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Georgia's Environmental Outlook - GEO

GUIDELINES ON ESTABLISHMENT OF SENSITIVE AREAS IN RIVER BASINS IN GEORGIA

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Note: Definition for this report are used from the EU Directive No. 91/271/EEC that is enclosed as Annex to this report.

ABBREVIATIONS

N_{total}:	Total Nitrogen
P_{Total}:	Total Phosphorus
COD_{Cr}:	Chemical Oxygen demand
BOD_5:	Biological Oxygen Demand
TOC:	Total Organic Carbon

1. Introduction

The importance of waste waters treatment is growing all over the world. The requirement for removal only organic pollution is being supplemented by requirements to remove nutrients – nitrogen and phosphorus, and elimination of inorganic and specific organic pollutants that are accumulated especially in sewage sludge particles.

It is clear, that surface waters are more vulnerable from the point of view of quality, hygienic harmlessness as well as keeping the natural ecosystem and quantity of aquatic organisms than ground waters. Surface water is important environment from the point of view of transport, degradation, and accumulation of pollutants both from natural sources and anthropogenic activities. These factors when appear increasingly, imply significant risks for all kinds of organisms including human beings. Therefore, it is necessary to pay increased attention to their protection. The basic requirement is the optimal monitoring, evaluation of surface water quality, and implementation of necessary environmental measures to keep them in the good status.

The EU Directive No. 91/271/EEC is one of partial tools regulating the approach to gradual reaching good status of surface water through controlled collection and treatment of urban waste waters and treatment of waste water from certain industrial sectors. This is based on determination of emission values of pollutants discharged into recipients (surface water). The decisive parameters related to urban waste waters are Total Nitrogen (N_{total}) and Total Phosphorus (P_{total}), i.e. parameters expressing the contents of nutrients and parameters as COD_{Cr}, BOD_5, resp. TOC – representing the amount of carbon organic pollution of discharged urban waste waters. Taking into account the character and composition of urban waste waters, the aim of control of waste water treatment is to secure the water protection in recipients in such way that the oxygen regime would not be disturbed and the content of particular forms of nitrogen and phosphorus would not increase. This should result in reduction, or at least elimination of eutrophication potential in surface water.

This Guideline do not have ambition to be as “manual” for the delineation of the sensitive area, but should bring more lights into the process of the implementation of EU Directive 91/271/EC and to understand the main principles and criteria for sensitive areas delineation. The first part is dedicated to legislation analysis and criteria for delineation of the sensitive areas (including requirements on waste water treatment). Subsequently, the methods to be used for delineation are shortly described and also list of necessary data and information to be collected is presented. In this context, the Analysis of the present state of the surface water

The principles and concept of the eutrophication described in the EU Guidance Document No. 23 on Eutrophication Assessment are also used within this document.

The Guidelines are supposed to be applied in the Alazani River basin (as pilot) and the results will be presented on the workshop in the pilot river basin.

2. The EU legislation requirements on protection of waters against discharge of nutrients from sources of pollution

2.1 Legal provisions

The European Union legislation on Waters consists of several components. When looking at historical development of the legislation, it seems that drinking water has priority also in the EU as is in other parts of the World. In the legislation, availability of the water supplied to consumers as drinking water was addressed firstly than this issue was followed by the quality of water in sources where water is drawn to be used as drinking water and the conservation of such sources. By the end of 1980s, it was seen that the applicable legislation was not sufficient to meet the needs. Therefore, **the Urban Wastewater Treatment Directive (1991) and the Nitrate Directive (1991)** were inserted into second generation of the legislation.

In the mid of 90s, the needs for the development of a new frame of the water policy addressing the whole EU was recognised by the Member States. With regard to this need, the European Commission initiated some studies to create a Water Framework Directive (WFD). The main rationale and purpose of this WFD was to harmonize the national water legislations applied in the EU countries with each other in every respect.

2.2. Main principles and baselines

The basic objective of the EU Water Framework Directive is to reach good ecological status/ good ecological potential of surface waters and good chemical status up to 2015 (the 1st River Basin Management planning cycle (resp. 2021/2027 the 2nd and 3rd ones)).

The issue of urban waste waters is elaborated in the Directive No. 91/271/EEC from 21.5.1991 concerning urban waste water treatment in order to prevent harmful impact of insufficiently treated waste waters on environment (later as Directive). The Directive deals with collection, treatment and discharge of urban waste waters, and treatment and discharge waste waters from certain industrial sectors. The objective of the Directive is protection of water against impacts of discharged urban waste waters through statement of minimal level of secure of the system of urban waste water treatment. The reasons of elaboration and adoption of the Directive were as follows:

- Protection of North/Black sea and other waters in the Community on level of European Union (need to adopt generally valid measures regarding urban waste waters);
- Pollution caused by insufficient treatment of urban waste waters in one Member State often impacts waters in other Member States and there is necessary to coordinate measures in the framework of the Community;
- Need to prevent unpleasant impact of discharging insufficiently treated urban waste waters on environment (general need of secondary treatment of urban waste waters);
- Need to apply more stringent treatment in sensitive areas, but on the other hand in some less sensitive areas primary waste water treatment could be acceptable;
- Need that discharge of industrial waste waters, urban waste waters discharged by sewage system, and sludge treatment was executed according to generally valid rules and/or specific authorisation (permissions to treat waste waters);

- Need to formulate adequate requirements for discharging those industrial waste waters containing biologically removable pollution from some industrial sectors that are not treated in urban waste water treatment plants before discharging into recipient;
- Need of reuse of sludge; its discharge into surface waters must be gradually stopped;
- Need to monitor urban waste water treatment plants, water in recipient and treatment the sludge, in order to secure the protection of environment against impacts of discharged waste water;
- Making available the information on urban waste water and sludge treatment to public in the form of regular announcements and public participation.

Coming out from above mentioned objectives, the Directive defines requirements on discharge and treatment of urban waste waters generally, and moreover, to secure protection of recipients in sensitive areas against increased load of nutrients (N and P) from urban pollution sources. The Directive is an emission directive determining emission limits at the end of the pipe (on outlets) of urban sewage systems (ended by treatment plants), respectively some industrial systems (especially food production plants). The Emission – Imission approach in the framework of EU legislation comes out from requirements of so called „Qualitative" Directives that legally regulate and protect the quality of water in context of its main (decisive) use. However, this approach turns to ecosystem approach of the EU Water Framework Directive.
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2.3 Criteria for determination of sensitive areas according to requirements of the Directive 91/271/EEC

The obligation of Member States to identify sensitive areas is one of the most difficult but unavoidable requirements of the EU Directive No. 91/271/EEC (UWW) for overall protection of water systems. According to criteria for identification of sensitive areas under given condition (i.e. inland water status), the water body must be identified as a sensitive area if falls in to one of following groups:

1. Natural fresh water lakes, other fresh water areas that are considered eutrophic or can become eutrophic in the next future, if no steps will be made for the surface waters protection.

Note: The selection which nutrients must be reduced in the waste water treatment, can be taken into account for those lakes and streams, where there was found unsatisfactory exchange of water and where standing waters can be created. In these areas, there must be secured removal of phosphorus unless it is not possible to prove that its removal will not affect the decrease of eutrophication. However, in locations, where waste water is discharged from big agglomerations, removal of nitrogen has to be also evaluated.

2. Surface fresh waters under Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption (Drinking Water Directive).
3. Areas, where there is necessary treatment besides that prescribed in the article 4 of the Directive 91/271/EEC in order to fulfil requirements of other EEC Directives.

Furthermore, Member States are obliged to recognise the existence of sensitive areas outside their national jurisdiction (e.g. pollution of Black Sea and its coastal waters by nutrients). The approach to identification of sensitive areas on principle of river basins comes out from logical

principle of elimination of eutrophication potential due to required reduction of nutrients inflow from tributaries to the main stream (upstream - downstream principle).

When there are designated sensitive areas, Member States are obliged to secure:

1. Areas identified as sensitive will fulfil mentioned requirements to 7 years from designation of those areas and will be revised according to statements of the UWW Directive (criteria for identification of sensitive areas),
2. Revision of identified sensitive areas is made in intervals not longer than 4 years.

Besides, the UWW Directive requires the control of impact of discharged urban waste waters on water quality of recipient (rivers, lakes).

Similarly to identification of sensitive areas, Member States can designate also less sensitive areas. In less sensitive areas, primary treatment of waste waters is considered as adequate. This means disposal/improvement/treatment of the urban waste waters by physical and/or chemical process including sedimentation or other processes with effect of decreasing the pollution at least by 20 % in the BOD_5, and at least by 50 % in the Suspended Solids concentrations before discharging into recipient. In this case, studies have to prove that this discharge will not impact the environment. This part of UWW Directive is relevant only for the coastal and transitional waters.

2.4 Requirements on quality of treated urban waste waters discharged into recipients in sensitive areas

Sensitive areas in the UWW Directive are understood as the surface water bodies which quality is deteriorated or potentially threatened in parameters Total Phosphorus (P_{total}) and Total Nitrogen (N_{total}) due to untreated or insufficiently treated urban waste waters. Therefore, it is necessary to secure higher level of treatment urban waste waters discharged by sewage system like secondary treatment of waste waters (determined by parameters and their values in the Appendix I, Table 1 of the Directive No. 91/271/EEC) for every discharge from agglomerations of more than 10 000 PE (Potential Equivalent). Requirements on quality of discharged water should be supplement by removal of nutrients on level of values N_{total} and P_{total} as stated in the Appendix I, Table 2 of the Directive 91/271/EEC (required qualitative level of treatment is presented in the Tab. 1 below). Based on local situation, there can be used one or both parameters and corresponding values of concentrations or values of percentile decrease of pollution. Alternatively, these requirements need not to be kept on outflow from every treatment plant, if it is proved that minimal percentage of decrease of total pollution from all urban waste water plants in this area is at least 75 % of P_{total} and at least 75 % from N_{total}. The Member State needs not to identify sensitive areas for purpose of the UWW Directive if the waste water treatment is applied in its whole territory as required for the sensitive areas.

Table 1. Requirements for discharge from urban treatment plants into sensitive areas prone to eutrophication

Parameter, size of agglomeration	Concentration*	Min. % of decrease of pollution**
Total phosphorus 10 000-100 000 PE >100 000 PE	 2 mg/l 1 mg/l	80
Total nitrogen *** 10 000-100 000 > 100 000 PE ****	 15 mg/l 10 mg/l	70-80

* average annual concentration, ** decrease in relation to pollution on inlet ***total nitrogen = sum of Total concentration of nitrogen (organic N + $N\text{-}NH_4$), nitrate nitrogen ($N\text{-}NO_3$) and nitrite nitrogen (NO_2), ****alternatively, daily average must not exceed 20 mg/l. This requirement applies for waste water with temperature ≥ 12 °C during operation of biological reactor of the treatment plant. Alternatively to condition of temperature it is possible to use limited time of operation that takes into account regional climatic conditions. This alternative is used if it is possible to prove that the paragraph 1 of Appendix I.D on use of reference methods for monitoring and evaluation of results is fulfilled.

More requirements as stated in the Table 1 and/or Table 2 of the Appendix I of the UWW Directive should apply if necessary, in order to ensure the compliance of values of qualitative parameters of surface water with requirements of any other EEC Directives.

Outflows of urban waste water treatment plants should be situated is such way that they should minimise the impact on recipient waters.

3. Method for designation of sensitive areas

Methodology approach to designate the sensitive areas is based on the analysis of impact of discharged urban waste waters on pollution of surface waters by nutrients (N and P) and thus especially to eutrophication potential of surface waters, respectively analysis of eutrophication of surface waters. By using this approach, there is ensured the protection of the surface water and its quality for purposes of its use (production of drinking water, bathing, support of natural occurrence of fish, etc.).

An important principle in identification of sensitive areas is, that the whole river basin is designated as a sensitive area in order to restrict the transport of nutrients to downstream sections of rivers, lakes or reservoirs, as they are due to character of flow regime more susceptible to development of eutrophication processes.

Designation of sensitive areas includes following steps:

1) Delineation of surface water bodies influenced by discharge of urban waste waters,
2) Delineation of eutrophic areas of surface waters (water bodies in category lakes, rivers),
3) Delineation of areas of surface waters (water bodies in category lakes, rivers) susceptible to eutrophication,
4) Delineation of the protected areas (Bathing Water, Freshwater Fish Directive and Drinking Water Directive),
5) Designation of sensitive areas.

Based on technical proposal of sensitive areas **there will be elaborated the evaluation of economic impacts on construction of urban waste water treatment plants.** Sensitive areas in the territory of the Member State will be set by generally obliged legislation.

3.1 Determination of locations (streams, surface water bodies) affected by discharge of urban waste waters

Selection of locations connected to designate the sensitive areas is made especially according to following criteria:

- Lakes and/or reservoirs, where urban waste waters are discharged.
- Rivers or their parts (water bodies) affected by discharge from agglomerations of size 10 000 PE and more.

- Protected areas of surface waters (an important criterion can be e.g. protection of drinking water sources in river basins upstream to abstraction object for drinking water use (especially, if they have increased content of NO_3).
- Surface waters (water bodies), where is necessary also other treatment except the one prescribed in the paragraph 4 of the UWW Directive, in order to fulfil requirements of other EC Directives and especially reaching the good status according to the EU Water Framework Directive,
- Downstream sections of rivers.

In selected locations, there is evaluated the quality, respectively the status of surface water bodies from the point of view of nutrients content or direct occurrence of eutrophication, expressed by the biological indices.

An information on contribution of urban sources of pollution to quality (nutrients contents) of surface waters provides the balance of total nitrogen and total phosphorus. This is conducted in according to data from monitoring of pollution sources. If they are not available, it will be calculated from theoretical knowledge on production of pollution and amount of discharged urban waste waters. Then, using data on river flows in recipient (e.g. Q_{365}/Q_{min}, Q_a) and its quality (upstream and downstream of the pollution sources) it is possible to evaluate the impact of pollution sources on recipient. Also, there can be calculated a total balance for the whole river or lake (basin, drainage area).

3.2 Determination of eutrophic areas in surface waters (water bodies in the category lakes, rivers)

Eutrophic areas of surface waters (surface bodies in category lakes, rivers) can be determined in several ways depending from available data. If the data on chlorophyll-a and/or concentration of nutrients are available, it is possible to use them for direct assessment of the eutrophication of the surface water bodies. However, if the concentrations of chlorophyll-a are not known, it is possible to calculate them by using simple or complex models as for example correlation relationship formulas (Hosper 1980, in Klapwijk 1998):

$$Chl\text{-}a\ priem. = -15{,}53 + 776{,}32 \times P_{celk.}$$

$$Chl\text{-}a\ max. = 1206{,}9 \times P_{celk}$$

The assessment (calculation) should be made for the reference time period that can be assumed as representative for a present state of the surface water bodies.

Note: Use of above mentioned formulas for calculation of average concentration of chlorophyll-a can lead (in case of very low content of total phosphorus – P_{total} (0,02 mg.l^{-1}) to negative values and in such a case expert judgement should be used.

If biological elements and their metrics that are sensitive on increased content of nutrients in surface waters are available, it is possible to directly determine the eutrophication in a given surface water body. These taxonomic communities and metrics use to be a part of evaluation of ecological status.

For evaluation of pollution cause by increased concentration of nutrients, there are selected those taxonomic communities of aquatic biota that reflect such impact as phytoplankton, phytobenthos and water macrophytes through specific evaluating metrics as for example, ratio of groups of cyanobacteria, concentration of chlorophyll-a and abundance of phytoplankton, IPS (index reflecting total pollution) and EPI-D (index detecting eutrophication processes in streams) for phytobentos; IBMR index for water macrophytes. Using such metrics, there is possible to determine the class of ecological quality for each element and surface water body.

Classes 1 and 2 mean that the water body is without risk of eutrophication. Classes 3 up to 5 mean, the eutrophication already occurred due to increased income of nutrients. This approach follows the Guidance document No. 23 on Eutrophication, is type specific and complies with evaluation of ecological status of surface water bodies.

Due to fact that there is not yet Classification system of surface water quality based on 5 classes in Georgia, it proposed to use the limit values as defined in the Slovakia (see Table below).

Table 2 Limit values for eutrophic waters

Parameter	Concentration	Class
N_{total}, mg/l	<6,5*	III
P_{total}, mg/l	<0,4*	III
Chlorophyll-a, µg/l	<30*	III

*Limit values for boundaries of the 3rd class quality for lowland rivers in Slovakia (classification schemes for ecological status assessment are type-specific).

Note: It can be a case that some of the surface water bodies in Georgia are characteristic with high level of salinity. This fact should be taken into account when assessing the nutrient status especially the phosphates removal (phosphate removal only is more usually required for discharges affecting freshwaters and nitrate removal for discharges affecting more generally saline waters). The balance of nitrate to phosphate in environmental waters can also influence eutrophication and it would be evaluated from case to case.

3.3 Determination of surface water bodies (lakes, rivers) potentially eutrophic

Surface waters are primary recipient of substances that are present in discharged waste waters from urban areas. These substances get to recipients through outlets as treated, respectively untreated urban, industrial waste waters or rain waters entering the sewer system. High load of nutrients entering surface water bodies (including reservoirs) lead to instant deterioration of water quality and of its use for supplying inhabitants by drinking water and other purposes, either as technological water for industries and/or irrigation.

The content of nutrients in rivers and lakes (reservoirs) is necessary to be monitored. Results of surface water quality monitoring in given reference period (e.g. one year or two years, the period used for evaluation of ecological status of surface water bodies as is assumed as representative) are necessary to be evaluated in the framework of sub-basin and followed by the overall river basin (district).

The evaluation of present state of surface water quality from the point of view of nutrient load is based on characteristic values (C_{90}, or Annual Average value – according to setup of classification schemes in Georgia) of $N\text{-}NO_3$, $N\text{-}NO_2$, $N\text{-}NH_4$ or N_{total} and P_{total}. Based on the requirements on water quality or classification schemes for evaluation of physical and chemical quality elements of quality of the ecological status, there is evaluated the load of surface waters by nutrients. The limit value as good status (Class II) of surface water bodies is decisive. If there are used classification schemes for evaluation of physical and chemical quality elements (supporting elements of evaluation of ecological status), evaluation is type specific and complies with the evaluation of ecological status.

Based on the results of evaluation, surface water bodies are divided to „Loaded by Nutrients“ (LBN) and „Unloaded by Nutrients“ (ULBN). The evaluation results for the surface water bodies is possible to summarize, as it is presented Table below.

Table 3. Evaluation of surface waters quality (nutrients) in reference period representing the present state of surface water body

Stream	Sampling location	River km	Type of load	Note – determining parameter (ecological status class)
			LBN	P-PO4 (Class IV)
			LBN	P-PO4 (Class V)
			ULBN	All nutrients parameters in Class I or II
			LBN	N-NH4 (Class V), P_{total} (ClassV)

Important note: It is necessary to know that at present time there is not developed classification system for the assessment of the ecological status of surface water bodies in Georgia. Based on this context, it would not be easy to use water body classes as basis for the designation of the sensitive areas. On the other hand, 5 water quality classes physico-chemical parameters used in Slovakia, may be applied as alternative in the first step in the designation of the sensitive areas.

4. Designation of sensitive areas

It is possible to identify the problematic streams, lakes, reservoirs (water bodies) as sensitive areas – as eutrophic or potentially eutrophic area, where eutrophication can develop unless relevant measures are adopted. The identification is based on above mentioned criteria (chapter 3), and requirements of the UWW Directive as follows:

- Eutrophic or could become in the near future without tertiary protection;
- Abstraction sources that have or could have high nitrate levels without tertiary protection;
- Other Directives need or already receiving tertiary protection.

The first two criteria relate to tertiary treatment requirements for the purposes of the UWW Directive. The third criterion those of Other Directives, is usually applied for the Bathing Water and the Freshwater Fish Directive, but potentially, it can be applied for any water quality directive whose waters are impacted by secondary treatment discharges.

Sensitive areas are those surface waters, where is possible to prove the impact of urban waste waters on increased content of nutrients in surface water bodies.

By the definitions, a section of river, eventually water bodies in a river basin become sensitive, where there occurs an increased impact of urban waste water on quality/status of surface waters or in other words, if the concentration of nutrients, respectively effects of eutrophication in surface waters due to discharge of urban waste waters is significantly increased.

The proposal of sensitive areas can be extended by other water bodies with defined priorities in order to fulfil objectives stated by Other Directives or to reach good status of surface water body. It is necessary to remember that sensitive area concerns the whole river basin from upstream to downstream. Sensitive areas can be summarised in the template form as it is shown in Table below.

Table 4 Sensitive areas in the River Basin District

Stream	Type of Sensitive Area	Starting point in river km	End point	River km	Length (km)	Area (km^2)
Alazani River – river without tributaries	Eutrophic water, designation of sensitive area is required	Below	Border with AZ			
Stori - tributary	Non-Eutropic water, designation of sensitive area is not required	Spring	Upstream Lechuri			
Stori - tributary	Eutrophic water, designation of sensitive area is required	Below Lechuri	Mouth			
Protected water areas*						
Name Protected area 1	Drinking water					
Name Protected area 2	Drinking water					

**Bathing Water, Fresh Water for Fish, Drinking Water*

Note: All surface water bodies in the territory of the state can be declared as sensitive area. There are also cases that inland Member States have not designated sensitive areas but announced that they will act as if their whole territory can be a sensitive area. It means that all agglomerations over 10 000 PE will have in agreed deadlines the tertiary treatment (removal of nutrients). The advantage of this approach is that there is not necessary to re-evaluate sensitive areas.

4.1 Basic data necessary for determination of sensitive areas in river basin district

For the purpose of the development of proposal of the sensitive areas in the river basin district, it is proposed to use following data:

1. To select 2 successive years as reference period with available data from monitoring (e.g. from the period 2014-2018) of surface water bodies in river basin, and eventually from monitoring of urban waste water discharges.
2. Water management map of river basin with hydrological network, river kilometres and coordinates of point sources of pollution (GIS referenced).

Case 1: The surface water quality data are available

The following data will be necessary in order to delineate sensitive areas in river basin there from monitored places – upper section of the main stream of specific river basin and its important tributaries, upstream of the agglomeration, downstream of the agglomeration, confluence of main stream and main tributaries, tributaries where agglomerations in river basin are situated:

a. Data on river flow discharges – average annual flow Q_a (m^3/s, l/s), in the main stream in the framework of river basin and its tributaries where agglomerations are situated;

b. Data on surface water quality – monitored biological quality elements (phytoplankton, phytobenthos, macrophytes (macroinvertebtrates only in case of rivers) – such metrics that are sensitive on the content of N and P - concentrations of chlorophyll–a (these concentrations can also be calculated by using formulas presented in chapter 3), concentrations of N_{total}, NO_3, NH_4, P_{total};

c. Data on volume (m^3/year, l/s) and quality (N_{total}, P_{total}) of discharged urban waste waters;

d. Data on agglomerations in pilot river basin – size (number of PE), position (location of outlet in relation to recipient) name of recipient, river km, GIS referenced coordinates, etc.

e. Map and the List of Protected areas in the river basin.

Case 2: Limited surface water quality data are available

If there are only limited data available or not measured, they may be technically estimated by using models or expert judgement with sufficient level of justification. The models will be used to estimate the loads of total nitrogen and total phosphorus from both point and diffuse sources of pollution. The loads values will be used to calculate the concentration values of N_{total} and P_{total} in surface waters and used for classification of the eutrophication state.

UWW discharges

The settlements with population higher than 2000 should be included in the assessment. The loads of N_{total} and P_{total} will be calculated for each of them. The following data will be used: settlement name, 13.5 g/capita/day N_{total} and 2 g/per capita/day P_{total} (expert judgement based on the ratio C:N:P in UWW). The annual loads in tonnes will be calculated by multiplying population number. Subsequently, concentrations of N_{total} and P_{total} in surface water body will be calculated by using flow rates (m^3/year).

Note for the industrial waste water discharges the concentration values of N_{total} and P_{total} may be calculated by using expert judgement based on the ratio C:N:P in industrial waste water discharges.

Note: In case that fish farms are located in the surface water body the following approach is proposed to be used as a basis for the estimation of nitrogen and phosphorus loads from aquaculture plants (Cho et al. 1991):

$$\boldsymbol{L} = 0{,}01 \ * \ (ICi - PCf)$$

L: phosphorus (P) or nitrogen (N) discharge to water body (tonnes/year)
I: food used (tonnes/year)
Ci: P or N content in food (%)
P: production (tonnes/year)
Cf: P or N content in produced organisms (%)

The total nitrogen and phosphorus values presented in the following table will be used. These figures are indicative for salmonid species production.

Case	*Total phosphorus content (%)*	*Total nitrogen content (%)*
Dry food	*1.2*	*7.5*
Fish	*0.45*	*3.0*

Source: Cho et al. 1991

When only statistics on production or food used were available, an assumption of the food conversion ratio (FCR) was applied. FCR is the ratio between the weight of food used (based on dry food) and the weight-gain of the organism (production), which is explained as follows:

$$\boldsymbol{FCR} = \frac{Food\ used\ (tonnes/year)}{Production\ (tonnes/year)}$$

The following default values were used for FCR: a value of FCR = 1.1 for big fish and FCR = 0.6 for fingerlings (these values are obtained from salmonid production under optimal growth conditions).

Diffuse sources of pollution

Fertilizers

The following steps will be applied to estimate the loads and concentrations entering the surface water body from applied fertilizers:

- Agricultural areas in the SWB drainage areas will be estimated (e.g. CORINE).

  Note: For avoiding overestimation of the nutrients loads (losses) by surface run-off only distance 500 m from the streams is recommended to be used for calculations (This assumption is due to limited volume of water reaching surface water body).

- Nitrogen and phosphorus (due to infiltration, plant uptake, adsorption, etc.) losses will be calculated from the total input loads (average application rate of nitrogen and phosphorus in Georgia) by using the loss coefficients 0.15 for N, and 0.03 for P, respectively.
- Finally, calculated losses in tonnes/year will be used to calculate the concentrations by using the average flow rates (m^3/year).

Livestock

The general assumption in this study is that all nutrients generated by livestock within a water body drainage area cause pressure on that particular drainage area (and relevant water body). In other words, the total number of bovine, ovine and poultry animals in each settlement within each drainage area is assumed to be affecting the water quality of the water body within that particular drainage area.

The input nitrogen and phosphorus values will be selected as presented in the table below (Sebek et. al., 2014).

Table 5. Loads calculation (N and P) caused by livestock.

Animal	N (kg/head/year)	P (kg/head/year)
Cattle		
Dairy cow	115	25
Young stock > 1 year	60	20
Average cattle	**87.5**	**22.5**
Sheep		
Breeding ewe	10.2	1.6
Other sheep	7.4	1
Average sheep	**8.8**	**1.3**
Goat		
Dairy goat	5.8	1.6
Other goats	3.1	1
Average goat	**4.45**	**1.3**
Poultry		
Laying hens	0.73725	0.1755
Broilers	0.37975	0.0835
Average poultry	**0.5585**	**0.1295**

Source: Sebek et al, (2014).

The following steps are taken to calculate N and P loads of livestock:

- Basin based bovine, ovine and poultry numbers will be obtained from the relevant databases (e.g. Statistical Year Book).
- Losses (due to infiltration, plant uptake, adsorption, etc.) will be calculated by using coefficients of 0.15 for N and 0.03 for P, respectively.
- Finally, calculated losses in tonnes/year will be used to calculate the concentrations by using the average flow rates (m^3/year).

For the impact assessment of the waste water discharges and diffuse sources by N_{total} and P_{total} on eutrophication data and information as presented above will be used by comparing with the limit values presented in chapter 3.

5. Conclusions and recommendations

Based on experience from Slovakia in designation of sensitive areas, it can be advised to use in the pilot river basin under the present project as follows:

- Proper delineation of sensitive areas is necessary for correct implementation of the UWW Directive;
- Data from national monitoring programme, surveys and other investigative projects can be used in the process of the identification of the sensitive areas;
- Existing classification system of surface water from on-going projects, where appropriate also Slovak classification scheme can be applied in Georgia for designation of sensitive areas;
- In principle, tertiary treatment of urban waste waters for all agglomerations of 10 000 PE and more does not increase total cost (sum of investment cost and operational cost) of waste water treatment plants. Even small increase of investment cost of waste water treatment plant is not decisive in process of construction of sewage system. In this stage, construction of sewer collectors makes about 80 % of total investment cost.
- Although the construction of urban waste water treatment plants itself mostly does not guarantee the good status of surface water bodies, treatment plants are one of the important components for its reaching. Here the treatment of waste water from big agglomerations plays a decisive role.

With the help of controlled discharge and treatment of urban waste water there is significantly increased not only the rate of hygienic aspects and comfort of human population, but also protection of surface water bodies and secondary also ground waters which are often important drinking water resources.

6. Literature

Directive 91/271/EEC of 21 May 1991 on urban waste waters treatment

Commission Directive 98/15/EC of 27 February 1998 amending Council Directive 91/271/EEC.

Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption.

Directive 78/659/EEC of 18 July 1978 on the quality of fresh waters needing protection or improvement in order to support fish life

Directive 76/160/EEC of 8 December 1975 on the quality of bathing water.

Directive 2000/60/EC Water Framework Directive

Klapwijk, S.P., Dijkstra-Stam, U.G., Fleuren-Kemilä, A.K., van der Vlugt, J.C.: Comparison of different methods to determine growth limiting factors for phytoplankton in the Reeuwijk Lakes (Netherlands), in „Eutrophication of surface waters in the Dutch polder landscape“, PhD. Thesis, LPEden, The Netherlands, 1998.

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Glossary

Except where indicated 'the Directive 'Articles', 'Annexes' and 'Table(s)' refer to the Urban Waste Water Treatment Directive 91/271/EEC

1 population equivalent: '1 Population Equivalent' is the unit of measure employed in the Directive for assessing the polluting potential of waste water discharges. 'Population' does not refer to a population headcount of communities. It is defined in the Directive as: *'1 p.e. (population equivalent)' means the organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen per day.* This means the oxygen used, largely by bacterial organisms, in breaking down the organic matter in waste water. The use of 'equivalent' is therefore a proxy for any organic matter, not just that arising from human metabolism, that when broken down by bacterial cultures utilises dissolved oxygen. The sensitivity of waters to discharges, such as if they are impacted by excess nutrients in discharges, may also need to be considered. See Article 2(6).

Agglomeration: An agglomeration is a community of homes, shops, hospitals, offices etc, and generally food and drinks industries which are sufficiently concentrated for their waste water to be collected and conveyed for treatment at a waste water treatment works. See Article 2(4).

Anaerobic digestion: 'Anaerobic' means 'without oxygen'. Processing of sewage sludge using this process refers to the use of bacterial cultures in the absence of oxygen to break down organic matter.

Appropriate treatment: The term used in the Directive to refer to the waste water treatment applicable to smaller communities. It can be involve processes* and/or disposal systems that ensure receiving waters meet water quality objectives set by environmental regulators can potentially mean no treatment to tertiary treatment. See Articles 2(9) and 7.

Bathing Water Directive: Introduced in 1975 to help protect bathers (in identified waters) from the harmful bacteria and viruses arising from sewage discharges largely. It sets microbiological and physico-chemical quality requirements for identified bathing waters. A revised Bathing Water Directive was adopted in March 2006 requiring higher water quality standards than the 1975 Bathing Water Directive.

Biochemical oxygen demand (BOD): A widely used measure of polluting potential – BOD is a measure of oxygen use or 'demand' of bacteria and other organisms breaking down the biodegradable load present in waste water. BOD is the basis for deriving a community's **population equivalent**. See Article 2(6) and Annex I, Table 1.

Biodegradation: The chemical deconstruction of organic matter by largely by bacteria, fungi and other organisms. When biodegradation occurs in the water environment dissolved oxygen is utilised generally through bacterial action. If acting on significant amounts of organic matter, such as that present in untreated waste water, the process rapidly deoxygenates waters and can lead to fish and invertebrate deaths.

Diffuse pollution: Pollution not arising from a specific, identifiable point. Agricultural land and brownfield sites are often cited as sources of diffuse pollution. Contrasts with **Point source pollution**.

Effluent: Generally, the treated waste water discharged from a sewerage system. Effluent from treatment plants is typically sampled and analysed to ensure discharged water complies with standards set in **discharge authorisations**. Where percentage reduction standards for parameters are to be achieved, effluent is sampled in conjunction with **influent** to enable reductions to be measured.

Eutrophication: Naturally occurring eutrophication is usually the beneficial enrichment of the environment by various mechanisms such as animal and plant decay, mineral and nutrient deposition from rock weathering and soil erosion, nitrogen-fixing by bacteria or lightning. The natural state of environments with low to high nutrient levels (their trophic status) are classed as: oligotrophic (low), mesotrophic (medium), eutrophic (high). Ecosystems associated with these naturally arising trophic states can be adversely impacted by nutrient inputs from human activities. For example, small inputs of nutrients to oligotrophic ecosystems can cause more damage than larger inputs to a mesotrophic environment and so on. 'Eutrophic' describes the status of waters chronically impacted by excessive nutrient inputs (for that ecosystem) from human activities. Eutrophic waters may usually be populated by plant and algal species that are better able to utilise excess nutrients and that are more tolerant of poor quality water arising from eutrophication, (such as low oxygen or light levels), and so outcompete other species. See Article 5 and Annex II (A)(a).

Parameter: In the context of waste water treatment and a **discharge authorisation** a parameter is a pollutant present in waste water that is to be controlled through relevant treatment, such as UV light irradiation to destroy bacterial or viral contaminants. Examples of other parameters that may need to be controlled are: **BOD**, named toxic metals or nutrients or sewage litter.

Pathogen: Disease causing agent, more generally referring to viruses, bacteria and protozoa, but can include microscopic invertebrates, fungi and alga.

Point source pollution: Pollution arising from specific identifiable points, such as the end of pipes discharging waste water. Contrasts with **Diffuse pollution**.

Primary treatment: Primary treatment involves the passive and/or chemically-enhanced process of settlement of suspended solids not removed by preliminary treatment. The Directive sets percentage reduction figures for biochemical oxygen demand of the influent by at least 20% and a reduction in total suspended solids in the influent by at least 50% before discharge to receiving waters. Discharges from agglomerations to inland and estuarine waters above 2,000 PE and coastal discharges above 10,000 PE to **normal waters** receive secondary treatment with more stringent **BOD** standards. Primary treatment standards are therefore generally intended to apply to discharges made to **less sensitive areas** provided comprehensive studies demonstrate a minimum of primary treatment would not impact the environment. See Article 2(7).

Secondary treatment: Secondary treatment is the biological treatment of waste water. It generally involves use of bacterial cultures to break down biodegradable matter in waste water. The objective of secondary treatment is to reduce the **BOD** of waste water to avoid chronic oxygen depletion in receiving waters, the immediate and most damaging effect of untreated sewage discharges to the environment. Various processes are used to achieve BOD reductions, such as: aeration of waste water with bacterial culture sludges to accelerate biodegradation of organic matter, often used for larger communities; trickle filter beds containing aggregate covered with bacterial cultures to maximise the surface area over which waste water is trickled, used for small to medium size communities. See Article 4 and Annex I, Table 1.

Sensitive area: A 'sensitive area' is a legally designated body of water. There are three criteria for their designation with the objective of (a) protecting water ecosystems from excessive nutrients; (b) protecting abstraction source waters from high nitrate levels and (c) 'flagging' other directives' waters that require tertiary treatment to achieve their parent directives' quality requirements. The common thread is that whatever the criterion, sensitive areas receive tertiary treatment protection from impacting discharges. See Article 5 and Annex II (A) (a), (b) and (c).

Sewage: The more commonly used term to refer to '*urban waste water*'. In general this report uses the term '*waste water*'.

Sewerage: Generally, a term to describe the network, or system, of pipes, and for larger systems, also tunnels, that collect waste water; their receiving drains, manholes, pumping stations, combined sewer or emergency overflows, screening chambers and waste water treatment plants. Sewerage ends at the point of discharge of treated or untreated waste water to the environment.

Suspended solids: This is a term used to describe the matter, both organic and artificial, such as **sewage litter**, suspended in water. See **Sewage solids** also.

Tertiary treatment: Treatment provided after preliminary, primary and secondary treatment. It is provided to address a variety of polluting agents so can take a variety of forms such as ultra-violet light irradiation (UV treatment), microfiltration or chemical dosing. The Directive uses the term **more stringent treatment** (then secondary treatment) to refer to tertiary treatment. The Directive does not set (environmental) quality standards for other directives' waters identified as sensitive areas – the Directive only sets emission standards.

ANNEX

THE EU DIRECTIVE NO. 91/271/EEC