# IDENTIFICATION OF UNCERTAINTIES IN ASSESSMENTS OF THE NUTRIENT LOADS AND SOURCES TO LAKE PEIPSI AND RECOMMENDATIONS TO THE ESTONIAN-RUSSIAN TRANSBOUNDARY WATER COMMISSION

WORKSHOP REPORT, Pskov, Russia, June 19-20, 2001

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## BACKGROUND

This background report takes it starting point in a completed in 1999 project 'Environmental Monitoring of Lake Peipsi/Chudskoe 1998-99'; a joint venture between Sweden, Estonia and Russia. The environmental monitoring project was aimed at strengthening the capacity of regional environmental authorities in the Lake Peipsi Basin - Estonian-Russian transboundary region - for quality-assured environmental monitoring and information exchange. In one of the subprojects 'Nutrient loads to lake Peipsi' estimation of nutrient load to Lake Peipsi were conducted. As a part of the project, river and lake water quality data, land cover data and point source data in Lake Peipsi and its drainage basin were collected and analysed for the period 1995-1998. Based on these data, the project team performed an estimation of the riverine load of nutrients to Lake Peipsi, an identification and quantification of the point and diffuse source discharges, and an estimation of the retention of nutrients in Lake Peipsi. In addition, the project developed recommendations for a future coordinated monitoring program for the lake and its inlets, and constitute a basis for future measures to reduce the risk of further eutrophication of the lake.

As communities in the Lake Peipsi area recover from the economic recession of the beginning of the 1990s; and agriculture, tourism and industry around the lake show visible signs of development; the potential risk for the increase of anthropogenic pressure to the Lake Peipsi Basin ecosystem increases. So there was an urgent need in going from the recommendations for a coordinated monitoring program to specific proposals for future measures to reduce the risk of further eutrophication of the lake.

The seminar "*Identification of uncertainties in assessments of the nutrient loads and sources to Lake Peipsi*" that was held in Pskov on the 19th June 2001, was aimed to discuss the present knowledge of the nutrient loads and sources, to identify the major uncertainties in assessment of nutrient loads and sources and to develop proposals tha would bring environmental authorities in the Lake Peipsi Basin to the formulation of specific actions for reduction of the nutrient load in the Lake Peipsi Basin.

The seminar was a part of the Swedish EPA supported project "Support to the Estonian - Russian transboundary water commission" and was organized within a joint meeting of two working groups under the Estonian/Russian transboundary water commission[1] – a working group on monitoring and research and a working group on cooperation with local authorities, international and non-governmental organizations. The meeting adopted recommendations to the Estonian-Russian transboundary water commission for the measures to be implemented aimed to decrease the nutrient load into the lake. Minutes of the joint meeting of the working groups with Recommendations developed and a list of meeting participants enclosed in the Annex 1.

[1] See more information on the Commission at address www.envir.ee/jc

# PRESENT KNOWLEDGE OF NUTRIENT LOADS AND SOURCES

## *MONITORING PROGRAMME*

In Estonia, the national monitoring program for water quality in rivers and water discharge covers eight rivers, or almost 90% of the total drainage area of Lake Peipsi (Table 1). The sampling frequency is normally monthly. The sampling site is normally close to the mouth but several upstream sites also exist. In total, river water quality is monitored at 28 sites (See Figure 1).

In Russia, the corresponding program includes 5 rivers (the Velikaya, Gdovka, Zhelcha, Chornaya and Cherma Rivers) which covers more than 90% of the drainage basin on the Russian side of the lake (see Figure 2). The monitoring of Zhelcha and Cherma rivers was restarted in 1999. Additional sampling upstream the mouth site of the Velikaya River is performed at Ostrov and Opochka.

## *NUTRIENT LOADS AND SOURCES*

### *Nutrient loads*

The results of the study by Stålnacke et al. (2001), showed that the riverine transport is the most important pathway for the input of nutrients to Lake Peipsi. In particular, it was shown that the lake, from its rivers, received an average of 20 500 tonnes of nitrogen (N) and 910 tonnes of phosphorus (P) annually during the time period 1995-1998. These estimates are substantially lower than previously reported (Loigu&Leisk, 1996). The study by Loigu and leisk (1996) reflects the situation in the mid and late 1980s. Therefore it cannot be ruled out that the discrepancy in results also reflect a decline in riverine loads due to the huge economic recession in the drainage basin.

The average water discharge in the study period (1995-1998) was found to be approximately 20% higher than the long-term average. There was a relatively large interannual variation in riverine loads, due to *e.g.* dry hydrometeorological conditions in 1996 and wet hydrometeorological conditions in 1998.

Examination of the relative contribution of the total nutrient loads showed that the two largest basins, *i.e.* those of the Velikaya and Emajogi, contributed approximately 80 % (16 500 tonnes $yr^{-1}$) of the nitrogen load and 84% (760 tonnes $yr^{-1}$) of the phosphorus load transported to the lake via rivers (Table 2). The Velikaya River alone accounted for approximately 65% of the total riverine load. The highest area-specific loads of N and P were observed in one of the agriculturally dominated tributaries of the Emajogi River. However, the nutrient levels in almost all the studied rivers were relatively low or moderate given the large share of agricultural land in the drainage basin (42%).

## *NUTRIENT SOURCES*

According to Stålnacke *et al.* (2001) only 7% of the nitrogen load from Estonian rivers originates from wastewater (point pollution sources); more than half of the load comes from agriculture and more than 35% originates from forests and other diffuse sources. Of the phosphorus load in Estonian rivers, 30% comes from point pollution sources and almost 40% from agriculture via the rivers in the catchment area. In Russia, the source apportionment showed that almost 80% of the N load and approximately 70% of the P load originates from agriculture. Point sources account only for less than 10% and approximately 20% of the N and P load in Russian rivers, respectively.

## UNCERTAINTIES IN ASSESSMENT OF NUTRIENT LOADS AND SOURCES

When discussing the uncertainty of estimated riverine loads, special attention should be given to the estimation of observed concentrations of organic-N in the Russian rivers where no measurements presently exist. The absence of water quality and water discharge data for the catchments located between the major river basins in the Lake Peipsi drainage area was regarded as a minor source of uncertainty since these catchments account for only 10-15% of the entire drainage area. Other sources of uncertainty, such as variation in nutrient concentrations between sampling occasions or within river cross-sections, have most likely affected the load estimates. For example, the annual sampling frequency of 2-6 times in Velikaya and Gdovka Rivers is too low for accurate and precise estimation of the annual nutrient load. It is suggested that an evaluation of these sources of uncertainty should be considered when and if the monitoring programmes are revised. The pollution load of nutrients is transported into the lake mainly from two river catchment areas, the Emajogi and Velikaya. The Emajõgi and Velikaya Rivers account for approximately 80% of the total nitrogen load and almost 85% of the total phosphorus load to Lake Peipsi. Therefore, emphasis on these rivers should be given priority when monitoring programmes is discussed.

The largest part of the Lake Peipsi basin (>65%) is located in Russia. This is the part of the basin where the monitoring data of water quality is the poorest. The available environmental data, particularly with regard to the chemical analysis of total-N and total-P, are presently so fragmentary that they cannot be accepted as scientific evidence of the 'true' riverine loads of nutrients and the water quality conditions in the Russian part of the basin.

The land-use statistics suffered from some uncertainty. This was particularly true for the agricultural statistics. Various land cover classifications are used in Estonia and Russia that make the source apportionment relatively uncertain.

There is also an uncertainty in the source apportionment calculations. It could for example be noted that when summing up the contribution from the various sources (see Table 2) the estimates were lower than the estimated riverine load for both N and P (Table 1). This is an illustrative example of the uncertainties involved. Most likely the estimation of emissions from the various source categories were underestimated. The estimated coefficients for each land use category are estimated by model calculations, and in some cases also assigned coefficients from literature were used. Therefore, the source apportionment should not be interpreted in absolute and exact terms. Instead the calculations gives the relative share of point and non-point sources to the total riverine load of nutrients to the Lake Peipsi.

It should also be noted that the point sources are the emissions from sewage treatment plants and industries and do not include the contribution from people not connected to sewage treatment plants (i.e. scattered dwellings, individual rural household households). In addition, the point source data in Russia only included the inorganic forms of nitrogen and phosphorus. This source of uncertainty was regarded as less critical since total-N and total-P can be relatively easily estimated from known relationships between inorganic and total forms of nitrogen and phosphorus, respectively, in combination with per capita coefficients and the treatment efficiency at sewage treatment plants. In addition, point sources account for a relatively small fraction of the total load to Lake Peipsi.

To summarise:

1. SAMPLING FREQUENCY. The sampling frequency for nitrogen and phosphorus is low in the Russian rivers monitored, with only 2-6 samples per year.
2. PARAMETERS MONITORED. Total-N and total-P are not standard parameters in the Russian national monitoring program for water quality.

This (1. and 2.) makes the estimation of the total riverine loads of nutrients from the Russian part of the drainage basin very uncertain.

3. SPATIAL VARIABILITY IN NUTRIENT LOADS. The spatial distribution of the nutrient loads at upstream sites/subwatersheds in Russia is almost unknown due to the fact that the monitoring is mainly concentrated on mouth sites at the 4 major rivers drscharging the Lake Peipsi. This lack of monitoring data at upstream site thus hamper to identify areas with high losses of nutrients and subsequently management and measures. Monitoring of agricultural losses in small catchments is also lacking (both on the Estonian Russian side of the basin (see 4. for further discussion).

4. SOURCE APPORTIONMENT. Due to the lack of direct monitoring of nutrient losses from diffuse sources (e.g. agricultural catchments), source apportionment must be based on (i) modelling with use of monitoring data in rivers or (ii) assignment of export coeffcients from the various land use categories. The second method can be difficult since it is not possible to calibrate or verify the results. The first method need data from several sampling sites in a river basin. As pointed out in 3. above, there are very few sampling sites at upstream sites in Russia which thus make source apportionment estimations uncertain and only indicative.

5. LAND USE STATISTICS: Stålnacke et al (2001) pointed out problems to use adminstrative statistics to obtain land use estimates for river basins. This is particularly true for small watersheds. Additionally, the division of agricultural land into arable land, pasture, grassland, fallow and unused land is regarded as particularly important. The use of CORINE land cover has started in Estonia which will improve the land cover classification even in small river basins. In the MANTRA-East project, two potential land cover sources are being considered: CORINE and BALANS land cover (Langaas pers. comm.). CORINE land cover, while being of higher accuracy, is presently only available for Latvia and Estonia.

6. POINT SOURCE STATISTICS: There are several uncertainties in the estimation of the point source contribution. Table 3 gives a summary from 3 studies. As seen there are large

discrepancies in the estimates. One reason is that some studies used monitored data from sewage treatment plants and industry while other studies is based on per capita emissions combined with assigned values for the treatment.

## RECOMMENDATIONS

The Joint Estonian-Russian Transboundary Commission with the working group *'Monitoring and Research'* shall facilitate and develop an Action Plan for how a coordinated monitoring program of water quality (specially focused on nutrients) in the Lake Peipsi Basin can be implemented. The Action Plan shall include a strategy for how to:

1. coordinate Estonian and Russian monitoring programmes focusing on (1) maximal harmonisation of nutrient load monitoring parameters, (2) harmonisation of the analytical methods used, (3) harmonisation of sampling frequencies, and (4) annual intercalibration;

2. prepare a biennial background report for the Joint Estonian-Russian Commission on the nutrient load and its sources, which shall include (1) more accurate data on land use in riverine catchments, especially, on agricultural lands subdivided into arable lands, pastures, grasslands, fallow lands and unused lands, and (2) more accurate and reliable data on nutrient load source apportionment;

3. prepare a background report on long-term trends in the riverine load dynamics and nutrients' concentration;

4. develop a joint coordinated database on water quality and quantity, land use, and point pollution sources.

Action No. 1 will for example require a strategy on how to:

- Include total-N and total-P as a standard parameter in the Russian national monitoring program for rivers.
- Include total-N and total-P as a standard parameter in the Russian national monitoring program for point sources.
- Increase the sampling frequency in Russian rivers.
- Perform water quality monitoring at more upstream sampling sites in the Velikaya River.

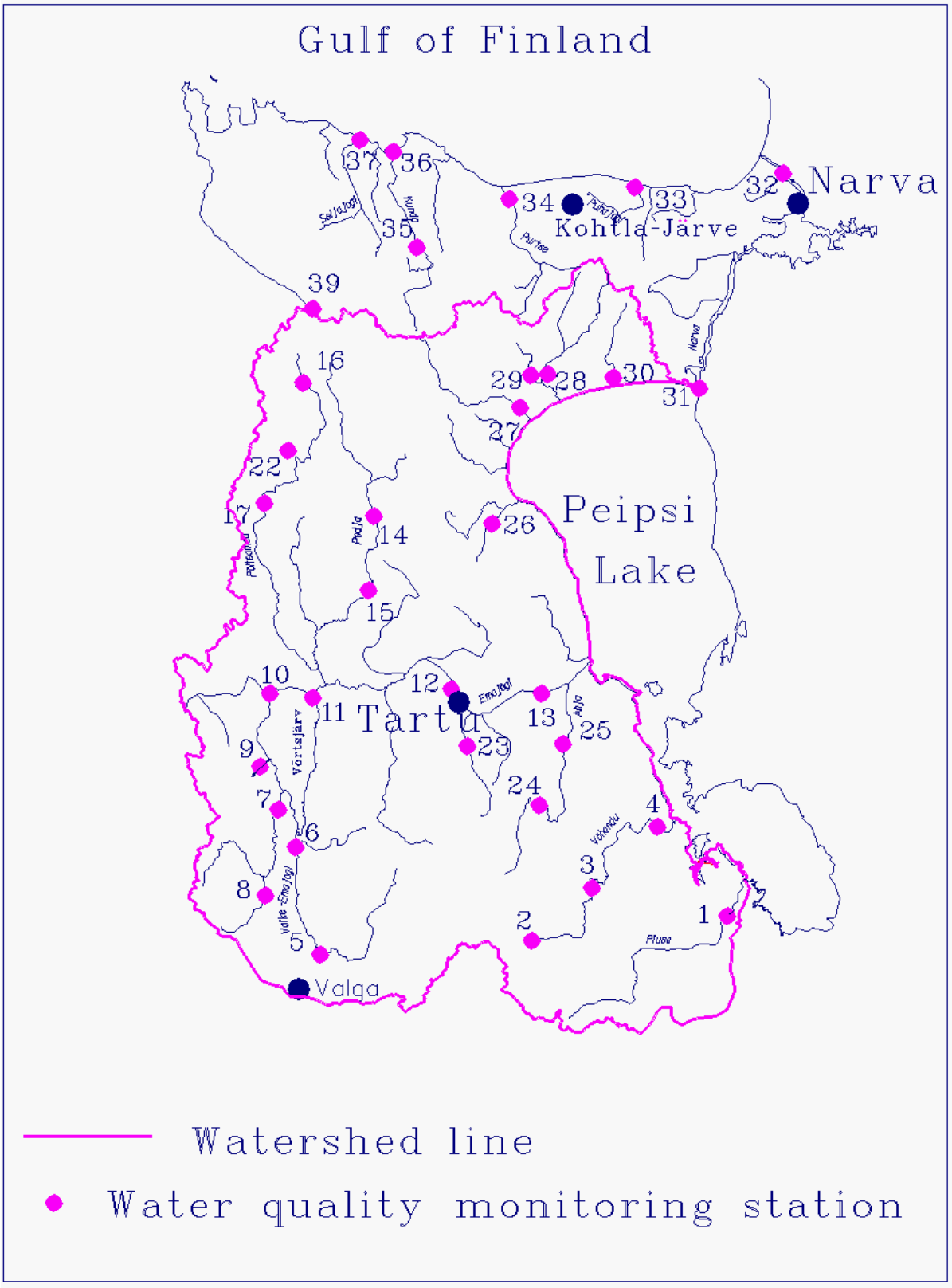


**Figure 1.** River water quality monitoring sites in the Estonian part of the Lake Peipsi drainage basin.

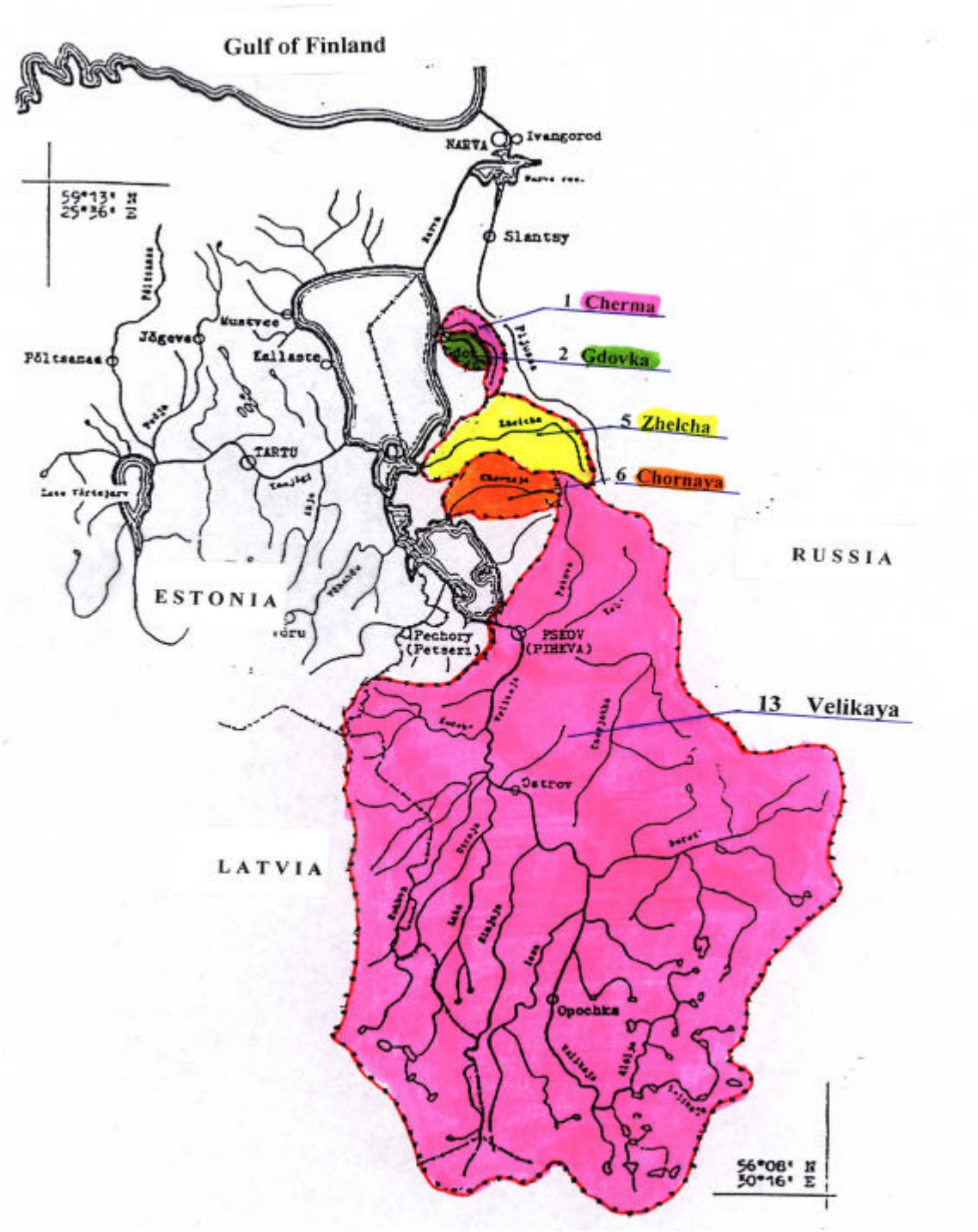


Figure 2. River water quality monitoring sites in the Russian part of the Lake Peipsi drainage basin.

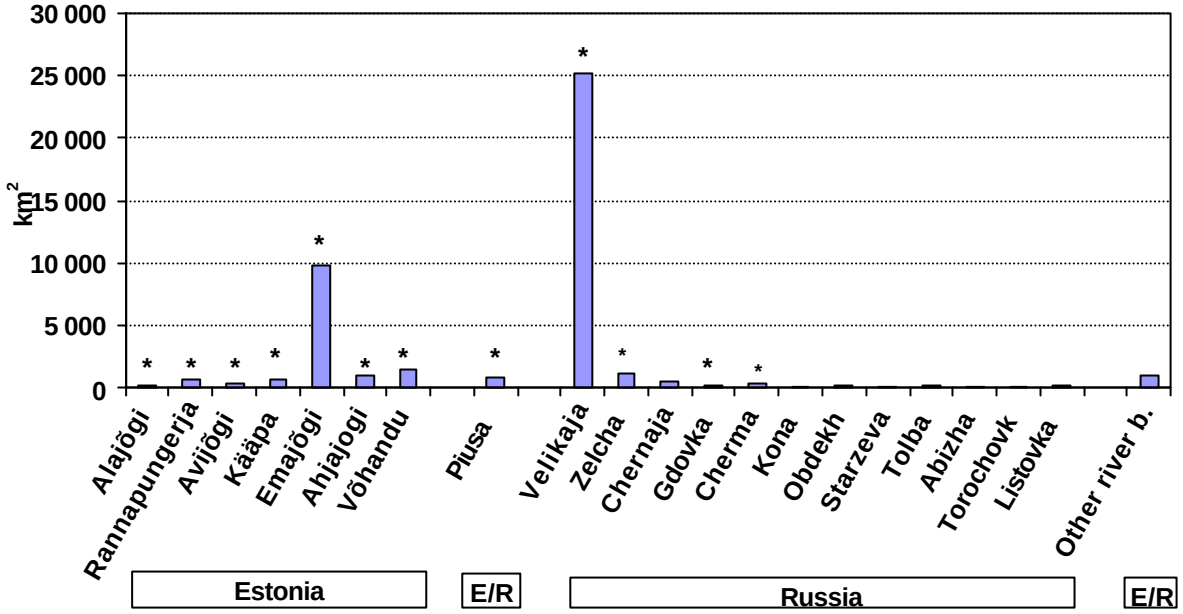


Figure 3. Drainage areas for the rivers discharging the Lake Peipsi. * indicate that river water quality exist in the river.

Table 1. Annual inputs of nitrogen and phosphorus, estimated load at the oulet from lake Peipsi and retention in the Lake Peipsi (1995-1998).

Source: Stålnacke et al. (2001).

| | Total-P (tonnes/yr) | Total-N (tonnes/yr) |
|---|---|---|
| Estonian Rivers | 240 | 6 500 |
| Russian Rivers | 670 | 14 040 |
| Atmospheric deposition | 18 | 2 850 |
| Total input | 928 | 23 350 |
| | | |
| Narva R. 1995-1997 | 266 | 16 700 |
| Narva R. 1995-1998 | 294 | 23145 |
| Retention in lake Peipsi (1995-1997) | 71% | 29% |
| Retention in lake Peipsi (1995-1998) | 68% | 1% |

Table 2. Nitrogen and phosphorus load (tonnes/yr) from various sources in the Lake Peipsi basin.

Source: Stålnacke et al (2001).

| | | Agriculture | Other diffuse sources | Point sources | Total |
|---|---|---|---|---|---|
| Total-N | Estonia | 3 997 | 2 588 | 453 | 7 038 |
| | Russia | 9 427 | 1 586 | 862 | 11 875 |
| Total-P | Estonia | 98 | 74 | 73 | 245 |
| | Russia | 372 | 48 | 106 | 526 |

Table 3. Estimation of nitrogen and phosphorus load (tonnes/yr) from point sources in the Lake Peipsi basin.

| Reference | Time period | Nitrogen (t/year) | phosphorus (t/year) |
|---|---|---|---|
| *Loigu & Leisk (1996)* | 1980s | 2 010 | 310 |
| *Stålnacke et al (2001)* | 1995-1998 | 1 315 | 179 |
| *Andersen et al (in prep)* | 2000 | 846 | 101 |

It should be noted that the point source contribution was somewhat underestimated since the inhabitants not connected to sewage treatment where not included in the calculations.

Annex 1

**Minutes**

**of the Joint Meeting of the Working Group on Monitoring and Research and the Working Group on Cooperation with Local Self-Governments, NGOs and International Organisations of the Joint Estonian-Russian Commission on Transboundary Waters**

**19 June 2001, Pskov**

**Agenda:**

1. Results of the 18-19 June 2001 meeting of the Working Group on Monitoring, presented by U.Lipps and Z.Mokrousova

2. Presentation by Per Stalnake "Identification of Uncertainties in Assessment of the Nutrient Loads and Sources to Lake Peipsi"

**1. Z.Mokrousova presented results of the 18-19 June 2001 meeting of the Working Group on Monitoring. The Working Group discussed the following issues:**

- Coordination of joint monitoring programmes by their parameters, sampling frequency and levels, monitoring points on rivers, outlets and on the lake;
- Joint field trips, including their programme, frequency, necessary equipment and organisational points (assistance from the Border Guard Service);
- Exchange of data on the environmental situation in the Lake Peipsi basin and results of research programmes;
- Preparation and publication by 2003 of the Background Report on the Environmental Situation in the Peipsi – Narva Basin, and the Hydrometeorological Reference Book;
- Estonian Report on Groundwater Monitoring. A decision was made to enlarge the working group by including experts on groundwater quality monitoring.

**Questions to the speaker:**

**G.Roll:** By the Commission's decision of August, 2001, the SEPA project on the support of the Commission was included in the Commission's action plan. R.Perents (Estonia), V.Nikolaev and V.Antonov (Russia) were appointed experts on groundwater management in the Working Group on Water Protection. Who will work as an expert in the Working Group on Monitoring on the Russian side, and how the two groups will coordinate groundwater management issues?

**Answer:** The groundwater monitoring is vested in the RF Ministry of Natural Resources (MNR), and it's the MNR's responsibility to appoint experts to the working group. We can request the MNR to include the experts working in the Group on Water Protection in our group as well.

**N.Munthe:** In April 2001, the SEPA project sponsored a workshop on groundwater management, which resulted in the Background Report on Groundwater Management. Is the Working Group on Monitoring going to use the workshop's recommendations and the report in their work?

**Answer:** We have included the development of a groundwater monitoring programme in our action plan and we are going to use the workshop's recommendations concerning the groundwater monitoring.

**2. Presentation by Per Stalnake on the Report "Identification of Uncertainties in Assessment of the Nutrient Loads and Sources to Lake Peipsi"** prepared by Per Stalnake (Jordforsk, Norway), Karin Pachel (Environmental Information Centre, Estonia) and Svetlana Basova (Northwest Roshydromet Directorate, Russia). The speaker offered recommendations to the Commission on the development of a coordinated programme of water quality monitoring.

**Comments on the Report:**

**U.Lipps:** I would like to thank the SEPA for the support to the project. I am glad that most recommendations mentioned by Per have been already included in our working programme. We should use all the project data making their critical analysis.

**Z.Mokrousova:** Our proposals on the joint programme have been already accepted.

**U.Sults:** I participated in the preparation of two reports, and I heard from Russian experts about a considerable drop in water use. Second, the reconstruction of water purification facilities in Estonia. In Tartu they have already achieved an 80% phosphorous removal. The first data concerned a different period and cannot be compared with the present situation. All this has to be taken into account in the MANTRA-East project. The work has been tremendous.

**S.Basova:** Another reason for uncertainties is the lack of data and late involvement of Roshydromet representatives. We should coordinate our actions much better. At present we have 17 monitoring stations on the Russian side with the monthly sampling frequency and for both total-P and total-N parameters. We didn't take into account the upstream points as we didn't have any inquiry on those. All projects should begin with the analysis of data and development of a data collection strategy.

**N.Munthe:** I coordinated the SEPA-supported monitoring project that generated Per Stalnake's report and computations. The quality of information is a very important issue, and in Sweden we are still discussing the quality of monitoring data. I know the amount of data in both Russia and Estonia is very large. If we take into account all this, we may have a constructive discussion. Speaking about the Roshydromet involvement, we had a preliminary meeting with Roshydromet representatives from Pskov, Petersburg and Moscow, and we didn't have the intention to exclude them from the data analysis and collection.

**J.Andersen:** I suggest adding to the second recommendation the need to determine the natural background in agricultural impacts and point pollution sources. Another recommendation is to use two monitoring stations: upstream and downstream, and also use the natural water body to study the natural background and compare it with the water body intensely used. This will improve the quality of our calculations.

**P.Gorelov:** It's good to have this report on nutrient load. Without it, we wouldn't have grounds for discussions and recommendations. It is also important for the development of local environmental strategies.

**G.Roll:** In 1999 the Commission made a decision to prepare the Lake Peipsi Basin Management Plan. To implement this decision, in 2001-2003 we are going to implement the GEF-funded project, and the CTC will coordinate this activity under the guidance of the Commission and the ministries and agencies involved. I ask the Working Group on Monitoring to prepare a technical assignment and a proposal concerning the development of a joint monitoring programme.

**V.Vuglinsky:** We are discussing uncertainties, and the most important task is to coordinate the systems of observation, monitoring programmes, methods and source apportionment approaches. I we manage to do it, the situation will improve. And we have made such a decision at our group's meeting.

**J.Andersen:** Unfortunately, there's no clear definition of the monitoring goals and tasks. I think the Working Group has to offer clear0cut goals for the Commission's approval.

**U.Lips:** I think the monitoring and evaluation of the situation create a foundation for further actions and determine the priority areas for investments.

**J.Andersen:** To set the main monitoring goal simply as the collection of data is not enough. The monitoring programme should become a basis for further decision-making.

**P.Stalnake:** First, some additional comments on the report. This is not just my personal work, it's a collective work of Russian and Estonian experts. It showed that even with the lack of data we could prepare a good joint report. I am glad to see that the Working Group on Monitoring has arrived at the same conclusions as mine. I fully support the proposal on coordination of monitoring programmes. I also liked the ideas on the Background Report on the Situation in the Lake Area by 2003 and the publication of all the data (Hydrometeorological Reference Book). But what the group has not discussed is the problem of land use data necessary to assess the nutrient load. The MANTRA-East project will deal with many issues concerning the Working Group on Monitoring, and we could cooperate in what concerns the data per se and their analysis, thus creating a firm scientific basis.

**The participants made the following recommendations for the further work of the Commission:**
The Joint Estonian-Russian Transboundary Water Commission and its Working Group on Monitoring and Research shall prepare an action plan on the development and implementation of the coordinated complex programme for water quality monitoring with focus on the Lake Peipsi basin. In addition to the surface water monitoring programme already developed by the group, the action plan shall include strategies for monitoring of point pollution sources and groundwater quality. The Commission and the Working Group shall:

1. coordinate Estonian and Russian monitoring programmes focusing on (1) maximal harmonisation of nutrient load monitoring parameters, (2) harmonisation of the analytical methods used, (3) harmonisation of sampling frequencies, and (4) annual intercalibration;
2. prepare a biennial background report for the Joint Estonian-Russian Commission on the nutrient load and its sources, which shall include (1) more accurate data on land use in riverine catchments, especially, on agricultural lands subdivided into arable lands, pastures, grasslands, fallow lands and unused lands, and (2) more accurate and reliable data on nutrient load source apportionment;
3. prepare a background report on long-term trends in the riverine load dynamics and nutrients' concentration;
4. develop a joint coordinated database on water quality and quantity, land use, and point pollution sources.

On behalf of the Working Group on Monitoring and Research signed by

U.Lips Z.Mokrousova

On behalf of the Working Group on Cooperation with Local Self-Governments, NGOs and International Organisations signed by

Yu.Nefiodova G.Roll

**Discussion Participants:**
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Ye.Garanzha, Laboratory of Pskov Committee for Natural Resources, Russia
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