling frequency should be optimized taking into account the variation of flow and concentration.

3.2.2.1. Municipal wastewater treatment plants

The EC Urban Wastewater Treatment Directive (UWWTD) calls for measurements at the outlet of municipal wastewater treatment plants, with a minimum frequency of sampling according to the number of PE (Population Equivalent) connected; the monitoring of pollutants is required for municipal wastewater treatment plants with more than 2,000 PE connected (**Table 3.1**).

Table 3.1. Number of PE (Population Equivalent) connected and number of samples required regarding nutrients.

Number of PE connected	Number of samples
< 2,000 PE	4 samples or theoretical quantification when no sampling
2,000 – 9,999 PE	4 samples ¹
10,000 – 49,999 PE	12 samples
≥ 50,000 PE	24 samples

¹ If one out of the four samples fails to comply with the requirements of the Urban Wastewater Treatment Directive, 12 samples should be taken in the year that follows.

For storm water treatments plants, 4-12 samples should be taken per year.

3.2.2.2. Industrial plants

In self-controlled large point sources (e.g. pulp, paper and metal processing mills, and larger plants producing chemicals) sampling and analyses should be made 2-7 times per week. At smaller point sources a sampling frequency 1-4 times per month, or even only a few times per year at very small sources, can be considered acceptable. Samples from treated and untreated wastewater should always be taken as composite samples, which are prepared either automatically or manually. In both cases 24-hours-flow-weighted composite samples² should be the target at a well-defined point in the outlet of the industrial plant. At plants with very small wastewater discharges the sampling period of the composite samples can be less than 24 hours (e.g. 8-12 hours).

For measurements at the outlet of industrial plants, the number of samples should be

- 12 times per year if water consumption is more than 500 m³ per day,
- 4 times per year if water consumption is 50-500 m³ per day, and
- 2 samples a year if 5-50 m³ water consumed per day.

² According to the Urban Wastewater Treatment Directive (UWWTD, Council Directive 91/271 EEC, Annex 1) alternative methods may be used provided that it can be demonstrated that equivalent results are obtained.

4. Quantification of load from monitored rivers

The annual load for all monitored rivers should be determined and reported every year. For every monitored river the annual load should be calculated for the measurement site, to have a calculated figure for the monitored part of the catchment. The load from the unmonitored part of the river catchment area can either be estimated for each river individually or estimated as a part of the unmonitored areas including coastal areas for each Baltic Sea sub-basin.

For transboundary rivers the receiving (HELCOM) country with the river mouth has the obligation to carry out measurements at the lowest monitoring station of the catchment area and to report total inputs entering the sea for the monitored and unmonitored area (see Chapter 8). Furthermore, measurements of the transboundary inputs entering to the HELCOM country should be carried out at the border, and reported to the PLC database. The Contracting Parties are also encouraged to cooperate with the upstream country in order to accommodate data collection. Surface water retention within Contracting Parties receiving transboundary inputs must be calculated in order to estimate net transboundary inputs entering the Baltic Sea by Contracting Party/country. The Contracting Party receiving transboundary input has the responsibility to quantify the retention within its country on the transboundary inputs (see Chapter 9).

The quantification, division and reporting of loads at the mouths of border rivers discharging into the Baltic Sea must be coordinated by the relevant countries ensuring it is clear how the total load should be shared between these countries.

4.1. Methods for calculation of the load from monitored rivers

The objective is to obtain the total load from monitored rivers into the Baltic Sea. The calculation should be made on the basis of water quality monitoring data and hydrological observations (see Chapter 5). Additional information on methodologies is available in the WMO, Guide to Hydrological Practices, vol. 1, 2008: Practices ([WMO-No. 168, 2008](#)).

By definition, monitored rivers have river flow and concentration measurements. When both hydrological and chemical measurements are performed at the same station (hydro-chemical monitoring station), one of the calculation methods recommended below should be applied. If the hydrological and chemical observations are not performed at the same station, the river flow should be calculated to the nearest chemical station prior to the load calculation, e.g. using method proposed in Chapter 4.2.

The following annual load calculation methods (presented in order from most recommended to least recommended) should be used:

a) Daily river flow and daily concentration (interpolated)

This method utilizes linear interpolated concentration values (C_t) for days where pollutants have not been measured.

If daily river flow (monitored or modelled) on day t (Q_t) is not available, it should be estimated by linear interpolation between day with river flow data.

Concentrations C to day t of a substance are denoted:

$$C_t \quad t = 1, 2, \dots, n.$$

When the linear interpolation is made (for concentrations and/or discharge), the last measurements from the previous year and the first measurements from the following year should be used when available.

When daily concentrations and discharges have been calculated, then the annual load is estimated by:

$$L = 0.0864 \sum_{t=1}^n (Q_t \cdot C_t)_t \quad (4.1)$$

\sum = denotes summation

n = number of days

L = annual load (kg a⁻¹)

C_t = concentration day t (mg l⁻¹ for nutrients, and µg l⁻¹ for hazardous substances)

Q_t = river flow (l s⁻¹)

The estimate in the equation is multiplied by 0.0864 for nutrient to obtain the daily loads that are summarized in the equation over the whole year and by 0.0000864 for hazardous substances.

b) Mean monthly concentration and monthly river flow

Annual load is calculated as:

$$L = 1/1000 * \sum_{i=1}^{12} W_i * C_i \quad (4.2)$$

L = Annual load (kg a⁻¹)

W_i = volume of monthly river flow (m³) in month i ;

C_i = mean monthly concentration (mg l⁻¹) in month i ;

When concentration is in µg l⁻¹ (hazardous substances) equation 4.2 must be divided with 1,000,000.

c) Daily river flow and daily concentration regression

Annual load is calculated as:

$$L = m \sum_{i=1}^n Q_i * C_{ri} \quad (4.3)$$

Concentration is calculated from regression:

$$C_{ri} = \frac{a}{Q_i} + b + c * Q_i \quad (4.4)$$

L = Annual load (kg a⁻¹)

Q_i = daily river flow day i (measured) (l s⁻¹);

C_{ri} = the regression value of the concentration for day i in (mg l⁻¹);

m = conversion factor of units (0.0864 with concentration in mg l⁻¹ (nutrients) and 0.0000864 with concentration µg l⁻¹ (hazardous substances);

a,b,c = coefficients typical of each quality parameter, observation station and time series;
n = number of days per year

This calculation using daily regression should only be applied if there is a good relationship between the specific compound and the daily river flow.

4.2. Methods for estimating the water flow for rivers where chemical and hydrological stations are not located at the same place

For rivers where chemical and hydrological stations are not located at the same place there are different methods to estimate the water flow at the chemical monitoring station for use in load calculations. For instance, there are sophisticated models using Geographic Information system (GIS). However, most such models are region-specific and have to be tested before they can be applied to other regions. A simpler methodology, that might be applied when the proportion of catchment area between the hydrological and chemical stations is low, is to extrapolate (area proportional) the water flow from the hydrologically monitored part to the unmonitored catchment area. When extrapolating to catchment with hydrological monitoring stations, knowledge about the hydrological behavior of water flow of a comparable monitored catchment area should be taken into account.

If there is no developed model or experience in modelling water flow, the following extrapolation method might be used:

- The annual river flow ($\text{m}^3 \text{s}^{-1}$) should be calculated for the catchment area covered by the chemical station by multiplying the specific flow ($\text{m}^3 \text{s}^{-1} \text{km}^{-2}$) at the hydrological monitoring station with the area of the chemically monitored catchment.

This method can be used for calculating monthly or annual flow, but not for daily values. For the estimation of the annual loads the same equations as in Chapter 4.1 should be used. If other methodologies are applied, information about the used methodology should be reported (cf. Annexes 2 and 3).

5. Quantification of load from point sources

This chapter covers calculation and estimation methods to quantify the load from point sources (MWWTP, industrial plants and aquaculture plants) into recipient water bodies. It should be noted that if a point source has several outlets, located in different sub-catchments, the load should be presented separately for each outlet. Details on wastewater sampling and flow measurement are provided in Chapter 3, and on reporting requirements in Chapter 13.

5.1. Municipal Wastewater Treatment Plants (MWWTP)

The wastewater outflow should be measured continuously (at least for plants > 10,000 PE) in order to calculate the total volume in a certain time period (day, month, and year). Furthermore, the wastewater samples should be taken frequently as flow-weighted composite samples. If that is not possible, the monitoring programme has to be optimized (see Chapter 3 for details concerning wastewater monitoring and sampling). Annual discharges should be calculated as the product of annual total quantity of wastewater and flow-weighted concentrations; the three ISO standard methods below (a, b and c) are examples of such quantification procedures. Where there is no reliable monitoring method, the load may be derived from per capita load estimates (d).

a) Continuous flow measurements and sampling (e.g. 24 hours' flow-weighted composite samples 7 times/week)

The annual load in kg a⁻¹ is the cumulative load of continuously monitored time periods and can be calculated as follows:

$$L = \sum_{i=1}^n Q_i * C_i * 0.001 \quad (5.1)$$

L = annual load (kg a⁻¹)

Q_i = wastewater volume of period i (m³)

C_i = flow weighted concentration of period i (mg l⁻¹ for nutrient and µg l⁻¹ for hazardous substances)

n = number of day in the year

When concentration is in µg l⁻¹ (hazardous substances) equation 5.1 must be divided with 1,000,000.

b) Continuous flow measurement and non-continuous sampling every second day, once a week or twice a month (preferably as 24 hour composites)

The annual load can then be calculated as follows:

$$L = \frac{\sum_{i=1}^n Q_i * C_i}{\sum_{i=1}^n Q_i} * Q_t * 0.001 \quad (5.2)$$

L = annual load (kg a⁻¹)

Q_i = wastewater volume of period i (m³)

C_i = concentration of sample i (mg l⁻¹ for nutrient and µg l⁻¹ for hazardous substances)

Q_t = total wastewater volume of the year in m³

n = number of sampling periods

When concentration is in µg l⁻¹ (hazardous substances) equation 5.1 must be divided with 1,000,000.

c) Flow measurement only on sampling days and sampling rather seldom i.e. 1–12 times per year

In this case the annual load can be calculated by multiplying the average load of sampling days by 365, as follows:

$$L = \frac{\sum_{i=1}^n Q_i * C_i}{n} * 365 * 0.001 \quad (5.3)$$

L = annual load (kg a⁻¹)

Q_i = wastewater volume on sampling day i (m³)

C_i = concentration on sampling day i (mg l⁻¹ for nutrient and µg l⁻¹ for hazardous substances)

n = number of sampling days

When concentration is in µg l⁻¹ (hazardous substances) equation 5.1 must be divided with 1,000,000.

d) Load estimate of small MWWTPs (<2,000 PE) and for untreated sewage discharges without reliable monitoring

If no reliable monitoring has been done for small MWWTP (<2,000 PE) or for untreated sewage discharges and only population data (PE) are available, the load may be derived on the basis of the below per capita load estimates:

- BOD₅ 1 PE = 60 g O₂/day (70 g O₂/day for BOD₇)
- TN 1 PE = 12 g N/day
- TP 1 PE = 2.7 g P/day

However, countries should use their own estimates if more specific data on the local conditions are available. These estimates, including the calculation methods used, must be reported (see chapter 13 on annual reporting).

During storm events, combined sewers³ may not be able to treat all wastewater in the wastewater treatment plant due to heavy loads of rainwater. This may lead to either an overflow⁴ in the sewage system or that the water is discharged directly to surface water via a bypass⁵. These portions need to be quantified and the related nutrient and/or hazardous substance loads estimated.

³ Combined sewage system includes both wastewater and drainage water from paved areas et.. Control of overflows is regulated with HELCOM Recommendation 23/5.

⁴ Overflows are discharges from combined sewerage system to the water body during rainfall when the flow (mixture of sewage and rainfall runoff) in the system is over-loading the designed volume of the system. Control of overflows is regulated with HELCOM Recommendation 23/5.

⁵ By-passes are discharges from a sewerage system to the water body to prevent station treatment plant overflow damages during breaks in electricity supply or emergency repairing works. Use of by-passes is regulated with HELCOM Recommendation 16/9.

5.1.1. Separately treated drainage water from paved areas

When the drainage water from paved areas etc. are treated separately (i.e. not included in a combined sewage system), the nutrient load via the drainage water should be included among the diffuse sources as this kind of sources often do not have a distinct outlet.

5.2. Industrial plants (INDUSTRY)

Ideally, all industrial plants should have a monitoring programme. Practically it is necessary to ensure that at least the industrial plants exceeding the EU Pollutant Release and Transfer Register (E-PRTR)⁶ capacity and pollutant threshold values (in Annex I and II to the Regulation (EC) No 166/2006 on the establishment of a European Pollutant Release and Transfer Register) have an adequate monitoring programme (see Annex 6 in this report). The ultimate aim of E-PRTR is to provide comparable and transparent figures, and that the reported figures are as complete as possible.

Wherever possible, the annual discharges from industrial plants should be calculated as the product of the total quantity of wastewater in a period multiplied with the corresponding flow-weighted concentrations and summed up annually. The three ISO standard methods (a, b and c) in Chapter 5.1 are examples of such quantification procedures. For industrial plants discharging less than the E-PRTR threshold value into waters, relevant standard discharge coefficients should be used in cases where no monitoring data is available. The determination of such coefficients should be based on experience with discharges from larger plants that have monitoring programmes, taking into account of differences in the degree of internal treatment at the plants.

According to minimum reporting of E-PRTR should include plants/facilities, which have a significant impact on the environment. The significance is demonstrated by covering facilities that,

1. undertake one or more of the activities and exceed the production capacity as listed in Annex I of the E-PRTR Regulation,
2. and exceed threshold values set for the release of substances according to Annex II of the E-PRTR Regulation.

Plants/facilities that fulfil these criteria have to report data to the E-PRTR available at <http://prtr.ec.europa.eu/>. The data reported to this Register could also be reported for the use in PLC and needs not to be recalculated. For completeness and the PLC assessments, any other plant with industrial effluents entering the Baltic Sea and national catchment areas should be included in PLC reporting.

Non-EU countries applying other rules are invited to strive for good correlation to these criteria and to measurements and analytical methods complying with international standards. Source identification and reporting details are in Annex 2, 3 and 6 of these guidelines.

5.3. Aquaculture

The term aquaculture refers to the cultivation of both marine and freshwater species (e.g. fish and shellfish) in either land-based systems that discharge either to rivers and inland lakes, through direct point sources or production systems in coastal and open-marine areas. In general, fish farms are the main concern regarding

⁶ E-PRTR = The European Pollutant Release and Transfer Register is the Europe-wide register that provides easily accessible key environmental data from industrial facilities in European Union Member States and in Iceland, Liechtenstein, Norway, Serbia and Switzerland. It replaced and improved upon the previous European Pollutant Emission Register (EPER).

aquaculture as a nutrient source to the sea. On the contrary, shellfish cultures could be seen as having a net export of nutrients from the water, as the nutrient supply is from the water, and by harvesting the produced shellfish nutrients are actually removed from the system. Also some freshwater aquaculture plants can net retain e.g. phosphorus.

The main source for nitrogen, phosphorus and organic matter (measured as BOD) discharges from aquaculture is the feed supplied into the farming system. Cultivation of mussels and other species that do not use artificial feed are not covered in this guideline. Discharges of nitrogen, phosphorus and BOD are derived from uneaten feed, undigested nitrogen, phosphorus and organic matter (faeces), and excretion via gills and urine. Measures aimed at the reduction of discharges from freshwater and marine fish farming in specific, are regulated in HELCOM Recommendation 25/4 "Measures aimed at the reduction of discharges from fresh water and marine fish farming" (HELCOM 2004).

According to HELCOM Recommendation 37-3 (HELCOM, 2016) HELCOM recommends "...to make better use or establish and maintain national databases of aquaculture or water permits and monitoring data in co-operation with the aquaculture sector. A better assessment of the nutrient loads from aquaculture should be based on data collected and reported to the HELCOM PLC database...". Further in order to fulfill the objectives in the Recommendation on of the actions that should be taken "The Contracting Parties should provide information according to HELCOM Guidelines for the annual and periodical compilation and reporting of waterborne pollution inputs to the Baltic Sea (PLC-water)".

Discharges from aquaculture plants into rivers or lakes can be determined by:

1. monitoring at the outlets from these plants or
2. through calculations. Calculations can be based either:
 - (a) on records of fish (or other farmed organism) production and feed used, or
 - (b) by using feed conversion rates (FCR) combined with chemical analyses of feed and fish and taking into account removal of nutrients (and organic matter) by natural processes and sludge removal (for more information, see OSPAR 2004 and HARP NUT Guideline 2, 2004).

Quantification of discharges from fish farming plants may be based on aggregated information extracted from national registers of annual figures for relevant parameters from each individual plant. Such statistics are usually collected as part of the requirements in the discharge permits. For the quantification of discharges, the distinction is made between two main production types:

1. Plants without treatment (e.g. plants where the sludge is not collected or where the sludge is collected, but discharged to the aquatic environment without treatment); and
2. Plants with treatment (e.g. plants with permanent removal of sludge), where the N and P contents (and organic matter) in the sludge removed are quantified.

The quantification of discharges from aquaculture plants is described in the following three approaches:

1. Approach 1 is based on calculations from production parameters. The starting point is that information is available on both production and feed consumption at plant level. The quantification method is based on mass balance equations. Valid for both marine and freshwater aquaculture plants.
2. Approach 2 is based on calculations from production parameters, but only information on either production or feed is available at national level. Valid for both marine and freshwater aquaculture plants.

3. Approach 3 is based on monitoring the discharge. It is feasible for ponds or other land based production systems where the discharges are distinct point discharges (such as end of pipe/channel). The quantification of losses is also based on mass balance equations, but in this case on monitoring results. The method is valid only for freshwater aquaculture plants.

5.3.1 Approach 1 (marine and freshwater plants)

This approach forms a basis for the estimation of nitrogen, phosphorus and BOD (organic matter) discharges from aquaculture plants (Cho *et al.* 1991).

- a) For plants without treatment (sludge removal):

Phosphorus (P) or nitrogen (N) discharge to water body in kg a⁻¹ (L_{P/N})

$$L_{P/N} = 0.01 * (IC_i - GC_f) - M - T \quad (5.4)$$

where

I = amount of feed used for feeding of fish in kg a⁻¹

C_i = P or N content in feed in %

G = net growth of fish including dead fish in kg a⁻¹

C_f = P or N content in fish in %

M = nutrient losses due to metabolism in fish in kg a⁻¹

T = nutrient removal processes on the fish farm not related to sludge removal (e.g. nutrient turnover, denitrification etc.) in kg a⁻¹

BOD discharge to water body in kg a⁻¹ (L_{BOD})

$$L_{BOD} = (P_L - D) \quad (5.5)$$

where

P_L = Internal fish farm loss from fish production

$$= (686 - 1671 * F_k + 1544 * F_k^2 - 354 * F_k^3) * G \quad (5.6)$$

F_k = I/G feed quotient, i.e. feed used for producing fish during a year

I = amount of feed used for feeding of fish in t a⁻¹

G = net growth of fish including dead fish in t a⁻¹

D = area-decomposition/turnover of BOD = E_d * A (5.7)

E_d = specific decomposition/turnover in kg m⁻² a⁻¹

$$= (6.4 * F_k - 4,2) * 0.365 \quad (5.8)$$

A = water covered surface area in the fish farm (estimate of the sedimentation basin surface area and of the plant lagoon, if present) in m²

- b) For plants with treatment (sludge removal):

Phosphorus (P) or nitrogen (N) discharge to water body in kg a⁻¹ (L_{P/N})

$$L_{P/N} = 0.01 * (IC_i - GC_f) - M - T - S \quad (5.9)$$

where

I = amount of feed used for feeding of fish in kg a^{-1}

C_i = P or N content in feed in %

G = growth of fish in kg a^{-1}

C_f = P or N content in fish in %

M = nutrient losses due to metabolism in fish in kg a^{-1}

T = nutrient removal processes on the fish farm not related to sludge removal (e.g. nutrient turnover, denitrification etc.) in kg a^{-1}

S = amount of P or N removed with the sludge in kg a^{-1}

BOD discharge to water body in kg a^{-1} (L_{BOD})

$$L_{BOD} = (P_L - D) * (1 - S) \quad (5.10)$$

where

$$P_L = \text{Internal fish farm loss from fish production} = (686 - 1671 * F_k + 1544 * F_k^2 - 354 * F_k^3) * G \quad (5.11)$$

F_k = I/G feed quotient, i.e. feed used for producing fish during a year

I = amount of feed used for feeding of fish in t a^{-1}

G = net growth of fish including dead fish in t a^{-1}

$$D = \text{area-decomposition/turnover of BOD} = E_d * A \quad (5.12)$$

E_d = specific decomposition/turnover in $\text{kg m}^{-2} \text{a}^{-1}$

$$= (6.4 * F_k - 4.2) * 0.365 \quad (5.13)$$

A = water covered surface area in the fish farm (estimate of the sedimentation basin surface area and of the plant lagoon if present) in m^2

S = reduction factor for nutrient removal processes on the fish farm not related to sludge removal.

The net growth (G) of one year in equations 5.4, 5.5., 5.9 and 5.10 is calculated as the sum of i, ii, and iii below + the difference between the standing stock by the end of the year and the beginning of the year:

- i. organisms taken out of the water for slaughter (alternatively the sum of slaughter weight and slaughter offal) or sold alive (t a^{-1})
- ii. dead organisms collected during the year (t a^{-1}), and
- iii. escaped organisms (t a^{-1}).

The total nitrogen and phosphorus content in the feed may be obtained from the feed manufacturers. In order to facilitate national calculations, average figures based on the typical feed used in the catchment area may be used, but if the type(s) of feed in each individual fish farm is known ideally that information should be used. The indicative figures in **Table 5.1.a and 5.1.b** may be used if the above mentioned figures are not

available. If “moist/semi-moist feed” (higher content of water than “dry feed”)⁷ is used, the quantity of moist/semi-moist feed should be converted to the comparable amount of dry feed, as an expression of the total quantity of feed used. The total phosphorus and nitrogen content in the produced organisms can be obtained as a standard figure for each catchment area. If such figures are not available, the figures in Table 5.1 may be used.

Table 5.1.a Content of total nitrogen and total phosphorus in fish and fish feed.

	Total phosphorus content (%)	Total nitrogen content (%)
Fish (fresh)	0.4	2.5
Dry feed ¹	1.0	7.5
Semi-moist feed ²	0.5	5.0
Moist(fresh) feed ³	0.45	2.5

¹ Dry matter >80 %

² Dry matter 35-80 %

³ Dry matter <35 %

Table 5.1.b Content of total nitrogen and total phosphorus from fresh water fish farms.

	Total phosphorus content (%)	Total nitrogen content (%)
Fish (fresh) up to 800 grams	0.43	2.75
Dry feed	Max. 1.0	Max. 9.0

The calculation of treatment yield requires that the nitrogen and phosphorus content in the sludge is calculated/measured regularly (e.g. based on requirements in the discharge permits) as basis for quantification of the fraction that is removed by the sludge. If such figures are unavailable and, in the case of regular removal of sludge, an average removal of 10% N and 40% P due to decantation may be considered.

5.3.2 Approach 2 (marine and freshwater plants)

If national registers on feed use and production on individual plants are not available, national sales statistics could be used. If only statistics on production or feed used is available, an assumption of the feed conversion ratio (FCR) should be made. FCR is the ratio between weight of feed used (dry feed basis) and weight gain of the organism (production), expressed as:

$$FCR = \frac{\text{Feed used (t a}^{-1}\text{)}}{\text{Production (ta}^{-1}\text{)}} \quad (5.14)$$

The FCR is, among other things, species dependent and varies by water temperature, as the fish metabolism is temperature dependent. Hence, it is preferred to use FCRs specific for the actual catchment or region based on estimates obtained from literature or determined from experimental work. If literature values are

⁷ The water content in this feed category varies, but a general guidance can be: semi-moist feed (35-80% is dry matter), moist feed (< 35% is dry matter), while a dry feed has > 80% dry matter.

used, the report should include a literature reference. If no values from literature or experimental work are available the following standard figures are recommended:

- FCR=1.1 for big fish over 0.8 kg (although use 3.0 for mother fish),
- FCR=0.8-1.0 for fish between 30 g and 800 g,
- FCR=0.6 for fingerlings.

The figures are obtained from salmonid fish production under optimal growth conditions. Other figures should be used for other fish. When FCR is available for the catchment/region to be reported on, the missing figures of feed used or production may be estimated from the above-mentioned equation (equation 5.14). Approach 1 can then be followed for the quantification of the discharge.

5.3.3. Approach 3 (freshwater plants only)

For land-based aquaculture systems such as artificial ponds, basins and raceways, the nitrogen and phosphorus discharges may be quantified by monitoring the nitrogen and phosphorus concentrations and the water flow in the inlet(s) and outlet(s) of the production system, followed by a mass balance calculation of the increased discharge. The discharge of nitrogen and phosphorus (and organic matter) from a production system may vary considerably over both the short and long timescale and depend, *inter alia*, on operational factors such as standing stock, application of feed, feed quality, time of feeding, time of cleaning operations, the presence of different purification tools and their effectiveness (e.g. plant lagoons are less effective during a cold winter), as well as on the natural variation in the inlet(s) water quality. The effluent monitoring strategy must reflect this variation.

All fish farming (or other aquaculture) plants with an annual production of more than 200 tonnes should, ideally, take as a minimum 12 contemporary samples a year in the inlet(s) and the outlet(s) for measurements of nitrogen and phosphorus concentrations.

In order to ensure a reliable quantification, sampling of water for analyses of nitrogen and phosphorus (and organic matter) should be flow-proportional over at least 24 hours and be carried out using automatic samplers.

Further, at least flow in inlet(s) and outlet(s) should be monitored on sampling days, but ideally monitored continuously providing daily water intake and outflow.

Good international laboratory practices, aiming at minimizing the degradation of samples between collection and analysis should be applied. The water flow should be registered continuously. Flow measurements should preferably be performed according to international standards (e.g. ISO standards).

The annual load of inlet(s) and outlet(s) may be calculated as follows:

$$L = \frac{\sum_{i=1}^n Q_i * C_i}{\sum_{i=1}^n Q_i} * Q_t * 0.001 \tag{5.15}$$

L = annual load (kg a⁻¹)

Q_i = wastewater volume of the period I (m³)

C_i = concentration of sample I (mg l⁻¹ for nutrients or µg l⁻¹ for hazardous substances)

Q_t = total wastewater volume of the year

n = number of sampling periods

When concentration is in $\mu\text{g l}^{-1}$ (hazardous substances) equation 4.2 must be divided with 1,000,000.

The total load of nitrogen, phosphorus or organic matter (or hazardous substances) from the production system is calculated by deducting the corresponding loads in the inlet(s) from the total nitrogen or phosphorus load in the outlet(s).

If flow and concentrations in inlet(s) to and outlet(s) from aquaculture plants are monitored regularly the method "*Daily river flow and daily concentration (interpolated)*" in Chapter 4.1 should be used (Eq. 4.1).

6. Quantifying diffuse losses of nutrients

Diffuse sources of nutrients are defined as any source of nutrients not accounted for as a point source. Within the periodic PLC-Water, quantifications of natural background and major diffuse anthropogenic nutrient losses to inland surface waters and to the sea are required (Chapter 14). In the annual reporting, the diffuse inputs are included in the total inputs from monitored rivers and unmonitored areas (cf. Chapter 13).

6.1. Quantification of the natural background nutrient losses

Procedures for the periodic quantification of natural nitrogen and phosphorous background losses into inland surface waters are described below. Natural background losses cover:

- Losses from unmanaged land; and
- Part of losses from managed land that would occur irrespective of anthropogenic, e.g. agricultural, activities.

Hence, the natural background losses are a part of the total diffuse losses. The Contracting Parties can use two different approaches or a combination of the approaches to estimate natural background losses:

- Monitoring of small unmanaged catchment areas without or with very minor inputs from point sources, and/or
- Use of models.

When background losses are estimated by models it is assumed that the anthropogenic surplus is zero, implying e.g. that the prevailing atmospheric nitrogen deposition needs to be taken into consideration.

Natural background losses of nutrients are monitored in several countries. The figures given in **Table 6.1** are related to the period 1990-2000 besides data from Denmark that covers 1989-2014. They are obtained from forested catchment areas and/or catchment areas with very low human impact (with the exception of the impact of atmospheric deposition).

Table 6.1. Annual natural background losses and flow-weighted concentrations of nutrients as reported by Contracting Parties.

Country	Total Nitrogen in kg ha ⁻¹	Total Nitrogen in mg l ⁻¹	Total Phosphorus in kg ha ⁻¹	Total Phosphorus in mg l ⁻¹	Flow in l (s · km ²) ⁻¹
Denmark	2.64±0.31 ²	1.25±0.08 ³	0.086±0,011 ²	0.046±0.002 ³	6.19±0.61 ¹
Estonia	3.3	1.1	0.12	0.04	
Finland	0.7-2.0		0.03-0.7		
Germany	1.23	0.733	0.061	0.036	
Latvia			0.11		
Lithuania	0.6-1.2	0.32-0.8	0.02-0.08	0.05-0.09	6.6
Poland	1.5		0.1		
Sweden		0.33-2.8		0.013-0.065	

¹ The average of median monitored values for 24 years (1989-2012) ± 2 SE (SE is the standard error, and the expressions corresponding to the 95% confidence interval) in seven small catchments without or with very low human activities.

² The average of median monitored values for 21 years (1989-2009) ± 2 SE in seven small catchments without or with very low human activities.

³ The average median monitored values for 26 years (1989-2014) ± 2 SE in six small catchments without or with very low human activities.

6.2. Quantification of nutrient losses from diffuse anthropogenic sources

Diffuse anthropogenic nitrogen and phosphorus losses from the following sources should be considered in the quantifications:

- Agricultural land,
- Managed forestry and other managed land,
- Atmospheric deposition directly on inland surface waters,
- Scattered dwellings,
- Rainwater constructions (e.g. paved surfaces without a distinct outlet).

Whereas point sources are discharging into inland surface waters or directly to the sea with a defined outlet, losses from diffuse sources may be delivered via a number of different pathways into inland surface waters (in monitored and unmonitored areas). Small, dispersed point source discharges e.g. from point sources in agriculture (e.g. farmyards) should also be dealt with as diffuse sources as long as they do not have a distinct and monitored outlet (in which case, they would instead be treated as a point-source). The pathways to inland waters are characterized by different flow characteristics and include very different processes (see **Figure 2.2**). Depending on the land use, losses of phosphorus and nitrogen can vary substantially. PLC-Water defines and considers the following seven diffuse pathways:

- Surface run-off,
- Erosion,
- Groundwater,
- Tile drainage,
- Interflow⁸,
- Atmospheric deposition on inland surface waters,
- Scattered dwellings,
- Rainwater constructions.

A large number of removal, storage or transformation processes may influence the final quantities of nitrogen and phosphorus entering inland surface waters. Knowledge about these processes of transformation and retention within inland surface waters is necessary to quantify and to predict nutrient losses into river systems in relation to their sources.

The different loss processes and pathways are very complex and variable including in time and regionally catchments, and the significance of their effects also varies between nitrogen and phosphorus. It is therefore difficult to quantify diffuse losses in a consistent and accurate way. The PLC-Water guidelines are not including a specific methodology for quantifying diffuse sources or delivery pathways. However, countries quantifying nutrient diffuse losses should as a general rule quantify direct losses into surface water bodies (not at root zone or other media). Surface water bodies ideally should be the same as in the national River Basin Management Plans. There are many different methodologies, e.g. OSPAR HARP-NUT Guideline 6 on diffuse sources (OSPAR 2007; only existing as a draft version that has not been finalized). In the absence of comprehensive measurements, it is necessary to apply calculation methodologies (e.g. various modelling techniques).

⁸ Substance transport within the vadose zone, i.e. unsaturated soils above the groundwater table.

6.2.1. Documentation on used estimation methods for diffuse sources

Processes and pathways widely differ. There exist many different methods to estimate the loss from diffuse anthropogenic sources, it is vital that the Contracting Parties comprehensively describe the methodology used for various sources to ensure transparency and to enable assessments. It is important that the documentation include how e.g. the following important factors have been taken into consideration:

- Seasonal variation,
- Retention (see chapter 9),
- Monitoring data as support to model or values from look-up tables or expert judgement, and
- Estimates based on source-oriented (sources are estimated) or load-oriented approach (only total diffuse anthropogenic sources) – see also Chapter 10.

There exist many different source-apportionment models, with varying capabilities to model the nutrient flow under various conditions, and with very different demands on supporting data. Some examples on commonly used models are given in **Table 6.2**. More examples are given in documentation from the EUROHARP project, in which thorough descriptions, as well as comparisons and assessments of commonly used models, can be found (e.g. Schoumans and Silgram 2003, and in 10 articles in *Journal of Environmental Monitoring* Vol. 11, pages 503–609 e.g. Hejzlar et al. 2009, Kronvang et al. 2009, Schoumans et al. 2009a, Schoumans et al. 2009b, and Silgram et al. 2009).

Important issues that need to be considered before a model is chosen are e.g.:

- The purpose with the modelling (only source-apportionment or also scenarios on remedial measures?),
- Coverage of important pathways for the nutrients in the prevailing conditions,
- Supporting data availability compared to model needs,
- Source availability regarding man-power or financial support compared to what is expected for data and model handling, and
- Result assessment.

Other important issues are temporal and spatial resolution (vertical and horizontal), high resolution generally implicate higher requirements on supporting data as well as higher labour demands, but maybe one of the most important issues is the applicability of the various models to the specific prevailing conditions that are to be modelled. If there are resources enough, it might be suitable with an ensemble modelling, i.e. several models are used and assessed together, to get more reliable estimates. More detailed concerns on various issues prior to start modelling may be found in e.g. Schoumans and Silgram (2003).

For documenting a model, the issues listed above should be described including a description of the process involved in the model and results of sensitivity and uncertainty analysis.

Table 6.2. Examples on source-apportionment models that may be used to estimate various nutrient sources and nutrient retention in different scales. Physically based model intend to describe relevant process in a physically correct way, while conceptual models are more or less based on empirical information. Physical models are generally relatively data demanding.

Name	Type of model	Model owner/origin
EUROHARP-NUTRET	Retention only	EUROHARP
FyrisNP	Conceptual	SLU, Sweden. Freely available for non-commercial purposes: http://www.slu.se/waterhub
HBV-NP	Semi-Physical	SMHI, Sweden; freely available ⁹
HSPF	Physical	US. EPA downloadable: http://water.usgs.gov/software/HSPF/
HYPE	Semi-Physical	SMHI, Sweden, open source
MESAW	Conceptual	Grimwall & Stålnacke (1996)
MIKE BASIN	Conceptual	DHI, Denmark; commercial
MONERIS	Semi-empirical	Downloadable: http://moneris.igb-berlin.de/index.php/model-structure.html
SWAT	Physically	Downloadable public domain model: http://swat.tamu.edu/software/
Vollenweider	Conceptual, retention only	P lake model (Vollenweider 1975)

⁹ The model is being phased out by SMHI in favour of the HYPE model

7. Methods for estimation of inputs from unmonitored areas

Unmonitored areas consist of unmonitored rivers, unmonitored parts of monitored rivers and coastal areas including unmonitored islands (see **Figure 2.4**).

In unmonitored areas there are no available data on the requested water chemical determinants or on flow measurements in rivers. For such areas it is recommended to use one of the methods described below for estimating the loads (see also Chapter 6.2 on quantification of nutrient losses from anthropogenic diffuse sources). Alternative load calculation methods may be used, but must be described in detail (cf. Annexes 2 and 3).

There are different methods to estimate the load from unmonitored areas:

- Using modelling results or
- Extrapolating the knowledge about neighbouring rivers under similar conditions.

If an unmonitored area has climate, topography, geology, soil type, land use (especially proportion of agricultural land) etc. that are similar with a monitored area, also similar load in the output (river) can be assumed.

The following method should only be used if more sophisticated methods are not available and if the unmonitored part of the catchments only constitutes a minor share of the total catchment:

A rough calculation then takes into account only the different surface areas of the basins, e.g.:

$$L_n = L_m \frac{A_n}{A_m} \quad (7.1)$$

L_n = input from unmonitored area A_n

L_m = known input coming from monitored area A_m

A_n = area of unmonitored catchment

A_m = area of monitored catchment

If possible the discharge from large point sources should be taken into account, as the discharges are rarely equal in the monitored area that is extrapolated to the unmonitored area. In some regions/countries the discharge from point sources is monitored and/or estimated also in unmonitored areas. Then the equation 7.1 above is changed to:

$$L_n = DL_m \frac{A_n}{A_m} + PL_u \quad (7.2)$$

L_n = estimated input coming from unmonitored area A_n

DL_m = known diffuse inputs coming from monitored area A_m (estimated as monitored load minus discharge from point sources taking into account retention)

PL_u = monitored or estimated point source discharge from unmonitored areas;

A_n = area of unmonitored catchment

A_m = area of monitored catchment.

Retention in surface waters within the unmonitored catchment should be taken into account when quantifying DL_m and PL_u .

Flow from unmonitored areas can be estimated with the methods described in Chapter 4.2.

8. Transboundary rivers

8.1. Introduction

The Fifth Baltic Sea Pollution Load Compilation, PLC-5 (HELCOM 2011) addressed challenges related to transboundary nutrient inputs originating from countries both inside and outside the HELCOM area, as well as ensuring a fair allocation of pollution reduction burden in case of sharing transboundary watersheds between two or more HELCOM Contracting Parties. The initial calculations of nutrient inputs allocated total riverine input to the country with the river mouth. This implies that e.g. Latvia and Lithuania are assigned the entire input via the Daugava and Nemunas to the Baltic Sea, respectively, while considerable proportions of these catchments belong to Belarus and Russia. Hence, there is a need for proper evaluations of the transboundary pollution inputs and to what extent these reach the Baltic Sea.

The follow-up system for the new CARTs, which was adopted at the Copenhagen 2013 HELCOM Ministerial Meeting (HELCOM 2013), require knowledge about transboundary riverine inputs from non-HELCOM Contracting Parties as well as between Contracting Parties to follow up on the progress towards reaching the nutrient reduction requirements. The new CARTs are specific for each Contracting Parties net inputs defined as their “own” share of the nutrient inputs to the Baltic Sea taking into account retention within surface waters. Further, and expected reductions in riverine inputs have also been allocated to non-Contracting Parties. Transboundary inputs between HELCOM Contracting Parties were taken into account when allocating the reductions requirements. Also the 2013 Copenhagen Ministerial Meeting underlined that transboundary nutrient inputs originating in the non-Contracting Parties should be addressed by initiating joint activities e.g. by bi- and/or multilateral projects and through other existing funding mechanisms as well as by international agreements such as the 1992 UNECE Convention on Transboundary Waters and Lakes, and the River Basin Management Plans of the EU Water Framework Directive for HELCOM Contracting Parties being also EU Member States.

Therefore, addressing transboundary inputs between Contracting Parties and non-Contracting Parties and between two or more Contracting Parties (including border rivers) has been identified as an important task for the HELCOM PRESSURE, HELCOM RedCore DG and future PLC assessments. Quantifying transboundary inputs between countries can also be used to evaluate the importance of these inputs as a source to the receiving countries and to follow development in transboundary inputs. For assessing the importance of measures taken in upstream loading countries on the net inputs to the Baltic Sea, retention in downstream countries surface waters must be taken into account (see Chapter 9). The importance of transboundary inputs also hold true for hazardous substances for proper estimates of the origin of the pollutants even though at the moment there are no reduction targets for this kind of substances.

This chapter defines actual and net transboundary inputs, and includes an overview of the rivers that are identified as transboundary rivers. Further it includes border rivers and how they are defined. It also includes a short overview of information necessary for assessing actual and net transboundary inputs.

About 7% of the total catchment draining to the Baltic Sea (total area is 1.73 million km²) is situated in non-Contracting Parties, but also a proportion of the catchment area within Contracting Parties contributes with transboundary riverine inputs to other Contracting Parties (see **Figure 2.5**). All big rivers draining to the Baltic Sea are transboundary/border rivers.

8.2. Definitions

A **transboundary river** is a river that crosses at least one country (political) border and has its outlet to the Baltic Sea in one of the HELCOM Contracting Parties. A transboundary river can cross more than one country, both between Contracting Parties and from a non-Contracting to a Contracting Party. Therefore, riverine inputs can originate from one or more countries. To estimate net transboundary riverine inputs entering to the Baltic Sea, retention in inland surface waters must be taken into account (see Chapter 9).

A **border river** is a river with its outlet to the Baltic Sea at the border between two countries. For these rivers, the inputs to the Baltic Sea are divided between the countries in relation to each country's share of total input.

Transboundary rivers are illustrated in **Figure 2.4**, which introduces and defines some main terms used in the PLC guidelines. As an example **Figure 8.1**, shows the lower part of the River Nemunas. River Nemunas has been classified as a transboundary river, and is regarded as a quite complicated case due to the fact that so many countries are involved in different parts of the catchment (see caption for figure 8.1).

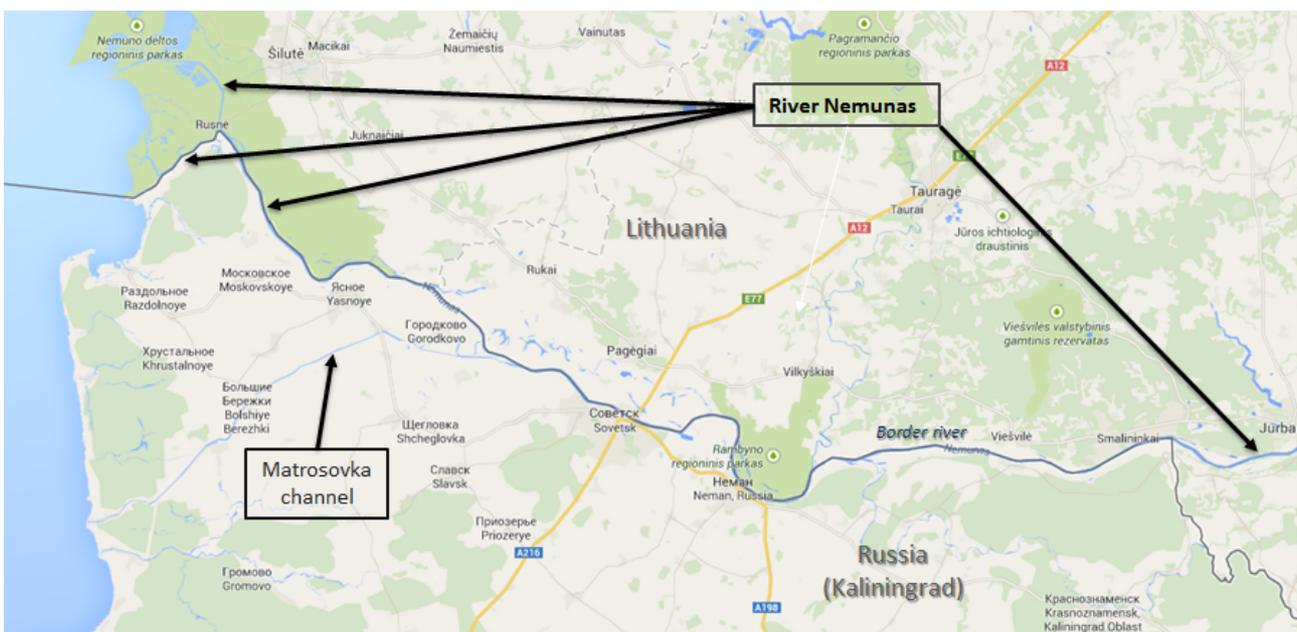


Figure 8.1. The lower part of the transboundary River Nemunas catchment. To the right from the map (not shown), Lithuania receives riverine transboundary inputs from the non-Contracting Party Belarus. In the central part of the map is the border between Russia (Kaliningrad Oblast) and Lithuania along the River Nemunas. There is also a river branch (with a quarter of the entire flow of Nemunas) – Matrosovka (or Gilija in Lithuanian) Channel – which transports

transboundary inputs from Lithuania to Russia. The channel has an outlet to the Baltic Sea in Russia while the outlet of the main branch of the River Nemunas is in Lithuania (not at the border between Russia and Lithuania). Source: Google Earth, with some amendments.

8.3. Estimates of actual and net transboundary inputs used in the 2013 Copenhagen HELCOM Ministerial Declaration

Available data shows that the transboundary nutrient inputs to the Baltic Sea are significant to some sub-basins of the Baltic Sea. However, the existing assessments have not so far enabled the evaluation of the significance of transboundary pollution accurately enough. **Table 8.1** and **Table 8.2** summarize estimates compiled by the Baltic Nest Institute, Sweden (BNI) (Gustafsson & Mörth, in prep.) on transboundary (actual and net inputs) divided between Contracting Parties and non-Contracting Parties (**Table 8.1**) and between Contracting Parties (**Table 8.2**) as used for calculating the CARTs adopted by the 2013 HELCOM Copenhagen Ministerial Meeting (HELCOM 2013).

Table 8.1. Transboundary riverine inputs from non-HELCOM countries in the Baltic Sea catchment area (in tonnes per year) used in the CARTs calculations. All data are averaged 1997-2003 except for the Belarusian data which are averaged 2004-2011. Input at the border is reduced by the retention coefficient to estimate net waterborne input to the Baltic Sea (see Chapter 10). ‘Share of inputs to the sub-basin’ expresses (in %) how large a proportion of the total waterborne input to a sub-basin originates from the non-Contracting Party during the reference period. GUR = Gulf of Riga, BAP = Baltic Proper, GUF = Gulf of Finland, TN = total nitrogen, TP = total phosphorus. For more information, see Gustafsson & Mörth, in prep.

From	Via	To	Border		Retention		To Baltic Sea		Share of input to the sub-basin	
			TN (t)	TP (t)	TN	TP	TN (t)	TP (t)	TN (%)	TP (%)
Czech	Poland	BAP	5,700	410	0.40	0.28	3,420	295	1.1	1.7
Belarus	Lithuania	BAP	13,600	914	0.54	0.53	6,256	430	2.1	2.5
Ukraine	Poland	BAP	4,124	127	0.40	0.28	2,474	91	0.8	0.5
Belarus	Poland	BAP	5,071	331	0.40	0.28	3,043	238	1.0	1.4
Total		BAP					15,193	1,055	5.1	6.1
Belarus	Latvia	GUR	8,532	1,360	0.27	0.32	6,228	925	7.9	41.4

Table 8.2. Transboundary riverine inputs between HELCOM Contracting Parties (in tonnes per year) in the reference period (1997-2003). The input at the border is reduced by the retention coefficient to estimate net waterborne transboundary inputs to the Baltic Sea. GUR = Gulf of Riga, BAP = Baltic Proper, GUF = Gulf of Finland, TN = total nitrogen, TP = total phosphorus, n.i. = no information. In the Finnish inputs to Gulf of Finland via Russia retention in Lake Ladoga has been taken into account. For more information, see Gustafsson & Mörth, in prep.

From	Via	To	Border		Retention		To Baltic Sea	
			TN (t)	TP (t)	TN (t)	TP (t)	TN (t)	TP (t)
Lithuania	Latvia	BAP	5,516	158	0.39	0.58	3,365	66
Poland	Russia	BAP	4,400	320	0.30	0.37	3,080	202
Germany	Poland	BAP	n.i.	n.i.	n.i.	n.i.	2,337	101
Total		BAP					8,782	369
Lithuania	Latvia	GUR	7,185	282	0.27	0.32	5,245	192
Russia	Latvia	GUR	4,256	734	0.54	0.71	1,957	215
Total		GUR					7,202	407
Finland	Russia	GUF			0.48	0.82	5,353	49

The waterborne transboundary inputs (to the Baltic Sea) from an upstream country for a river is given by the observed inputs at the border between the upstream country a and the receiving country b and by the retention in country b as:

$$TNT_{a,b,n}^{ref} = (1 - TNR_{b,n}^{ref}) TNB_{a,b,n}^{ref} \quad (8.1)$$

Where

$TNT_{a,b,n}^{ref}$ = total transboundary inputs of nitrogen from country a via country b to the Baltic Sea for river n in period ref

$TNR_{b,n}^{ref}$ = total nitrogen retention (expressed as a value between 0 and 1) in country b on transboundary inputs from country a in river n during period ref

$TNB_{a,b,n}^{ref}$ = Total nitrogen input at the border between country a and country b in river n in period ref.

There is three possibilities calculating the waterborne transboundary inputs for a subsequent period:

1. No data available – **Equation 8.2**,
2. Data available on the border inputs – **Equation 8.3** or
3. Data available on both the border inputs and on retention - **Equation 8.4**.

No data available:

If no data are available for a subsequent year than in equation 8.1 we assume that the transboundary inputs changes in proportion to the total water borne input from the country-basin catchment:

$$TNT_{a,b,n} = TNR_{b,n}^{ref} \frac{TNW_{b,n}}{TNW_{b,n}^{ref}} \quad (8.2)$$

$TNT_{a,b,n}$ = total transboundary input of nitrogen from country a via country b to the Baltic Sea for river n

$TNR_{b,n}^{ref}$ = total nitrogen retention (expressed as a value between 0 and 1) in country b on transboundary inputs from country a in river n during period ref

$TNW_{b,b}$ = Total waterborne input of nitrogen from country b in the country-basin catchment n

$TNB_{b,n}^{ref}$ = Total waterborne input of nitrogen from country b in period ref in the country-basin catchment n

Data available on the border inputs:

We use the same retention as in the period ref. but data for the subsequent year.

$$TNT_{a,b,n} = (1 - TNR_{b,n}^{ref}) TNB_{a,b,n} \quad (8.3)$$

$TNT_{a,b,n}$ = total transboundary input of nitrogen from country a via country b to the Baltic Sea for river n

$TNR_{b,n}^{ref}$ = total nitrogen retention (expressed as a value between 0 and 1) in country b on transboundary inputs from country a in river n during period ref

$TNB_{a,b,n}$ = Total nitrogen input at the border between country a and country b in river n

Data available on both the border inputs and on retention

We use the data to directly calculate the transboundary inputs for a subsequent year.

$$TNT_{a,b,n} = (1 - TNR_{b,n}) TNB_{a,b,n} \quad (8.4)$$

$TNT_{a,b,n}$ = total transboundary input of nitrogen from country a via country b to the Baltic Sea for river n

$TNR_{b,n}$ = total nitrogen retention (expressed as a value between 0 and 1) in country b on transboundary inputs from country a in river n

$TNB_{a,b,n}$ = Total nitrogen input at the border between country a and country b in river n

If other (more) reliable data does not exist on retention within the catchment area, the results estimated in the EU-funded RECOCA project can be used (Gustafsson & Mörth, in prep.). These results are shown in Chapter 9 (**Figure 9.1** and **Table 8.2**) and Annex 5. These retention coefficients can be used for calculation of net contribution of transboundary inputs from both Contracting and non-Contracting Parties at rivers mouths.

Data on sources in the non-Contracting Parties is still lacking and the available data does also not enable calculation of the share of pollution originating from the upstream countries that actually reaches the Baltic Sea as satisfactory estimates on retention in different individual rivers are not available.

8.4. Necessary information for quantifying transboundary input

The downstream HELCOM Contracting Party receiving riverine transboundary input from an upstream country (Contracting Party or not) and having the river mouth at the Baltic Sea is responsible to collect data, and to compile, quantify and report on the transboundary inputs. The downstream country is encouraged to cooperate with the upstream country in order to quantify inputs and river flow at the border using the methods described in the PLC guidelines and to ensure that all relevant transboundary inputs are quantified and reported to the PLC-Water database. Further, Contracting Parties should also report on retention in the catchment receiving the transboundary input, if new retention data is available that differ from the one used for calculating the CARTs that were adopted in Copenhagen 2013 HELCOM Ministerial Declaration. For border rivers, the involved Contracting Parties should agree on the responsibilities above and report accordingly to HELCOM.

Necessary information to be used for estimating transboundary riverine inputs includes:

- At the river mouth: annual water flow, total nitrogen, total phosphorus, hazardous substances and preferably also fractions of nutrients (see list of parameters in Chapter 3) quantifying actual total input to the Baltic Sea (divided in monitored and unmonitored inputs),
- At the border: annual water flow, total nitrogen, total phosphorus (if available also fractions of nutrients and heavy metals (see list of parameters in Chapter 3) quantifying actual annual transboundary inputs. Preferable this is based on monitoring. If the reported information has been

modelled, then information on how the estimates were obtained should be reported. If the river crosses several countries, Contracting Parties receiving inputs from non-Contracting Party should report the received inputs and flow. If a Contracting Party river enters into a non-Contracting Party, the Contracting Party should report the inputs and flow entering at the border,

- For monitoring stations in transboundary/border rivers name of the river and the location of the monitoring point(s) (geographical coordinates) should be reported,
- Size of sub-catchments in the up- and downstream countries,
- Estimate of retention (in inland surface waters) on transboundary N and P input in each receiving Contracting Party, and in each non-Contracting if any new information is available. The Contracting Party with the mouth are responsible to report retention non-Contracting Party surface waters catchment of the transboundary river,
- In periodic assessment of nutrient source quantifications: population in the catchment, point and diffuse sources, information on land use, life stock, fertilizer application etc. (all in both the up- and downstream countries),
- If a river crosses more than one country, all the information is needed from each country in order to enable separation of the information per country.

8.5. Overview of transboundary rivers to take into account in annual reporting

This sub-chapter describes how transboundary inputs can be divided between Contracting Parties. The division for the biggest rivers is based on monitored inputs at the border where the river enters another Contracting Party. When quantifying net transboundary inputs from the involved countries retention with surface waters in the catchment in the downstream Contracting Party receiving the transboundary inputs must be taken into account. For a few rivers, also the location of big point sources is taken into account. In a strict sense, there are 82 transboundary rivers in the catchment to the Baltic Sea, but for many of these almost the whole catchment is situated in one country only and for these the transboundary inputs are neglected.

Table 8.3 contains an overview of the transboundary rivers from which annual transboundary riverine inputs should be taken into account and net transboundary inputs should be estimated. The reported transboundary inputs will serve as input to the PLC assessments and to the annual follow-up of the BSAP nutrient reduction requirements (CART) adopted by the 2013 HELCOM Ministerial Declaration. The table provides information about the involved Contracting and non-Contracting Parties for each river, the division of the catchment, monitoring stations in HELCOM Contracting Parties at the border where transboundary riverine inputs enters, expected available information in upstream country etc. In addition, **Table 8.3** also provides information on border rivers within the Baltic Sea catchment. Note! This table indicates the situation by autumn 2018.

Table 8.3 List of transboundary and border rivers that should be taken into account in annual and periodical PLC reporting. CP = Contracting Party, BY = Belarus, CZ = Czech Republic, DE = Germany, DK = Denmark, EE = Estonia, FI = Finland, LT = Lithuania, LV = Latvia, NO = Norway, PL = Poland, RU = Russia, SE = Sweden, SK = Slovakia, UA = Ukraine, BAP = Baltic Proper, BOB = Bothnian Bay, BOS = Bothnian Sea, GUF = Gulf of Finland, GUR = Gulf of Riga, KAT = Kattegat, MS = monitoring stations.

River name	Transboundary/ border river between which CP's/countries	CP to provide information and involved CP	Total catchment and proportion of catchment in involved countries	Monitoring station in CP and what is monitored	Expected available information in upstream country(ies)	Other comments
Narva (GUF):	Border and transboundary river LV to RU; EE and RU, BY	EE (own catchment) and RU (LV and RU catchment)	Total area: 58,126 km ² EE: 30.2% LV: 6.3% RU: 63.0% BY: 0.5%	EE: 2 hydrochemical stations (7 km from mouth and outflow from Peipsi), 2 hydrological stations (20 km from mouth outflow from Peipsi) RU: chemical monitoring station -12 km from mouth; hydrological - 16 km	LV: No hydrochemical surveillance monitoring stations with annual measurements; 1 hydrological – flow monitoring station (Zilupe – Pasiene)	RU to contact LV or to decide whether to take on LV input as part of RU inputs. No reporting/quantification of Belarussian inputs expected
Torne älv (BOB)	Border river between SE and FI	SE	Total area: 40,112 km ² SE: 63.9% FI: 35.0% NO: 1.2%	SE: Chemical station at Mattila (approx. 7 km from outlet). Hydrological station at Kukkolankoski (approx. 20 km from outlet) Fi:		It is agreed that 55 % of the inputs of N and P entering the sea via the river is from SE and the remaining 45 % from FI. Sweden report the total inputs. Sweden includes Norwegian inputs in their net inputs
Gauja (GUR)	Transboundary river EE/LV	LV	Total area: 8,950 km ² LV: 87.5%	LV: 1 hydrochemical surveillance MS (Gauja, 2.0 km below Carnikava, mouth);	EE: 1 hydrological station and 1 hydrochemical	

			EE: 12.5%	1 hydrological – flow MS (Gauja – Sigulda)	station (river Mustjõgi, 4 km from LV border)	
Lielupe (GUR):	Transboundary river LI/LV	LV	Total area: 17,814 km ² LV: 50.4% LT: 49.6%	<p>LV:</p> <p><u>Border MS:</u></p> <p>River Mūsa: 1 hydrochemical surveillance MS (Mūsa, on Latvia – Lithuania border); 1 hydrological – flow MS (Mūsa-Bauska);</p> <p>River Mēmele:</p> <p>1 hydrochemical surveillance MS (Mēmele, 0.5 km below Skaistkalne); 1 hydrological – flow monitoring station – data from LT (Mēmele – Tabokine);</p> <p><u>Mouth MS:</u></p> <p>River Lielupe:</p> <p>1 hydrochemical surveillance MS (Lielupe, 0.5 km below Kalnciems); 1 hydrological – flow monitoring station (Lielupe-Mežotne)</p>	<p>LT:</p> <p>4 chemical stations (rivers Platone, Sidabra, Musa ir Nemunelis) and 7 hydrological stations (rivers Svete, Platonis, Sidabra, Yslykis, Musa, Nemunelis 2 stations) near the LT/LV border</p>	
Oder (BAP):	Transboundary river CZ/DE/PL	PL	Total area: 118,840 km ² CZ: 6.1% DE: 4.7% PL: 89.2%	<p>PL:</p> <p>1 station with hydrological and hydrochemical measurements (Krajnik, 71.9 km from the mouth)</p>	<p>DE:</p> <p>2 hydrochemical stations (one of them on PL border), 3 hydrological stations</p> <p>CZ:</p>	The river is crossing from Poland into Germany and back to Poland and is bordering the two Countries for some reaches. Germans monitoring station do not represent inputs from Germany. Some fix percentages (5.5% for TN and 3.1% for TP) of total inputs

					1 station with hydrological and hydrochemical measurements (border station, Chalupki 741.9 from the mouth)	from Oder was used for German share of reference inputs of Oder in the PLC-6 assessment.
Neva (GUF)	Transboundary river BY/FI/RU	RU	Total area: 281,000 km ² BY: 0.3% FI: 20.2% RU:79.5%	RU: mouth hydrological station – 27 km from mouth and 4 chemical stations in each branch of Neva river (one-in 1.4 from mouth, three – in 0.025 km from mouth)		No reporting/quantification of Belarussian inputs expected
Pregolya (BAP)	Transboundary river LT/PL/RU	RU	Total area: 15,500 km ² LT: 0.6% PL: 51.1% RU:48.3%	RU: chemical monitoring station -1 km from mouth; hydrological - ≈50 km and includes only nutrient fractions (P-PO ₄ ,N-NO ₂ ...etc) PL: PL Monitoring stations: Lyna 73.7 km (lack of flow data since year 2007; Wegorapa 96.5 km (lack of flow data since 2007)		PL: In PLC-5.5 PL inputs were calculated based on data from the river Lyna and Wegorapa with using average flow from years 1994-2003 and 2006)
Venta (BAP):	Transboundary river	LV	Total area: 11,692 km ² LT: 44.3%	LV: <u>Border MS:</u>	LT: 3 chemical stations (rivers Varduva, Venta,	

	LT/LV		LV:55.7%	1 hydrochemical surveillance MS (Venta, 0.5 km below Nigrande) ; <u>Mouth MS :</u> 1 hydrochemical surveillance MS (Venta, Vendzava, hidroprofilis). 1 hydrological – flow monitoring station (Venta-Kuldīga).	Vadakstis) near the LT/LV border and 1 hydrological station (river Venta)	
Barta (BAP):	Transboundary river LT/LV	LV	Total area: 2,016 km ² LT: 37.1% LV: 62.9%		LT: 1 chemical station and 1 hydrological station in the Bartuva river near the LT/LV border	
Daugava (GUR):	Transboundary EE/LT/RU/BY/LV	LV	Total area: 87,900 km ² EE: 0.2% LT: 2.2% RU: 31.6% BY: 38.2% LV: 27.7%	LV: <u>Border MS:</u> 1 hydrochemical surveillance MS (Daugava, Piedruja, Latvia - Belarus border); 1 hydrological – flow monitoring station (Daugava-Daugavpils) <u>Mouth MS :</u> 1 hydrochemical surveillance MS	RU: chemical monitoring station at the RU/BY border; LT: 1 chemical and 1 hydrological station at the LT/BY border in the river Birveta (around 3 km away from the border) and 1 chemical and 1 hydrological station in the river	No reporting/quantification of Estonian inputs expected

				(Rīga reservoir, 1.0 km below Lipši) ; 1 hydrological – flow monitoring station (Daugava-Jēkabpils).	Dysna (around 1.5 km away from the border) EE: river Pedetsi, no monitoring
Sventoji (BAP)	Transboundary LT/LI	LT	Total area 480 km ² LT: 84.4% LV: 15.6%	LT:1 monitoring station LV: No monitoring	Reported for PLC6
Nemunas (BAP):	Transboundary RU/LV/BY/PL/LT	LT	Total area: 97,920 km ² RU: 1.6 % LV: 0.1 % BY: 47.1 % PL: 2.6 % LT: 48.6 %	LT: 2 chemical and 2 hydrological stations at the LT/BY border (one of each in the Nemunas river around 10 km away from the border and in the Neris river around 2 km away from the border). 5 hydrological and 4 chemical stations are on the LT/RU border in the Nemunas river. Last one around 8 km from the mouth. RU: 2 chemical stations: 1 st in the Nemunas river in 59 km from mouth; 2 nd in the Matrosovka canal in 24 km from mouth (monitoring includes only nutrient fractions (P-PO ₄ ,N-NO ₂ .etc)	LT: Sesupe river at the LT/RU border has 1 chemical and 1 hydrological station. No reporting/quantification of Latvian inputs expected

Vistula (BAP):	Transboundary BY/UA/SK/PL	PL	Total area: 194,424 km ² BY: 6.5% UA: 5.7% SK: 1.0% PL: 86.7%	PL: Polish inputs (Kieźmark 12km from the mouth) Inputs from BY (Monitoring stations on the Bug river 222.0; 227.5 and 291.0km and Narew river 44.6 km) Inputs from UA (monitoring station on Bug river 578.1km)	PL: No (BY, UA, SK)	PL: Bug river, (transboundary and borer river with BY and UA). For PLC-5.5 inputs were estimated basing on own data)
Göta älv (KAT)	Transboundary NO/SE	SE	Total area: 50,233 km ² NO: 16.7% SE: 83.3%		SE: Sweden to investigate the availability and continuity of point source and land use data during the PLC-6 project	SE: Currently (and in previous PLC deliveries), Sweden has treated the input entering the sea from these areas as negligible due to low anthropogenic pressures in the mountainous areas of all these rivers and high retention in lakes between these regions and the sea. Sweden will evaluate this approach within the PLC-6 project, investigating the availability and continuity of point source and land use data and the expected nutrient retention in lakes and water courses.
Indalsälven (BOS):	Transboundary NO/SE	SE	Total area: 26,726 km ² NO: 7.9% SE: 92.1%	SE:	SE: Sweden to investigate the availability and continuity of point source and land use data during the PLC-6 project	
Ångerman älv (BOS):	Transboundary NO/SE	SE	Total area: 31,864 km ² NO: 4.9% SE: 95.1%	SE:	SE: Sweden to investigate the availability and continuity of point source and land use data during the PLC-6 project	Based on these estimates, a decision will be taken as to whether to maintain the current approach (which assumes that the Norwegian contribution to the total inputs from each of these three rivers is negligible compared

to the Swedish inputs) or whether this approach should be re-evaluated and the rivers treated as conventional transboundary watercourses.

Coast LV/Baltic Proper	LT/LV	LV	Total area: 5,257 km ² LT: 14.2% LV: 85.8%	LV: Bārta river: <u>Border MS:</u> 1 hydrochemical surveillance MS (Bārta, Latvia - Lithuania border); <u>Mouth MS :</u> 1 hydrochemical surveillance MS (Bārta, 0.2 km above Dūkupji, hidroprofil). 1 hydrological – flow monitoring station (Bārta-Dūkupji).	LT: Bartuva is included separately in this list. There are no more significant transboundary coastal catchments shared between LT and LV
Coast RU/Baltic Proper (RU: Propose to refer this section to Mamonovka and Prokhladnaya rivers)	PL/RU	RU	Total area: 1,538 km ² PL: 25% RU: 75%	This will be included in the Russian	

Seleznevka GUF)	Transboundary Ru/Fi	RU	Total area: 642 km ² RU: 40% FI: 60%	RU: FI:	This river has been separated from Coast RU/Gulf of Finland
Coast RU/ Gulf of Finland	FI/RU	RU	Total area: 8,611 km ² FI: 14% RU: 86%	RU: chemical station on river Seleznevka – 12 km upstream mouth; hydrological station – 25 km upstream mouth.	
Salaca (GUR)	Transboundary LV/EE	LV	Total area 3,471 km ² LV: 91.9 % EE: 8.1 %	LV: 1 hydrochemical surveillance MS (Salaca, 0.5 km above Salacgrīva) ; 1 hydrological – flow monitoring station (Salaca-Lagaste).	

Table 8.3 includes transboundary rivers where the Contracting Party having the river mouth includes the complete input from the river without allocating any proportion to upstream countries.

Table 8.4 List of transboundary rivers where the Contracting Party with the river mouth include the complete input from the rivers in their net inputs. . EE = Estonia, FI = Finland, LV = Latvia, NO = Norway, RU = Russia, SE = Sweden, BOB = Bothnian Bay, GUR = Gulf of Riga.

River name	Transboundary/ border river between which CP's/countries	CP to provide information and involved CP	Total catchment and proportion of catchment in involved countries (m2)	Other comments
Kemijoki (BOB):	FI/Ru	FI	94,0/6,0	Total inputs is allocated to Finland

Oulujoki (BOB):	FI/RU	FI	94,1/5,9	Total inputs is allocated to Finland
Gota älv (Kat):	SE/NO	SE	83,2/16,8	Total inputs is allocated to Sweden
Dalälven (BOS)	SE/NO	SE	96,0/4,0	Total inputs is allocated to Sweden
Ume älv (BOS)	SE/N	SE	99,4/0,6	Total inputs is allocated to Sweden
Lule älv (BOB):	SE/NO	SE	97,4/2,6	Total inputs is allocated to Sweden
Pite älv (BOB)	SE/NO	SE	99,3/0,7	Total inputs is allocated to Sweden
Skellefte älv (BOB):	SE/NO	SE	99,8/0,2	Total inputs is allocated to Sweden

9. Quantification of nutrient retention

9.1. Introduction

Retention of nitrogen and phosphorus in surface waters (lakes, rivers including flooded riparian zones) is a process that permanently removes nitrate through denitrification or stores of nitrogen and phosphorus for shorter or longer time periods in sediments and vegetation thus delaying the nutrient transport in river basins. In some cases, retention can even be negative due to the release of nutrients from lake and river sediments. In general, phosphorus retention is influenced by sedimentation and other physical and chemical processes, while nitrogen retention to a large extent is influenced by biological processes.

Retention needs to be estimated in order to enable quantification of sources of nutrients to marine areas from different parts of river basins. A geographically detailed estimate of retention will make a reliable source apportionment of the inputs to the sea possible, which in turn will enable efficient water protection measures. Ideally, if individual evaluation of all different measures and sources are expected, retention should be estimated separately for all categories of nutrient sources in a river system, also taking into account the distance to the coast.

If the loads from agriculture are expressed as losses from the root zone, the retention estimates will also include soil retention, i.e. removal processes that occur in soil and groundwater. These guidelines only deal with retention of phosphorus and nitrogen in inland surface waters, which is also the reporting obligation for the PLC periodic assessments.

9.2. Quantification

The total retention in the river catchment (R) is the sum of retention for each source category, expressed as:

$$R = R_p + R_D + R_B \quad (9.1)$$

Where:

- R_p = retention for point sources ($t a^{-1}$),
- R_D = retention for diffuse sources ($t a^{-1}$),
- R_B = retention for background load ($t a^{-1}$).

It is generally difficult to distinguish retention from the different sources in equation 9.1. The calculation can be simplified if it is assumed that retention is proportional to the total load of each source and that the retained fraction is the same for all sources. Then only the total retention) is needed. Further, the procedure outlined above requires measurements at one or several monitoring sites of the selected river in order to determine riverine load (can be a normalized riverine load). It also requires data on nitrogen and phosphorus point source discharges and natural background losses in the river catchment area. If there is a significant degree of uncertainty in the retention estimate, more than one retention methodology or a sensitivity analysis should be applied to get a range for the quantification of diffuse sources entering inland surface waters.

The following main quantification approaches can be used:

- A. Mass balance approach
- B. Modelling approach

A. Mass balance approach

This approach is based on monitoring data from inland waters, used to calculate mass balances for selected parts of the river system. The method can be applied to:

- the whole river catchment
- lakes, (use results on lakes retention from parts of the catchment for lakes in the remaining part scaled to the whole catchment)
- sub-catchments covering the whole catchment

Basically, the methodology is the same irrespective of the size of the calculation unit. The retention is calculated as the difference between the input and output of the considered water body, preferably on an annual basis, according to the equation:

$$(I_a + I_b + I_c + I_n) - U = R \quad (9.2)$$

Where:

$I_a - I_n$ = input sources,

U = Output, and

R = retention.

Estimates of diffuse inputs based on a longer time period (more than one year) will result in a retention estimate for the corresponding period.

Estimation using equation 9.2 can be simplified by ignoring small input sources. Another simplification can be made by analyzing only a few sub-catchments representing different parts of the river system and transforming the results to the whole river. If possible, retention in big lakes should always be assessed separately

The simplest way of calculating total retention in a catchment is to make a mass balance for the whole river system and calculate retention as the difference between the sum of all inputs at source (gross load) from the load calculated at the river mouth station (net load). A major problem with this approach is that it only gives an average retention figure for the whole river system. Retention may differ between sources positioned in different parts of the catchment, and thus the source apportionment at the coast will not be precise. For small rivers this difference may be less important. When applying the mass balance approach to larger river catchments the calculations become more complicated and the use of numerical models may be necessary.

B. Modelling approach

A modelling approach is often applied when retention is calculated in a river system for the whole catchment or for sub-catchments. The retention is calculated with empirical or dynamical models covering from mass balance models to algorithms describing the relationship between retention and river characteristics. The selected model should preferably be able to calculate retention of individual sub-catchments as well as for the whole river system.

There are several, both freely available and commercial, models that can be used to calculate retention. They all need input data on point and diffuse nutrient sources as well as river and lake characteristics. Some available models are described in **Table 6.2**. They have variable applicability depending on e.g. the scale and climatologically conditions of the study catchment. In the EUROHARP project several models compiling retention have been compared regarding their retention estimates and the results are published in Hejzlar et al. (2009).

9.3. Available retention data

Where available, retention data provided by Contracting Parties has been used. If such data have not been available, then e.g. results estimated by projects such as RECOCCA were used for estimating net transboundary inputs.

Several studies have been made in different Baltic Sea countries to estimate nutrient retention. One example is the RECOCCA project (2009-2012) in which total and surface water nutrient retention of the major river catchments around the Baltic Sea were calculated. Total retention, including both soil and water retention, were estimated using a regional mass balance model (Hong et al. 2012). The results show quite high retention values for the largest catchments of the Baltic Sea (50-86% for total nitrogen and 85 to nearly 100% for phosphorus). Nutrient retention in surface waters (river and lakes) was also calculated for all major river catchments around the Baltic Sea using the MESAW model (Stålnacke et al. 2003). Both retention datasets from the RECOCCA project are available from BNI-Sweden.

Retention estimates of transboundary inputs should only contain retention in rivers and lakes. Inputs and retention coefficients of transboundary inputs were compiled during the revision of MAI and CARTs for the BSAP (see **Table 8.1** and **8.2**, and **Figure 9.1**).

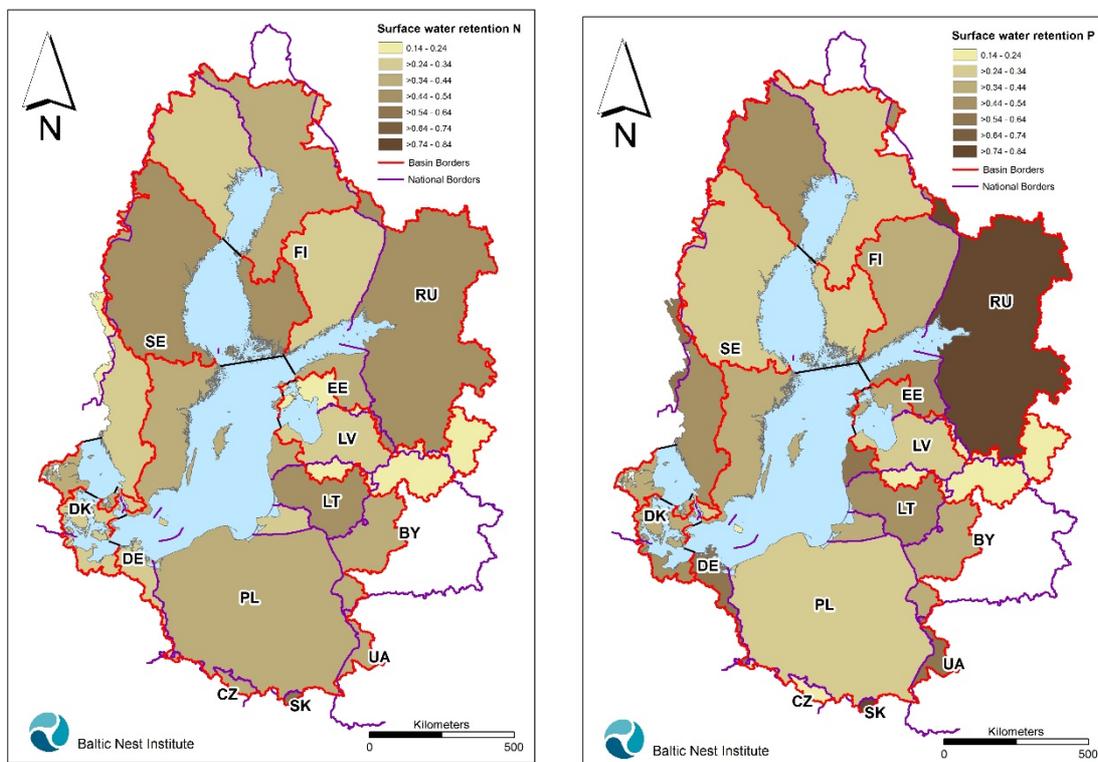


Figure 9.1. The nitrogen and phosphorus surface water retention coefficients used to estimate waterborne transboundary inputs by the RECOCCA project (cf. Chapter 8.3). The retention data calculated by RECOCCA has been used if Contracting Parties have not provided data. From Gustafsson & Mörth, in prep.

10. Quantification of sources of waterborne inputs to inland waters and to the sea

Quantifying the total gross loads from point sources, diffuse sources and natural background losses into inland surface waters within the whole Baltic Sea catchment area (the so called source oriented approach) is important to get a comprehensive overview of the total loading originating in the Baltic Sea catchment area. This is also a prerequisite for the estimation of retention and source apportionment. The quantification of gross loads together with retention is also important for evaluating effectiveness of measures for reducing waterborne pollution to the sea. The quantification of input sources to inland surface waters is described in Chapter 10.1.

Quantification of sources of waterborne riverine inputs to the sea (or the so called load oriented approach) is a tool to evaluate the contribution from different inland point and diffuse sources of the total riverine input of nitrogen and phosphorus entering the Baltic Sea (see Chapter 4 for a description on how to quantify riverine inputs). The objective is to divide riverine input to the sea into different sources (anthropogenic sources and natural background losses). This apportionment is done on the basis of the total nitrogen and phosphorus inputs taking into account the retention in inland surface waters (see Chapter 9 for information on retention). The quantification of sources of waterborne inputs to the sea is described below in Chapter 10.2.

Retention in inland surface waters is the connecting link between the “Source Orientated Approach” and the “Load Orientated Approach”. See also **Figure 2.3**.

10.1. Source oriented approach: Quantification of sources of waterborne inputs into inland surface waters

The source-oriented approach aims to quantify all inputs from point sources, diffuse sources and natural background losses into inland surface waters within the Baltic Sea catchment area. Quantifying these inputs is important for assessing e.g. the effectiveness of pollution reduction measures and the extent of retention of pollutants in the catchment area.

Quantification of losses from point sources is described in Chapter 5 and quantification of diffuse sources and natural background losses are described in chapters 6 and 7.

Quantification of loads using the source-oriented approach is carried out only periodically for PLC projects, ideally every sixth year in accordance with HELCOM Recommendation 26/2 (HELCOM 2005). All information and data that have to be reported are summarized in Annexes 2 and 3.

10.2. Load oriented approach: Quantification on sources of waterborne inputs to the sea

According to HELCOM Recommendation 26/2 the sources of waterborne inputs to the sea (riverine load apportionment) should be quantified for the periodic pollution input compilations. It should be done for the monitored rivers and reported either individually per monitored river or aggregated for several rivers. For unmonitored areas, riverine load apportionment figures should be reported per Contracting Party for each Baltic Sea sub-basin.

Point and diffuse sources behave differently in relation to meteorological/hydrological factors: Discharges from point sources are normally comparatively constant during the whole year, while losses from diffuse sources vary strongly with the meteorological and/or hydrological conditions. Thus, in order to reduce temporal variability of diffuse sources it may be suitable to base the source apportionment on flow

normalized data. In addition, quantification of natural background losses to inland surface water is necessary for calculating the total nutrient loading entering inland surface waters.

Part of the loading entering inland surface waters is retained in lakes, rivers and flooded riparian zones before it is discharged into the Baltic Sea. Thus, to divide the riverine net export into its sources, the retention processes must be taken into account (see Chapter 9 for more information on retention).

10.2.1. Calculation principles for riverine load apportionment

The recommended procedure for large river catchments is to first divide the catchment into sub-catchments, and then estimate the nutrient input and calculate retention using a mass balance approach or by using a numerical model tool in each sub-catchment. In this way both the total retention and the retention of individual nutrient sources at the river outlet can be achieved. A simpler approach may be used for smaller river catchments and unmonitored areas. Methodologies to calculate retention are described in Chapter 9.

As a minimum the riverine source apportionment should cover the following three source categories: point sources, losses from anthropogenic diffuse sources and natural background sources. If possible it is recommended to divide these main sources into further categories in accordance with the sources listed in chapters 5 and 6.

If models for quantifying net inputs entering the Baltic Sea sub-basin from each source are not available a simplified approach can be used. This starts out by expressing the riverine load apportionment (L_{river}) in the following equation:

$$L_{river} = D_p + LO_D + LO_B - R_p - R_d - R_B \quad (10.1)$$

Where:

- D_p = discharges from point sources ($t a^{-1}$),
- LO_D = losses from anthropogenic diffuse sources ($t a^{-1}$),
- LO_B = natural background losses ($t a^{-1}$),
- R_p = retention for point sources ($t a^{-1}$),
- R_D = retention for diffuse sources ($t a^{-1}$), and
- R_B = retention for background load ($t a^{-1}$).

Also an aggregated value for total retention might be used.

See Chapter 9 for a description on how to calculate retention.

The following equation can then be used for calculating nitrogen and phosphorus losses from diffuse sources (LO_D):

$$LO_D = L_{river} - D_p - LO_B + R_p + R_d + R_b. \quad (10.2)$$

In equations 10.1 and 10.2 flow normalized data can be used to reduce temporal variability of diffuse sources.

11. Statistical methods and data validation

11.1. Introduction

The aim of this chapter is to describe statistical methods. Sub-chapters 11.2-11.4 are expected to be carried out by the Contracting Parties whereas sub-chapters 11.5-11.8 will be carried out when assessing the results.

This chapter includes equations for the required mathematical calculations in the statistical methods to be applied when compiling pollution input (PLC) assessments, with focus on waterborne inputs, involving preparation of key input pressure indicators and annual assessments of whether the Contracting Parties fulfil the reduction requirements. The described methods include flow normalization of nutrient loads, testing for trends, filling in data gaps, estimation of the uncertainty of datasets and, finally, how to test for fulfilment of CART.

Note that some of the methods are presented as guidance for elaboration of PLC assessments and that normalization, trends analysis and statistical tests on fulfilment of MAI and CART will be performed in a uniform way within the HELCOM PLC data processing framework (Contracting Parties will not be required to make these calculations).

Some examples are included in sub-chapters 11.5-11.7.

The chapter is based on the statistical reports by Larsen & Svendsen (2013 and in prep.) elaborated as products under PLC-6 and PLC-7 projects.

11.2. Data gaps

Before forwarding data to the PLC Data Manager, Contracting Parties should check for data gaps and can make use of the proposed method in this sub-chapter. Further, the methods are used for PLC-assessments.

Several methods can be applied to fill in data gaps. Depending on the type of gap, the following methods can be applied to fill in the gap::

- Mean value of a statistical distribution. The distribution is determined either by including all relevant data on the given catchment or from a shorter time series, for instance when estimating missing data from point sources in the beginning or end of a time series. *Note! This procedure is not directly appropriate to use on data that has a clear seasonality (e.g. as concentration data or other kinds of cyclic data. In that case, the data used need to be split into the appropriate seasons before the calculations.*
- Mean of adjacent values. Supposing that x_a and x_c are two time series values with the value x_b missing, then

$$x_b = \frac{x_a + x_c}{2} \quad (11.1)$$

- Linear interpolation. Supposing that x_a and x_b are the two adjacent values to n missing values, then the k^{th} missing value (from x_a) will be

$$x_k = x_a + k \cdot \frac{x_b - x_a}{n+1} \quad (11.2)$$

- If runoff is known and a good relationship can be established between the input by a certain variable and runoff, this relationship can be used to estimate missing values.
- A q-q relationship can be used to estimate missing runoff values; a good q-q relationship can often be established for a similar nearby river (q is the runoff).
- A load-load relationship for another river for which high correlation can be verified.
- Model estimations of unmonitored catchment inputs, if possible – otherwise, inputs can be estimated from reference data.

- Assignment of a real value in the interval between zero and the LOQ to observations below the limit of quantification according to the description in Chapter 12.7 on how to handle concentrations under LOQ when calculating loads.

Above, a number of methods for filling in gaps are presented. The question is which method is the best to use. Usually, this will be decided by the given situation, but the following rank is suggested:

1. Model approach – i.e. a regression type model for estimating load or flow
2. Linear interpolation including average of adjacent observations
3. Values from a look-up table or values provided by experts
4. No filling in of data gaps. Uses the available time series as it is and continue with the assessment.

11.3. Outliers

Contracting Parties should check their data for outliers before they are submitted to the PLC Data Manager. Before PLC assessments, reported data are checked for outliers.

Outliers are extreme data values compared to other reported values for the same locality (country, sub-catchment, sub-absin etc.), and can only be determined and flagged by conducting a formal outlier test using for instance:

- Dixon's 4 sigma (σ) test: Outliers are the values outside the interval consisting of the mean ± 4 times the standard deviation
- A box and whisker diagram
- Experience-based definition of maximum and minimum values that is not likely to be exceeded or fallen below
- Water quality standards (interval values or limits), if available.

It is important to note that outliers are not necessarily faulty data, but could be extreme observations requiring an extra careful evaluation prior to use in statistical analyses and other assessments.

Suspect or dubious values are values that do not fulfil the requirement of being determined as a formal outlier, but differ significantly from the remaining values in the time series and are suspected to be wrong but cannot be proven to be wrong. For instance, it could be an unreliable (high or low) load value compared with the reported runoff. Suspect or dubious values may occur if changes in laboratory standards have occurred, or if changes have been made in other measurement methods, resulting in an abrupt change in data values. Also calculation mistakes may occur due to use of wrong units, faulty water samples, laboratory mistakes, etc. Abnormal observations may also be true values caused by for instance accidental emissions. Suspect or dubious values should be treated as a formal outlier.

Usually, filling in data gaps or replacing suspect data cannot substitute measured data; thus, if possible, preferably measured or consistent model data should be found and used. If a reported data value is determined to be an outlier and deemed to be omitted from assessments, the outlier can be replaced in the assessment using a method from the list on data gaps. If a dubious value is determined, deemed to be wrong and omitted from assessments, and if it is not possible for the Contracting Party to correct the value, it should be removed from the PLC-Water database by the Contracting Party. It should be stressed that filled-in data gaps must be clearly marked in the PLC-Water database.

11.4. Uncertainty of inputs (yearly input from a specific country or area)

The uncertainty of input data is very important information when assessing data. Contracting Parties are expected to report as a minimum the total uncertainty on their total inputs by sub-catchment level (sub-chapters 13.4 and 14.3). Further the total uncertainty will be estimated for elaboration of PLC assessments. The method below can be used as standard methodology for performing the uncertainty estimates in a uniform way.

A standardized methodology is needed to estimate uncertainty in national datasets. One such methodology is DUET-H/WQ that was developed for monitored rivers and is described in a paper by Harmel et al. (2009) (software is available at the [PLC-6 project page](#) on the HELCOM website). It is based on the so-called RMSE (root mean square error) propagation method and gives a fair approximation of the true value, which often is very hard to derive.

In DUET-H/WQ the uncertainty of individual measurements is estimated by the equation:

$$EP = \sqrt{E_Q^2 + E_C^2 + E_{PS}^2 + E_A^2 + E_{DPM}^2}, \quad (11.3)$$

Where, according to Harmel et al. (2009):

E_Q = Uncertainty of the discharge measurement ($\pm\%$)

E_C = Uncertainty of sample collection ($\pm\%$)

E_{PS} = Uncertainty of sample preservation/storage ($\pm\%$)

E_A = Uncertainty arising from laboratory analysis ($\pm\%$)

E_{DPM} = Uncertainty arising from data processing and data management ($\pm\%$).

Then the total uncertainty of the aggregated data can be estimated by:

$$EP_{total} = \frac{100}{\sum_{i=1}^n x_i} \sqrt{\sum_{i=1}^n \left(x_i \cdot \frac{EP_i}{100} \right)^2} \quad (11.4)$$

Where:

EP_{total} is given as $\pm\%$,

EP_{total} is the uncertainty of the sum $x = \sum_{i=1}^n x_i$,

x_i is the monthly load from a catchment or country.

The Contracting Parties will need to gather information on the different uncertainties, either from empirical data or from national or international papers and reports based on the same kind of data, i.e. riverine measurements based on more or less similar methods.

Bias and precision

Uncertainty consists of two components precision and bias, but is often given as one value. The uncertainties for many of the components listed above are not quantified or estimated, but the uncertainty on individual water flow quantifications are well known and should in most cases be lower than $\pm 5\%$ (Herschy 2009 and WMO 2008). The precision on daily water flow depends on the number of discharge observations, and is estimated for open gauging stations in streams channels in Denmark to be from 8% (given as standard deviation) with 10 annual discharge observations (measurements of discharge), about 6% with 12 measurements to less than 1% with more than 40 annual measurements (Kronvang et al. 2014). For modelled

water flow the uncertainty might be higher. For chemical analysis the requirement in Denmark is that the total (expanded) uncertainty for total nitrogen and total phosphorus is less than 15% (or 0.1 mg N l⁻¹ and 0.01 mg P l⁻¹ at low concentration values in freshwater, respectively 5 mg N l⁻¹ and 1 mg P l⁻¹ at low concentration values in wastewater).

A examples of calculating the uncertainty is from using Danish data for total nitrogen inputs to the marine areas around Denmark. The total input to the Danish marine environment is a sum of two components. One component is from the monitored catchment area and the other is from the unmonitored area. The inputs from the unmeasured area is estimated by using a model.

Monitored area:

The calculation of the uncertainty is done by using the statistical principle “Propagation of errors”. This principle can be explained as:

Let X be the sum of n stochastically independent measured inputs:

$$X = \sum_{i=1}^n X_i. \quad (11.5)$$

The variance of X can be calculated as:

$$\sigma_X^2 = Var(X) = \sum_{i=1}^n \sigma_{X_i}^2. \quad (11.6)$$

The standard deviation is then calculated as:

$$\sigma_X = \sqrt{\sum_{i=1}^n \sigma_{X_i}^2}. \quad (11.7)$$

And the relative standard deviation (denoted the precision) is calculated as:

$$100 \cdot \frac{\sigma_X}{X} = \frac{100}{\sum_{i=1}^n X_i} \sqrt{\sum_{i=1}^n \sigma_{X_i}^2}. \quad (11.8)$$

The calculation of the total inputs from the monitored areas constitute of measurements from 169 stations in streams. These stations cover approximately 55% of the total Danish catchment area. Bias and precision can then be calculated as:

$$bias (\%) = \frac{100}{\sum_{i=1}^{169} X_i} \sum_{i=1}^{169} bias_i \cdot X_i, \quad (11.9)$$

$$precision (\%) = \frac{100}{\sum_{i=1}^{169} X_i} \sqrt{\sum_{i=1}^{169} (precision_i \cdot X_i)^2}. \quad (11.10)$$

Here *bias* and *precision* are the individual biases and precisions (given in decimal notation) for each river indexed by *i*. The total uncertainty can then be calculated as:

$$uncertainty (\%) = \frac{100}{\sum_{i=1}^{169} X_i} \sqrt{\sum_{i=1}^{169} (bias_i \cdot X_i)^2 + (precision_i \cdot X_i)^2}. \quad (11.11)$$

A Monte Carlo study (Kronvang & Bruhn, 1996) based on daily samples has shown that for Danish streams categorized by their catchment area, the following values for bias and precision are valid for nitrogen load:

0-50 km ² :	Bias: -1% to -3%;	Precision: 1-3%
50-200 km ² :	Bias: -0.7% to -3%;	Precision: 1-3%
>200 km ² :	Bias: -1% to -4%;	Precision: 2-5%

These number are valid for the yearly load from one stream station and include the uncertainty of laboratory analysis, yearly variation of concentrations and stream discharge and uncertainty from the method for calculating yearly load (by linear interpolation). The uncertainty from the measurement of the concentration in the stream (placement of bottle horizontal and vertical in the stream) is not included and therefore 2% is added to the precision in the 3 categories.

Using the formulae, it can be calculated that the total bias is -1% to -3%, the total precision is 0.7% to 1.2% and the total uncertainty is 0.7% to 1.3%. For an average stream station the bias is -1% to -3%, the precision is 3% to 5% and the uncertainty is 3.2% to 5.8%.

Unmonitored areas

The nitrogen input from the unmonitored areas is based on model estimates for 1286 very small catchments covering the rest of the Danish area (45%). The year load from each small catchment is calculated using the formula:

$$L = N_{diffuse_{model}} + R_{lake} + R_{stream} + N_{waste} - R_{total}, \quad (11.12)$$

where

$N_{diffuse_{model}}$ = Estimated nitrogen inputs from the model,

R_{lake} = Estimated nitrogen retention in lakes,

R_{stream} = Estimates nitrogen retention in streams,

N_{waste} = Nitrogen load from waste water,

R_{total} = Total nitrogen retention.

Table 11.1. Bias and precision for the components in formula 11.12. Based on both numerical calculations, the study by Kronvang & Bruhn (1996) and estimates.

Components	Bias (%)	Precision (%)
Model	-15 to 25	12 to 15
Retention lake	-5 to 5	40

Retention stream	-5 to 10	40
Retention total	-5	40
Point source: industry	-1 to -3	1 to 10
Point source: wastewater	-1 to -3	1 to 10
Point source: fish farms	-1 to -3	1 to 20
Point source: rain water	-5	40

Using the formulae (11.5) to (11.11) the total bias for the unmonitored area is calculated to 20% to 28%, the total precision is 0.8% to 2.0% and the total uncertainty is 1.2% to 2.2%. For an average small unmonitored catchment the bias is 27%, precision 15% to 20% and the uncertainty 31% to 34%.

For the total Danish catchment area, combining the calculated bias, precision and uncertainty for both the monitored and unmonitored areas and using special versions of formulae (11.9) to (11.11), we get a total bias of 7.4% to 12.8%, a total precision of 0.5% to 1.1% and a total uncertainty of 7.4% to 12.8% on total nitrogen inputs.

With respect to total phosphorus (TP), calculations show that for the measured area the bias is -6 to -3%, the precision is 1 – 2% and the uncertainty is then 1 – 2.5%. For the unmeasured area the bias is between -5 and 30%, the precision is 1 – 3% and the uncertainty is 1 – 4%.

11.5. Hydrological normalization of riverine inputs

Input data are normalized in order to be better able to detect possible trends in inputs over time by smoothing out the effects of meteorological and hydrographical conditions. The methods presented below are to serve as guidance for elaboration of PLC assessments and will be performed in a uniform way within the HELCOM PLC data processing framework, and the Contracting Parties will not be required to make these calculations.

According to Silgram and Schoumans (ed., 2004), the empirical hydrological normalization method should be based on the linear relationship between annual runoff (Q) and the annual load (L) in year i of a nutrient:

$$L_i = \alpha + \beta \cdot Q_i + \varepsilon_i, \quad (11.13)$$

α and β = Parameters associated with linear regression

ε_i = Residual error in the linear regression

Then, the normalized load L_N is calculated as:

$$L_{iN} = L_i - (Q_i - \bar{Q}) \cdot \hat{\beta}, \quad (11.14)$$

\bar{Q} = Average runoff for the whole time series period

Q_i = Runoff in year i

$\hat{\beta}$ = Indicates that it is an estimated parameter.

Normally, the relationship is modelled after log-log transformation, reducing the influence of large loads and runoff values giving a slightly more precise fit with residuals that are more likely to be Gaussian distributed, which is a statistical prerequisite for the regression method. Thus, normalization should be based on a log-

log regression between load and runoff. We use then linear relationship between the log-transformed annual runoff (log Q) and the log-transformed annual load (log L) of a nutrient where α and β are parameters associated with linear regression and ε_i stands for the residual error in the linear regression.

$$\log L_i = \alpha + \beta \cdot \log Q_i + \varepsilon_i, \quad (11.15)$$

Where:

α and β = Parameters associated with linear regression

ε_i = Residual error in the linear regression

Q_i = Annual runoff year i.

To avoid large negative values when log transforming very small loads or runoff values, it is suggested to multiply load and runoff with 1000 before log transforming.

Formula 11.15 gives the following equation to avoid negative values for normalized loads:

$$L_{iN} = \exp(\log L_i - (\log Q_i - \overline{\log Q}) \cdot \hat{\beta}) \cdot \exp(0.5 \cdot \text{MSE}), \quad (11.16)$$

Where

Log = Natural logarithmic function,

Exp = Exponential function,

\overline{Q} = Average runoff for the whole time series period,

$\hat{\alpha}$ = Estimated (^) interception with y-axis,

$\hat{\beta}$ = Estimated (^) inclination of regression line

MSE = Mean Squared Error.

$\hat{\beta}$ and MSE are all derived (estimated) by the regression analysis.

The MSE is normally calculated in standard statistical software and is in general defined as:

$$\text{MSE} = \frac{1}{n-2} \sum_{i=1}^n (x_i - \hat{x}_i)^2, \quad (11.17)$$

Where

n = Number of observations in the time series,

x_i = Observed value, and

\hat{x}_i = Modelled value from linear regression.

In this chapter x_i would be $\log L_i$ and \hat{x}_i would be $\widehat{\log L}_i$, and \log the natural logarithm function.

Formula (11.16) is the recommended method for PLC-5.5 assessment and onwards.

Note! Caution should be taken when handling loads/inputs with significant upstream point sources, as these sources affect the relationship between the substance and the discharge, which may result in different relationship during high and low flow situations. In addition, large changes in the load from the upstream point sources may have an impact on the normalization.

The factor “ $\exp(0.5 \cdot \text{MSE})$ ” in the formulae is a bias correction factor and is derived as described by Ferguson (1986). The factor is needed in order to back-transform to a mean value and not to a geometric mean, whose calculation does not require this factor. If $\exp(0.5 \cdot \text{MSE}) > 1.25$, this indicates that the fit in formula (11.13) is not very good and it is probably better not to log transform and use formula (11.16) and (11.17) below.

In principle, the presented methods can be applied even with a significant trend in the runoff time series, as long as the relationship between runoff and load is unchanged. Usually, the relationship changes with a significant change in the runoff over time. This implies that a trend analysis of the runoff time series is needed in order to determine whether an upward or downward trend in the flow is present. There it is recommended to divide the time series in two or more parts of equal length, and do the normalization for the each part separately. Each part of the time series should at least have a length of 8-10 years.

As an example, the relationship between log-transformed inputs of total phosphorus and runoff in the Vistula River, Poland is shown in **Figure 11.1**. **Figure 11.2** shows the normalized time series together with the unnormalized loads. Note the large reduction in between-year variation in the normalized time series.

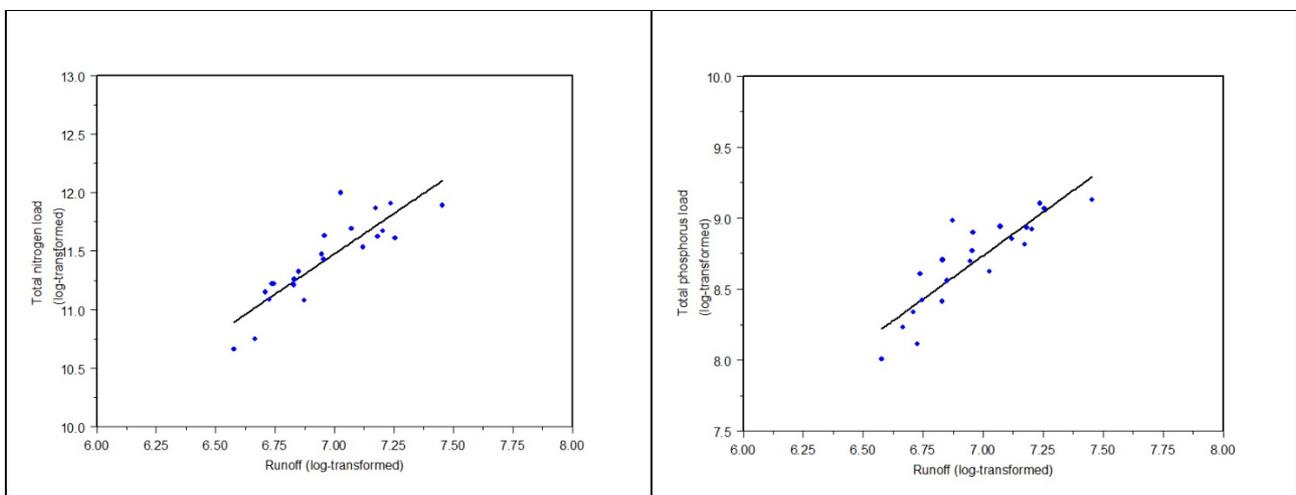


Figure 11.1. Linear regression on total waterborne nitrogen (left figure) and phosphorus (right figure) inputs and river flow for Vistula River in Poland. The transformation is based on the natural logarithmic function.

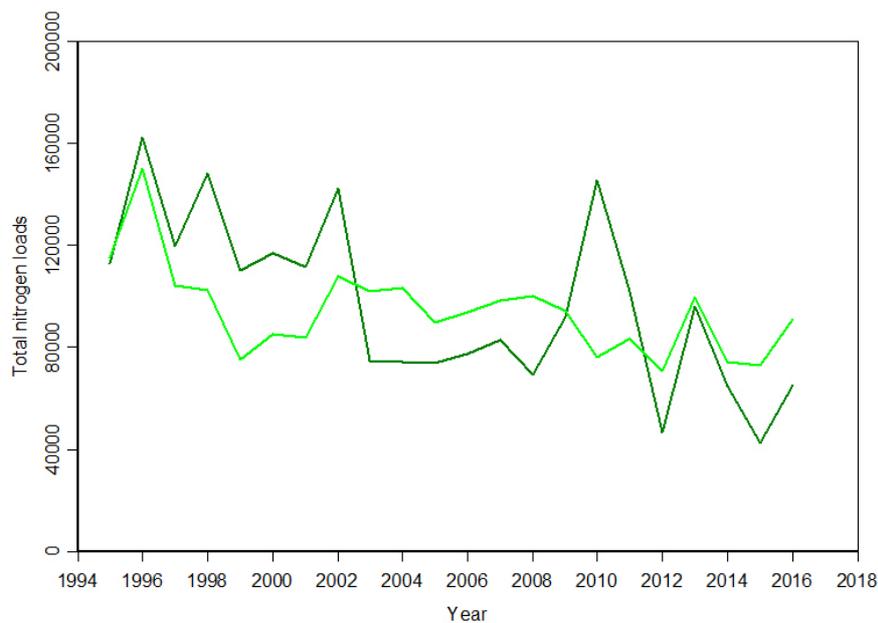
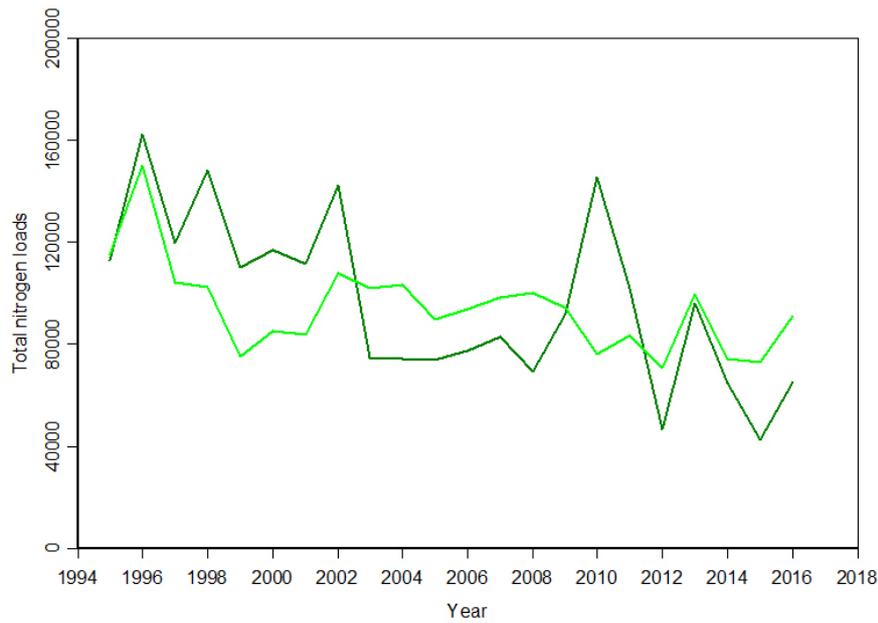


Figure 11.2. Time series plot of annual actual (not normalized) time series (red) and of normalized time series (green) of annual TN and TP (tonnes) of Vistula River, Poland 1995-2016.

Figure 11.3 shows the normalized inputs of total nitrogen and total phosphorus summed up for all rivers discharging to Bothnian Bay 1995-2016 including direct point sources (not normalized) and climate normalized airborne inputs Normalized according to annex 7) . As can be seen, the variation between years is reduced significantly. These normalized inputs summed for all the rivers together with inputs from direct point sources and from atmospheric deposition are used for trend analysis and target testing.

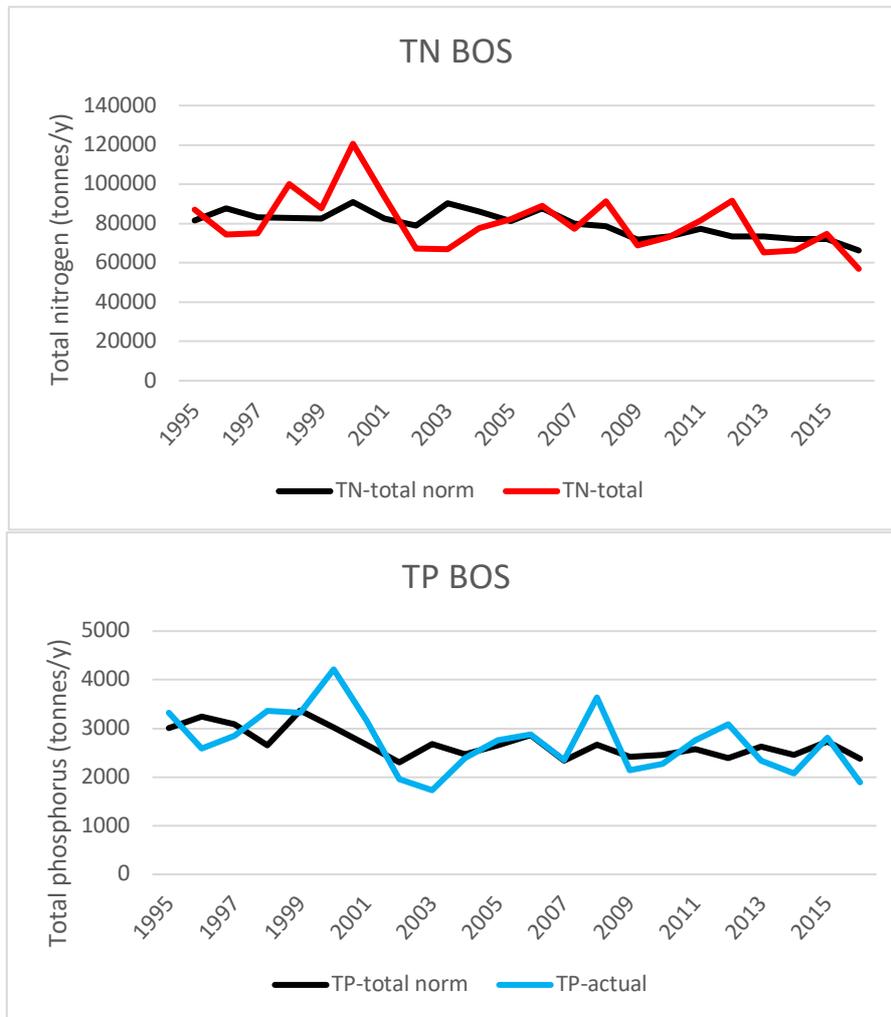


Figure 11.3. Annual normalized (green) and measured total nitrogen and phosphorus inputs (riverine, direct and airborne) to the Bothnian Bay during 1995-2016.

11.6. Trend analysis, change points and the estimation of change

As with e.g. hydrological normalization in Chapter 11.5, the trend analysis will be performed in a uniform way within the HELCOM PLC data processing framework, and Contracting Parties are not be required to make these calculations. The procedure in chapter 11.6 is called the trend based methodology to estimate latest year value in a normalized time series.

The Mann-Kendall trend method is used for a preliminary analysis of possible trends in the TN and TP load time series. Furthermore, the Mann-Kendall method is used for analyzing possible trends in runoff time series. The remaining trend analysis, as estimating trend line (slope, intersect), estimating latest year input and changes in inputs is based on linear regression and parametric testing. In the first MAI and CART assessment more focus was placed on using the Mann-Kendall method.

Concerning trend analysis it is suggested to use the Mann-Kendall non-parametric trend method for testing a significant monotonic trend in the normalized time series. This is a fairly robust method although autocorrelation can deflate the power of the test. We assume that the autocorrelation in the time series of annual nutrient inputs is of minor importance and therefore we see the Mann-Kendall trend test as a very good approximation. This non-parametric method can be used on “raw” nutrient time series, normalized time series and river flow (meteorological) time series. If it will be decided to use monthly load time series in

the future, the Mann-Kendall trend test is available in an extended seasonal version (Hirsch and Slack 1984), which can be applied provided that seasonal trends are homogeneous.

The Mann-Kendall method (Hirsch et al. 1982) is a well-established procedure to test for a monotonic trend in a time series and is a non-parametric method based on Kendall's tau, which is a measure of the correlation between two different variables. The method is robust towards outliers and a few missing data. If the trend is linear, Mann-Kendall's method has slightly less power than ordinary regression analysis. A detailed mathematical description of the method can be found in sub-chapter 11.8 and software can be freely downloaded at e.g. <http://en.ilmatieteenlaitos.fi/makesens>.

Ordinary regression analysis is also a well-known statistical method (**Figure 11.4**), but demands a linear relationship with Gaussian distributed residuals, which are stochastic independent as well (Snedecor and Cochran, 1989). If the time series is serially correlated, both the Mann-Kendall test and ordinary regression must be modified, since the tests will be impacted by this, and the probabilities of statistical test values can therefore not be trusted. On the other hand, it appears that the autocorrelation for annual time series of either loads or runoff is small and can be ignored; thus, the methods can be used without modifications as a good approximation. The minimum time series length for application of the Mann-Kendall test is 8 years.

Both Mann-Kendall's trend analysis and ordinary linear regression allow performance of a one-sided trend test if focus is on testing for a downward or increasing development in a time series. This is of relevance in the PLC assessments and when evaluating progress towards HELCOM BSAP reduction targets.

If a time series plot shows one or two clear trend reversals (also called change points in time), i.e. when the first part of the time series shows a linear increase and the second part shows a linear decrease in nutrient inputs. The trend analysis can be carried out by using a model with two or three linear curves or by applying two or three Mann-Kendall trend tests if time series parts include a sufficient number of years (example in **Figure 11.5**). Year of trend reversal (the change point) can either be determined by inspecting the time series plot or by applying a statistical method (Carstensen and Larsen, 2006). If an exact year of change in the inputs is known (changes to sewage plants, etc.), this year should be applied as change point, and the time series should be divided accordingly. Statistical estimation of the time when a change occurs in a time series is complex and involves a calculation procedure with iterative estimations. The LOESS (locally weighted scatterplot smoothing) regression method can be used as a supplement for detecting non-linear trends and for helping detecting change points/step trends. See the plots in **Figure 11.4b and 11.5b** for examples of using LOESS.

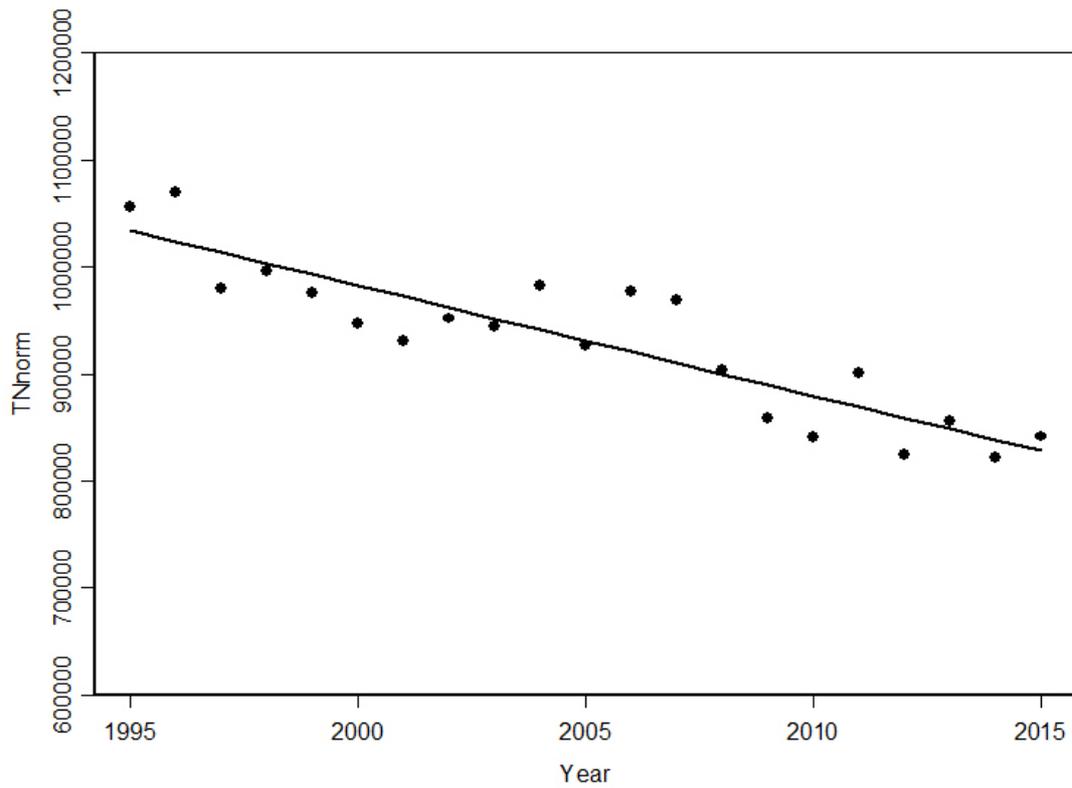


Figure 11.4a Total annual normalized air and waterborne nitrogen inputs to the Baltic Sea. Trend-line estimated with linear regression model.

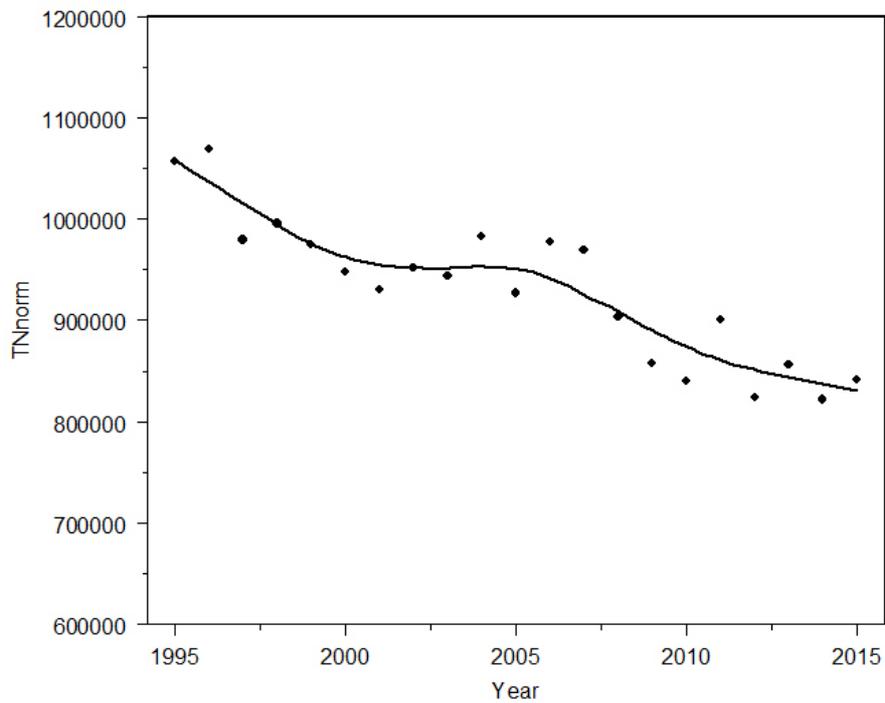


Figure 11.4b As figure 11.4a but the trend-line is estimated with LOESS (locally weighted scatterplot smoothing) regression method.

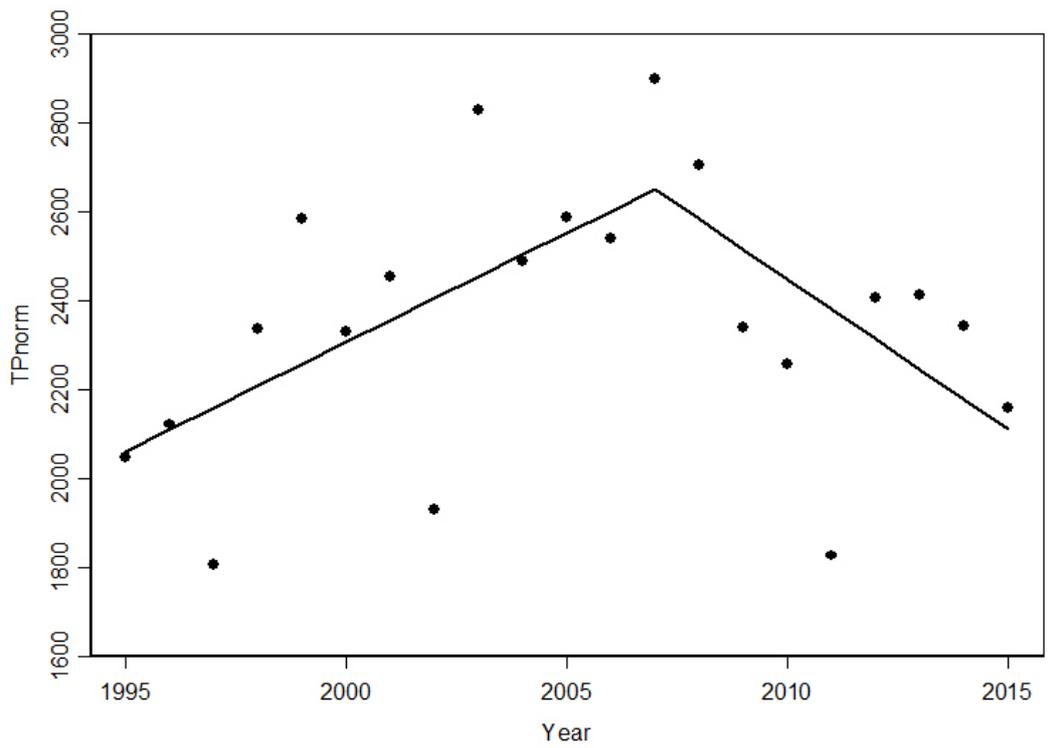


Figure 11.5a Total annual normalized phosphorus 1995-2015. One change point in the time series are detected, and the trend-line is based on Mann-Kendal trend test and linear regression.

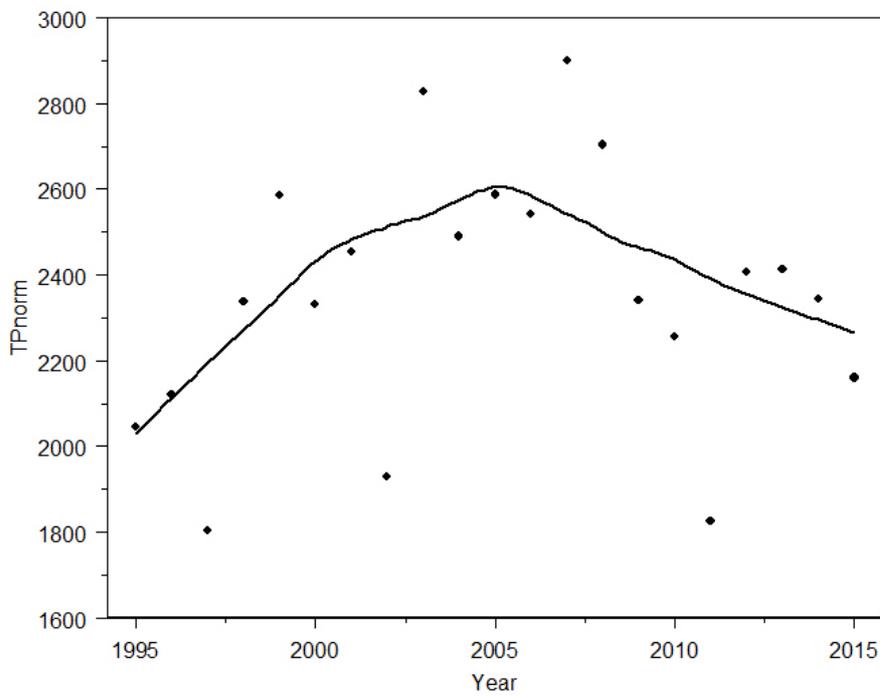


Figure 11.5b As figure 11.4a but the trend-line is estimated with LOESS regression method.

It is suggested to use models with 1, 2 or 3 linear parts for different sections of the time series (it is still possible that no part of the time series includes significant linear trends). Determination of breakpoints will be statistically analyzed by using an iterative statistical process, which will determine the most significant breakpoint (the significance of the breakpoint is evaluated by the change in $-2\log Q$) – or automatically ($-2\log Q$ is the result from testing a statistical hypothesis with likelihood-ratio test). At least 5 years at the ends, before change-points.

It is proposed to investigate two different breakpoint models, here described with two linear parts:

$$\text{Model 1: } L_{Ni} = \begin{cases} \alpha + \beta \cdot i, & \text{for } i < Y \\ \alpha + \beta \cdot i + d \cdot (i - Y), & \text{for } i \geq Y \end{cases} \quad (11.18)$$

$$\text{Model 2: } L_{Ni} = \begin{cases} \alpha_1 + \beta_1 \cdot i, & \text{for } i < Y \\ \alpha_2 + \beta_2 \cdot i, & \text{for } i \geq Y \end{cases} \quad (11.19)$$

Where

Y = A given year

L_N = Normalized input

α = Intercept

β and d = Slopes

i = Different years in the time series.

Model 1 is continuous at the breakpoint (the two lines are connected) while model 2 has disconnected lines at the breakpoint (a step).

After the first breakpoint is determined, another iterative process looking for a second breakpoint is performed.

Change-points models are an aid for estimating the last year value, and to get an idea of the overall trend during the full time series period.

Finally, significance of the slope in the last segment is tested, and if not significant different from zero then we use the model:

$$L_{Ni} = \begin{cases} \alpha + \beta \cdot i, & \text{for } i < Y \\ c, & \text{for } i \geq Y \end{cases} \quad (11.20)$$

c = Estimated input (a constant)

Summarizing the procedure:

Analyzing for one change-point:

No: Is there an overall significant trend?

Yes: Fit a linear model

No: Estimate a constant throughout time series

Yes: Analyzing for a second change-point

Yes: Testing the significance of the last segment
 Yes: Fit model
 No: A constant in the last segment
 No: Testing the significance of the last segment
 Yes: Fit model
 No: A constant in the last segment

The second part of the trend analysis concerns estimating the size of the trend or the change per year. Again, several different methods exist and which to use depends on the shape of the trend. The Theil-Sen slope estimator (Hirsch et al. 1982) is a non-parametric estimator that is resistant towards outlier (suspicious) values. The method assumes a linear trend and estimates the change per year. However, the estimator fails if a trend is non-linear, and if the time series contain one or several change-points the time series must be split into two or more parts.

The size of a linear trend can also be estimated by regression. This is the classical approach, but it is not flexible with regard to all shapes of trends. The simplest method is using the start and end values in the time series of flow-normalized inputs. However, if the start and/or end values are too distant from the general trend, this method is not to be trusted.

If we are interested in the total change in nutrient inputs over the whole time series expressed as a percentage, we can use one of the following two methods. Using the estimated linear slope the total change can be calculated as:

$$100 \cdot \frac{(n-1) \cdot \hat{\beta}}{\hat{\alpha}}, \quad (11.21)$$

where

n = Length (number of years) of the series,

$\hat{\alpha}$ = Estimated intercept (input at start year minus one year), and

$\hat{\beta}$ = Estimated slope.

In the case of change-points use the formula for each segment and add up the percentages. Remember to add the step trend if such one is detected at the change point. If the slope is not significant in one or more of the segment use a slope estimate equal zero in the formula.

For the evaluation of BSAP reduction targets and PLC assessments intercept and slope in formula 11.21 is based on linear regression estimates. Alternatively, slope can be determined with Theil Sen slope estimator and intercept using the estimator suggested by Conover (1980).

Using start and end values we have the equation for calculating the total change:

$$100 \cdot (\text{end-start})/\text{start}. \quad (11.22)$$

In the case of change-points the formula should be used for each segment and the percentages are added up. Further, add the step trend if such one is detected at the change point. If the slope is not significant in one or more of the segment use the average value in the segment for starting and ending values.

For some times series the start value, the end value or both can differ too much from the general trend – in such cases an approach using the average value of, for instance, the first three years and the last three years would reduce the influence of single years.

The trend analysis methods are illustrated below based on the time series of normalized TN inputs to Danish Straits. In figure 11.6, the normalized time series are shown together with a model fit of the trends. The

model fit consists of one change point in year 2003 and the linear fits before and after the change point are significant. A trend analysis should always be initiated with a time series plot of the data series. The Mann-Kendall trend test is also significant with $Z=-5.24$ ($P<0.0001$).

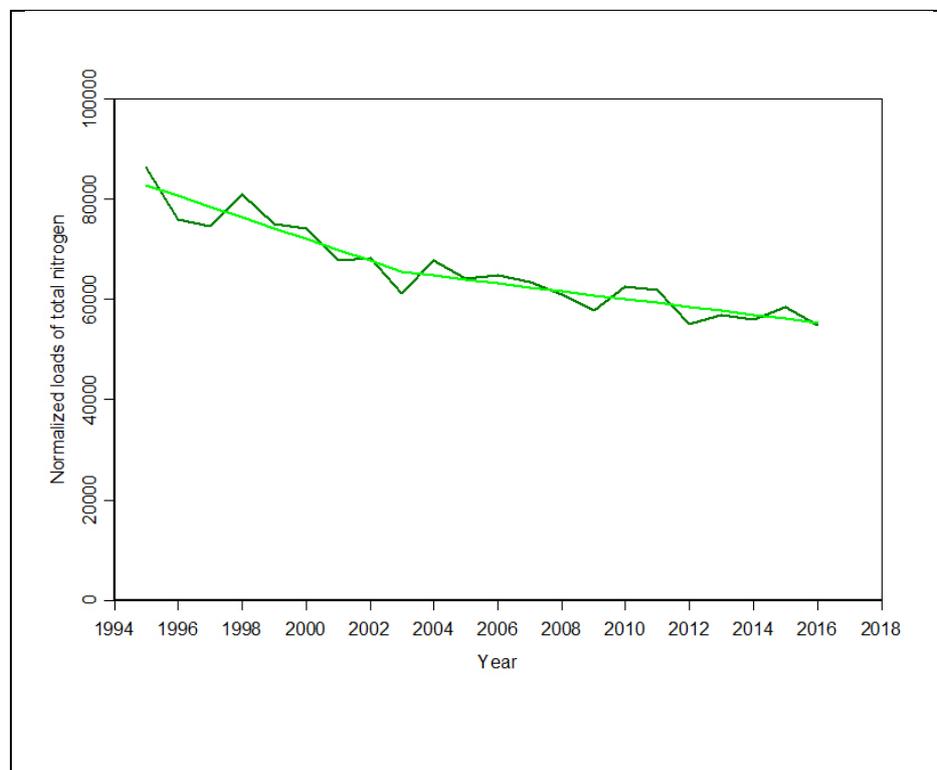


Figure 11.6. The fitting of linear regressions to flow-normalized inputs of nitrogen (a) and phosphorus (b). Data are annual riverine inputs from Poland.

The estimated change over the whole period for the normalized TN inputs is -32% according to formula 11.19 and -36% according to formula 5.2. Using the model with one change point the estimated change over the whole period is -33%.

11.7. Testing fulfilment of BSAP reduction targets

This methodology will be applied in a uniform way by HELCOM when evaluating progress in and fulfilment of MAI and CART. Contracting Party are not supposed to make these test.

11.7.1. Testing without significant trends

To test if a nutrient reduction target has been fulfilled is assumed that we have a time series of normalized inputs. The time series is initially presumed to be without a statistically significant trend and without a significantly large serial correlation, and we assume that the reduction target T (or any kind of target such as CART) is defined without error, i.e. is a fixed value (an amount of nitrogen/phosphorus without uncertainty).

Finally, it is assumed that the data are sampled from a Gaussian distribution with mean value μ and variance σ^2 .

As null hypothesis for the statistical test, we assume that the target has not been fulfilled, i.e.

$$H_0 : \mu \geq T$$

Where:

H = Hypothesis

T = Target

The alternative hypothesis

$$H_A : \mu < T$$

follows from this, i.e. the target has been fulfilled. Now assume that the test probability α is defined to be 5% (0.05), and then calculate the statistic

$$\bar{x}_{AD} = \bar{x} + t_{n-1,0.05} \cdot SE, \quad (11.23)$$

Where:

\bar{x}_{AD} = Adjusted mean

\bar{x} = Mean of all values in the time series,

SE = Standard error (SE = standard deviation divided by square root of n)

n = Number of observations in the time series), and

$t_{n-1,0.05}$ = 95% percentile in a t-distribution with $n-1$ degrees of freedom.

A test probability of 5% means that we have a 5% probability of incorrectly rejecting the null hypothesis.

This statistic is called the adjusted mean and if the statistic is less than the target T , then the reduction target is met.

11.7.2. Testing with significant trends

In the case of a time series of nutrient inputs with a significant trend, another statistical method is needed for testing if a BSAP target is met. Let us assume that the trend is linear, that a linear regression model with year as the independent variable can be fitted to the time series and that estimates for α and β can be calculated – then the linear model can be used to predict a normalized nutrient input for the last year

($year_n$) in the time series. This estimate is calculated as:

$$\widehat{L}_{nN} = \hat{\alpha} + \hat{\beta} \cdot year_n. \quad (11.24)$$

\widehat{L}_{nN} = Estimated normalized input in year n

$\hat{\alpha}$ = Estimated intercept

$\hat{\beta}$ = Estimated slope

Next, we need the standard error of the prediction (predicted input) defined as:

$$SE = \sqrt{MSE} \cdot \sqrt{1/n + year_n^2 / \sum_{i=1}^n year_i^2} \quad (11.25)$$

where

MSE = the Mean Squared Error as defined in formula 11.15,

n = the number of years in the time series,

$year_n$ = the last year in the time series (i.e. 2014), and

$year_i$ = a given year in the time series (i.e. 1997).

As reference year for the time series of years is used $year=0$.

Then the statistic is calculated as:

$$\bar{x}_{AD} = \widehat{L}_{nN} + t_{n-2,0.05} \cdot SE, \quad (11.26)$$

Where

$t_{n-2,0.05}$ = the 95% percentile in a t -distribution with $n-2$ degrees of freedom.

A list with the 95% percentiles for different values of $n-2$ is given in annex 2 in Larsen & Svendsen (in prep.).

The mathematical definition of the standard error of the prediction SE given in (11.26) is from ordinary linear regression (Snedecor and Cochran, 1989). If the trend is not linear, other models have to be used for the time series, and the formula for the standard error needs to be revised. The form of the trend in the data will dictate the methods to be applied. These methods are based on the assumption of the existence of one or two change points in the time series (see chapter 11.5).

“Trend method”

A few examples are given here, the examples are based on models with one change-point Y , and we assume that the last year in the time series is denoted by $year_n$. In general, we denote the method the “trend method”. The first example is a model with one change point and a linear model before and a linear model after the change point, and no change in level before and after the change point. The second example is equal to the first example but with a change in level at the change point. The last example (example 3) is with a constant level after the change point.

Example 1:

$$L_{Ni} = \begin{cases} \alpha + \beta \cdot i, & \text{for } i < Y \\ \alpha + \beta \cdot i + d \cdot (i - Y), & \text{for } i \geq Y \end{cases}$$

$$\widehat{L}_{nN} = \hat{\alpha} + \hat{\beta} \cdot year_n + \hat{d} \cdot (year_n - Y)$$

Example 2:

$$L_{Ni} = \begin{cases} \alpha_1 + \beta_1 \cdot i, & \text{for } i < Y \\ \alpha_2 + \beta_2 \cdot i, & \text{for } i \geq Y \end{cases}$$

$$\widehat{L}_{nN} = \widehat{\alpha}_2 + \widehat{\beta}_2 \cdot year_n.$$

Example 3:

$$L_{Ni} = \begin{cases} \alpha + \beta \cdot i, & \text{for } i < Y \\ c, & \text{for } i \geq Y \end{cases}$$

$$\widehat{L}_{nN} = \widehat{k}$$

The SE (standard error) for the estimated input for the last year ($year_n$) has the general form of

$$SE = \sqrt{MSE} \cdot \sqrt{1/m + year_n^2 / \sum_{i=Y}^{year_n} i^2} \quad (11.27)$$

Where

m = Number of years after Y ($\geq Y$).

MSE is calculated for the full model i.e. including all years in the time series.

Correction for calculating control value for $year_n$

$$\bar{x}_{AD} = \widehat{L}_{nN} + k \cdot SE. \quad (11.28)$$

Where

k factor = 95% percentile in a t-distribution with $n-p$ degrees of freedom,

p = Number of parameters in the final model.

Traffic light system

Finally, the following “traffic light” system will be used for evaluating whether a country or a sub-basin has met the BSAP target, is close to meeting the target or has not met the target. Statistically, the system is defined as:

Red:

If \bar{x} or $\widehat{L}_{nN} > T$ i.e. estimated normalized input for the last year or the average normalized nutrient input over the considered period (when there is no trend) is above target value T .

Yellow:

If \bar{x} or $\widehat{L}_{nN} < T$, and if $\bar{x}_{AD} > T$, i.e. the null hypothesis of the target test is accepted, but the estimated normalized input for the last year or the average normalized input over the considered period (when there is no trend) is lower than the target.

Green:

If $\bar{x}_{AD} < T$, i.e. the null hypothesis of the target test is rejected, i.e. the alternative hypothesis is accepted meaning the target has been fulfilled, and the estimated normalized input for the last year or the average normalized input over the considered period (when there is no trend) is lower than the target value.

Testing whether estimated last year inputs is lower than input in the reference period

For testing whether the estimated last year value \widehat{L}_{nN} is significantly different from the mean value in the reference period we apply the following procedure.

The reference period is defined to be the period 1997-2003. First calculate the mean value in the reference period

$$\overline{L_{N(ref)}} = \frac{1}{7} \sum_{i=1997}^{2003} L_{Ni} \quad (11.29)$$

and calculate the 95% confidence interval for $\overline{L_{N(ref)}}$ by

$$\overline{L_{N(ref)}} \pm k \cdot SE_{ref}. \quad (11.28)$$

The k factor is the 97.5% percentile in a t-distribution with 6 degrees of freedom ($k=2,447$) (7 years in the reference period minus 1). The SE_{ref} is the standard error of the mean value.

For the estimate of the last year \widehat{L}_{nN} we can calculate the 95% confidence interval as well by calculating

$$\widehat{L}_{nN} \pm k \cdot SE \quad (11.30)$$

where the k factor is the 97.5% percentile in a t-distribution with $n-p$ degrees of freedom. The number p is the number of parameters in the final model.

Testing the hypothesis of no difference between the reference period and the last year value can simply be done by determining if

$$(\overline{L_{N(ref)}} - \widehat{L}_{nN}) - k \cdot \sqrt{SE_{ref}^2 + SE^2} > 0 \quad (11.31)$$

where k is the 97.5% percentile in a t-distribution with $n-p+6$ degrees of freedom..

To illustrate the principles, we tested if the normalized TN inputs to the Danish Straits met the provisional MAI input ceiling of 65,998 tonnes TN per year. Using the model with one change point in 2003 (se figure 11.5) the estimating input in year 2016 is 55,442 tonnes with a SE of 1,082 tonnes. According to formula 11.26 the control value becomes 57,313 tons, which is less than 65,998 tonnes, so in the example the traffic light evaluation results in a green light. This example is illustrated in figure 11.7.

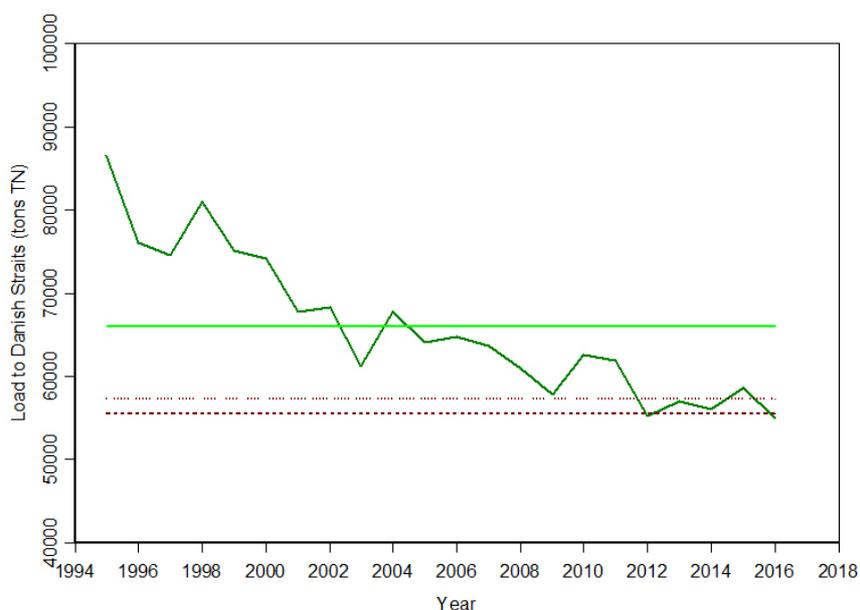


Figure 11.7. Principles on time series with trend created annual TN input to the Danish Straits. Full green line is the target (MAI), “-----” line is the estimated value (TN input) in 2016, and “....” line is the test value (TN input taking into account uncertainty) according to formula 11.26.

The average TN inputs in the reference period to Danish Straits were 71,728 tonnes and the confidence interval according to formula 6.6 is [65,789; 77,667] tonnes. The confidence interval for the 2016 estimate is [53,177; 57,707] tonnes according to formula 6.7. Using formula 6.9 we calculate that the left side of the inequality sign is 11,288 tonnes, which is larger than zero, so we conclude that TN input in 2016 to Danish Straits is statistical significant reduced (with 23%) since the reference period 1997-2003.

Table 11.2 includes another example of applying of the statistical analysis described to evaluate fulfilment of Finish phosphorus input ceilings based on data from 1995-2014. TP inputs to Gulf of Finland (322 tons P) are higher than the inputs ceiling to GUF (322 tons P), and the traffic light is then red and taking into account uncertainty the remaining reduction to fulfill reductions targets was 351 tons. The traffic light for Bothnian Sea is yellow, because the estimated total phosphorus inputs in 2014 when including uncertainty on the input estimate are higher than the input ceilings to BOS. For Bothnian Bay meet the input ceiling (green) with 137 tons P (extra reduction) taking into account uncertainty.

Table 11.2. Illustration of the traffic light system. Evaluation of progress towards reductions targets (nutrient inputs ceiling) of total phosphorus (TP) for Finland to Bothnian Bay (BOB), Bothnian Sea (BOS) and Gulf of Finland (GUF) based on normalized annual total phosphorus inputs from Finland during 1995-2014. Green: input ceiling are meet. Red: input ceilings are not fulfilled. Yellow: It can not be judge if Input ceilings are fulfilled taking into account uncertainty.

Finland TP	BOB	BOS	GUF
A : Input ceiling	1668	1255	322
B: Estimated input 2014	1483	1248	647
C: Inputs 2014 including uncertainty (test value)	1531	1311	673
Extra reduction (A-C)	137		
Remaining reduction to fulfill MAI		56	351

11.8. Mathematical description of the Mann-Kendall trend test

Trend analysis of a time series of length T consisting of yearly inputs of nutrients can be done by applying Mann-Kendall's trend test (Hirsch et al. 1982). This test method is also known as Kendall's τ (Kendall 1975). The aim of this test is to show if a downward or an upward trend over the period of T years is statistically significant or if the time series merely consists of a set of random observations of a certain size. The Mann-Kendall's trend test has become a very effective and popular method for trend analysis of water quality data.

The Mann-Kendall's trend test is a non-parametric statistical method, which means that the method has fewer assumptions than a formal parametric test method. The data do not need to follow a Gaussian distribution like in ordinary linear regression, but should be without serial correlation. Furthermore, the method tests for monotonic trends and not necessarily linear trends, and it thus tests for a wider range of possible trend shapes. Monotonic trends are an either downward or upward tendency without any specific form. If the time series data are Gaussian distributed and the trend is actually linear, the power of the Mann-Kendall trend method is slightly lower than that of ordinary linear regression due to the accommodation of the slightly less restrictive assumptions.

Let x_1, x_2, \dots, x_n be yearly inputs of total nitrogen or total phosphorus for the years $1, 2, \dots, n$. The null hypothesis of the trend analysis is that the n yearly data values are randomly ordered. The null hypothesis is tested against the alternative hypothesis that the time series has a monotonic trend. The Kendall statistic is calculated as

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{sgn}(x_j - x_i), \quad (11.32)$$

where

$$\text{sgn}(x) = \begin{cases} 1 & x > 0 \\ 0 & x = 0 \\ -1 & x < 0 \end{cases}$$

If either x_j or x_i is missing then $\text{sgn}(x_j - x_i) = 0$ per definition.

The trend is tested by calculating the test statistic

$$Z = \begin{cases} \frac{S-1}{(\text{var}(S))^{\frac{1}{2}}} & S > 0 \\ 0 & S = 0 \\ \frac{S+1}{(\text{var}(S))^{\frac{1}{2}}} & S < 0 \end{cases}$$

The variance of S under the hypothesis of no trend is calculated as

$$\text{var}(S) = \frac{n(n-1)(2n+5)}{18}, \quad (11.33)$$

where n is the number of loads in the time series.

A positive S -value indicates an upward trend and a negative value a downward trend. When both a downward and an upward trend are of interest (a two-sided test), the null hypothesis of randomly ordered data is rejected when the numerical value of Z is less than the $(\alpha/2)$ -percentile or greater than the $(1 - \alpha/2)$ -percentile

(two-sided test) in the Gaussian distribution with mean value 0 and variance 1. A one-sided test can be carried out as well. The significance level α is typically 5%. The reason for evaluating Z in the standard Gaussian distribution is the fact that S under the null hypothesis is Gaussian distributed with mean value 0 and variance $\text{var}(S)$ for $n \rightarrow \infty$. The Gaussian approximation is very good if $n \geq 10$ and fair for $5 \leq n \leq 10$.

An estimate of the trend β (a slope estimate) can be calculated by assuming a constant (linear) trend during the period and presenting the estimate as change per year. Hirsch et al. (1982) introduced Theil-Sen's slope estimator: for all pairs of observations (x_i, x_j) with $1 \leq j < i \leq n$ calculate

$$d_{ij} = \frac{x_i - x_j}{i - j}. \quad (11.34)$$

Then the slope estimator is the median value of all the d_{ij} -values and is a robust non-parametric estimator and will generally work for time series with serial correlation and non-Gaussian distributed data. A $100(1 - \alpha)\%$ confidence interval for the slope can be obtained as follows (Gilbert 1987):

Choose the desired confidence level α (1, 5 or 10%) and apply

$$Z_{1-\alpha/2} = \begin{cases} 2,576 & \alpha = 0.01 \\ 1,960 & \alpha = 0.05, \\ 1,645 & \alpha = 0.10 \end{cases}$$

in the following calculations. A confidence level of 5% is standard.

Calculate

$$C_\alpha = Z_{1-\alpha/2} \cdot (\text{var}(S))^{\frac{1}{2}}. \quad (11.35)$$

Calculate

$$M_1 = \frac{N - C_\alpha}{2}, \quad (11.36)$$

and

$$M_2 = \frac{N + C_\alpha}{2}, \quad (11.37)$$

where

$$N = \frac{1}{2}n(n-1).$$

Lower and upper confidence limits are the M_1 th largest and the $(M_2 + 1)$ th largest value of the N ranked slope estimates d_{ij} .

A non-parametric estimate for the intercept α can be calculated according to Conover (1980). The estimator is calculated as

$$\hat{\alpha} = M_x - \hat{\beta} \cdot M_i, \quad (11.38)$$

where M_x is the median value of all the data in the time series and M_i is the median value of $1, 2, \dots, n$.

If the time series consists of data from different seasons (i.e. monthly loads), Mann-Kendall's seasonal trend test may be applied (Hirsch and Slack 1984). This is done by calculating the test statistic S for every season separately. Then the test statistic for the whole time series is equal to the sum of each of the seasonal test statistics. We refer to Carstensen and Larsen (2006) for a detailed mathematical description of the seasonal trend test.

12. Quality assurance on water chemical analysis

12.1. Specific aspects of quality assurance

The Article 3, paragraph 5, of Helsinki Convention states that the Contracting Parties shall ensure that measurements and calculations of emissions from point sources to water and air, and of inputs from diffuse sources to water and air, are carried out in a scientifically appropriate manner in order to assess the state of the marine environment of the Baltic Sea Area and ascertain the implementation of this Convention. Additionally, HELCOM 16 has adopted a quality assurance policy, according to which:

1. Contracting Parties acknowledge that only reliable information can provide the basis for effective and economic environmental policy and management regarding the Convention area
2. Contracting Parties acknowledge that environmental information is the product of a chain of activities, constituting programme design, execution, evaluation and reporting, and that each activity has to meet certain quality requirements
3. Contracting Parties agree to quality assurance requirements be set for each of these activities
4. Contracting Parties agree to make sure that suitable resources are available nationally (e.g. ships, laboratories) in order to achieve this goal
5. Contracting Parties fully commit themselves to follow the guidelines, protocols etc. adopted by the Commission and its Committees in accordance with this procedure of quality assurance.

Basic principles of quality assurance are also referred to in the [HELCOM Monitoring and Assessment Strategy](#) adopted by the 2013 HELCOM Copenhagen Ministerial Meeting.

Detailed description of general aspects of QA/QC is described in the HELCOM COMBINE Manual, Part B. General Guidelines on Quality Assurance for Monitoring in the Baltic Sea, available on the HELCOM website: [HELCOM COMBINE Manual](#). Technical specifications for chemical analysis and monitoring of water status in relation to the water framework directive can be found in the QA/QC directive (Commission Directive 2009/90/EC) as well.

The Contracting Parties are responsible of the quality assurance of the data submitted to HELCOM PLC-Water database.

The laboratories providing data to PLC should have a quality assurance system that follows the requirements of EN ISO/IEC 17025. Participating laboratories are encouraged to endeavour the obtainment of official accreditation for variables on which they report data in accordance with PLC.

All institutes/laboratories should participate in regular (annual) inter-laboratory comparison tests at relevant levels of nutrients and metals. Also, the laboratories should use appropriate reference materials for internal quality control and assurance. The use of certified reference material is encouraged.

All institutes/laboratories performing the collection of samples to PLC have to be careful in order to get representative and uncontaminated samples. Guidance on sampling can be found in [WMO Guidance 168](#) chapter 7.3 and ISO 5667 standards on Water Quality – Sampling. Different aspects of sampling are covered in different parts of the ISO standard.

All Contracting Parties have to nominate a national QA contact person responsible for PLC quality assurance.

The national QA contact person will help in ensuring comparability and reliability of analytical data provided by the laboratories in their country. The national QA contact person should:

- provide information about PLC-Water at the national level and guarantee that information on the PLC Guidelines and the QA section of the COMBINE Manual reach the laboratories submitting PLC data
- co-operate nationally with the laboratories participating in PLC-Water data collection
- collect the mandatory information (see end of Chapter 13.4) from laboratories and report them to PLC-7 Project by the end of March 2018.

The PLC-Water laboratories are asked to estimate the uncertainty of their analytical measurements. The estimated uncertainties should be reported for the individual variables in the form of expanded measurement uncertainty including a 95% confidence interval together with information on the concentration level. The expanded uncertainty U is obtained by multiplying the combined standard uncertainty U_c by a coverage factor k , which is 2 (rounded values 1.96 from student t-factor) when the level of confidence is 95%:

$$U = U_c \cdot 2 \quad (12.1)$$

12.2. Minimum quality assurance by the Contracting Parties

The COMBINE Manual for marine monitoring in HELCOM describes quality assurance as covering all aspects of analytical investigation, and includes the following principal elements (last updated 16 November 2017):

- Knowledge of the purpose of the investigation is essential to establish the required data quality
- Provision and optimization of appropriate laboratory facilities and analytical equipment
- Selection and training of staff for the analytical task in question
- Establishment of definitive directions for appropriate collection, preservation, storage and transport procedures to maintain the integrity of samples prior to analysis
- Use of suitable pre-treatment procedures prior to analysis of samples, to prevent uncontrolled contamination or loss of the determinant in the samples
- Validation of appropriate analytical methods to ensure that measurements are of the required quality to meet the needs of the investigations
- Conduct of regular intra-laboratory checks on the accuracy of routine measurements, by the analysis of appropriate reference materials, to assess whether the analytical methods are remaining under control, and the documentation and interpretation of the results on control charts
- Participation in inter-laboratory quality assessments (proficiency testing schemes, ring-tests, training courses) to provide an independent assessment of the laboratory's capability of producing reliable measurements
- The preparation and use of written instructions, laboratory protocols, laboratory journals, etc., so that specific analytical data can be traced to the relevant samples and vice versa.

As minimum quality assurance in PLC, Contracting Parties has to consider:

- Monitoring water level and discharge, and establish water level-discharge relationships
- Guidance on water sampling
- Demands on sample storage and preservation
- Demands on laboratory performance
- Guidance on compiling and assessing data, and reporting data including data on quality assurance.

12.3. Inter-laboratory comparison tests on chemical analyses

All institutes/laboratories should participate in regular (annual) inter-laboratory comparison tests. It is recommended to perform the inter-laboratory comparison tests according to the ISO/IEC Guide 17043. Participation in inter-laboratory comparison tests is obligatory for accredited laboratories as well as for laboratories that have a quality assurance system that follows the requirements of EN/ISO 17025.

For the inter-laboratory comparison tests that the laboratories participate in, it is essential that:

- The test material is as similar as possible to the matrices (e.g. riverine water and/or wastewater) to be analysed within PLC-Water,
- Different concentration levels of each substance in each matrix are included in the test and they are adequate to the concentrations of the samples collected in PLC-Water,
- The participating laboratories use the analytical methods, which are intended to apply for PLC-Water.

Inter-laboratory comparison tests can be found in the Internet. Here are some examples:

- QUASIMEME: <http://www.quasimeme.org>
- Eurofins: <http://www.eurofins.dk/dk/milj0/vores-ydelsler/praestationspr0vning-milj0/proficiency-testing-environment.aspx>
- EPTIS: <http://www.eptis.bam.de>
- Department of Applied Environmental Science, Stockholm University: <http://enviropro.itm.su.se>
- ProfTest SYKE, Finnish Environment Institute: <http://www.syke.fi/proftest/en>

12.4. The PLC-7 inter-laboratory comparison test on chemical analyses

An inter-laboratory comparison test was conducted in 2018 within the PLC7 project in order to have laboratories from each of the CPs participating in the same test study. The aim was to get an overall picture of the quality of the data from chemical analyses and of the comparability of data in PLC.

The inter-laboratory comparison study was performed with statistical analysis with outlier test according to ISO/DIS 5725 and Youden plots. The study included nutrients and metals in riverine water and wastewater. In total, 26 laboratories representing all CPs participated with either analyses of nutrients or metals or both in either riverine water and/or wastewater.

In the report on the inter-laboratory comparison test (Lassen & Larsen 2018) it is concluded that:

- Generally the analytical quality is good and comparable between the laboratories with a few exceptions
- NO₂-N showed relative low recovery in fresh water. However, the main reason is likely to be due to very low concentration of NO₂-N
- Lead showed low recovery and outliers in both fresh water and waste water. The inter-comparison test did not clarify the reason for that. The former inter-comparison test did not show the same deviation for Pb concerning outliers and recovery
- Mercury showed improvement compared to the results from the former inter-comparison test. It is most likely caused by higher concentration levels.

12.5. Validation of PLC-Water chemical data

The national QA contact persons are responsible for validation of the chemical data to be submitted to the HELCOM PLC-Water Database.

The validation by Contracting Parties of the data should be carried out at the national level based on information on:

- accreditation status (strongly advised for laboratories)
- use of quality assurance system that follows the requirements of EN ISO/IEC 17025 (strongly advised for laboratories)
- measurement uncertainty, estimated as expanded uncertainty, see Annex 5 (mandatory for laboratories)
- limit of quantification (mandatory for laboratories)
- use of reference material (recommended for laboratories)
- use of control charts (mandatory for laboratories)
- participation in laboratory inter-comparison tests (strongly advised for laboratories).

The measurement uncertainty has to be estimated as combined standard uncertainty, which means that reproducibility within laboratory and repeatability between laboratories are included in the calculation of the uncertainty and the further calculation of expanded uncertainty. Examples can be found in Annex 5 and further explanation in Magnusson et al (2004).

Measurement uncertainty can be calculated with a new software tool – Mukit (measurement uncertainty kit), which is based on the Nordtest method [Näykki et al., 2012]. This free software is available in the webpage of the SYKE calibration laboratory (ENVICAL): <http://www.syke.fi/envical/en>.

Missing mandatory information will be flagged in the PLC-Water database.

12.6. Recommended limits of quantification (LOQ)

The levels of quantifications should in principle be lower than the expected concentrations in order to have as few observations as possible below LOQ (to avoid inclusion of concentrations estimated on basis of LOQ in the load calculation). As guidance, in table 12.1 levels of quantification not to be exceeded are suggested.

Table 12.1 Recommended LOQ (should be seen as a guidance level Suggested limit of quantification (LOQ))

Parameter	River water	Wastewater
BOD	0.5 mg l ⁻¹	
TOC	0.5 mg l ⁻¹	
NH ₄ -N	10 µg l ⁻¹	20 µg l ⁻¹
NO ₂₃ -N	20 µg l ⁻¹	40 µg l ⁻¹
N _{tot}	50 µg l ⁻¹	200 µg l ⁻¹
PO ₄ -P	5 µg l ⁻¹	20 µg l ⁻¹
P _{tot}	10 µg l ⁻¹	50 µg l ⁻¹
Cd	0.01 µg l ⁻¹	0.5 µg l ⁻¹
Cr	0.05 µg l ⁻¹	1.0 µg l ⁻¹
Cu	0.1 µg l ⁻¹	10 µg l ⁻¹
Ni	0.05 µg l ⁻¹	1.0 µg l ⁻¹
Pb	0.05 µg l ⁻¹	1.0 µg l ⁻¹
Zn	0.5 µg l ⁻¹	5 µg l ⁻¹
Hg	0.005 µg l ⁻¹	0.5 µg l ⁻¹

Comparing the recommended LOQ above with the corresponding LOQ requirements in the Water Framework Directive according to the QA/QC directive (with $LOQ \leq 0.33 \cdot EQS^{10}$) the HELCOM LOQ recommendations are lower for those metals where it is possible to compare (cadmium, nickel and lead). It must be emphasized that the LOQs in WFD are set in order to determine if the water quality criteria are met, while in PLC they are

¹⁰ EQS = Environmental Quality Standard; EQS-Directive 2013/39/EU

set in order to obtain as many observations > LOQ as possible in order to estimate the load as precisely as possible.

12.7. Values under the limit of quantification

It is important to distinguish between the limit of detection (LOD – the lowest detectable amount of a compound) and the limit of quantification (LOQ – the lowest quantifiable amount of a compound). LOD is the smallest amount or concentration of an analyte in the test sample that can be reliably distinguished from zero. LOQ is a performance characteristic that marks the ability of an analytical method to adequately “quantify” the analyte.

LOQ is in the WFD QA/QC directive (Commission Directive 2009/90/EC) defined as a stated multiple of LOD. There has been much diversity in the way in which LOD of an analytical system is defined. Most approaches are based on multiplication of the within-batch standard deviation of results of blanks by a factor. Further information can be found in the ISO/TS 13530 or in the chapter B.4.2.3. of the [HELCOM Combine Manual](#).

In PLC-7 the LOQ is used to assign a numeric value when handling low-level data. The use of LOQ instead of LOD is in accordance to the EC-directive on quality assurance of water chemical analyses (2009/90/EC).

If measured concentrations are below LOQ, the estimated concentration should be calculated using the equation:

$$\text{Estimation} = ((100\%-A) \cdot \text{LOQ})/100, \quad (12.2)$$

Where

A = percentage of samples below LOQ¹¹.

12.8. Technical notes on the determination of variables in rivers and wastewater

This chapter includes technical notes for determination of some variables. For PLC-Water, analysis should be made using unfiltered samples.

The well tested and documented European or international standard methods (EN or ISO) or methods based on these standards are highly recommended to use.

Particles can give rise to light-scattering effects that result in interferences in all photometric nutrient analyses. This bias can be avoided by measuring the sample before addition of the color reagent, or by filtration or centrifugation where this does not cause contamination.

Particularly in the case of nutrients and metal analysis, a satisfactory blank control is necessary. Therefore, it is important to control the blank daily, for reproducibility and constancy over a longer time. The blank should include all analytical pre-treatment procedures, including the addition of the same quantities of chemical substances as for the samples.

In all analytical work, water of sufficiently high purity shall always be used when needed. High purity water can be distilled or deionized water, “MilliQ-water” or comparable. When very high purity is needed the water

¹¹ The QA/QC directive says that when the amount of a measure and is below LOQ the result shall be set to half the value of LOQ in the calculation of annual average values. In PLC it is not annual average values that are calculated but loads, which means that it is two different situations and therefore use of different methods makes sense.

might need treatment in several steps, e.g. double or triple distilled water. More information on various degrees of water purity and testing of the purity may be found in ISO 3696:1987.

For calibration purpose in general, a working standard should be prepared from a stock standard solution for every batch of samples.

Apart from manual methods, various automated methods are in use. The analyst has to be aware of the effects of the different analytical conditions in automated analysis that might affect accuracy.

Biological Oxygen Demand (BOD)

For the determination of BOD in wastewater samples it is strongly recommended to follow ISO 5815:2003 "Water quality - Determination of biochemical oxygen demand after n days (BOD_n) - Part 1: Dilution and seeding method with allylthiourea addition" and in surface water samples " - Part 2: Method for undiluted samples".

ISO 5815-1:2003 is applicable to all waters having biochemical oxygen demands greater than or equal to 3 mg/l of oxygen (the limit of quantification) and not exceeding 6,000 mg/l of oxygen.

ISO 5815-2:2003 specifies determination of the biochemical oxygen demand in undiluted samples of water. It is applicable to all waters having biochemical oxygen demands greater than or equal to 0.5 mg/l of oxygen (the limit of quantification) and not exceeding 6 mg/l of oxygen.

BOD should be reported as either BOD₅ or BOD₇. If BOD is reported as BOD₇ it will be stored in the HELCOM PLC-Water database, and for PLC assessments a conversion factor $BOD_5 = BOD_7 / 1.15$ will be used for converting to BOD₅.

Nutrients

Sample bottles of plastic or glass can be used. It is recommended to use new clean plastic bottles. Every new batch of plastic bottles need to be verified that they are clean by filling them with water of high purity, and after several days analyse the water for potential nutrients. If plastic bottles are reused or if glass bottles are used, they need to be cleaned e.g. by rinsing them in hydrochloric acid (ca 2 mol l⁻¹) and thereafter rinsing them carefully with high purity water. The cleaning procedure has to be verified regularly. The samples should be stored cold (4 °C) and dark from sampling until analysis.

Orthophosphate

The molybdenum blue method with reduction by ascorbic acid is recommended for determination of orthophosphate.

The analyses should be carried out as soon as possible. Samples that are not analysed within one day have to be preserved. The samples should be stored cold (4 °C) and dark.

Total Phosphorus

Digestion with potassium peroxodisulfate is recommended. For analyses of wastewater with a high content of organic matter a more powerful oxidation method (with nitric-sulfuric acid) may be necessary. A quality control sample can be prepared of e.g. Na-β-glycerophosphate or thiamine pyrophosphate chloride.

The samples should be stored cold (4 °C) and dark, and should be preserved as fast as possible (within one day).

Ammonium

Samples for determination of ammonia should not be preserved. The indophenol blue method is recommended. High concentrations of ammonium can be determined by sample dilution. The Nessler method is not recommended.

The analyses should be carried out as soon as possible and within one day on unpreserved samples. The samples should be stored cold (4 °C) and dark.

Nitrate

The cadmium reduction method is recommended for the analyses of nitrate. It is necessary to check the capacity of the reductor (at least 90 % exchange) systematically. The salicylate method is not recommended because of many interfering effects.

The analyses should be carried out as soon as possible. Samples that are not analysed within one day have to be preserved. The samples should be stored cold (4 °C) and dark.

Total Nitrogen

Total nitrogen in river water can be analysed by a method based on oxidation with potassium peroxodisulfate followed by reduction of nitrate with a cadmium reductor (cf. Nitrate above) (ISO 11905-1:997). Especially for analyses of industrial wastewater the modified Kjeldahl method with Dewarda's alloy or the Kjeldahl method and the determination of nitrate separately is recommended.

The quality control sample can be prepared of e.g. EDTA, glycine or 4-nitroaniline.

Metals

The basis for reliable measurements at low metal concentrations in water is to avoid contamination when handling the samples in all the different stages from sampling to the analysis of the samples.

For sampling of riverine water for measurement of metals except mercury (for Hg see below) bottles of polypropylene, polyethylene, polytetrafluoroethylene (PTFE) or resistant glass (e.g. Pyrex) are recommended. The bottle and the cap should be prepared from colourless material.

Bottles, glass and plastic ware and containers have to be cleaned by soaking them in nitric acid at least for one day and then be rinsed with water of high purity at least three times. For determination of ultra trace level it is necessary to follow more extensive cleaning procedures. If the laboratory collect both river and wastewater it is necessary to use separate samplers and bottles for sampling at low levels and high levels of metals. It is essential to maintain a clean environment during analyses. All chemicals should be of highest possible purity and high purity water shall be used for preparation of solutions. If low content of metals are to be determined, a field blank shall be analysed as well.

Samples that contain particulate material shall be digested with nitric acid in a closed vessel under pressure.

For measurement of metals, atomic absorption spectroscopy (AAS flame or flameless), inductive plasma-optical emission (ICP-OES) or inductive coupled plasma-mass spectroscopy (ICP-MS) can be used. For measurement of low contents of metals in rivers ICP/MS or anodic stripping voltametry (ASV) are highly recommended.

Calibration is important to carry out correctly. Commercial stock solutions are available for preparation of calibration solutions. The calibration should be performed with a blank solution and 4-5 different calibration solutions for an appropriate concentration range. Need for recalibration has to be checked by measuring a quality control sample once per 20 determinations. In order to reduce potential effects of chemical and physical interferences (i.e. high contents of chlorides) the method of standard addition may be applied. Interference effects can also be reduced by gradual dilution or by addition of different chemical modifiers to the sample. If both high and low contents of metals are determined in the same batch, the high level samples

should preferably be analysed after low level samples. If this is not possible there should be a blank sample between the samples in order to prevent the memory effect.

Mercury

Good quality of plastic or resistant glass bottles should be used for collecting of samples for measurement of mercury.

The quality of the reagents used for the analyses of mercury should be controlled.

Mercury can be detected with cold vapour atomic absorption or fluorescence spectroscopy. For measurement of low contents of mercury ($\mu\text{g l}^{-1}$) it is recommended to enrich the mercury on a gold trap before analysis by fluorescence technique.

The control chart on blanks has to be used to enhance the detection of contamination during analyses.

Total Organic Carbon (TOC)

For the determination of TOC in surface and wastewater samples it is strongly recommended to follow the standard ISO 8245:1999 "Water quality -- Guidelines for the determination of total organic carbon (TOC) and dissolved organic carbon (DOC)", which is identical to EN 1484:1997

Further information on determination on chemical variables is described in Annex B-17 of the [HELCOM COMBINE Manual](#).

13. Annual PLC reporting requirements

According to **HELCOM Recommendation 37-38/1** “Waterborne pollution input assessment (PLC -WATER)” (HELCOM, 2016a), the total waterborne inputs to the Baltic Sea should be quantified annually. Hence, every year Contracting Parties should quantify and report the total input to the Baltic Sea from:

- Monitored rivers (Chapter 4),
- Unmonitored areas (Chapter 7),
- Point sources (Chapter 5) which *discharge directly* into the Baltic Sea and
- Monitoring stations (chemical and hydrological).

Transboundary riverine nutrient inputs should be also annually reported to follow-up progress towards national input ceilings and the nutrient reduction requirements adopted by the 2013 HELCOM Copenhagen Ministerial Declaration. The specific nutrient reduction targets were set for each Contracting Party to Helsinki Convention and for countries in the Baltic Sea catchment area which are non-Contracting Parties (Chapter 8).

The inputs should be reported for catchment areas of each Baltic Sea sub-basin (Fig 2.5) (the sub-basin division is described in Chapter 2.6) and each monitored river should be reported separately.

The reporting of data on monitored rivers and unmonitored areas is based on the parameters referenced to sub-catchments (**Figure.2.6 and 2.7**). Monitored sub-catchments are parts of river basins upstream from the monitoring stations within the national borders. All sub-catchments are to be coded.

Transboundary areas are upstream parts of the river basins located within the borders of countries without the river mouth. Transboundary inputs and their parameters are reported separately by the receiving country (**Figure 2.8**). It's important to emphasize that the parameters characterizing loads from the transboundary sub-catchments are to be reported as they are at the border. Despite the loads from the transboundary sub-catchments are reported by receiving (downstream) country, the country responsible for the transboundary loads is obliged to verify the data in the PLC-WATER database and approve them.

The data on inputs from the whole transboundary river basin should also be reported by the country where river mouth is located. This report has geographical reference to a point located in the river mouth and does not have polygonal geographical reference.

Unmonitored sub-catchments represent unmonitored rivers, unmonitored parts of monitored rivers and other areas where reported parameters are estimated by modelling approach.

Before reporting Contracting Parties should perform quality assurance (Chapter 12) and data validation (Chapter 11). Selected quality parameters should be reported (Chapter 13.4).

All data have to be reported electronically according to the reporting format prepared by the Data Manager (see Annex 2).

Annex 4 contains a user guide on reporting and quality assuring of the annual and periodic data.

13.1. Reporting of the inputs from monitored sub-catchments (monitored rivers)

Contracting Parties should annually report parameters of the monitored sub-catchment according to the Table 1.1, Chapter 1. Contracting Parties should report the input calculation method(s) and equations applied for quantifying river flow and load. It is recommended to use one of the input calculation methods described in chapters 4 and 5.

- Daily flow and daily concentration (interpolated)
- Annual input (in kg a⁻¹) calculation based on daily flow and daily concentration regression
- An alternative input calculation method (country specific)

If alternative input calculation methods have been used, they need to be described in detail.

All information and data that have to be reported electronically are summarized in Annex 2.

Countries should use their own estimates of retention if specific data about the local conditions are available. Where Contracting Parties do not follow the methods in the guidelines the method should be described, including the calculation methods used, and relevant data and information must be reported (see also Chapter 9).

13.2. Reporting of the input from unmonitored areas

The annual input from unmonitored areas should be reported every year as a total input from the Contracting Party to each Baltic Sea sub-basin. Alternatively, the unmonitored part of monitored rivers can be reported individually. Parameters, which should be annually reported for the unmonitored sub-catchment are listed in to the Table 1.1, Chapter 1. Chapter 7 describes methods for estimating inputs from unmonitored areas on the basis of:

- Model results,
- Land use within these areas, and
- Extrapolating the knowledge about neighboring rivers under similar conditions.

The method(s) used to estimate the input from unmonitored areas should be reported. If Contracting Parties use an alternative method, it should be described in detail when reporting.

Diffuse sources discharging directly into the sea must be reported as part of the inputs from unmonitored areas.

All information and data which have to be reported electronically are summarized in Annex 2.

13.3. Reporting of the inputs from direct point sources

Contracting Parties are to quantify and report annually the inputs from point sources discharging directly into the Baltic Sea. Point source categories are municipal wastewater treatment plants (MWWTP), industrial plants (INDUSTRY) and aquaculture plants (AQUACULTURE). A guidance to identify direct point sources is given in Chapter 2.5 and direct (point) sources are defined in Annex 1. Reporting parameters are listed in Table 1.1, Chapter 1 with the remark that flow parameter might not be applicable for marine based aquaculture. Point sources discharging directly to the sea should preferably be reported individually, but can be reported as a sum for every Baltic Sea marine sub-basin for municipal effluents, industrial effluent and aquaculture plants, respectively.

Chapter 5 describes how the discharges from point sources are quantified, and these methods should be used when quantifying discharges from point sources entering directly to the Baltic Sea. Contracting Parties are urged to report individually by plant, but it is possible to report aggregated by point source category by marine sub-basin. Quantification of discharges is described in Chapter 5.1 for MWWTP, Chapter 5.2 for INDUSTRY and Chapter 5.3 for AQUACULTURE.

In addition to reporting of inputs from direct point sources, also the methods used for estimating the discharges should also be reported. If Contracting Parties apply any alternative (country specific) method, a detailed description of the calculation method should be reported.

All information and data that have to be reported electronically are summarized in Annex 2.

13.4. Reporting of the monitoring stations.

Information on monitoring stations is substantial for data quality verification including their spatial parameters. Information on monitoring stations consists of background data characterizing the type of monitoring station (chemical, hydrological) as well as data used to compute the flow. The reported data also sets the link between monitoring stations and monitored sub-catchment.

Flow data should be carried out according to the recommendations given in the Chapter 3. If Contracting Parties use an alternative method, it should be described in detail when reporting. Countries should report information on monitoring stations as given in the Annex 2.

13.5. Reporting on quality assurance

When reporting PLC-6 data Contracting Parties should report their quality assurance criteria as:

- LOQ
- Expanded uncertainty
- Fraction of samples below LOQ

If there are different values for either LOQ or expanded uncertainty for a specific substance, because of more than one laboratory carrying out the monitoring, the most representative values should be reported.

For more information, see Chapter 12 on quality assurance on water chemical analysis.

For modelling, data uncertainty should be reported, see Chapter 13.5.

13.6. Reporting on uncertainty on national data sets

Contracting Parties should estimate and report on the estimated total uncertainty on their reported data according to Chapter 11.4. The estimated total uncertainty on the total input per sub-catchment should as a minimum be reported. Individual uncertainty categories (see Chapter 11.4) can also be reported.

The uncertainty can be divided in bias (B) and precision (P), where the total uncertainty U is $(B^2 + P^2)^{0.5}$.

14. Periodic PLC reporting requirements

According to **HELCOM Recommendation 37-38/1** “Waterborne pollution input assessment (PLC -WATER)”, in addition to annual quantification of the total waterborne inputs to the Baltic Sea as described in Chapter 13, an assessment of the inputs from different sources within the catchment area of the Baltic Sea located within the borders of the HELCOM Contracting Parties, should be carried out periodically in accordance with the decision by the Contracting parties.

In such comprehensive waterborne pollution load compilations (assessments), sources of waterborne inputs to inland waters and to the sea should be quantified.

The following should be reported in order to quantify sources of inputs to inland surface waters (the so called **source oriented approach**):

1. Municipal wastewater treatment plants (Chapter 5.1)
2. Industrial plants (Chapter 5.2)
3. Aquaculture (Chapter 5.3)
4. Nutrient losses from diffuse sources (Chapter 6.2), and
5. Natural background nutrient losses (Chapter 6.1).

In order to quantify the importance of the different sources of waterborne input to the total input entering the Baltic Sea (the so **called load-oriented approach**), the following information need to be reported in addition to the annually reported inputs from direct point sources and unmonitored areas:

- Apportionment of riverine load (Chapter 10), and
- Retention (Chapter 9).

The inputs should be reported for catchment areas of each Baltic Sea sub-basin (Fig 2.5) (the sub-basin division is described in Chapter 2.6).

Periodic reporting format contains sheets with background and factual data. Reporting of data on monitored, unmonitored and transboundary areas is based on the same structure of sub-catchments as annual reporting (Chapter 13) in order to assure consistency of the PLC-water data. In addition, the data on inland point sources and retention is included into the periodic reporting format while the data on direct sources reported annually and should not be included into the dataset for periodic reporting.

The periodic reporting template contains spreadsheets with background information and information on loads. Background information for monitored, unmonitored and transboundary sub-catchments is identical to one in annual reporting for the same year. Additional background information for inland point sources should be provided.

The load parameters to be reported are listed in Chapter 1 (**Tables 1.2**).

Annual PLC-reporting requirements are also valid in the year decided for periodic reporting. Contracting Parties report the annual data separately utilizing reporting format for annual reporting (Chapter 13, Annex 2) and in the timeframe set to report annual data.

Before reporting Contracting Parties should perform quality assurance (Chapter 12) and data validation (Chapter 11). Selected quality parameters should be reported (Chapter 14.3).

All data have to be reported electronically according to the reporting format prepared by the Data Manager (see Annex 3).

Where Contracting Parties do not follow the methods in the guidelines the used method should be described, including the calculation methods used, and all relevant data and information must be reported.

Annex 4 contains a user guide on reporting and quality assuring of the annual and periodic data.

14.1. Source-orientated approach: Methodology for quantifying sources of waterborne inputs to inland waters

14.1.1. Data requirements

According to the source-oriented approach, the inputs from point sources, diffuse sources and natural background losses into inland surface waters should be quantified. Contracting Parties should supplement information on inputs from different sources with description of methods used to identify it.

14.1.2. Point source discharges into inland surface waters.

14.1.2.1. MWWTP discharges into inland surface waters

Discharges from MWWTPs into inland surface waters within the Baltic Sea catchment area is a part of periodic reporting. Descriptions for measuring flow and calculating input are given in chapters 3.1 and 5, respectively. Information on MWWTPs discharging directly into the Baltic Sea is to be reported annually as described in Chapter 13 and is not included as a part of the periodic reporting.

Discharges from MWWTPs into inland surface waters should be reported as follows:

All MWWTP > 10,000 PE should preferable be reported individually. MWWTP < 10,000 PE can be reported aggregated by sub-catchment.

Flow data, flow measurement methods and estimates of their accuracy should be reported by each Contracting Party. The calculation methodology should be reported.

In addition to parameters mentioned in **Table 1.2**, also the following information should be reported:

- The number of municipalities (if aggregated);
- number of connected PE
- main and supplementary treatment methods.

All information and data that have to be reported are summarized in Annex 3.

14.1.2.2. Industrial point source discharges into inland surface waters

The quantification of discharges from industrial plants into inland surface waters within the Baltic Sea catchment area should be carried out as a part of PLC-water periodic reporting. Plants discharging directly into the Baltic Sea are reported annually and not a subject for periodic reporting (Chapter 13). The identification of sources as well as descriptions for measuring flow and calculating input are given in chapters 3.1 and 5, respectively. EU members can submit data reported on Industry linked to the E-PRTR, but for completeness of the dataset for the HELCOM PLC assessments, any other plants with industrial effluents entering surface water in the Baltic Sea catchment areas should be reported. Description of reporting requirements is given in **Annex 3**. The division of industry in sectors to be reported is listed in annex 6.

Industrial plants areas should preferably be reported individually, but in some cases they can be aggregated by sector as described in Annex 6 within sub-catchment area.

In addition to load data, the following information should be reported for indirect industrial point sources:

- the number of industrial plants (if aggregated);
- indication of level of treatment and elimination of nitrogen and phosphorus¹² according to the classification in Annex 3
- size of industrial plan
- flow data, flow measurement methods and estimation of their accuracy
- all calculation and/or estimation methods;

14.1.2.3. Discharges from aquaculture into inland surface waters.

The quantification of discharges from aquaculture plants into inland surface waters within the Baltic Sea catchment area should be carried out as a part of PLC-water periodic reporting. Descriptions for measuring flow and calculating input are given in chapters 3 and 5.3, respectively.

For the HELCOM PLC assessments, the discharges from aquaculture plants should be reported separately for aquaculture plants with a production > 200 t a⁻¹; but can be reported in aggregated form for aquaculture plants with a production ≤ 200 t a⁻¹. Further aquaculture discharge could be reported aggregated for unmonitored areas.

The direct discharges from aquaculture plants into the Baltic Sea are to be reported annually and are not a subject for periodic reporting.

Flow data, flow measurement methods and estimates of their accuracy should be reported by each Contracting Party. The calculation methodology should be reported. All information and data that have to be reported are summarized in Annex 3.

In addition to the information on nutrient loads to inland water the following information on aquaculture plants should be reported:

- the number of plants (if aggregated)
- production
- feed consumption
- Type of treatment, e.g. no treatment, sediment traps, microsieves, biofilter, plant lagoons and/or sludge storage (if any)
- flow data, flow measurement methods and estimation of their accuracy
- all calculation and/or estimation methods.

14.1.3. Diffuse losses to inland surface waters

The quantification of losses from diffuse sources of nutrients into inland surface waters within the Baltic Sea catchment area is a part of PLC water periodic reporting. A description for quantifying losses from diffuse sources is given in Chapter 6.

¹² Russia is clarifying whether they can provide aggregated figures for Russian point sources

According to the Chapter 6 the following categories of diffuse anthropogenic nitrogen and phosphorus losses should be considered in the reporting:

- Agricultural land
- Managed forestry and other managed land
- Atmospheric deposition directly on inland surface waters
- Scattered dwellings
- Rainwater constructions (e.g. paved surfaces without a distinct outlet)

In the absence of harmonized quantification procedures, the Contracting Parties should apply the most appropriate method/model to quantify losses from diffuse sources taking into account the relevant geology, topography, soil type, climate, land use, and agricultural practices in their region. Applied models must be calibrated with monitoring data and afterwards validated on another set of monitoring data. The Contracting Parties should provide documentation on model validations and calibrations (see Chapter 6.2).

Whatever methodology is adopted by a Contracting Party, it is essential that certain minimum requirements are fulfilled as described in Chapter 6. In particular, the methodology should be based on measurements or upon objectively determined loss coefficients that should be sensitive to variations in losses associated with different land use types (e.g. different agricultural crops, forestry practices and livestock densities).

Information on pathway type might also be provided on the voluntary basis in accordance with the following classification (Chapter 6):

- Surface run-off
- Erosion
- Groundwater
- Tile drainage
- Interflow¹³
- Atmospheric deposition on inland surface waters
- Scattered dwellings
- Rainwater constructions

The nutrient losses from diffuse sources to inland waters should be reported in accordance with the requirements of the source oriented approach and:

- Monitored and transboundary rivers should be reported individual
- Unmonitored areas should be reported aggregated for each catchment to Baltic Sea sub basin per country

The applied method should be described in detail and reported. All information and data that have to be reported are summarized in Annex 3.

14.1.4. Natural background losses into inland surface waters

The quantification of natural background nutrient losses to inland surface waters within the Baltic Sea catchment area is a part of the periodic reporting. The losses should be reported in accordance with the requirements for the source-orientated approach. Information on background losses should be provided for all catchment to monitored rivers within national borders of Contracting Parties. A description of the quantification of inputs from natural background losses is given in Chapter 6.1. The parameters to be reported are given in the table 1.2.

¹³ Substance transport within the vadose zone, i.e. unsaturated soils above the groundwater table.

All information and data that have to be reported are summarized in Annex 3.

14.1.5. Transboundary inputs

Point and Diffuse sources of nutrient loads for transboundary parts of river catchments should be reported separately utilizing “transboundary inputs” spreadsheet. Countries receiving transboundary loads can consider it as a separate source for the apportionment of national sources of nutrient loads. The Contracting Party where transboundary input originates from should report sources of transboundary inputs according to classification given in the Chapter 5 and 6 and applied for reporting point and diffuse sources.

14.1.6. Retention of nutrients

Data on retention of nutrients is also a part of periodic reporting. The applied estimation method should be reported together with retention figures. The Contracting Party may report retention for different source categories if possible, but this is voluntary. Methods for calculating retention are described in Chapter 9. The parameters to be reported are given in the Table 1.2. The retention parameters should be reported individually for all sub-catchments to monitored rivers and for unmonitored areas by sub-catchment on the territory of the Contracting Party utilizing the sub-catchment’s structure described in the Chapter 3 and used for both annual and periodic reporting.

All information and data which have to be reported electronically are summarized in Annex 3. The methods used to identify retention should also be reported to assure data transparency and compatibility. Since the nutrient retention rate may vary considerably during a year, the retention should be reported as a yearly or longer than yearly average.

14.2. Load-oriented approach - reporting riverine load apportionment

HELCOM PLC periodic assessments includes evaluation of contribution of different sources (point, diffuse and natural background losses) on the riverine nutrient load taking into account retention in inland surface waters. This assessment requires the quantification of:

- Retention in inland surface waters and
- Riverine load apportionment.

The method for qualification of sources of riverine inputs by their loads at the river mouth is described in Chapter 10.2.

Riverine load apportionment should be made as a part of HELCOM PLC-water periodic reporting. Categories used for the apportionment are natural background load, diffuse anthropogenic load, point source load, transboundary load and unknown load. These categories might be further specified as described in Annex 3. The data should be reported for all sub-catchments on the territory of the Contracting Party utilizing the sub-catchment’s structure described in the Chapter 3 and used for both annual and periodic reporting.

Only two parameters – total nitrogen and total phosphorus – should be reported for all categories used for the load oriented apportionment of nutrient sources. All values should be reported in tons per year except for the natural background where percentage of total load is to be also report for both nitrogen and phosphorus.

Load oriented approach should be reported individually per monitored river and aggregated for unmonitored areas in sub catchment to Baltic Sea sub-basins pr. country.

The applied estimation methods should be reported together with riverine load apportionment data. All information and data that have to be reported are summarized in Annex 3.

14.3. Reporting on uncertainty on national data sets

Contracting Parties should estimate and report on the estimated total uncertainty on their reported data according to Chapter 11.4. The estimated total uncertainty on the total input per sub-catchment on reported data according to Chapter 14 should be estimates and reported as a minimum. Individual uncertainty categories (see Chapter 11.4) can also be reported.

The uncertainty can be divided in bias (B) and precision (P), where the total uncertainty U is $(B^2 + P^2)^{0.5}$.

14.4. Reporting spatial data.

Most of the spatial parameters of the PLC water data is a part of periodic reporting, except coordinates of direct point sources and monitoring stations which should be reported annually. Spatial parameters of the PLC water data consists of the coordinates of the point features and spatial borders of polygonal features.

Spatial parameters of the point features such as monitoring stations, direct and indirect point sources are reported in the format of the coordinates as a part of background information. The coordinates reported in the decimal degrees in the WGS-84 coordinate system.

Table 14.1. The list of attributes mandatory reported for spatial data on sub-catchments.

	Attribute name	Description
1	SourceCode	The code of sub-catchment according to PLC-water database
2	NAME	Name of the river basin or coastal area
3	SubBasin	Sub-basin of the Baltic Sea (see Chapter 2.6)
4	COUNTR	Abbreviation of the country within the BS catchment area
5	COMMENT	Free comment to set the link with national databases
6	MONITORING	M-monitored, U-unmonitored, N-not reported
7	TRANSBOUND	Abbreviation of receiving country for the load from transboundary sub-catchment
8	DATA_SOURCE	Reporting period (e.g. PLC-6)

Spatial parameters of monitored, unmonitored and transboundary sub-catchment, polygonal features, are to be reported in ArcGIS shape format contemporary with periodic reporting. Verification and reporting of the spatial data on sub-catchments includes update of the geometrical parameters of the polygons and update of the attributes. The list of mandatory attributes of the polygonal feature is given in the table 14.1.

In order to simplify reporting of polygonal spatial data, PLC data manager provides national data reporters with national datasets reported for the previous reporting period. The national data reporters are requested to verify and make corrections to the dataset or re-report the whole national dataset in case of substantial changes in the national monitoring programme. Please note that changes in the polygonal data are to be supplemented by related updates of coordinates in the background information for monitoring stations.

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Annex 1. List of definitions and acronyms

<i>Airborne</i>	Substances carried or distributed by air.
<i>Anthropogenic</i>	Caused by human activities.
<i>Aquaculture</i>	The cultivation of aquatic animals and plants, in natural or controlled marine or freshwater environments.
<i>ARC</i>	Achipelago Sea
<i>Atmospheric deposition</i>	Airborne nutrients or other chemical substances originating from emissions to the air and deposited from the air on land and water surfaces.
<i>Border river</i>	A river that has its outlet to the Baltic Sea at the border between two countries. For these rivers, the loads to the Baltic Sea are divided between the countries in relation to each country's share of total load.
<i>BAP</i>	Baltic Proper
<i>BAS</i>	The entire Baltic Sea (as a sum of the Baltic Sea sub-basins). See the definition of sub-basins.
<i>BNI</i>	Baltic Nest Institute, Stockholm University, Sweden.
<i>BI₅ or BI₇</i>	Biological oxygen demand within 5 or 7 days as a estimate of easily available organic matter
<i>BOB</i>	Bothnian Bay
<i>BOS</i>	Bothnian Sea
<i>BSAP</i>	Baltic Sea Action Plan
<i>BY</i>	Belarus
<i>Calculated value</i>	A value determined by mathematical calculation as opposed to a value derived from monitoring.
<i>Catchment area</i>	The area of land bounded by watersheds draining into a body of water (river, basin, reservoir, sea).
<i>Contracting Parties (CP)</i>	Signatories of the Helsinki Convention (Denmark, Estonia, European Commission, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden).
<i>Country-Allocated Reduction Targets (CARTs)</i>	Country-wise requirements to reduce waterborne and airborne nutrient inputs to reach the maximum allowable nutrient input levels (MAI) in accordance to the Baltic Sea Action Plan.
<i>DCE</i>	Danish Center for the Environment and Energy, Aarhus University, Denmark.
<i>DE</i>	Germany
<i>Diffuse sources</i>	Sources without distinct points of emission e.g. agricultural and forest land, natural background sources, scattered dwellings, atmospheric deposition (mainly in rural areas)
<i>Direct (point) sources</i>	Point sources (municipal wastewater treatment plants (MWWTP), industrial plants and aquaculture plants) discharging (defined by location of the outlet) directly to the sea.
<i>DK</i>	Denmark
<i>DS</i>	Danish Straits
<i>EE</i>	Estonia
<i>EMEP</i>	Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

Estimated value	A number that has been calculated approximately (the amount, extent, magnitude, position, or value of something). A tentative evaluation or rough calculation, which accepts that there is uncertainty in the values.
Eutrophication	Condition in an aquatic ecosystem where increased nutrient concentrations stimulate excessive primary production, which leads to an imbalanced function of the ecosystem.
FCR	Feed conversion ratio
FI	Finland
Flow normalization	A statistical method that adjusts a data time series by removing the influence of variations imposed by river flow, e.g. to facilitate assessment of development in e.g. nitrogen or phosphorus inputs without being obstructed by variations in water flow.
GIS	Geographic Information System
GUF	Gulf of Finland
GUR	Gulf of Riga
HOD	Head of Delegation
Input ceiling	The allowable amount of nitrogen and phosphorus input per country and sub-basin. It is calculated by subtracting the CARTs from the input of nitrogen and phosphorus during the reference period of the BSAP (1997-2003).
ISO	International organization for Standardization
KAT	Kattegat
HELCOM PRESSURE	HELCOM Working Group on Reduction of Pressures from the Baltic Sea Catchment Area
LOD	Limit of detection
LOD	Limit of quantification
LT	Lithuania
LV	Latvia
Maximum Allowable Input (MAI)	The maximum annual amount of a substance that a Baltic Sea sub-basin may receive and still fulfil HELCOM's ecological objectives for a Baltic Sea unaffected by Eutrophication.
Measured value	An amount determined by measurement.
Monitored areas	The catchment area upstream of the river monitoring station. The chemical monitoring decides the monitored area in cases where the locations of chemical and hydrological monitoring stations do not coincide.
Monitoring stations	Stations where hydrographic and/or chemical parameters are monitored.
MWWTP	Municipal wastewater treatment plant
NO	Norway
Non-contracting parties	Countries that are not partners to the Helsinki Convention 1992, but that have an indirect effect on the Baltic Sea by contributing with inputs of nutrients or other substances via water and/or air.
PE	Person Equivalent
PL	Poland
PLC	Pollution Load Compilation
Point sources	Municipal wastewater treatment plants (MWWTP), industrial plants and aquaculture plants that discharge (defined by location of the outlet) into

	monitored areas, unmonitored areas or directly to the sea (coastal or transitional waters) through one or several outlets.
QA	Quality assurance
Reference period	The BSAP reference period is 1997-2003
Reference input	The average normalized water + airborne input of nitrogen and phosphorus during the reference period 1997-2003 used to calculate CARTs and input ceilings.
Retention (R)	The amount of a substance lost/retained during transport in soil and/or water including groundwater from the source to a recipient water body. Generally, retention is only related to inland surface waters in these guidelines.
Riverine inputs	The amount of a substance carried to the maritime area by a watercourse (natural or man-made) per unit of time.
RU	Russia
SE	Sweden
SK	Slovakia
SOU	The Sound
Statistically significant	In statistics, a result is called "statistically significant" if it is unlikely to have occurred by chance. The degree of significance is expressed by the probability, P. $P < 0.05$ means that the probability for a result to occur by chance is less than 5%.
Sub-basins	Sub-division units of the Baltic Sea: the Kattegat (KAT), The Sound (SOU), Western Baltic (WEB), Baltic Proper (BAP), Gulf of Riga (GUR), Gulf of Finland (GUF), Archipelago Sea (ARC) Bothnian Sea (BOS) and Bothnian Bay (BOB). The whole Baltic Sea is abbreviated BAS. Cf. Figure 2.5
Sub-catchment	Is a portion of a catchment as e.g. the corresponding catchment to each monitoring station or the unmonitored area of a river catchment
TOC	Total organic carbon
Transboundary input	Transport of an amount of a substance (via air or water) across a country border.
TN and TP	Total nitrogen and total phosphorus, which includes all fractions of nitrogen and phosphorus.
UA	Ukraine
Unmonitored area	Any sub-catchment(s) located downstream of the (riverine) chemical monitoring point within the catchment and further all unmonitored catchments; e.g. unmonitored part of monitored.
UWWTD	Urban Waste Water Treatment Directive
Waterborne	Substances carried or distributed by water.
WEB	Western Baltic Sea
WFD	EU Water Framework Directive
WMO	World Meteorological Organization

Annex 2. Annual reporting formats

The annual data are to be reported electronically utilizing a WEB reporting application of the PLC-WATER database. Annual reporting template in MS Excel format is to be used for the reporting. The annual reporting template can be down loaded as prefilled from the Application and the background information on the reported data is to be verified. Once verified and updated the template should be uploaded to the Application and the data manager is to make related updates in the database prior the actual data reporting.

eporting and quality assurance procedures using PLC WEB-application are described in the Annex 4. F

Reporting in general

Actual data reporting is to be done utilizing the verified templates. No additional columns should be inserted or any prefilled rows, columns shouldn't be deleted in the prefilled spreadsheets

Decimal separator to be used '.' (dot) not a ',' (comma)

If the type of an attribute is '**NOT NULL**', data must be reported.

Each reported attribute heading has a comment box (Table 1), which consists of a format of the data and a list of options and/or instructions for data entry. Any of the boxes can be made visible by moving the mouse to the heading.

Many of the cells also include an instruction box or a drop-down menu for entering the data, but they also may include constraints and may even show an error message, when trying to enter data in an incorrect format. Instructions will be displayed as drop down menu (Table 2) and the constraints will block false data entry and error messages will give further advice.

The aim is to improve the quality of the entered data and to ease the final QA process. The constraints work only for the punched data. 'Copy – Paste' -commands in the templates will remove the defined constraints.

When entering any data the length and the type of format must be respected, e.g., (CHAR (9)) = 9 characters SCDK00001, (CHAR (7)) = 7 characters MDE0005, Date (10) dd.mm.yyyy as should be 01.01.2014. Period name format is (STRING 4-10) like 01-07-2014 (day), 07-2014 (month) or 2014 (year).

Fixed length of characters has been noted as e.g., 'CHAR (9)', a variable length of characters either as 'STRING (1-255)', 'CHAR (4)' and small numbers as '(INTERGER)'. In case of number with decimal the length and the number of decimals have been noted as (DECIMAL (8.2)) (=nnnnn.nn).

Reporting obligations will be indicated in each of the spreadsheet of the template as follows:

 = 'Prefilled data' i.e. tentative definitions of existing in the database once established will be indicated in gray color in the template

 = Mandatory information - data will be indicated in pink in the template, e.g. sub-catchment and point source codes in load flow tables, parameters, parameter types, values, value units, etc.

 = Voluntarily reported information - data will be indicated in white in the template, e.g. national codes, links, sector codes, etc.

Table 1. An example of a comment box

1	STATION_CODE	SUBCATCHMENT_CODE	SUBCATCHMENT_NAME	PARAMETER_ID	PARAMETER_TYPE	PERIOD_NAME	PERIOD_TYPE	VALUE
2	HDK0129	SCDK00210	HERREDS Å		AVE	2013	A	
3	HDK0128	SCDK00209	HVIDBJERG Å		AVE	2013	A	
4	HDK0130	SCDK00211	TREND Å		AVE	2013	A	
5	HDK0115	SCDK00059	LINDENBORG Å		AVE	2013	A	
6	HDK0112	SCDK00047	KASTBJERG Å		AVE	2013	A	
7	HDK0024	SCDK00031	HASLEV GÅRDS Å		AVE	2013	A	
8	HDK0097	SCDK00114	VILLESTRUP Å		AVE	2013	A	
9	HDK0004	SCDK00006	BREDKÆR BÆK		AVE	2013	A	
10	HDK0106	SCDK00014	FALD Å		AVE	2013	A	
11	HDK0131	SCDK00212	LYBY-GRØNNING GRØFT		AVE	2013	A	
12	HDK0071	SCDK00085	SIMESTED Å		AVE	2013	A	
13	HDK0073	SCDK00087	SKALS Å		AVE	2013	A	
14	HDK0035	SCDK00043	JORDBRO Å		AVE	2013	A	
15	HDK0036	SCDK00046	KARUP Å		AVE	2013	A	
16	HDK0008	SCDK00010	ELLING Å		AVE	2013	A	
17	HDK0104	SCDK00001	ALLING Å		AVE	2013	A	
18	HDK0021	SCDK00026	GUDEN Å		AVE	2013	A	
19	HDK0127	SCDK00208	FELDBÆK		AVE	2013	A	
20	HDK0101	SCDK00018	ÅRHUS Å		AVE	2013	A	
21	HDK0023	SCDK00030	HAMSTED Å		AVE	2013	A	
22	HDK0006	SCDK00008	BYGHOLM Å		AVE	2013	A	
23	HDK0093	SCDK00010	VEJLE Å		AVE	2013	A	
24	HDK0018	SCDK00024	GREJS Å		AVE	2013	A	
25	HDK0033	SCDK00041	HØJEN Å		AVE	2013	A	
26	HDK0076	SCDK00090	SPANG Å		AVE	2013	A	
27	HDK0039	SCDK00050	KOLDING Å		AVE	2013	A	
28	HDK0075	SCDK00089	SOLKÆR Å		AVE	2013	A	
29	HDK0022	SCDK00027	HADERSLEV MØLLESTRØM		AVE	2013	A	
30	HDK0041	SCDK00044	KÆR MØLLE Å		AVE	2013	A	
31	HDK0085	SCDK00099	TAPS Å		AVE	2013	A	
32	HDK0009	SCDK00011	ELSTED BÆK		AVE	2013	A	
33	HDK0012	SCDK00015	FISKBÆK		AVE	2013	A	
34	HDK0062	SCDK00076	PULVERBÆK		AVE	2013	A	
35	HDK0080	SCDK00094	STORÅ		AVE	2013	A	
36	HDK0098	SCDK00015	VINDINGE Å		AVE	2013	A	
37	HDK0060	SCDK00074	ODENSE Å		AVE	2013	A	
38	HDK0078	SCDK00092	STAVIS Å		AVE	2013	A	
39	HDK0049	SCDK00061	LINDVED Å		AVE	2013	A	
40	HDK0098	SCDK00076	GEFFS Å		AVE	2013	A	

FORMAT: (SMALLINT); NOT NULL!
Code for measured/estimated flow
parameter; loads or flow of parameters which are indicated in red should be collected annually
2 = BOD5
3 = BOD7
4 = Cd
7 = Cr
8 = Cu
9 = FLOW
10 = Hg
11 = Ni
12 = NH4
13 = NO2
14 = NO23
15 = NO3
16 = Ntot
18 = Pb
19 = PPO4
20 = Ptot
23 = Zn

Table 2. An example of a drop-down menu.

1	SUBCATCHMENT_CODE	CATCHMENT	PARAMETER_ID	PARAMETER_TYPE	PERIOD_NAME	PERIOD_TYPE
2	SCDK00259	BAPDKLAND	12	TOT	2013	A
3	SCDK00259	BAPDKLAND	14	TOT	2013	A
4	SCDK00259	BAPDKLAND	16	TOT	2013	A
5	SCDK00259	BAPDKLAND	19	TOT	2013	A
6	SCDK00259	BAPDKLAND	20	TOT	2013	A
7	SCDK00260	KATDKLAND	12	TOT	2013	A
8	SCDK00260	KATDKLAND	14	TOT	2013	A
9	SCDK00260	KATDKLAND	16	TOT	2013	A
10	SCDK00260	KATDKLAND	19	TOT	2013	A
11	SCDK00260	KATDKLAND	20	TOT	2013	A
12	SCDK00261	SOUDKLAND	12	TOT	2013	A
13	SCDK00261	SOUDKLAND	14	TOT	2013	A
14	SCDK00261	SOUDKLAND	16	TOT	2013	A
15	SCDK00261	SOUDKLAND	19	TOT	2013	A
16	SCDK00261	SOUDKLAND	20	TOT	2013	A
17	SCDK00262	WEBDKLAND	12	TOT	2013	A
18	SCDK00262	WEBDKLAND	14	TOT	2013	A
19	SCDK00262	WEBDKLAND	16	TOT	2013	A
20	SCDK00262	WEBDKLAND	19	TOT	2013	A
21	SCDK00262	WEBDKLAND	20	TOT	2013	A

As it is described in the Chapter 13, the annual reporting template consists of background information and actual data on monitored and unmonitored sub-catchments, including transboundary; point sources and monitoring stations. Further related tables of the annual reporting format will be described.

Background information

The annual data reporting includes collection of background information on different sources, i.e. areal definitions, stations and point sources.

The sources are: Monitored sub-catchments, river catchments, unmonitored areas (by parameter), transboundary sub-catchments (country wise), hydrological and chemical stations and individual point sources in three different categories (MWWTP, Industry and Aquaculture).

In the MON RIVER_BACKGROUND sheet will be listed

- monitored sub-catchments within one country (code example SC+cc+nnnnn)

- monitored transboundary rivers (code example RC+cc + nnnnn); and
- monitored border rivers (code example RC+cc + nnnnn)

Transboundary and border rivers will be listed in the template of the Contracting Party who has the reporting responsibility of the river, i.e., The CP which has the lowest monitoring station of the river has the reporting responsibility if not agreed differently. Both the transboundary and border rivers have a slightly different catchment code compared with the sub-catchments (RCccnnnnn instead of SCccnnnnn). Figure 1 at the end of the annex clarifies the difference between a sub-catchment and a river catchment and the background information to be reported.

For example, for the entire river (RCLV00055) DAUGAVA the following sub-catchments should be listed:

SCLV00055 (only the Latvian part), SCBY00001, SCR000049, SCLT00009 and SCCE00035, as listed in table 3. In the sheet the attribute 'IS_PRIMARY_STATION' indicates the catchment, which includes the lowest monitoring station.

Additional information to be collected from rivers and separate sub-catchments are: river mouth coordinates, as latitude and longitude (in WGS-84), national sub-catchment and river code, monitoring status (IS_MONITORED), and surface and lake areas (in km²).

Transboundary catchments will be divided to sub-catchments by country (TRANS_SUBCATCHMENT_BACKGROUND).

Table 3. An example for transboundary sub-catchments

SUBCATCH	SUBCATCHMENT_NAME	RIVER_CATCHMENT_CODE	RIVER_TYPE	NATION	NATIONAL_R	RNR_CAT	IS_MONITORED	PERIOD_NAME	IS_PRIMARY	CREATION	END_DATE	TOTAL_DR	COUNTRY_DR
SCLV00001	BARTA	BAP07001	T				1	2013	1	01.01.1994		1968.00	1227
SCLV00005	GAUJA	GUR07002	T				1	2013	1	01.01.1994		8890.00	7790
SCLV00009	LIELUPE	GUR07004	T				1	2013	1	01.01.1994		17600.00	8730
SCLV00013	SALACA	GUR07005	T				1	2013	1	01.01.1994		3471.00	3190
SCLV00015	VENTA	BAP07003	T				0	2013	0	01.01.1994		11795.00	6648
SCLV00055	DAUGAVA	GUR07001	T				1	2013	1	01.01.1994		87900.00	23735
SCLT00010	BARTA	BAP07001	T				0	2013	0	01.01.1994		1968.00	741
SCCE00033	GAUJA	GUR07002	T				0	2013	0	01.01.1994		8890.00	1100
SCLT00003	LIELUPE	GUR07004	T				0	2013	0	01.01.1994		17600.00	9390
SCCE00034	SALACA	GUR07005	T				0	2013	0	01.01.1994		3471.00	281
SCLT00008	VENTA	BAP07003	T				0	2013	0	01.01.1994		11795.00	5169
SCBY00001	DAUGAVA	GUR07001	T				0	2013	0	01.01.1994		87900.00	33100
SCCE00035	DAUGAVA	GUR07001	T				0	2013	0	01.01.1994		87900.00	1335
SCLT00009	DAUGAVA	GUR07001	T				0	2013	0	01.01.1994		87900.00	1875
SCR000049	DAUGAVA	GUR07001	T				0	2013	0	01.01.1994		87900.00	27000
SCLV00018	NEMUNAS	BAP06002	T				0	2013	0	01.01.1994		98179.00	88
SCLV00017	NARVA	GUF04005	T				0	2013	0	01.01.1994		56225.00	3570
SCLV00020	SVENTOJI	BAP06003	T				0	2013	0	01.01.1994		472.00	82
SCLV00019	PARNU	GUR04002	T				0	2013	0	01.01.1994		6920.00	2

All unmonitored sub-catchment information of a country will be listed in the UNMONITORED SUBCATCHMENT BACKGROUND sheet. In case an unmonitored area varies by parameter, each unmonitored area (in km²) and parameter should be listed individually as in table 4.

Table 4. An example of unmonitored sub-catchments

SUBCATCHMENT_CODE	SUBCATCHMENT_NAME	SUBCATCHMENT_TYPE	PARAMETER_ID	PERIOD_NAME	UNMONITORED_AREA	LAKE_AREA	REMARKS
SCSE00309	BAPSELAND	L	0	2013	24559.00		
SCSE00310	BOBSELAND	L	0	2013	17644.00		
SCSE00311	BOSSELAND	L	0	2013	19765.00		
SCSE00312	KATSELAND	L	0	2013	4536.00		
SCSE00313	SKASELAND	L	0	2013	2942.00		
SCSE00314	SOUSELAND	L	0	2013	2389.00		

The 'station' and 'point source' information in STATION_BACKGROUND and in POINT_SOURCE_BACKGROUND –sheets to be collected are:

- code of a station or a point source and their activity status ('IS_ACTIVE' and 'REPORTING_END_DATE');

- location, i.e., coordinates of each monitoring station or an outlet of an individual point source (in decimal degrees, (WGS-84) latitude and longitude),
- related sub-catchment (of each station)
- recipient sea area (for a discharging point source) and
- size (in km²) of the monitored area of each station

In addition, information on national station code, EU national point source code and E- PRTR sector type can be reported.

Reference sheet of the MS Excel reporting template for each set of background information is indicated in table 5 and the type and the format of all the reported background information are listed by attribute and by spreadsheet in table 6 and 7.

Once the definitions and background information by country have been updated in the database, a tentative list of information will be prefilled by the application when annual reporting templates are downloaded.

The prefilled information of areal definitions, stations or point sources to be reported will be updated before the actual reporting. Once the prefilled information have been provided, none of the data sets, i.e. monitored rivers or sub-catchments, unmonitored areas, transboundary catchments or point sources should be deleted. For rivers and sub-catchments the attribute 'IS_MONITORED' indicates whether the catchment has been reported or not in that year, and similarly for stations 'IS_ACTIVE' attribute indicates if the station has been reported or not.

Table 5. Background information to be reported.

GENERAL VIEW OF THE ANNUAL BACKGROUND INFORMATION TO BE PROVIDED							
BACKGROUND DEFINITIONS	REPORTING	REFERENCE TABLE	SURFACE AREAS				ADDITIONAL INFORMATION
			TOTAL_DRAINAGE (in km ²)	COUNTRY_DRAINAGE (in km ²)	CONTROL AREA by STATION (in km ²)	TRANSBOUNDARY DRAINAGE (in km ²)	
RIVER/MONITORED SUB-CATCHMENT ^a	INDIVIDUAL	MON_RIVER_BACKGROUND	X	X		X	River mouth coordinates; IS_MONITORED /IS_UNMONITORED during the period; end date of the catchment validity; lake area of the catchment
UNMONITORED SUBCATCHMENT	BY SUBBASIN and PARAMETER	UNMON_SUBCATCHMENT_BACKGROUND	X				Lake area of the catchment
TRANSBOUNDARY SUBCATCHMENT ^a	INDIVIDUAL	TRANSB_SUBCATCHMENT_BACKGROUND	X	X		X	Lake area of the catchment
MONITORING STATION	INDIVIDUAL	STATION_BACKGROUND			X		activity/station coordinates
POINT SOURCES of 3 CATEGORIES	INDIVIDUAL	POINT_SOURCE_BACKGROUND					outlet coordinates; PRTR_sector code; end date of a PS (date of closing)

Table 6. Data type and format of catchment background information

ATTRIBUTE/SHEET	MON_RIVER_BACK GROUND	UNMON_SUBCATCHMENT _BACKGROUND_	TRANS_SUBCATCHMENT_ BACKGROUND
SUBCATCHMENT_CODE	CHAR (9)	CHAR (9)	CHAR (9)
SUBCATCHMENT_NAME	STRING (1-255)	STRING (1-255)	STRING (1-255)
SUBCATCHMENT_TYPE	CHAR(1)	CHAR(1)	
RIVER_CATCHMENT_CODE	CHAR(8)	-	CHAR(8)
PARAMETER_ID	-	INTEGER	-
RIVER_MOUTH_LATITUDE	DECIMAL (dd.dddd)	-	-
RIVER_MOUTH_LONGITUDE	DECIMAL (dd.dddd)	-	-
RIVER_TYPE	CHAR(1)	-	CHAR(1)
NATIONAL_SUBCATCHMENT_CODE	STRING (1-255)	-	STRING(1-255)
NATIONAL_RIVER_CODE	STRING (1-255)	-	STRING(1-255)
NR_CATCHMENTS	INTEGER	INTEGER	INTEGER
IS_MONITORED	INTEGER	-	INTEGER
PERIOD_NAME	STRING (4-10)	STRING (4-10)	STRING (4-10)
IS_PRIMARY_STATION	-	-	BIT 0/1
CREATION_DATE	DATE(10) dd.mm.yyyy	DATE(10) dd.mm.yyyy	DATE(10) dd.mm.yyyy
END_DATE	DATE(10) dd.mm.yyyy	DATE(10) dd.mm.yyyy	DATE(10) dd.mm.yyyy
TOTAL_DRAINAGE_AREA	DECIMAL (8.2)		DECIMAL (8.2)
UNMONITORED_AREA	-	DECIMAL (8.2)	-
COUNTRY_DRAINAGE_AREA	DECIMAL (8.2)	-	DECIMAL (8.2)
TRANSBOUNDARY_AREA	-	-	DECIMAL (8.2)
LAKE_AREA	DECIMAL (8.2)	DECIMAL (8.2)	DECIMAL (8.2)
REMARKS	STRING(1-255)	STRING(1-255)	STRING(1-255)

Table 7. Data type and format of station and point source background information

ATTRIBUTE/SHEET	STATION_BACKGROUND	POINT_SOURCE_BACKGROUND
STATION_CODE	CHAR (7)	-
SUBCATCHMENT_CODE	CHAR (9)	CHAR (9)
SUBCATCHMENT_NAME	STRING (1-255)	STRING (1-255)
STATION_NAME	STRING (1-25)	-
PLANT_CODE	-	STRING (7)
PLANT_NAME	-	STRING (1-255)
PERIOD_NAME	STRING (4-10)	STRING (4-10)
IS_ACTIVE	BIT 0/1	-
RIVER_CATCHMENT_CODE	CHAR(8)	-
NATIONAL_STATION_CODE	STRING (1-25)	-
EU/NATIONAL_CODE	-	CHAR(255)
PRTR_SECTOR_CODE *)	-	CHAR(1)
STATION/PLANT_CODE_LAT	DECIMAL (dd.dddd)	DECIMAL (dd.dddd)
STATION/PLANT_CODE_LON	DECIMAL (dd.dddd)	DECIMAL (dd.dddd)
WFD_CODE	STRING (1-50)	-
REPORTING_START_DATE	-	DATE(10)
REPORTING_END_DATE	-	DATE(10)
TOTAL_NR_OF_PLANTS	-	INTEGER
TOTAL_NR_OF_TREATED_PLANTS	-	INTEGER
MONITORED_AREA	DECIMAL (8.2)	-
REMARKS	STRING(1-255)	STRING(1-255)

*) The document listing new E-PRTR_SECTOR_CODES can be downloaded:

http://prtr.ec.europa.eu/docs/Summary_activities.pdf

Actual Data

Actual data on loads from monitored sub-catchments and transboundary rivers should be reported individually and for unmonitored areas as aggregated by basin. Though, unmonitored parts of monitored rivers can be reported as individual sub-catchments.

MONITORED SUB-CATCHMENTS AND RIVER

The loads of monitored rivers should be reported in the MON_RIVER_LOAD sheet. The following loads should be reported:

- loads of monitored rivers within one country
- loads of transboundary rivers
- loads of border rivers

The collected mandatory and voluntary parameters have been listed in the PLC-6 Guidelines (Table 1.1)

In some cases the conducted measurements are below the LOQ / LOD (Limit of quantification / detection). LOQ/LOD information (LIMIT_VALUE, LIMIT_UNIT NR_BELOW_LIMIT) should be reported in the MON_RIVER_LOAD sheet. Related to LOQ/LOD information, also the number of measurements and total uncertainty for the obtained load should be reported.

Total flow of a monitored river should be reported in the STATION_FLOW_CONCENTRATION sheet by monitoring station. All records of the monitoring stations in the spreadsheet should also contain code of the sub-catchment where the monitoring station is located.

The collected mandatory and voluntary parameters have been listed in the PLC-6 Guidelines (Table 1.1)

Flow will be reported as m^3 and the other parameters as $t a^{-1}$ or $kg a^{-1}$ (heavy metals).

As for the background information, the reporting responsibility of a transboundary/border river is for the country which has the lowest monitoring station of the catchment

- to report the total inputs
- to report transboundary input at the border

Reporting of loads will be agreed between the countries sharing a transboundary river. Figure 1 at the end of the document clarifies the reporting of sub-catchment and transboundary loads.

The loads and flows of separate catchments (by country, i.e. country allocations) of transboundary and border rivers should be reported in the TRANSBOUNDARY_FLOW_LOAD sheet. Related to the transboundary loads their retention can be reported on a voluntary basis in the TRANB_SUBCATCHMENT_RETENTION

Reported parameters are: average flow, N_{tot} and P_{tot} and they will be reported in $m^3 s^{-1}$ and in $t a^{-1}$ or $kg a^{-1}$.

Additional information on total uncertainty and basic calculation information should be reported. Reporting of LOQ/LOD information should be reported for monitored transboundary loads, as well.

UNMONITORED SUB-CATCHMENTS

The data for unmonitored area should be reported by country and by basin. Each unmonitored area consists of the areas between the monitored catchments, unmonitored parts of the monitored rivers, coastal areas and islands. Both the loads and flow of unmonitored areas should be reported in the UNMON_SUBCATCHMENT_FLOW_LOAD sheet.

The loads and flow of each unmonitored area should also include all loads and flow for the point sources in the area.

The reported parameters for unmonitored areas have been listed in table 1.1. Flow will be reported as $m^3 s^{-1}$ and the other parameters as $t a^{-1}$ or $kg a^{-1}$. Total uncertainty of obtained loads should be reported. Calculation methodology can also be reported.

An overview of the reported data has been presented in table 8 and type and format of loads, flow and metadata by attribute and for each spreadsheet have been compiled in table 9.

Table 8. An overview of the data for the annual reporting

GENERAL VIEW OF THE ANNUAL DATA REPORTING ON SUBCATCHMENTS AND STATIONS						
SOURCE	REPORTING	REFERENCE TABLE	FLOW	LOAD	ADDITIONAL INFORMATION	CALC. ESTIMATION METHODS
MONITORED SUB-CATCHMENTS/RIVERS	INDIVIDUALLY	MON_RIVER_LOAD		as listed in Table 1.1	LOQ/LOD information, total uncertainty	X
UNMONITORED SUBCATCHMENT (*)	BY COUNTRY AND BASIN, (OPTIONALLY BY PARAMETER)	UNMON_SUBCATCHMENT_FLOW_LOAD	average flow (in $m^3 s^{-1}$)	as listed in Table 1.1	Total uncertainty	X
TRANSBOUNDARY SUBCATCHMENT (**)	INDIVIDUALLY for each SUBCATCHMENT	TRANSBOUNDARY_FLOW_LOAD	average flow (in $m^3 s^{-1}$)	as listed in Table 1.1		X
TRANSBOUNDARY SUBCATCHMENT (***)	INDIVIDUALLY for each TRANSBOUNDARY SUBCATCHMENT	TRANSBOUNDARY_RETENTION		as listed in Table 1.1		
MONITORED STATION	INDIVIDUALLY	STATION_FLOW_CONCENTRATION	average flow (in $m^3 s^{-1}$) (****)		Annual min, max and long-term flows (1981-2010) and concentrations voluntarily (m^3/s , $\mu g/l$ or mg/l)	X

(* Unmonitored parts of monitored rivers should be reported together with unmonitored areas

(** Transboundary loads/flow of monitored rivers only Flow, Ntot and Ptot should be reported on a mandatory basis

(*** Retention of the nutrient load of transboundary sub-catchments can be reported on a voluntary basis

(**** Voluntarily minimum, maximum and long-term flows can be reported

Table 9. Type and format of sub-catchment (load and flow) and station (flow and concentration) data

ATTRIBUTE/SHEET	MON_RIVER_LOAD	UNMON_SUBCATCHMENT_FLOW_LOAD	TRANSBOUNDARY_FLOW_LOAD	TRANSBOUNDARY_RETENTION	STATION_FLOW_CONCENTRATION
STATION_CODE	-	-	-		CHAR (7)
SUBCATCHMENT_CODE	CHAR (9)	CHAR (9)	CHAR (9)	CHAR (9)	CHAR (9)
SUBCATCHMENT_NAME	STRING (1-255)	STRING (1-255)	STRING (1-255)	STRING (1-255)	STRING (1-255)
PARAMETER_ID	INTEGER	INTEGER	INTEGER	INTEGER	INTEGER
PARAMETER_TYPE	CHAR (3)	CHAR (3)	CHAR (3)	CHAR (3)	CHAR (3)
PERIOD_NAME	STRING(4-10)	STRING(4-10)	STRING(4-10)	STRING(4-10)	STRING(4-10)
PERIOD_TYPE	CHAR (1)	CHAR (1)	-		CHAR (1)
IS_LOQ/LOD	BIT (0/1)	-	BIT (0/1)		-
LIMIT_VALUE	DECIMAL (8(.6))	-	DECIMAL (8(.6))		-
LIMIT_UNIT	CHAR(4)	-	CHAR(4)		-
NUMBER_BELOW_LIMIT	INTEGER	-	INTEGER		-
NR_MEASUREMENTS	INTEGER	-	INTEGER		INTEGER
VALUE	DECIMAL (10(.3))	DECIMAL (10(.3))	DECIMAL (10(.3))	DECIMAL (10(.3))	DECIMAL (10(.3))
VALUE_UNIT	STRING(3-6)	STRING(3-6)	STRING(3-6)	STRING(3-6)	STRING(3-6)
TOT_UNCERTAINTY	INTEGER	INTEGER	INTEGER	INTEGER	INTEGER
DATA_SOURCE_FLAG	CHAR(2)	CHAR(2)	CHAR(2)	CHAR(2)	CHAR(2)
METHOD_ID	INTEGER	INTEGER	INTEGER	INTEGER	INTEGER
REMARKS	STRING(1-255)	STRING(1-255)	STRING(1-255)	STRING(1-255)	STRING(1-255)

Actual data on DIRECT POINT SOURCES

Annual loads and flows of direct point sources will be reported individually and for three different categories, municipal wastewater treatment plants (MWWTP), industries and aquaculture. Direct point source has been defined in chapter 2.5 and in Annex 1 as: “Direct point sources: Point sources discharging (defined by location of the outlet) directly to the sea”. Further, this implies, that the loads and flow data of point sources, which are located downstream the monitoring station, but not discharging directly to the sea, should be included in the loads of unmonitored areas.

The data to be reported by different category have been listed below (table 10).

MWWTPs

The data to be collected on municipal wastewater treatment plants have been listed in the table 1.1.

Flow will be reported as total flow in $m^3 a^{-1}$ and the other parameters as $t a^{-1}$ or $kg a^{-1}$.

Information on LOQ or LOD (IS_LOQ/LOD) and related data, number of measurements (NR_MEASUREMENTS) and total uncertainty (TOT_UNCERTAINTY) are mandatory to report. Information on sampling methodology, and used methods can be reported voluntarily.

INDUSTRIES

The data to be collected on industrial plants have been listed in the table 1.1

Flow will be reported as total in $m^3 a^{-1}$ and the other parameters as ta^{-1} or $kg a^{-1}$. Information on LOQ or LOD (IS_LOQ/LOD) and related data, number of measurements (NR_MEASUREMENTS) and total uncertainty (TOT_UNCERTAINTY) are mandatory to report. Information on sampling methodology, and used methods can be reported voluntarily.

AQUACULTURAL PLANTS

The parameters to be collected on aquacultural plants have been listed in the table 1.1

Flow will be reported as total in $m^3 a^{-1}$ and N_{tot} , P_{tot} or $BOD_{5/7}$ as $t a^{-1}$ or as $kg a^{-1}$. Total uncertainty of the obtained loads should be reported and used methods on a voluntary basis, respectively.

Apart from the load reporting, amount of feed, feed type and fish production can be reported on a voluntary basis in the AQUACULTURE_PRODUCTION -sheet

The type and format of point source load flow and metadata as well as the information on aquacultural production is given in Table 11.

Table 10. An overview of the point source data for annual reporting

GENERAL VIEW OF THE ANNUAL DATA REPORTING ON POINT SOURCES						
SOURCE	REPORTING	REFERENCE TABLE	FLOW	LOAD	ADDITIONAL INFORMATION	CALC. ESTIMATION METHODS OF INPUTS
MWWTP	MWWTPs INDIVIDUALLY(*)	MUNICIPAL_LOAD_FLOW	$m^3 a^{-1}$	as listed in Table 1.1	LOQ/LOD and related information, total uncertainty	X
INDUSTRY	INDUSTRIES INDIVIDUALLY (*)	INDUSTRIAL_LOAD_FLOW	$m^3 a^{-1}$	as listed in Table 1.1	LOQ/LOD and related information, total uncertainty	X

					PRTR sector/ individual reporting	
AQUACULTURE	AQUACULTURE INDIVIDUALLY(*	AQUACULTURE_LOAD	m ³ a ⁻¹ (**	as listed in Table 1.1	Total uncertainty	X
AQUACULTURE PRODUCTION	AQUACULTURE INDIVIDUALLY(*	AQUACULTURE_PROD UCTION			Voluntarily feed type, amount of feed used and total production	

(* Point sources might be reported as aggregated by sub-basin

(** Flow of an individual aquaculture can be reported on a voluntary basis when it is relevant, i.e. outlet of discharges exists.

Table 11. Type and format by attribute and spreadsheet of the point source data

ATTRIBUTE/SHEET	MUNICIPAL_ LOAD_FLOW	INDUSTRIAL_ LOAD_FLOW	AQUACULTURE_ LOAD	AQUACULTURE_ PRODUCTION
PLANT_CODE	CHAR (7)	CHAR (7)	CHAR (7)	CHAR (7)
SUBCATCHMENT_CODE	CHAR (9)	CHAR (9)	CHAR (9)	-
SUBCATCHMENT_NAME	STRING (1-255)	STRING (1-255)	STRING (1-255)	-
PARAMETER_ID	INTEGER	INTEGER	INTEGER	
PARAMETER_TYPE	CHAR (3)	CHAR (3)	CHAR (3)	
PERIOD_NAME	STRING (4-10)	STRING (4-10)	STRING (4-10)	STRING (4-10)
PERIOD_TYPE	CHAR (1)	CHAR (1)	CHAR (1)	-
IS_LOQ/LOD	BIT 1/0	BIT 1/0	-	-
LIMIT_VALUE	DECIMAL (8(.6))	DECIMAL (8(.6))	-	-
LIMIT_UNIT	CHAR(4)	CHAR(4)	-	-
NUMBER_BELOW_LIMIT	INTEGER	INTEGER	-	-
NR_MEASUREMENTS	INTEGER	INTEGER	-	-
VALUE	DECIMAL (10(.3))	DECIMAL (10(.3))	DECIMAL (10(.3))	-
VALUE_UNIT	STRING(3-6)	STRING(3-6)	STRING(3-6)	-
TOT_UNCERTAINTY	INTEGER	INTEGER	INTEGER	-
SAMPLING_METHODODOLOGY	CHAR(1)	CHAR(1)	-	-
DATA_SOURCE_FLAG	CHAR(2)	CHAR(2)	CHAR(2)	-
METHOD_ID	INTEGER	INTEGER	INTEGER	-
FEED_TYPE	-	-	-	CHAR(1)
AMOUNT_OF_FEED	-	-	-	DECIMAL (10(.3))
AQUACULTURE_PRODUCTION	-	-	-	DECIMAL (10(.3))
REMARKS	STRING(1-255)	STRING(1-255)	STRING(1-255)	-

TRANSBOUNDARY SUBCATCHMENT information (TOTAL_ COUNTRY_ and TRANSBOUNDARY_DRAINAGE) to be reported in 'TRANS_SUBCATCHMENT_BACKGROUND'

TRANSBOUNDARY LOADS to be reported in 'TRANSBOUNDARY_FLOW_LOAD' by the responsible contracting party

SCcc00003
SCcc00002
SCcc00001

SCcc00001-SCcc00003 form an 'RCcc00001' (RIVER CATCHMENT) = TOTAL DRAINAGE

CHEMICAL/HYDROLOGICAL STATION and STATION COORDINATES
Upstream the station is 'MONITORED AREA' which should be reported in 'STATION_BACKGROUND'
Reported by the responsible CP

RIVER MOUTH COORDINATES

TOTAL DRAINAGE of TRANSBOUNDARY RIVER CATCHMENT (RCcc00001) = sum of SCcc00001-SCcc00003) down to the river mouth
COUNTRY DRAINAGE = from the river mouth up to the border (in case of transboundary river)
If TOTAL DRAINAGE = COUNTRY DRAINAGE a river is in one country's area (as SCccnnnnn) and should be reported in 'MON_RIVER_BACKGROUND'

The load of TRANSBOUNDARY RIVER (RCcc00001) and the load of SUBCATCHMENT of one country (as SCccnnnnn) as monitored should be reported in 'MON_RIVER_LOAD' and flow in 'STATION_FLOW_CONCENTRATION'

Figure 1. Reporting river catchment and monitored sub-catchment background information and flow and loads.

Annex 3. Periodic reporting formats

Periodic PLC-water reporting is arranged on decision of the Contracting Parties with the main aim to identify sources of the Baltic Sea pollution and evaluate effectiveness of measures to reduce nutrient loads undertaken in various sectors. The data on retention of nutrients in the different sub-catchments of the Baltic Sea region are also updated based on the results of periodic data reporting.

Reporting instructions also include data reporting sheets. They have been established separately for each Contracting Party as CC_PERIODIC REPORTING_2014_XLSX (CC = COUNTRY CODE: DK = DENMARK, EE = ESTONIA, FI = FINLAND, DE = GERMANY, LV = LATVIA, LT = LITHUANIA, PL = POLAND and SE = SWEDEN). For example, for Estonia the file is: **EE_PERIODIC_REPORTING_2014.XLSX**. This data entry file of Estonia works as an example. Similar files with the same structure will be submitted to each contracting party, including prefilled data by country.

REPORTING IN GENERAL

When entering the data general settings should be used:

- No additional columns should be added or any columns deleted in the prefilled spreadsheets.
- Decimal separator to be used '.' (dot) not a ',' (comma)
- If the type of an attribute is '**NOT NULL**', data should be reported.

Each reported attribute has a comment box (Table 1), which consists of a format of the data and a list of options and/or instructions for data entry. Any of the boxes can be made visible by moving the mouse to the attribute.

Many of the cells also include an instruction box or a drop-down menu for entering the data, but they also may include constraints and may even show an error message, when trying to enter data in an incorrect format. Instructions will be displayed as drop down menu (Table 2) and the constraints will block false data entry and error messages will give further advice.

The aim is to improve the quality of the entered data and to ease the final QA process. The constraints work only for the punched data. 'Copy – Paste' -commands in the templates will remove the defined constraints.

When entering any data the length and the type of format must be respected, e.g., (CHAR (9)) = 9 characters SCDK00001, (CHAR (7)) = 7 characters MDE0005, Date (10) dd.mm.yyyy or dd-mm-yyyy e.g., 01.01.2014 and 01-07-2014

Fixed length of characters has been noted as e.g., 'CHAR (9)', a variable length of characters either as 'STRING (1-255)', 'CHAR (4)' and small numbers as '(INTERGER)'. In case of number with decimal the length and the number of decimals have been noted as (DECIMAL (8.2)) (=nnnnn.nn).

Reporting obligations will be indicated in each of the spreadsheet of the template as follows:

 = 'Prefilled data' i.e. tentative definitions of existing in the database once established will be indicated in gray color in the template

 = Mandatory information - data will be indicated in pink in the template, e.g. subcatchment and point source codes in load flow tables, parameters, parameter types, values, value units, etc.

= Voluntarily reported information - data will be indicated in white in the template, e.g. national codes, links, sector codes, etc.

Table 1. An example of a comment box

A	B	C	D	E	F	G	H	I	J	K	
STATION CODE	STATION NAME	SUBCATCHMENT	CATCHMENT NAME	RIVER CATCHMENT CODE	PERIOD	NATIONAL STATION CODE	IS ACTIVE	ST LAT	ST LON	MONITORED AREA	
2	CEE0001	LINNAMAE	SCEE0001	JÄGALA	GUF04001	PLC-6	SJA2203000	1	59.4717	25.1523	1570.00
3	CEE0002	KASARI ISLD	SCEE0003	KASARI	GUR04001	PLC-6	SJA4483000	1	58.7336	23.9895	2640.00
4	CEE0003	SUIUE	SCEE0005	KEILA	GUF04002	PLC-6	SJA5960000	1	59.3953	24.2964	682.00
5	CEE0004	SUIUE	SCEE0007	KUNDA	GUF04003	PLC-6	SJA8841000	1	58.5098	26.5383	528.00
6	CEE0005	VHÄSÖD	SCEE0009	LOOBU	GUF04004	PLC-6	SJA5258000	1	58.5517	25.785	308.00
7	CEE0006	SUIUE (NARVAST ALLAVOOLU)	SCRU00025	NARVA	GUF04005	PLC-6	SJA9741000	1	4204	28.1354	56000.00
8	CEE0007	PUDISOO	SCEE0015	PUDISOO	GUF04007	PLC-6	SJA9316000	1	5175	25.5556	123.00
9	CEE0008	SUIUE (TALLINN-NARVA MINT)	SCEE0017	PURTSE	GUF04008	PLC-6	SJA3032000	1	4117	27.0068	810.00
10	CEE0009	OORE	SCEE0021	PÄRNU	GUR04002	PLC-6	SJA8483000	1	4553	24.7835	5154.00
11	CEE0010	SUIUE	SCEE0019	PÜHAJÕGI	GUF04009	PLC-6	SJA3956000	1	4199	27.5279	196.00
12	CEE0012	LOKSA JALAKÄUATE SLD	SCEE0025	VALGEJÕGI	GUF04011	PLC-6	SJA6880000	1	5831	25.7114	453.00
13	CEE0013	VASALEMMA JÕGI	SCEE0027	VASALEMMA	GUF04012	PLC-6		1			403.00
14	CEE0014	VHTERPALU	SCEE0029	VHTERPALU	GUF04013	PLC-6	SJA2051000	1	2595	23.8734	474.00
15	CEE0015	SUIUE	SCEE0031	VÄÄNA	GUF04014	PLC-6	SJA7837000	1	4314	24.3642	316.00
16	CEE0016	LUKATI	SCEE0013	PIRITA	GUF04006	PLC-6	SJA5140000	1	6065	24.85526	794.00
17	CEE0017		SCEE00109	SELJAJÕGI	GUF04010	PLC-6		1			380.00
18	HEE0001	KEHRA	SCEE0001	JÄGALA	GUF04001	PLC-6	SJA3814000	1	3333	25.3333	903.00
19	HEE0002	KASARI	SCEE0003	KASARI	GUR04001	PLC-6	SJA9179000	1	58.7336	23.9895	2640.00
20	HEE0003	KEILA	SCEE0005	KEILA	GUF04002	PLC-6	SJA6896000	1	59.3102	24.4344	635.00
21	HEE0004	SÄMI	SCEE0007	KUNDA	GUF04003	PLC-6	SJA1417000	1	59.3667	26.6	406.00
22	HEE0005	ARBAVERE	SCEE0009	LOOBU	GUF04004	PLC-6	SJA7798000	1	59.44242	25.96859	205.00
23	HEE0006	NARVA	SCEE0011	NARVA	GUF04005	PLC-6	SJA4515000	1	59.35	28.2	56000.00
24	HEE0007	PUDISOO	SCEE0015	PUDISOO	GUF04007	PLC-6	SJA4401000	1	59.5175	25.5556	123.00
25	HEE0008	LÜGANUSE	SCEE0017	PURTSE	GUF04008	PLC-6	SJA5163000	1	59.3833	27.5	784.00
26	HEE0009	OREKÜLA	SCEE0021	PÄRNU	GUR04002	PLC-6	SJA2731000	1	58.4553	24.7835	5154.00
27	HEE0010	TOLA-ORU	SCEE0019	PÜHAJÕGI	GUF04009	PLC-6	SJA5604000	1	59.42305	27.53	196.00
28	HEE0012	VANAKÜLA	SCEE0025	VALGEJÕGI	GUF04011	PLC-6	SJA8764000	1	59.4667	25.7833	404.00
29	HEE0013	URBA	SCEE0027	VASALEMMA	GUF04012	PLC-6		1	59.3013	24.1954	
30	HEE0014	VHTERPALU	SCEE0029	VHTERPALU	GUF04013	PLC-6	SJA3959000	1	59.2595	23.8734	474.00
31	HEE0015	HÜÜRÜ	SCEE0031	VÄÄNA	GUF04014	PLC-6	SJA2072000	1	59.3833	24.5333	209.00
32	HEE0016	KLOOSTRIMETSA	SCEE0013	PIRITA	GUF04006	PLC-6	SJA6279000	1	59.46598	24.87791	794.00

FORMAT (BIT):
when any
Measurements
have carried out
at the station
then
1 = MONITORED
otherwise
0 = UNMONITORED
(DEFAULT)

Table 2. An example of a drop-down menu.

A	B	C	D	E	F	G	H
STATION CODE	SUBCATCHMENT CODE	SUBCATCHMENT NAME	PARAMETER ID	PARAMETER TYPE	PERIOD NAME	PERIOD TYPE	LTA_S
2					PLC-6		
3							
4				AVE			
5				MIN			
6				MAX			
7				LTA			
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							

As it was described in the Chapter 14, the periodic reporting template consist of background information and actual data on contribution of various sources into total nutrient loads from monitored, unmonitored and transboundary sub-catchments as well as on inland point sources. Further the tables of the periodic reporting format will be described.

BACKGROUND INFORMATION

The collection of periodic background information is very similar to annual background information (i.e. areal definitions, stations and point sources) collection. The main difference is that for periodic reporting the number of PLC assessment (e.g., PLC-6) is to be used as PERIOD_NAME, but for annual reporting the reporting year, (e.g. 2013), is used as PERIOD_NAME.

The background information should be reported for the monitored, unmonitored and transboundary sub-catchments as well as for individual point sources discharging into the fresh water either individually or as aggregated by sub-catchment.

Background information for the monitored, unmonitored and transboundary sub-catchments in the periodic reporting should be identical to the annual reporting in the same year (see Chapter 13 and Annex 2). The only difference is that the number of PLC assessment (e.g. PLC-6) is to be used as the period name in the periodic reporting. Examples of background data for transboundary and unmonitored sub-catchments are given in the tables 3 and 4.

Table 3. An example of background information for transboundary sub-catchments

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
SUBCATCHMENT	RIVER_CAT	RIVER_TYPE	NATION	NATIONAL_R	RNR_CAT	IS_MONITORED	PERIOD_NAME	IS_PRIMARY_STATION	CREATION	END_DATE	TOTAL_DRA	COUNTRY_DRAIN	TRANSBOUNDARY_AREA	
SCEE00033	GAUJA	GUR07002	T			1	0 PLC-6	0	01.01.1995		8890.00	7790.00	1100.00	
SCEE00034	SALACA	GUR07005	T			1	0 PLC-6	0	01.01.1995		3471.00	3190.00	281.00	
SCEE00035	DAUGAVA	GUR07001	T			1	0 PLC-6	0	01.01.1994		87045.00	1335.00	85710.00	
SCEE00021	PARNU	GUR04002	T			1	1 PLC-6	1	01.01.1994		6920.00	6918.00	2.00	
SCEE00011	NARVA	GUF04005	B			1	1 PLC-6	1	01.01.1994		56225.00	17215.80	39009.20	
SCLV00017	NARVA	GUF04005	B			1	0 PLC-6	0	01.01.1994		56225.00	3570.00	52655.00	
SCRU00025	NARVA	GUF04005	B	104100001		1	0 PLC-6	0	01.01.1995		56255.00	39000.00	17255.00	
SCLV00019	PARNU	GUR04002	T			1	0 PLC-6	0	01.01.1994		6920.00	2.00	6918.00	

Table 4. An example of background information for unmonitored sub-catchments.

A	B	C	D	E	F	G
SUBCATCHMENT_CODE	SUBCATCHMENT_NAME	SUBCATCHMENT_TYPE	PARAMETER_ID	PERIOD_NAME	UNMONITORED_AREA	LAKE
SCDK00259	BAPDKLAND	L	4	PLC-6	1043.00	
SCDK00259	BAPDKLAND	L	12	PLC-6	200.00	
SCDK00259	BAPDKLAND	L	16	PLC-6	200.00	
SCDK00259	BAPDKLAND	L	20	PLC-6	200.00	
SCDK00260	KATDKLAND	L	0	PLC-6	7687.00	
SCDK00261	SOUDEKLAND	L	0	PLC-6	886.00	
SCDK00262	WEBDKLAND	L	0	PLC-6	7719.00	
			NOT NULL!			

The following background information for indirect point sources should be reported:

- Code of a point source and the change of activity status (REPORTING_END_DATE, in case the point source has been closed);,
- Location, i.e., coordinates of each outlet of an individual point source (in decimal degrees, (WGS-84) latitude and longitude),
- Recipient area of a discharging point source (a defined monitored, unmonitored or a sea area for a discharging point source) is a must, otherwise the location of the point source cannot be defined
- EU national point source code and E- PRTR sector type. E-PRTR sector codes and their descriptions can be found in table 12 or to be downloaded in http://prtr.ec.europa.eu/docs/Summary_activities.pdf.

Reference sheets for each background information in the periodic reporting template are listed in table 5 and the types and the formats of attributes are given in table 6 and 7.

Once the definitions and background information for individual indirect point sources have been updated in the database, a prefilled periodic reporting templates can be downloaded.

In case the prefilled information doesn't contain all point sources to be reported, data manager should be contacted. Aggregated point sources cannot be prefilled and thus data manager should be contacted if point sources will be reported as aggregated.

Table 5. Background information to be reported.

GENERAL VIEW OF THE PERIODIC BACKGROUND INFORMATION TO BE PROVIDED

BACKGROUND DEFINITIONS	REPORTING	REFERENCE SHEET	SURFACE AREAS				ADDITIONAL INFORMATION
			TOTAL_ DRAINAGE (in km ²)	COUNTRY_ DRAINAGE (in km ²)	CONTROL AREA by STATION (in km ²)	TRANSBOUNDARY DRAINAGE (in km ²)	
RIVER/MONITORED SUB-CATCHMENT	INDIVIDUAL	MON_RIVER_BACKGROUND	X	X		X	River mouth coordinates; IS_MONITORED /IS_UNMONITORED during the period; end date of the catchment validity; lake area of the catchment
UNMONITORED SUB-CATCHMENT	BY SUBBASIN and PARAMETER	UNMON_SUBCATCHMENT_BACKGROUND	X				Lake area of the catchment
TRANSBOUNDARY SUB-SUBCATCHMENT	INDIVIDUAL	TRANSB_SUBCATCHMENT_BACKGROUND	X	X		X	Lake area of the catchment
INDIRECT POINT SOURCES	INDIVIDUALLY or AGGREGATED	INDIR_POINT_SOURCE_BACKGROUND					outlet coordinates; PRTR_sector code; end date of a PS (date of closing)

Table 6. Data type and format of catchment background information for periodic reporting.

ATTRIBUTE/SHEET	MON_RIVER_BACK GROUND	UNMON_SUBCATCHMENT _BACKGROUND_	TRANS_SUBCATCHMENT_ BACKGROUND
SUBCATCHMENT_CODE	CHAR (9)	CHAR (9)	CHAR (9)
SUBCATCHMENT_NAME	STRING (1-255)	STRING (1-255)	STRING (1-255)
SUBCATCHMENT_TYPE	CHAR(1)	CHAR(1)	
RIVER_CATCHMENT_CODE	CHAR(8)	-	CHAR(8)
PARAMETER_ID	-	INTEGER	-
RIVER_MOUTH_LATITUDE	DECIMAL (dd.dddd)	-	-
RIVER_MOUTH_LONGITUDE	DECIMAL (dd.dddd)	-	-
RIVER_TYPE	CHAR(1)	-	CHAR(1)
NATIONAL_SUBCATCHMENT_CODE	STRING (1-255)	-	STRING(1-255)
NATIONAL_RIVER_CODE	STRING (1-255)	-	STRING(1-255)
NR_CATCHMENTS	INTEGER	INTEGER	INTEGER
MONITORING_TYPE	INTEGER	-	INTEGER
PERIOD_NAME	STRING (4-10)	STRING (4-10)	STRING (4-10)
IS_PRIMARY	-	-	BIT 0/1
CREATION_DATE	DATE(10) dd.mm.yyyy	DATE(10) dd.mm.yyyy	DATE(10) dd.mm.yyyy
END_DATE	DATE(10) dd.mm.yyyy	DATE(10) dd.mm.yyyy	DATE(10) dd.mm.yyyy
TOTAL_DRAINAGE_AREA	DECIMAL (8.2)		DECIMAL (8.2)
UNMONITORED_AREA	-	DECIMAL (8.2)	-
COUNTRY_DRAINAGE_AREA	DECIMAL (8.2)	-	DECIMAL (8.2)
TRANSBOUNDARY_AREA	-	-	DECIMAL (8.2)
LAKE_AREA	DECIMAL (8.2)	DECIMAL (8.2)	DECIMAL (8.2)
REMARKS	STRING(1-255)	STRING(1-255)	STRING(1-255)

Table 7. Data type and format of background information for indirect point sources in the periodic reporting template.

ATTRIBUTE/SHEET	INDIR_POINT_SOURCE _BACKGROUND
STATION_CODE	-
SUBCATCHMENT_CODE	CHAR (9)
SUBCATCHMENT_NAME	STRING (1-255)
STATION_NAME	-
PLANT_CODE	STRING (7)
PLANT_NAME	STRING (1-255)
PERIOD_NAME	STRING (4-10)
IS_ACTIVE	-
RIVER_CATCHMENT_CODE	-
NATIONAL_STATION_CODE	-
EU/ NATIONAL_CODE	CHAR(255)
PRTR_SECTOR_CODE *)	CHAR(1)
STATION/PLANT_CODE_LAT	DECIMAL (dd.dddd)
STATION/PLANT_CODE_LON	DECIMAL (dd.dddd)
WFD_CODE	-
REPORTING_START_DATE	DATE(10)
REPORTING_END_DATE	DATE(10)
TOTAL_NR_OF_PLANTS	INTEGER
TOTAL_NR_OF_TREATED_PLAN	INTEGER
MONITORED_AREA	-
REMARKS	STRING(1-255)

*) PRTR_SECTOR_CODEs are listed below in table 13.

ACTUAL PERIODIC DATA REPORTING

Since the data on loads and flows from monitored, unmonitored and transboundary sub-catchments as well as direct point sources is the subject for annual reported this data are no included into periodic reporting template.

INDIRECT POINT SOURCES (point sources discharging into the fresh water)

Point source discharges into the fresh water is a part of periodic reporting. The indirect point source data should preferably be reported individually, but unlike the direct point source data, periodic loads could also be reported as aggregated, if individual reporting wouldn't be possible.

If the loads will be reported as aggregated, the level of aggregation should correspond to sub-catchment and point source category (MWWTP, INDUSTRY and AQUACULTURE). This means that the load of aggregated MWWTPs could be reported as totals by each monitored sub-catchment and unmonitored sub-catchment. The point source data in the transboundary sub-catchments could also be reported either individually or as aggregated. Unlike the annual reporting, the reported parameters of indirect point sources discharges are: Flow, Ntot, Ptot, and voluntarily Cd, Hg and Pb. The collected parameters on indirect point sources (MWWTP, INDUSTRY and AQUACULTURE) have been listed in the table 1.2. Flow will be reported as total flow in m³/a and the other parameters as t/a or kg/a. Heavy metals will be reported only for MWWTPs and INDUSTRIES on a voluntary basis. Reporting of indirect discharges should be carried out in INDIR_MWWTP_FLOW_LOAD, INDIR_INDUSTRY_FLOW_LOAD and INDIR_AQUACULTURE_LOAD.

The data to be reported have been listed below in table 8 and the type and format of each attribute in table 9.

Table 8. An overview of the point source data for periodic reporting.

GENERAL VIEW OF THE PERIODIC DATA REPORTING ON POINT SOURCES						
SOURCE	REPORTING	REFERENCE TABLE	FLOW	LOAD	ADDITIONAL INFORMATION (***)	CALC. ESTIMATION METHODS OF INPUTS
MWWTP DISCHARGES INTO FRESH WATER	INDIVIDUALLY/AGGREGATED(*)	INDIR_MUNICIPAL_FLOW_LOAD	m ³ /a	as listed in Table 1.2	Treatment method and PE (individual reporting)	X
INDUSTRIAL DISCHARGES INTO FRESH WATER	INDIVIDUALLY/AGGREGATED(*)	INDIR_INDUSTRIAL_FLOW_LOAD	m ³ /a	as listed in Table 1.2	(PRTR sector/ individual reporting)	X
AQUACULTURAL DISCHARGES INTO FRESH WATER	INDIVIDUALLY/AGGREGATED(*)	INDIR_AQUACULTURE_LOAD	m ³ /a (**)	as listed in Table 1.2	Voluntarily feed type, amount of feed used and total production	X

(* Preferably to be reported individually, but can be reported as aggregated by subcatchment (monitored, unmonitored or transboundary subcatchment)

(**Flow of an individual aquaculture can be reported on a voluntary basis when it is relevant, i.e. outlet of discharge exists.

(*** Only for individually reported point sources

ADDITIONAL INFORMATION ON POINT SOURCES

In addition to the discharges of MWWTPs, information on LOQ or LOD, number of measurements (NR_MEASUREMENTS), treatment method (TREATMENT_METHOD), number of population equivalent (NR_PE) should be reported for each individual MWWTP, as well as the information on sampling

methodology (e.g., non-systematic, systematic, etc.), uncertainty (in %) and used methods of calculation and/or estimation (METHOD_ID) of loads.

Additional data on individually reported industrial plants include information on Limit of quantification or detection (LOQ or LOD), number of measurements (NR_MEASUREMENTS), treatment methods, (TREATMENT_METHOD), E-PRTR sectors, sampling methodology, total uncertainty (in %) and used methods of calculation and estimation of loads (METHOD_ID).

Wastewater treatment methods are listed in tables 10a and 10b and calculation and estimation methods in table 11 for individual MWWTPs and INDUSTRIAL PLANTS. PRTR sectors for industrial plants have been listed in table 12.

Apart from reporting the loads of aquacultural plants, amount of feed (as t/a), feed type (moist, semi-moist and dry) and production (in t/a) can be reported on a voluntary basis in the AQUACULTURE_PRODUCTION sheet. Total uncertainty (TOT_UNCERTAINTY, in %) of the obtained loads and used methods (METHOD_ID) can also be reported. The methods are listed in table 13.

Table 9. Type and format of attributes of the point source data.

ATTRIBUTE/SHEET	DIR/INDIR_MUNICIPAL_LOAD_FLOW	DIR/INDIR_INDUSTRIAL_LOAD_FLOW	DIR/INDIR_AQUACULTURE_LOAD	AQUACULTURE_PRODUCTION
PLANT_CODE	CHAR (7)	CHAR (7)	CHAR (7)	CHAR (7)
SUBCATCHMENT_CODE	CHAR (9)	CHAR (9)	CHAR (9)	-
SUBCATCHMENT_NAME	STRING (1-255)	STRING (1-255)	STRING (1-255)	-
PARAMETER_ID	INTEGER	INTEGER	INTEGER	
PARAMETER_TYPE	CHAR (3)	CHAR (3)	CHAR (3)	
PERIOD_NAME	STRING (4-10)	STRING (4-10)	STRING (4-10)	STRING (4-10)
PERIOD_TYPE	CHAR (1)	CHAR (1)	CHAR (1)	-
IS_LOQ/LOD	BIT 1/0	BIT 1/0	-	-
LIMIT_VALUE	DECIMAL (8,(6))	DECIMAL (8,(6))	-	-
LIMIT_UNIT	CHAR(4)	CHAR(4)	-	-
NUMBER_BELOW_LIMIT	INTEGER	INTEGER	-	-
NR_MEASUREMENTS	INTEGER	INTEGER	-	-
VALUE	DECIMAL (10(.3))	DECIMAL (10(.3))	DECIMAL (10(.3))	-
VALUE_UNIT	STRING(3-6)	STRING(3-6)	STRING(3-6)	-
TOT_UNCERTAINTY	INTEGER	INTEGER	INTEGER	-
NR_PE	INTEGER	-	-	-
TREATMENT_METHOD	INTEGER	INTEGER	-	-
SAMPLING_METHODODOLOGY	CHAR(1)	CHAR(1)	-	-
DATA_SOURCE_FLAG	CHAR(2)	CHAR(2)	CHAR(2)	-
METHOD_ID	INTEGER	INTEGER	INTEGER	-
FEED_TYPE	-	-	-	CHAR(1)
AMOUNT_OF_FEED	-	-	-	DECIMAL (10(.3))
AQUACULTURE_PRODUCTION	-	-	-	DECIMAL (10(.3))
REMARKS	STRING(1-255)	STRING(1-255)	STRING(1-255)	-

Table 10a and b. Wastewater treatment methods (a) and supplementary methods (b) of individually reported MWWTPs and industrial plants.

TREATMENT	METHOD DESCRIPTION
N	UNKNOWN
U	UNTREATED
P	PRIMARY
S	SECONDARY
T	TERTIARY

SUPPLEMENTARY	METHOD DESCRIPTION
0	NO SUPPLEMENTARY METHOD
1	ADDITIONAL N REMOVAL
2	ADDITIONAL P REMOVAL
3	UV DISINFECTION
4	CHLORINATION
5	SAND FILTRATION
6	MICRO - / ULTRA FILTRATION
7	OTHER METHOD (TO BE SPECIFIED)

Table 11. List of calculation / estimation methods of individually reported MWWTPs and industrial plant discharges.

METHOD_ID	METHOD DESCRIPTION
0	UNKNOWN
11	CONTINUOUS FLOW AND CONCENTRATION MEASUREMENTS
12	CONTINUOUS FLOW AND NON-CONTINUOUS CONCENTRATION
13	NON-CONTINUOUS FLOW AND CONCENTRATION SAMPLING
14	ESTIMATION OF LOAD BASED ON NUMBER OF POPULATION CONNECTED $BOD_7 = 70g O_2/PERSON/DAY$, $N_{tot} = 12g N/PERSON/DAY$, $P_{TOTAL} = 2.7g P_{100}/PERSON/DAY$
15	A COUNTRY SPECIFIC METHOD (SHOULD BE DESCRIBED IN DETAIL)

Table 12. List of E-PRTR sectors of industrial plants.

PRTR	CODE DESCRIPTION
1	ENERGY SECTOR
2	PRODUCTION AND PROCESSING OF METALS
3	MINERAL INDUSTRY
4	CHEMICAL INDUSTRY
5	WASTE AND WASTEWATER MANAGEMENT
6	PAPER AND WOOD PRODUCTION AND PROCESSING
7	INTENSIVE LIVE STOCK PRODUCTION AND AQUACULTURE
8	ANIMAL AND VEGETABLE PRODUCTS FROM THE FOOD AND BEVERAGE SECTOR
9	OTHER ACTIVITIES

Table 13. List of estimation / calculation method of aquaculture discharge.

METHOD_ID	METHOD DESCRIPTION
0	UNKNOWN
36	MONITORING AT THE OUTLETS FROM THESE PLANTS
37	BASED ON PRODUCTION AND FEED CONSUMPTION OF A PLANT
38	BASED ON PRODUCTION OR FEED CONSUMPTION OF A PLANT

DIFFUSE SOURCES INTO THE INLAND SURFACE WATER (Source orientated approach)

Diffuse sources to be reported include natural background and anthropogenic gross loads (losses) of nutrients into the fresh water. Data on diffuse sources should be reported by sub-catchment as defined in 'BACKGROUND INFORMATION' above. The sub-catchments are:

- monitored sub-catchments
- monitored transboundary rivers
- monitored border rivers
- unmonitored sub-catchments

Transboundary and border rivers will be listed in the template of the Contracting Party who has the reporting responsibility of the river.

Diffuse sources of the monitored sub-catchments and monitored rivers should be reported in MONITORED_DIFF_SOURCE sheet, diffuse sources of unmonitored sub-catchments in UNMON_DIFF_SOURCE sheet and the transboundary diffuse sources in the TRANSB_SUBCATCHMENT_DIFF_SOURCE sheet, respectively (Table 14).

Diffuse loads into the fresh water to be reported include the following source categories:

- Natural background source (NBS),
- Agricultural source (AGS),
- Source of managed forestry (MFS),
- Source of atmospheric deposition into the inland surface waters (ATS),
- Source of scattered dwellings (SCS),
- Source of storm water overflow and by-passes (SWS),
- Transboundary sources (TRS),
- Unknown sources (UKS)

In case transboundary losses cannot be divided into above categories then a common category for transboundary sources (TRS) can be used.

Unknown sources (UKS) should be used if none of the above categories can be defined.

Agricultural and managed forestry sources can be divided further into pathways, which are:

- Soil erosion (ER),
- Surface run-off (SR),
- Natural interflow (NI),
- Tile drainage (TD),
- Ground water (BF, formerly = base flow),
- Sum of pathways (SP)

If 'pathways' cannot be defined then 'sum of pathways' (as 'SP'), should be used instead. Diffuse sources into the inland surface waters should be calculated or estimated to each defined sub-catchment. Applied calculation/estimation methods of sources should be reported, as well. Types and formats of attribute in spreadsheet for diffuse losses reporting are listed in table 17.

Table 14. Overview of reporting obligations related to diffuse sources.

GENERAL VIEW OF THE PERIODIC DATA REPORTING ON DIFFUSE SOURCES				
AREA	REPORTING	DIFFUSE SOURCES INTO THE INLAND SURFACE WATER		
		REFERENCE TABLE	ANTHROPOGENIC AND NATURAL SOURCES	
			DIFFUSE SOURCES	DIFFUSE SOURCE PATHWAY
MONITORED SUBCATCHMENT	INDIVIDUALLY	MONITORED_DIFFUSE_SOURCE	Total N and total P t/a by diffuse source category (*)	Total N and total P t/a by pathway (**)
TRANDBOUNDARY/BORDER RIVERS	INDIVIDUALLY	TRANSB_SUBCATCHMENT_DIFFUSE_SOURCE	Total N and total P t/a by diffuse source category (*)	Total N and total P t/a by pathway (**)
UNMONITORED AREAS	AGGREGATED by country and subbasin	UNMONITORED_DIFFUSE_SOURCE	Total N and total P t/a by diffuse source category (*)	Total N and total P t/a by pathway (**)

(* Diffuse source categories are: natural background, agriculture, managed forestry, atmospheric deposition into the inland surface water, scattered dwellings, storm water overflow and by-passes and if the listed sources aren't available, then transboundary sources and unknown sources to be used.

(** Agricultural and manage forestry pathways are: Soil erosion (ER), surface run-off (SR), natural interflow (NI), tile drainage (TD), ground water (formerly base flow, BF). If all pathways cannot be reported separately then for the 'sum of pathways' (SP) should be used.

RETENTION (retained nutrients in the inland surface waters)

Retention, total amount of retained nutrients in inland surface water, should be reported by sub-catchment as defined in '**BACKGROUND INFORMATION**' above. The sub-catchments are:

- Monitored sub-catchments;
- Monitored transboundary rivers,
- Monitored border rivers;
- Unmonitored sub-catchments

Sources, reporting reference tables and reported parameters are given in table 15 and the type and the format of the reported attributes in table 17.

Table 15. Overview of reporting obligations related to retention.

GENERAL VIEW OF THE PERIODIC DATA REPORTING ON RETENTION			
SOURCE	REPORTING	RETENTION IN THE INLAND SURFACE WATER	
		REFERENCE TABLE	RETENTION
MONITORED SUBCATCHMENT	INDIVIDUALLY	MON_SUBCATCHMENT_RETENTION	Retention of N and P t/a
TRANDBOUNDARY/BORDER RIVERS	INDIVIDUALLY	TRANSB_SUBCATCHMENT_RETENTION	Retention of N and P t/a
UNMONITORED AREAS	AGGREGATED by country and sub-basin	UNMONITORED_RETENTION	Retention of N and P t/a

Retention of nutrients should be reported for the same sub-catchments as the total loads. Also negative or 'zero' retention values should be reported. The losses of upper parts of the transboundary rivers (at border) should be taken into account and the Contracting Parties sharing the river should agree on retention values between the countries.

In addition, methods estimating retention should be reported. It has been agreed on that the Contracting parties can use their own specific methods, but they should be described in detail.

LOAD ORIENTATED APPROACH (loads by source to the Baltic Sea)

Loads by source to the Baltic Sea should be reported by sub-catchment as specified in '**BACKGROUND INFORMATION**'.

The sub-catchments are:

- Monitored sub-catchments;
- Monitored transboundary rivers;
- Unmonitored sub-catchments

Transboundary and border rivers will be listed in the template of the Contracting Party who has the reporting responsibility of the river.

The load by source should be reported to the same defined sub-catchments as the loads of monitored, transboundary and border rivers and sub-catchments as well as the loads of unmonitored sub-catchments. If the loads by source cannot be reported for the same sub-catchments as the annual total loads, periodic data verification and comparison of total annual loads and periodic loads will not be possible, i.e., total annual discharges by sub-catchment = sum of loads by source by sub-catchment.

Source categories to be reported are:

DL = Diffuse load (including natural background load) **(A reference below)**

PL= Point source load **(B reference below)**

TL = Transboundary load **(C reference below)**

UL = Unknown load **(D reference below)**

If discharges cannot be divided into origins of loads (as below in A: Diffuse loads and B: Point source loads), then a sum of all sources should be reported (Diffuse loads, DIL and Point source loads, PIL). If none of the three sources cannot be defined then only unknown load (UL) should be used.

A: DIFFUSE LOADS

AGL = Load of agriculture

ATL = Atmospheric deposition

DIL = Diffuse load can be used as a sum of the sources if sources cannot be defined

DUL = Unknown load (total river load to the sea if not reported)

MFL = Load of managed forestry and other managed land load

NBL = Natural background load

SCL = Load of scattered dwellings

SWL = storm water and overflows

B: POINT SOURCE LOADS

MWL = Municipal

INL = Industry

AQL = Aquaculture

OTL = Other point source load (none of the three categories)

PIL = Point source loads from more than one category

PUS = Point source unknown load

C: TRANSBOUNDARY LOAD

-to be left empty

D: UNKNOWN LOAD

-to be left empty

Table 16. Overview of reporting obligations related to load orientated approach.

AREA	REPORTING	LOAD ORIENTATED APPROACH		
		DIFFUSE LOAD	POINT SOURCE LOAD**)	TRANSBOUNDARY LOAD***)
RIVER/MONITORED CATCHMENT	INDIVIDUALLY	Ntot and Ptot in t/a by source*)	Total N and total P t/a by point source load category **)	Total N and total P t/a by source
TRANDBOUNDARY/BORDER RIVERS	INDIVIDUALLY	Ntot and Ptot in t/a by source*)	Total N and total P t/a by point source load category **)	Total N and total P t/a by source
UNMONITORED AREAS	BY SUBBASIN and COUNTRY	Ntot and Ptot in t/a by source*)	Total N and total P t/a by point source load category **)	

(*Diffuse loads to be reported separately for agriculture, managed forestry, atmospheric deposition into the fresh water, scattered dwellings, storm water overflows and by-passes and transboundary load

**Point source load categories are: MWWTP, industry, fish farms

*** For transboundary loads both DIFFUSE LOAD and POINT SOURCE LOAD sources should be used, but if not possible then total estimate of transboundary load should be used reported for transboundary/ border river loads

In order to ensure a complete coverage of the data collection same areas should be used in reporting the point source loads in the catchments, diffuse losses by source into the fresh water, retention and loads by source finally entering to the Baltic Sea.

Table 17. Type and format by attribute and spreadsheet of diffuse losses, retention and loads by source.

ATTRIBUTE/SHEET	MON/UNMON/TRANS_ DIFFUSE_SOURCE	MON/UNMON/TRANS_ RETENTION	MON/UNMON/TRANS_LOAD ORIENTATED
SUBCATCHMENT_CODE	CHAR (9)	CHAR (9)	CHAR (9)
SUBCATCHMENT_NAME	STRING (1-255)	STRING (1-255)	STRING (1-255)
PARAMETER_ID	INTEGER	INTEGER	INTEGER
PARAMETER_TYPE	CHAR (3)	CHAR (3)	CHAR (3)
PERIOD_NAME	STRING (4-10)	STRING(4-10)	STRING (4-10)
PERIOD_TYPE	CHAR (1)	-	CHAR (1)
START_TIME	-	DATE(10)	-
END_TIME	-	DATE(10)	-
DIFFUSE_TYPE	CHAR (3)	-	-
PATHWAY_TYPE	CHAR (2)	-	-
SOURCE_CATEGORY	-	-	CHAR (2)
SOURCE_NAME	-	-	CHAR (3)
VALUE	DECIMAL (10(.3))	DECIMAL (10(.3))	DECIMAL (10(.3))
VALUE_UNIT	STRING(3-6)	STRING(3-6)	STRING(3-6)
TOT_UNCERTAINTY	INTEGER	INTEGER	INTEGER
DATA_SOURCE_FLAG	CHAR(2)	CHAR(2)	CHAR(2)
METHOD_ID	INTEGER	INTEGER	INTEGER
REMARKS	STRING(1-255)	STRING(1-255)	STRING(1-255)

Annex 4 - Reporting and quality assurance using PLC WEB-application

Annual and periodic data should be reported using the PLUS web application which can be found at http://nest.su.se/helcom_plus. The application provides set of tools to report and manage the data in the HELCOM PLC-Water database. Generally, reporting of the data consists of four steps:

1. Fill in data into a template, obtained from the PLUS system;
2. Upload the template with the data to the PLUS archive in Excel format;
3. Run Quality assurance checks and then insert the data into the database;
4. Check and approve the data in the database.

Annual and periodic templates with prefilled background information are prepared by the HELCOM secretariat (**data manager**) for each country and they can be downloaded from the system (**Figure 1 and Figure 2**). Contracting Parties are invited to verify prefilled background information and update it if necessary. In the latter case the modified template should be uploaded to the system in order to make related updates of the database.

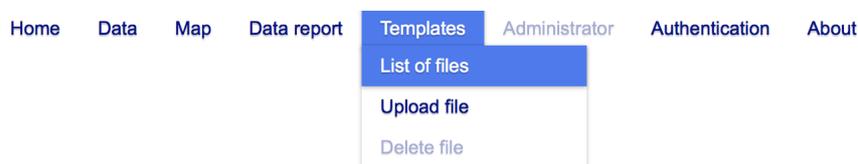


Figure 1. Show list of templates and documents.

Document id	Notes	File name	Date of upload	First name	Surname
48		FI_ANNUAL_REPORTING_2016_04122017.xlsx	2017-12-04 15:42:32.997	Antti	Raike
47		RU_ANNUAL_REPORTING_2016_updated.xlsx	2017-11-10 07:55:14.987	Natalia	Ivaskova
46		DK_ANNUAL_REPORTING_2016_updated.xlsx	2017-11-08 06:53:41.95	Henrik	Tornbjerg
45		LT_ANNUAL_REPORTING_2016_updated.xlsx	2017-10-20 11:54:17.1	Svajunas	Plunge
44		SE_ANNUAL_REPORTING_2016.xlsx	2017-10-11 06:16:56.437	Dmitry	Frank-Kamenetsky
43		RU_ANNUAL_REPORTING_2016.xlsx	2017-10-11 06:16:50.337	Dmitry	Frank-Kamenetsky

Figure 2. List of prepared and updated templates.

Templates (MS Excel files in .xlsx format) filled with the actual data should be uploaded to the database (**Figure 3**).

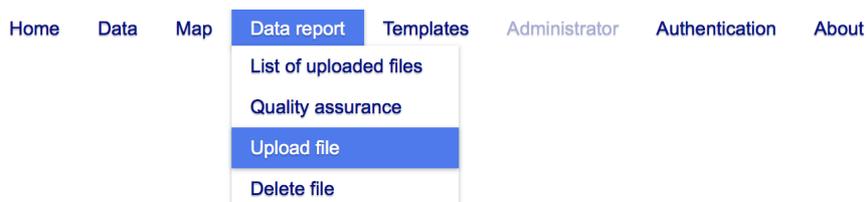


Figure 3: Dialog menu for uploading data.

Uploaded data reports are stored in the database in original form as archived copy and to make data available in the database additional steps have to be made. Firstly, one need to check that uploaded file is in the database archive (**Figure 4**).

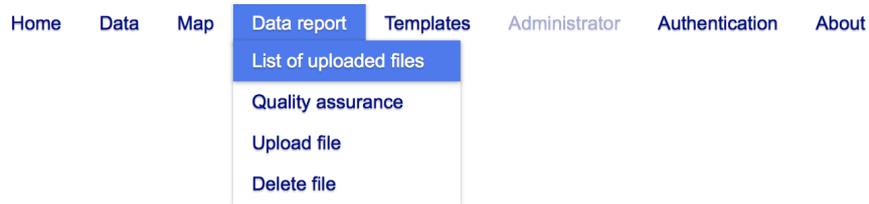


Figure 4: Show list of uploaded files (data in Excel format).

In the example presented in **Figure 5**, the file with ID=1866 has been uploaded to the system. Note, empty cells **Date of QA** and **QA log** indicate that this report has not been processed and the data are not available from the database.

ID	Name	Surname	e-mail	Date of report	File name	Date of QA	QA log	Notes
1866	Lars	Sonesten	[REDACTED]	2017-10-18 08:27	SE_ANNUAL_REPORTING_2016_REV2			
1865	Lars	Sonesten	[REDACTED]	2017-10-16 15:17	SE_ANNUAL_REPORTING_2016v2.xlsx	2017-10-16 15:17	Show log	
1864	Lars	Sonesten	[REDACTED]	2017-10-16 15:07	SE_ANNUAL_REPORTING_2016.xlsx	2017-10-16 15:08	Show log	

Figure 5: Example of list of uploaded data

To check the data a quality an assurance procedure should be performed. To do so the corresponding line should be selected in the table (**Figure 6**) to indicate the report to be processed.

ID	Name	Surname	e-mail	Date of report	File name	Date of QA	QA log	Notes
1866	Lars	Sonesten	[REDACTED]	2017-10-18 08:27	SE_ANNUAL_REPORTING_2016_REV2			
1865	Lars	Sonesten	[REDACTED]	2017-10-16 15:17	SE_ANNUAL_REPORTING_2016v2.xlsx	2017-10-16 15:17	Show log	
1864	Lars	Sonesten	[REDACTED]	2017-10-16 15:07	SE_ANNUAL_REPORTING_2016.xlsx	2017-10-16 15:08	Show log	

Figure 6: Select uploaded data before run quality assurance procedures.

Quality assurance menu (**Figure 7**) provides several tools to work with the selected data report. Here we are interested in the first one - **Check data**. It performs QA level 1 and QA level 2 checks and writes diagnostics to the log file. Nothing is inserted into the database by this procedure. This is a first step just to check quality of the data.

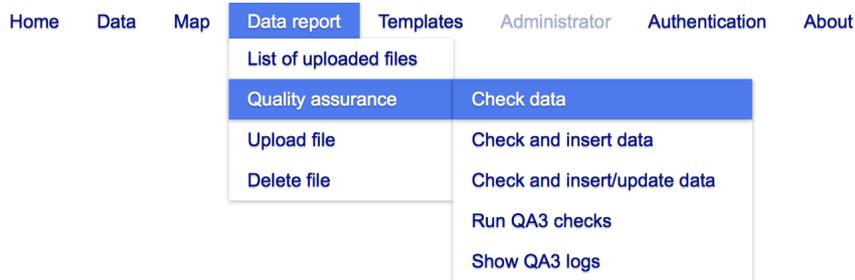


Figure 7: Check the data by running quality assurance procedure.

After performing the **Check data** procedure one can click the link **Show log** (Figure 8)

ID	Name	Surname	e-mail	Date of report	File name	Date of QA	QA log	Notes
1866	Lars	Sonesten	[REDACTED]	2017-10-18 08:27	SE_ANNUAL_REPORTING_2016_REV2	2017-10-26 10:14	Show log	
1865	Lars	Sonesten	[REDACTED]	2017-10-16 15:17	SE_ANNUAL_REPORTING_2016v2.xlsx	2017-10-16 15:17	Show log	
1864	Lars	Sonesten	[REDACTED]	2017-10-16 15:07	SE_ANNUAL_REPORTING_2016.xlsx	2017-10-16 15:08	Show log	

Figure 8: Date of QA and link to the log is added to the checked reported data and analyse the results of QA Check data procedure (Figure 9).

QA level 1: verification of the format and conformity of the data with the database structure

Number of errors: 9

ERROR - 'AQUACULTURE_PRODUCTION'!A2 Cell PLANT_CODE cannot be null or blank
 ERROR - 'TRANSBOUNDARY_FLOW_LOAD'!A2 Cell SUBCATCHMENT_CODE cannot be null or blank
 ERROR - 'TRANSBOUNDARY_FLOW_LOAD'!C2 Cell PARAMETER_ID cannot be null or blank
 ERROR - 'TRANSBOUNDARY_FLOW_LOAD'!D2 Cell PARAMETER_TYPE cannot be null or blank
 ERROR - 'TRANSBOUNDARY_FLOW_LOAD'!L2 Cell VALUE_UNIT cannot be null or blank
 ERROR - 'TRANSB_SUBCATCHMENT_RETENTION'!A2 Cell SUBCATCHMENT_CODE cannot be null or blank
 ERROR - 'TRANSB_SUBCATCHMENT_RETENTION'!C2 Cell PARAMETER_ID cannot be null or blank
 ERROR - 'TRANSB_SUBCATCHMENT_RETENTION'!D2 Cell PARAMETER_TYPE cannot be null or blank
 ERROR - 'TRANSB_SUBCATCHMENT_RETENTION'!G2 Cell VALUE_UNIT cannot be null or blank

Number of warnings: 0

Number of notifications: 0

Number of missing required values: 7730

Total number of processed rows : 2164

Number of rows passed QA level 1 : 2161

Commented Excel file SE_ANNUAL_REPORTING_2016v2_20171016151759.xlsx is available.

QA level 2: verification of the content for questionable data values

Number of distrust values: 8

Number of suspicious values: 59

Number of unchecked values: 606

Figure 9: Log of the Quality assurance - Check data task.

There are nine errors in this example, which should be corrected in the original data report, then corrected report should be reuploaded to the system and checked again. When all errors and warnings are corrected the data can be inserted into the PLC-Water database. It can be done by selecting **Quality assurance > Check and insert data** (Figure 10)

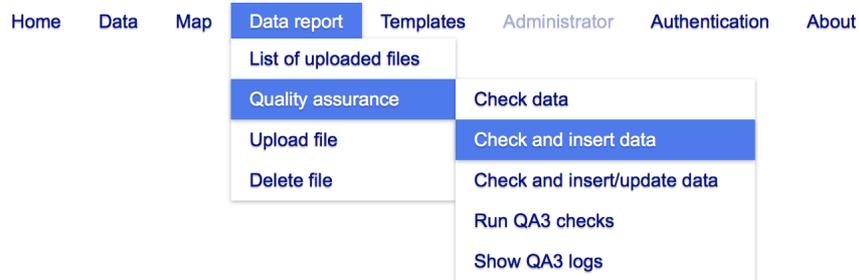


Figure 10: Command to insert data into the database.

In this step the data will be checked in the same way as it was done before and data from the rows without errors are inserted into the database. Example of the log file is presented in Figure 11. One should pay attention on the line “Number of rejected rows”. It should be equal to zero. Otherwise the errors should be located and whole procedure (correct data in the template, upload it, check data, check and insert data) should be repeated.

QA level 1: verification of the format and conformity of the data with the database structure

Number of errors: 0

Number of warnings: 0

Number of notifications: 0

Number of missing required values: 7721

Total number of processed rows : 2161

Number of rows passed QA level 1 : 2161

Number of rejected rows: 0

Commented Excel file SE_ANNUAL_REPORTING_2016_REV20171018_20171026101407.xlsx is available.

QA level 2: verification of the content for questionable data values

Number of distrust values: 8

Number of suspicious values: 60

Number of unchecked values: 606

Figure 11: Log after insertion of the data into the database.

Now the data are in the database and they can be checked using “Data > Request data for year” (Figure 12)



Figure 12: Command to request data from the database.

Here one can select appropriate set of parameters and click **Get data** button (Figure 13).

Source:	Period:	Parameters:	Value	Quality Flag	Value	Quality Flag
SUBCATCHMENT	PLC-3	NNO3	3.14	No quality assurance	3.14	Corrected by data reporter
STATIONS	2016	NTOT	3.1415	Questionable data	3.1415	Rejected by data reporter
AQUACULTURE	2015	Oil	3.1415926536	Accepted data	3.1415926536	Approved by data reporter
DIRECT AQUACULTURE	2014	Pb	3.1415926 m3/s	"Unexpected" unit		
INDIRECT AQUACULTURE	2013	PPO4				

Source code	Source name	Country code	Subbasin code	Period	Cd [t/a]	COD-Mn [t/a]	Cr [t/a]	Cu [t/a]	Hg [t/a]
SCSE00001	ALSTERÅN	SE	BAP	2016	3.4800e-03	2610.0000	0.0521	0.2990	5.3400e-04
SCSE00005	BOTORPSSSTRÖMMEN	SE	BAP	2016	4.2400e-04	883.0000	9.7400e-03	0.0967	7.9100e-05
SCSE00013	EMÅN	SE	BAP	2016	0.0195	6465.0000	0.1300	0.6000	1.2400e-03
SCSE00031	HELGE Å	SE	BAP	2016	0.0272	21655.0000	0.3610	1.3100	4.6900e-03
SCSE00041	LJUNGBYÅN	SE	BAP	2016	5.2300e-03	2504.0000	0.0526	0.1650	6.3100e-04
SCSE00047	LYCKEBYÅN	SE	BAP	2016	3.5400e-03	2650.0000	0.0382	0.1910	5.8000e-04
SCSE00051	MOTALA STRÖM	SE	BAP	2016	0.0104	12027.0000	0.2290	3.3000	2.4900e-03
SCSE00053	MÖRRUMSÅN	SE	BAP	2016	5.6800e-03	7132.0000	0.0979	0.5920	1.1900e-03

Figure 13: Example of the data. Background colour of the cells represents a quality flag. Background colour represents data quality flags which were assigned to the data during quality check (QA level 2: statistical testing of the data with the existing data) of the data. The QA level 2 procedure can assign following flags to the data:

- No quality assurance – there are not enough data for statistical tests;
- Questionable data – data lie outside of a 95% confidence interval;
- Accepted data – data lie inside the confidence interval;
- “Unexpected” unit – data are reported in a unit which is not the same as a majority of the data.

The contracting parties should manually approve the data without quality assurance (grey colored cells) and the questionable data (light brown colored cells). It can be done by selecting the cell and right mouse click will show pop-up dialog to manage the data (**Figure 14**).

Source code	Source name	Country code	Subbasin code	Period	Cd [t/a]	COD-Mn [t/a]	Cr [t/a]	Cu [t/a]	Hg [t/a]
SCSE00001	ALSTERÅN	SE	BAP	2016	3.4800e-03	2610.0000	0.0521	0.2990	5.3400e-04
SCSE00005	BOTORPSSSTRÖMMEN	SE	BAP	2016	4.2400e-04	883.0000	9.7400e-03	0.0967	7.9100e-05
SCSE00013	EMÅN	SE	BAP	2016	0.0195	6465.0000	0.1300	0.6000	1.2400e-03
SCSE00031	HELGE Å								
SCSE00041	LJUNGBYÅN								
SCSE00047	LYCKEBYÅN								
SCSE00051	MOTALA STRÖM								
SCSE00053	MÖRRUMSÅN								
SCSE00057	NORRSTRÖM, MÅLARENS UTLOPP								
SCSE00059	NYKÖPINGSÅN								
SCSE00309	BAPSELAND	SE	BAP	2016	0.0852	46630.0000	0.9965	8.4463	9.4859e-03

Value: QA flag:
 Approved by data reporter
 Corrected by data reporter
 Rejected by data reporter
 No Quality Assurance

Remarks:

Figure 14: Quality assurance level 3: manual approval of the data.

Data, passed the statistical tests and automatically accepted (light green colored cells) considered to be of a good quality and shouldn't be manually approved. As a result of the approval procedure (see for example **Figure 15**), the data should be marked as:

- Accepted; Approved by data reporter; Approved by quality assurer/data manager
- Corrected by data reporter; Corrected by quality assurer/data manager
- Rejected by data reporter; Rejected by quality assurer/data manager

Source code	Source name	Country code	Subbasin code	Period	Cd [t/a]	COD-Mn [t/a]	Cr [t/a]	Cu [t/a]	Hg [t/a]
SCSE00001	ALSTERÅN	SE	BAP	2016	3.4800e-03	2610.0000	0.0521	0.2990	5.3400e-04
SCSE00005	BOTORPSSTRÖMMEN	SE	BAP	2016	4.2400e-04	883.0000	9.7400e-03	0.0967	7.9100e-05
SCSE00013	EMÅN	SE	BAP	2016	0.0195	6465.0000	0.1300	0.6000	1.2400e-03
SCSE00031	HELGE Å	SE	BAP	2016	0.0272	21655.0000	0.3610	1.3100	4.6900e-03
SCSE00041	LJUNGBYÅN	SE	BAP	2016	5.2300e-03	2504.0000	0.0526	0.1650	6.3100e-04
SCSE00047	LYCKEBYÅN	SE	BAP	2016	3.5400e-03	2650.0000	0.0382	0.1910	5.8000e-04
SCSE00051	MOTALA STRÖM	SE	BAP	2016	0.0104	12027.0000	0.2290	3.3000	2.4900e-03

Figure 15: Example of quality assured data.

Annex 5. Example of instructions to personnel carrying out the sampling

Note: Collection of water samples in rivers can potentially be dangerous and CPs should therefore ensure that safety instructions are given. Some countries have legislative requirements for the safety of personnel.

Suggested instructions to personnel carrying out the sampling:

- a. Make sure that you collect the sample from a location where the water is well mixed (e.g. downstream a weir, waterfall, or in turbulent rapids). Avoid locations just downstream of a road, drainage pipe, tributary or other potential pollutant sources. Also ensure that the location is upstream of saltwater intrusion.
- b. Make sure that all bottles are properly labelled with the required information (e.g., sample number, date, time, and site).
- c. Bottles should preferably be filled directly from the river water. If this is not possible, and a sampling container must be used, make sure to avoid cross-contamination between sites. In some cases, one set of sampling equipment per site should be used to avoid contamination. In some cases, bottles may already be filled with solutions (e.g., for preservation), and it is necessary to use a sampling vessel.
- d. If a sampling container is used, ensure that at no time any metal containing objects are stored in the container. Also, if a metal “messenger weight” is used to close the sampler, ensure that the weight is completely encapsulated with plastics or other inert material to avoid contamination (often the weight contains metals like Pb and/or Cu and Zn).
- e. Wade into the river if possible, but make sure the sample will not be contaminated by disturbed (resuspended) bank or bed material.
- f. If the sample is collected from the bank side, an extension pole or a rope can be useful. Again, it is best if the bottle is filled directly from the river water, if this is not possible, see point c) above.
- g. If sampling is done from a boat, a bridge or similar constructions, care should be taken to avoid contamination of the sample from the boat or the construction, or with disturbed river sediments.
- h. If samples need to be taken under ice, the sampling point may have to be moved (this should be mentioned in the sampling report). Clear loose ice and snow from around the sampling point, and drill through the ice. Ensure that the area around the hole remains clean and free of potential contamination. Remove ice and slush from the hole and wait to let the water run freely before taking the sample. Take the sample from well below the lower layer of ice. Be cautious if there is water on the ice that will flow into the hole, as this might contaminate the sample.
- i. When taking the sample, face upstream towards the flow of the water and take the sample upstream from yourself. Remove the cap, and plunge the neck of the open bottle under the surface of the water, about 25 cm deep, with the bottle neck facing upstream. Ensure that the bottle does not touch the bottom in shallow streams.
- j. All bottles should be filled to the top, except glass bottles (since, at temperatures below zero, the glass may break if the water freezes).
- k. If there is reason to believe that the concentration of sampled substances can change markedly within a short time period, pooled sampling strategy is recommended. This involves that several sub-samples are taken and combined into one sample. Otherwise,

discrete grab samples can be collected. Ensure that a clean vessel is used for the pooling of the sample.

- l. Do not smoke while sampling, as this can contaminate the water samples. If the sampling personnel is smokers or using chewing tobacco, plastic gloves should be used.
- m. Do not touch the neck of the bottle or inside of the stopper/cork, as this may contaminate the sample.
- n. Transfer the bottles to a dark, cool place (e.g., use a cooler) as soon as possible before transport to the laboratory.
- o. Samples should be sent to the laboratory as soon as possible and preferably be received at the laboratory no later than 24 hours after sampling.
- p. Keep a sampling record where dates and time of each sample is recorded, as well as any additional information (weather conditions, sampling under ice, any anomalies, etc.).

Annex 6 Examples on reporting industrial point sources with references to IE Directive and PRTR Regulation

All industrial point sources registered in the E-PRTR and discharging to inland surface water or to the Baltic Sea are to be considered in annual and/or periodic PLC reports, but for the completeness and for the PLC assessments, any other plant with industrial effluents entering Baltic Sea and national catchment areas should be included in PLC reporting.

The E-PRTR also holds data from waste water treatment plants regardless of location or ownership (no distinction between “municipal” or “industrial”). But under sector 5 (especially 5f) there is distinction, as MMWTP’s > 100,000 PE need to report discharges into waterbodies if the pollutant threshold are exceeded. The E-PRTR does not distinguish between monitored and unmonitored areas but river basin districts acc. to European Water Framework Directive.¹⁴ This requires correlating river basin districts to HELCOM Baltic basins and national sub-catchments in order to separate direct from indirect discharges.

PLC pollutants/substances are almost subsets of E-PRTR pollutant (se Annex II of PRTR Regulation) and see **Table 2: Parameters and E-PRTR thresholds**. E-PRTR does not include flow data, BOD, COD and N and P compounds.

Industrial point sources fall in one of the nine industrial sectors specified for in the E-PRTR as follows:

1. Energy
 2. Production and processing of metals
 3. Mineral industry
 4. Chemical industry
 5. Waste and waste water management
 6. Paper and wood production and processing
 7. Intensive livestock production and aquaculture
 8. Animal and vegetable products from the food and beverage sector
 9. Other activities
- } 6,7 and 8 make up IED category 6 (other activities)

Industrial point sources are identified by activities (see Annex I of IED and E-PRTR Regulation), which were allocated to each sector. Activities, especially within sectors 5, 6, 7 and 8, generate a vast amount of releases to water bodies. These sources should, at any rate, be included in PLC reporting. Countries can extract data registered in the E-PRTR from <http://prtr.ec.europa.eu> and insert them in the PLC templates, but need to take into account that flow, N and P compounds are not reported to E-PRTR and PRTR facilities only need to report if the threshold values are exceeded. For the PLC assessment it is necessary to report all industrial effluents entering Baltic Sea and in the catchment area to the Baltic Sea, and some of these effluents are not included in the PRTR reporting.

¹⁴ Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy

1) Reporting (example on reporting to PRTR)

a) Examples of discharges of industrial effluents to sub-catchments (direct or indirect)

Releases to water [kg/a] year 2012							
Country	Point source / facility / plant	PRTR				PLC	
		Catchment	national ID	PRTR SECTOR CODE	Release to water in kg	ID	year
DK	SUN CHEMICAL A/S	Zealand	5842	4	79 Cu		
	CHEMINOVA A/S	Jutland and Funen	954	4	116 As, 22 Ni		
DE	PCK Raffinerie GmbH Schwedt	River Oder	12-20730670000	1+4+5	66 Cr, 127 Cu, 106 Ni, 84.000 Ntot	IDE0008	2006 and 2012
	VEO GmbH Eisenhüttenstadt	River Oder	12-30670510000	1+5	61 Pb, 922 Zn, 132 Cyanides	IDE0003	2012
EE	Eesti Energia Narva Elektriijaamad AS, Balti elektriijaam	East Estonia	EE051174	1+5	24 As, 13 Cd, 166 Cr, 167 Cu, 270 Pb		
FI	Kotkamills Oy	Kymijoki-Gulf of Finland	1406	6	374 As, 25 Cd, 125 Cu, 5 Hg, 120 Ni,		
	Sachtleben Pigments Oy	Kokemenjoki-Archipelago Sea-Bothnian Sea	2161	4	314 Cr, 1.210 Ni, 507 Zn		
LT	Akcinė bendrovė "LIFOSA"	River Nemunas	.000000005	4	447 Zn	yes	
	Akcinė bendrovė "Achema"	River Nemunas	.000000002	4	70 Cu, 190 Zn, 75.000 Ntot		
PL	Grupa LOTOS S.A.	Vistula	11G000136	1	11 As, 86 Ni, 252 Zn		
	Zakłady Chemiczne "POLICE" S.A. - ODRA	River Oder	16Z000445	1+4+5	53 As, 49 Hg, 2.320 Ni, 2.210 Zn		
SE	SCA Östrands massafabrik - Bothnian sea	Bothnian sea	2262-101	6	12 As, 39 Cd, 115 Cr, 547 Cu, 118 Ni, 37 Pb, 3540 Zn		
	St1 Refinery AB - Skagerrak and Kattegat	Skagerrak and	1480 - 1182	1	35 As, 29 Pb		

PLC details

PLC examples from Germany						
IDE0008	2	30,357076	tn/a	IDE0003	2	20,25135008 tn/a
IDE0008	4	Cd 0,001004	tn/a	IDE0003	4	0,001058684 tn/a
IDE0008	7	Cr 0,062267	tn/a	IDE0003	7	0,004475348 tn/a
IDE0008	8	Cu 0,094037	tn/a	IDE0003	8	0,079509608 tn/a
IDE0008	9	7.005.479	m ³ /a	IDE0003	9	2406101 m ³ /a
IDE0008	10		tn/a	IDE0003	10	tn/a
IDE0008	11	Ni 0,086950	tn/a	IDE0003	11	0,020223279 tn/a
IDE0008	12	68,455206	tn/a	IDE0003	12	42,47971316 tn/a
IDE0008	13	0,420329	tn/a	IDE0003	13	3,143971973 tn/a
IDE0008	15	14,361232	tn/a	IDE0003	15	2,634680595 tn/a
IDE0008	16	97,726432	tn/a	IDE0003	16	62,84735812 tn/a
IDE0008	18	Pb 0,005709	tn/a	IDE0003	18	0,089883913 tn/a
IDE0008	20	0,443680	tn/a	IDE0003	20	0,376955823 tn/a
IDE0008	23		tn/a	IDE0003	23	0,845664298 tn/a

PLC example from Lithuania			
Achema Lifosa			
3		17,520000	4,980000 tn/a
4	Cd		tn/a
7	Cr	0,010000	tn/a
8	Cu	0,070000	tn/a
9		4.112.000	1.687.000 m ³ /a
10			tn/a
11	Ni	0,010000	tn/a
12		7,150000	0,780000 tn/a
13		1,280000	0,220000 tn/a
15		65,290000	10,280000 tn/a
16		75,350000	14,080000 tn/a
18	Pb	0,020000	tn/a
20		2,570000	2,930000 tn/a
23		0,190000	0,450000 tn/a

2) Reporting for PLC assessments

Permitting authorities regularly receive monitoring data from, or can request the operator of any plant or installation, to supply data. They are regularly asked to submit data (concentration values, load and flow data) to the authorities that can provide national PLC data manager with data on industrial effluents.

For PLC assessment all industrial discharges should be reported, i.e. PLC reporting includes what have been reported to PRTR plus other industrial point sources discharging to inland surface water or directly to the Baltic Sea not registered in/reported to PRTRs.

Table 1 contains examples of data from the national permitting authority, which were included in the 2012 periodical report. The amount of releases indicates a rather small production volume/output of the plant where the E-PRTR threshold (see Table 2) was not exceeded. Therefore, this plant was not registered in the national PRTR.

Table 1.

Example of direct discharge: Sugar factory in Anklam/Germany, Plant code: IDE0015, subcatchment: BAPDESEA=SCDE00075

PARAMETER ID	PARAMETER STATUS	VALUE	VALUE UNIT
2	TOT	1,1994	tn/a
4	TOT	0,000008	tn/a
7	TOT	0,00268	tn/a
8	TOT	0,005689	tn/a
9	TOT	792881	m ³ /a
10	TOT	0,000004	tn/a
11	TOT	0,006738	tn/a
12	TOT	0,4549	tn/a
13	TOT	0,2004	tn/a
15	TOT	8,7979	tn/a
16	TOT	12,2101	tn/a
18	TOT	0,000102	tn/a
20	TOT	0,1799	tn/a
23	TOT	0,005797	tn/a

Example Indirect Discharges: VEO GmbH, Eisenhüttenstadt/Germany, Plant code: IDE0003, subcatchment: ODER=SCDE00035

PARAMETER ID	VALUE	VALUE UNIT
2	20,251350	tn/a
4	0,001059	tn/a
7	0,004475	tn/a
8	0,079510	tn/a
9	2.406.101	m ³ /a
10	n.a.	tn/a
11	0,020223	tn/a
12	42,479713	tn/a
13	3,143972	tn/a
15	2,634681	tn/a
16	62,847358	tn/a
18	0,089884	tn/a
20	0,376956	tn/a
23	0,845664	tn/a

Table 2: Parameter and threshold (load to water) for PRTR reporting.

PLC	E-PTPR		
		Threshold for releases to water [kg a ⁻¹]	
Parameter ID	Substance	100%	50%
16	Total nitrogen	50.000	25.000
20	Total phosphorus	5.000	2.500
	Arsenic and compounds (as As)	5	2,5
4	Cadmium and compounds (as Cd)	5	2,5
7	Chromium and compounds (as Cr)	50	25
8	Copper and compounds (as Cu)	50	25
10	Mercury and compounds (as Hg)	1	0,5
11	Nickel and compounds (as Ni)	20	10
18	Lead and compounds (as Pb)	20	10
23	Zinc and compounds (as Zn)	100	50

3) Concluding remark

The focus on thresholds gives a hint to production capacity and size of the plant, which are of less importance for individual reporting (and quantifying) total inputs from industry and therefore may be reported as aggregated by sub-basin. Non-EU countries applying other rules are invited to strive for good correlation to these criteria and to measurements and analytical methods complying with international standards.

Checking the E-PRTR for industrial point sources is useful. Care must be taken as differences and potential inconsistencies exist between data reported under different reporting obligations. While only direct point sources are to be included in annual reporting, all industrial point sources in the catchment (individually or aggregated) have to be included in periodical compilations.

Annex 7 EMEP assessment of atmospheric nitrogen and heavy metal deposition on the Baltic Sea

EMEP has provided Annex 7.

EMEP prepares annual assessments for HELCOM of emissions and depositions of nitrogen, heavy metals and PCDD/Fs to the Baltic Sea. These are based on modelling and monitoring data which are annually presented to the Steering Body of EMEP in Geneva.

Assessing atmospheric nitrogen deposition on the Baltic Sea

The atmospheric depositions of oxidized and reduced nitrogen were calculated with the latest version of EMEP/MSC-W model in Oslo. The latest available official emission data for the HELCOM countries have been used in the model computations. Emissions of the two nitrogen species for each year of the period 1995-2010 were officially reported to the UN ECE Secretariat by several HELCOM Contracting Parties. Missing information was estimated by experts. Both official data and expert estimates were used for modelling atmospheric transport and deposition of nitrogen compounds to the Baltic Sea - <http://www.ceip.at/>.

Atmospheric depositions of oxidized and reduced nitrogen were computed for the entire EMEP domain, which includes Baltic Sea basin and catchment. Time series of annual atmospheric depositions are available for the period 1995 – 2010.

Atmospheric input and source allocation budgets of nitrogen (oxidized, reduced and total) to the Baltic Sea basins and catchments are computed using the latest version of EMEP/MSC-W model. EMEP/MSC-W model is a multipollutant, three-dimensional Eulerian model which takes into account processes of emission, advection, turbulent diffusion, chemical transformations, wet and dry depositions and inflow of pollutants into the model domain. Complete description of the model and its applications is available on the web <http://www.emep.int>. The results of the EMEP Unified model are routinely compared with available measurements at EMEP and HELCOM stations and the comparison of calculated versus measured data indicates that the model predicts the observed air concentrations of lead and cadmium within the accuracy of approximately 30%.

Calculations of atmospheric transport and depositions of nitrogen compounds are performed annually two years in arrears on the basis of emission data officially submitted by Parties to the Convention on Long-Range Transboundary Air Pollution Convention and expert estimates.

Assessing atmospheric heavy metal depositions to the Baltic Sea

Atmospheric deposition of lead, cadmium, and mercury were obtained for the European region and surrounding areas covered by the EMEP modelling domain and time-series of annual atmospheric deposition are available for the period 1990 – 2010.

Atmospheric input and source allocation budgets of heavy metals (cadmium, lead, and mercury) to the Baltic Sea and its catchment area have been computed using the latest version of MSCE-HM model, which is a regional-scale model operating within the EMEP region. This is a three-dimensional Eulerian model that includes processes of emission, advection, turbulent diffusion, chemical transformations of mercury, wet and dry deposition, and inflow of pollutant into the model domain. Horizontal grid of the model is defined using stereographic projection with spatial resolution 50 km at 60° latitude. The description of EMEP horizontal grid system can be found in the internet (<http://www.emep.int/grid/index.html>). The vertical structure of the model consists of 15 non-uniform layers defined in the terrain-following s-coordinates and covers almost

the whole troposphere. Detailed description of the model can be found in EMEP reports (Travnikov and Ilyin, 2005) and on the EMEP web page (<http://www.emep.int>). Meteorological data used in the calculations for 1990-2009 were obtained using MM5 meteorological data preprocessor on the basis of the Re-analysis project data prepared by National Centers for Environmental Predictions together with National Center of the Atmospheric Research (NCEP/NCAR) in the USA (<http://wesley.ncep.noaa.gov/reanalysis.html>) and meteorological analysis of European Centre for Medium-Range Weather Forecasts (ECMWF).

The MSCE-HM model has been verified in a number of inter-comparison campaigns with other regional HM transport models (Sofiev et al., 1996; Gusev et al., 2000; Ryaboshapko et al., 2001, 2005) and has been qualified by means of sensitivity and uncertainty studies (Travnikov, 2000). It was concluded in these publications that the results of heavy metal airborne transport modelling were in satisfactory agreement with the available measurements and the discrepancies did not exceed on average a factor of two. The comparison of calculated versus measured data indicates that the model predicts the observed air concentrations of lead and cadmium within the accuracy of 30%. For concentrations in precipitation the difference between calculated and measured values may reach two times. Computed mercury concentrations deviate from measured values within a factor of two.

Calculations of atmospheric transport and deposition of lead, cadmium, and mercury are provided on the regular basis annually two years in arrears on the basis of emission data officially submitted by Parties to CLRTAP Convention.

Normalizing atmospheric deposition

In order to reduce the influence of meteorology on computed annual deposition and thus allow for better evaluation of the effectiveness of measures taken to reduce pollution loads, EMEP has developed a simple procedure for normalizing atmospheric deposition values. The following is a description of how EMEP have used the source-receptor matrices and depositions for calculating “normalized” depositions to the Baltic Sea for oxidized, reduced and total nitrogen and for each year of the period 1995-2010. The below equations were used for each of 16-year period 1995-2010 with available EMEP model runs.

The total nitrogen deposition to the Baltic Sea basin in the year *iy* can be calculated as:

$$D^{tot}(iy) = D^{ox}(iy) + D^{rd}(iy) = \sum_{i=1}^{ns1} A_i^{ox}(iy) \times E_i^{ox}(iy) + \sum_{i=1}^{ns2} A_i^{rd}(iy) \times E_i^{rd}(iy) \quad (A7.1)$$

where $D^{ox}(iy)$ and $D^{rd}(iy)$ is the annual total deposition of oxidized and reduced nitrogen, respectively, to the Baltic Sea in the year *iy*. The numbers of emission sources contributing to oxidized nitrogen deposition (*ns1*) and reduced nitrogen (*ns2*) are different in general, because some sources (e.g. ship traffic on the Baltic Sea) emit only oxidized nitrogen.

The annual depositions were calculated for each combination of meteorological and emission year:

$$\begin{aligned} D^{ox}(ie, im) &= \sum_{i=1}^{ns1} A_i^{ox}(im) \times E_i^{ox}(ie) + R^{ox}(ie, im) \\ D^{rd}(ie, im) &= \sum_{i=1}^{ns2} A_i^{rd}(im) \times E_i^{rd}(ie) + R^{rd}(ie, im) \end{aligned} \quad (A7.2)$$

Terms $R^{ox}(ie,im)$ and $R^{rd}(ie,im)$ are introduced mainly because of the contribution of BIC (Initial and Boundary Conditions) in the model calculations, additional source for which emissions cannot be specified. For the Baltic Sea basin this additional source is only contributing to oxidized nitrogen deposition, so $R^{rd}(ie,im) = 0$. The normalized deposition of total nitrogen for the emission year ie - $DN(ie)$ is defined as:

$$DN(ie) = MED\{D^{ox}(ie,1) + D^{rd}(ie,1), \dots, D^{ox}(ie,im) + D^{rd}(ie,im), \dots, D^{ox}(ie,16) + D^{rd}(ie,16)\} \quad (A7.3)$$

Where MED is the median taken over 16 values which correspond to 16 meteorological years. In addition, the maximum and minimum values are also calculated for each emission year. The results of these calculations for the years 1995-2010 are shown in the below **Figure A7.1** for oxidized, reduced and total nitrogen deposition.

Normalized deposition of total nitrogen

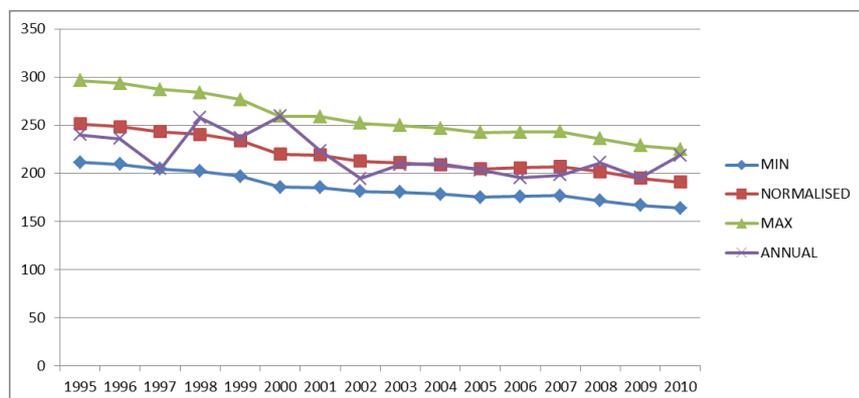


Figure A7.1. Normalized depositions of total nitrogen for the period 1995-2010. Minimum, maximum and actual annual values of the deposition are also shown.

For more information, see the latest annual report prepared by EMEP (Atmospheric supply of nitrogen, lead, cadmium, mercury and dioxins/furans to the Baltic Sea in 2011) as well as the latest Baltic Sea Environment Fact Sheets on emissions and depositions of nitrogen, heavy metals and PCDDF/s, which can be accessed via the HELCOM website.

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