SYSTEM DYNAMICS MODELLING:

THE KREMIKOVTZI WATER SYSTEM

by

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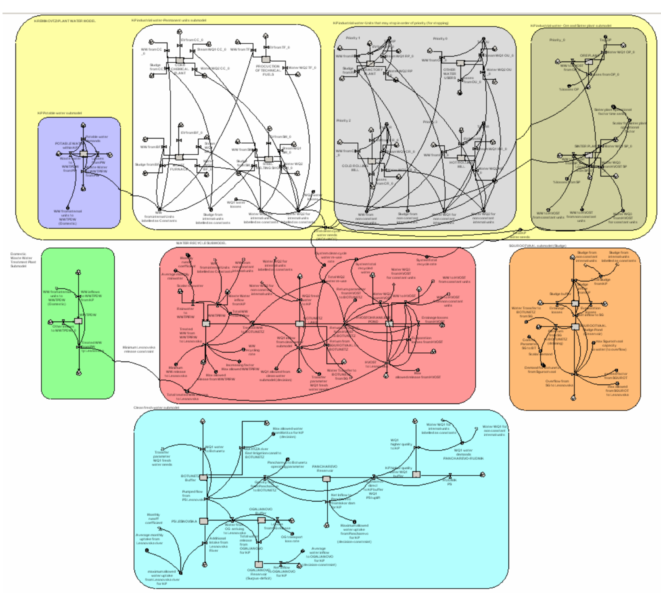

Report No: 2008/01

January, 2008

ABSTRACT

System Dynamics Modelling is a methodology for studying and managing complex feedback systems, typically used when formal analytical models do not exist, but system simulation can be developed by linking a number of feedback mechanisms. They are particularly useful for building, understanding and presenting models to non-engineers. In this report the procedure for developing conceptual and System Dynamic Modelling in participatory interdisciplinary context is presented, followed by a specific application case study, i.e. the conceptual model and SDM for the water system of Kremikovtzi in Sofia, Bulgaria.

Keywords: *System Dynamics Modelling, Water Re-use, Water Recycling, Complex Systems*

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1. Introduction

System Dynamics Modelling (SDM) is a methodology for studying and managing complex feedback systems, typically used when formal analytical models do not exist, but system simulation can be developed by linking a number of feedback mechanisms. Forrester (1961) introduced system thinking and SDM in the early 60's as a modelling and simulation methodology for long-term decision-making in dynamic industrial management problems. Since then, SDM has been applied to various business policy and strategy problems (Barlas 2002, Sterman 2000). Consequently it has proven to be very useful for the simulation and study of complex environmental (Ford 1999, Mulligan and Wainwright 2004, Mazzoleni et al 2004) and water systems (Simonovic 2003) in an integrated way.

Constructing, examining, and modifying System Dynamics Models (SDM) follows an iterative approach. Starting from conceptual qualitative models, simple quantitative models with few feedback loops and little detail are built, so as to allow the construction of an initial working numerical simulation model (Atanasova 2006). The working model can then be modified and improved as necessary to show the desired level of detail and complexity (Haraldsson & Sverdrup 2004).

AQUASTRESS-Mitigation of Water Stress through new Approaches to Integrating Management, Technical, Economic and Institutional Instruments (AQUASTRESS 2006a) is an EC FP6 IP project (2005-2009), comprising 35 international partners and 8 case studies, which differ considerably both in technical and spatial/societal terms. Some of the case studies involve agriculture/irrigation/water allocation issues, while others focus on urban/industrial water quantity/quality problems, the locations ranging from Northern Europe to Northern Africa. Most case studies involve re-cycling/re-use and/or re-allocation of water, whose water quality in turn varies over time and space.

Additional complications arise by occasionally incomplete data and by the need of introducing interactive participatory processes at every stage, leading to application-driven investigations. Each case study is considered to be a highly complex water system, where water management options technically available (e.g. water re-use, groundwater management, desalination etc), links, interactions and consequences, all aiming at water stress mitigation, are interlinked and hard to simulate separately, i.e. without taking into account their internal connections. Therefore in order to establish a common ground as well as a common approach from the engineering point of view, conceptual modelling and SDM have been applied (AQUASTRESS, 2006a).

In this report the procedure for developing conceptual modelling and SDM in participatory interdisciplinary context within AQUASTRESS is presented, followed by a specific application case study, i.e. the conceptual model and SDM for the water system of Kremikovtzi in Sofia, Bulgaria.

In order to build a model using standard SDM techniques system components have to be described as interlinked compartments (stocks), flows (directed links) and converters (influences) (Ford 1999). Over the years several SDM specialized software visual environments have been developed (Mulligan and Wainwright 2004), which enable the implementation and use of such models in a straightforward way, without the limitations of conventional programming languages, making the model accessible and understandable even to non-programmers. In this way SDM visual environments can be considered as suitable tools for developing models in a gradual, interactive and participatory way.

Mathematically all (or most) existing SDM visual environments are similar, as it can be seen in detail in previous WB4 reports and deliverables (AQUASTRESS 2005 Report WP 4.2.1, AQUASTRESS 2006b). Here SIMILE (Muetzelfeldt & Massheder 2003, www.simulistics.com) has been selected as the primary software platform for implementing the quantitative (numerical) model for Kremikovtzi, for two reasons: (a) it efficiently supports breaking the model into sub-models, thus facilitating the development process of very complex systems, and (b) it can automatically produce model documentation (code) in C++, thus making the model potentially re-usable for further specialized applications, if necessary. Additionally the VENSIM (www.vensim.com) graphical environment has been used for developing the qualitative conceptual/causal loop diagram of the system.

The Kremikovtzi case study is considered to be a highly complex water system, where water management options technically available (e.g. water re-use, reservoir management etc), links, interactions and consequences, all aiming at water stress mitigation, are interlinked and hard to simulate separately, i.e. without taking into account their internal connections (Vamvakeridou-Lyroudia et al, 2007). Therefore in order to establish a common ground as well as a common approach from the engineering point of view, conceptual modelling and SDM have been applied (AQUASTRESS 2006a).

2. SDM application procedure

Within AQUASTRESS a continuous interactive process is applied, between two different groups of participants. The first group consists of “experts”, who define, describe and suggest various “technical options” to be potentially applied for solving a problem (i.e. mitigating water stress) in specific case studies. It should be pointed out, that the group of experts is interdisciplinary, including non-engineers (i.e. from socio-economic disciplines). This fact alone adds to the complexity of the procedure, as far as mutual understanding is concerned. The second group comprises local “stakeholders”, who present the case study to the experts, together with initial suggestions for solving the problem, listen to further suggestions, react to them by accepting/ rejecting/modifying them and finally implement the “solution”. Obviously this process is strongly interactive, requiring mutual communication and understanding at all stages (Magnuszewski et al 2005).

As it has already been mentioned in the previous section, SDM has been applied for modelling the complex water system of the Kremikovtzi plant, according to the following step-by-step procedure:

1. Initially all (case study specific) technically available water management options available for improving water saving in the Kremikovtzi case study, have been defined and formally conceptualized in SDM terms by the Rheinisch-Westfaelische Technische Hochschule Aachen in Germany (RWTH) and the University of Exeter (UNEXE), completed in July, 2006.

2. Problem identification at system level for the water quantity and quality for the Kremikovtzi plant, together with the description of a dynamic hypothesis explaining the cause of the problem. This step requires interactive cooperation between "experts" and "stakeholders", which has taken place through various meetings between the University of Architecture, Civil Engineering and Geodesy in Sofia, Bulgaria (UACEG), UNEXE and RWTH.

3. The conceptual (qualitative) model (diagram for each system/case study is built, by combining and linking several technical options, again through an interactive procedure. (Completed Nov. 2006) The generic conceptual diagram for the Kremikovtzi water system (AQUASTRESS, 2006a) is considered to be the "building blocks" for the water system simulation

4. Consequently case study specific initial quantitative models (more than one- as it will be explained in detail in the following section for water quantity modelling) for Kremikovtzi (including numerical data and parameters), have been developed, in SDM visual environment/mode (SIMILE graphics environment) by UNEXE, which have been consequently revised and agreed upon by the other case study participants) and the stakeholders. The presentation to the local stakeholder panel has taken place in Nov. 21-23, 2006 during a meeting in Sofia. During the intermediate, interactive stage, several versions of the SDM models have been developed and revised, even using different graphics environment (VENSIM), before the final models and graphics environment were agreed upon.

5. The SDM models are updated, revised interactively, i.e. by technical meetings and discussions with the other case study participants (RWTH and UACEG), as well as by presenting and discussing intermediate models to the local stakeholders (Nov. 21-23, 2006), and by repeated meetings with specific local stakeholders (N. Savov, Kremikovtzi Ltd), gradually modifying and improving them through discussion and consent. This step took more than 6 months till June, 2007, when the final meeting between RWTH, UNEXE, UACEG and N. Savov took place in Sofia (June 21,22, 2007).

6. The final SDM models are being for generating alternative scenarios, exploring factors, policies and impacts, aiming at supporting the decision making process, as it is presented in detail in this report.

7. “Solutions” are selected and implemented. This step is planned for May 2008, after the workshop for the presentation of the model and the scenarios to the stakeholders.

At the end of the project, the SDM models will remain with the local stakeholders for further use.

Schematically the procedure for the application of SDM in Kremikovtzi is shown in Figure 1:

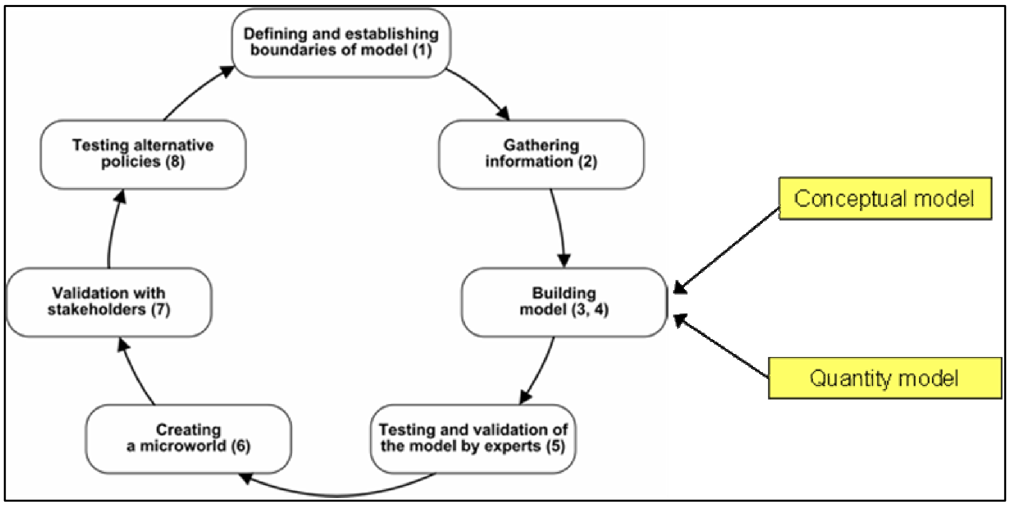

Figure 1: Schematic representation of SDM development for the Kremikovtzi case study

3. Conceptual diagram for the water management option involved for the Kremikovtzi case study.

As it has already been mentioned in previous reports (AQUASTRESS, 2006a) , the conceptual models (diagrams) of technically available water management options for all case studies within AQUASTRESS are the “building blocks” for each system (case study). Indeed, prior to any SDM or numerical modelling, all technically available water management options for all project case studies had to be selected, code named and schematically represented in a similar way, in terms which can be understood even by non-engineers.

The conceptual diagrams are independent of any specific software environment. They are schematic layouts representing the functionality of generic water management options, thus serving as introductory tools to the conceptual and SDM specific models for each case study. Although simple, these diagrams mainly conform to the semantics of SDM models. They contain: (a) stocks (compartments) representing water sources and water users, (b) directed arrows linking the components, and (c) “converters” i.e. processes affecting the volume (V), quality (Q) or mass transfer/conveyance (T) of water.

The conceptual diagram is shown in Figure 2, represents the technical option “Process optimization and recycling in industry”, which within the project has the code number

“3.3.2”. This technical option is part of the main building blocks of the SDM model developed for the Kremikovtzi plant case study.

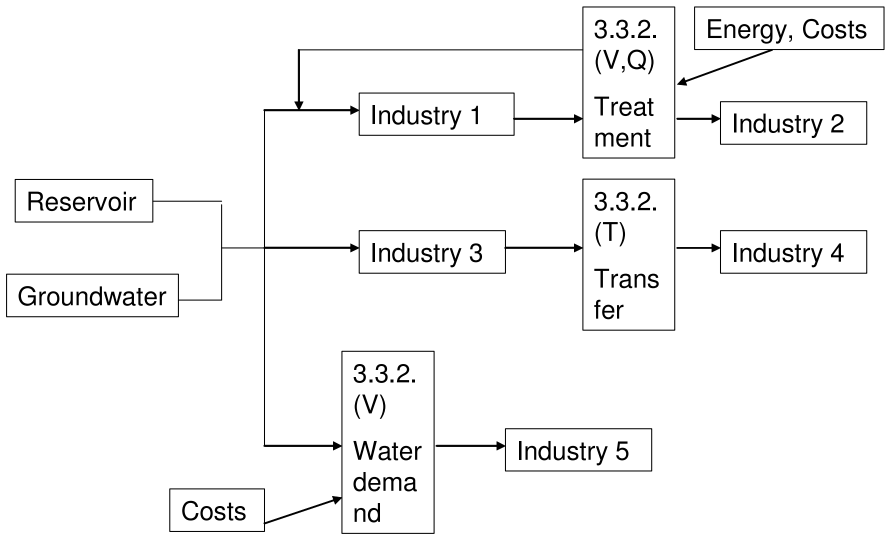

Figure 2: Conceptual model for the technical option “Process optimization and recycling in industry”

<u>4. The Kremikovtzi plant water system – Short description</u>

The Kremikovtzi plant, near Sofia, Bulgaria, initially constructed in 1963, was designed to support a complete metallurgical cycle, contributing nowadays to about 2% of the Gross Domestic Product of Bulgaria and over 10% of the Bulgarian exports to the EU. In terms of water use the plant is one of the biggest water consumers in the country.

The Kremikovtzi industrial water supply system is complex and consists of both fresh water and reused water sources. Apart from providing water for the metallurgical plant itself, the system also provides water for a number of satellite smaller plants, all sharing the same water resources. Some of the system fresh water sources are also used by urban and agricultural water users in the Sofia region, leading to regulations for priorities and upper limits to water consumption for industrial use, as well as water stress situations arising in times of drought.

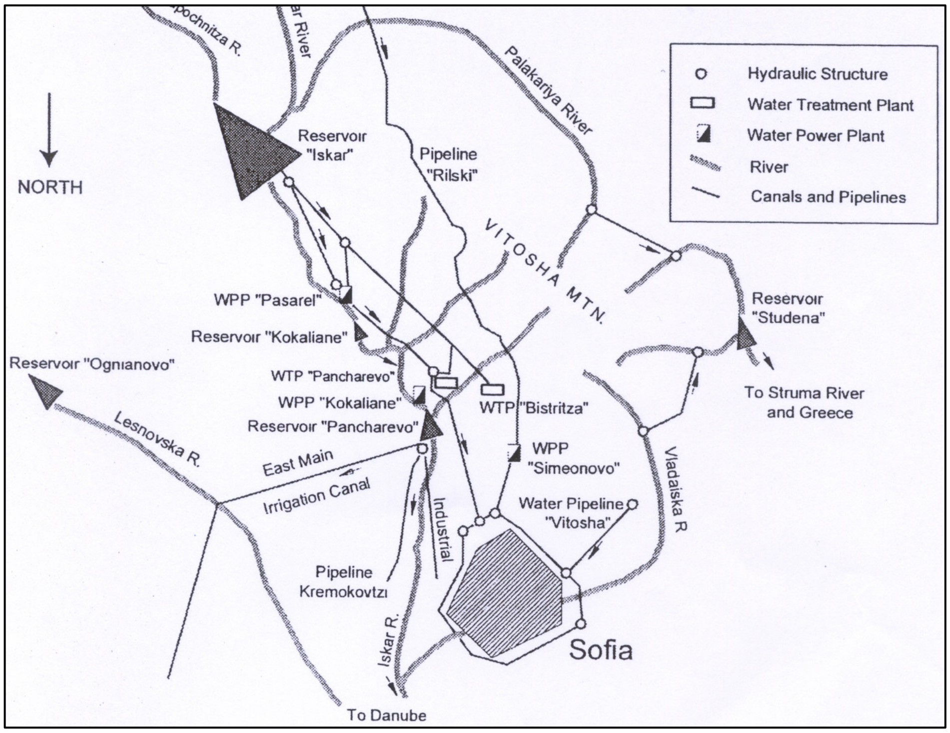

Figure 3. Map of Kremikovtzi plant and water resources in the Sofia area

Within the plant, fresh water is used for the following two types of turnover cycles (Dimova et al, 2007):

A. Clean cycle - for the cooling of machines and installations, where water is not in direct contact with the products of the manufacturing process. It can therefore be re-used for the clean cycle, after passing through cooling towers, whereas additional fresh industrial water is needed in order to compensate for expected and emergency water losses.

B. Dirty cycle - for the cooling of gasses and hot metals, where water is in direct contact with products. As a result its quality deteriorates (lower quality used industrial water). The processed water is mechanically treated in gravitational settlers, cooled and then reused again in the dirty cycle. Water losses in this case are compensated with water either from the clean cycle or with fresh industrial water.

The main quantity of industrial water used within the plant ($550x10^6$ m3 /year) belongs to both the clean and the dirty water cycle. However additional fresh water is needed in order to cover for turnover losses, for special industrial processes for which no reused water from the turnover cycles can be used and for the satellite industries, resulting in fresh total water consumption $50x10^6$ - $61x10^6$ m3 /year (roughly equivalent to the water needs of a city with a population of 600000). Additionally, potable water amounting to $5x10^6$ m3 /year, is provided by a separate drinking water supply system.

As it has already been mentioned the Kremikovtzi industrial water supply system is extremely complex (Fig. 4).

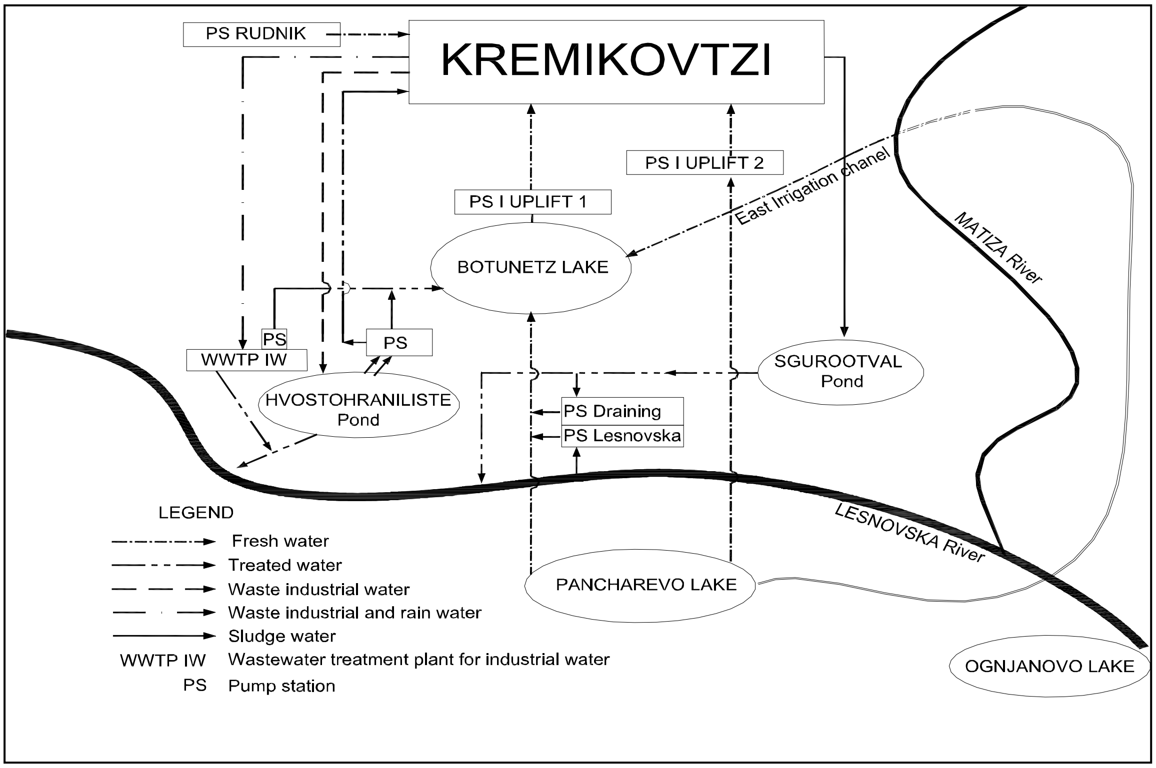

Figure 4: Schematic layout of the Kremikovtzi plant industrial water system (Source Dimova et al, 2007)

Clean fresh water for Kremikovtzi is being supplied by two reservoirs Pancharevo and Ognja-novo, two river intakes (Lesnovska and Matitza river respectively) and groundwater sources (Pumping Station -PS Rudnika). Industrial waste water is mechanically treated (removal of coarse matters, grit and oils) in the Waste Water Treatment Plant for Industrial and Rain Water (WWTPIRW), together with rain water drained from the site (surface runoff). Part of the treated industrial waste water is consequently collected in a specific small reservoir (Botunetz), acting as equalizer. There, treated waste water is mixed with clean water from the Pancharevo reservoir, and consequently supplied to the plant as part of the fresh industrial water supply system.

Industrial waste water from specific units, containing pollutants (e.g. phenol), which cannot be treated in the WWTPIW, are being lead separately to retention settling ponds (Sgurootvaal and Hvostohraniliste). Part of the excessive water from the ponds (after settling) is redirected to the industrial water supply system of the plant.

There exists also a separate drinking water supply system (not shown in Figure 4), while domestic waste water is treated partly at the Waste Water Treatment Plant for Domestic Water (WWTPDW) and partly at the WWTPIRW. All treated domestic waste water, as well as part of the industrial treated waste water (which is not being reused), together with excess water from the settling ponds is released to the Lesnovska river.

Industrial water sources	Type	Annual volume	%
Clean Fresh Industrial water of higher quality			
Pancharevo reservoir-direct to plant	Surface water	7200	12.93
Rudnik	Groundwater	3756	6.75
	Sum	10956	19.68
Fresh industrial water			
Ognjanovo reservoir	Surface water	6996	12.56
Pancharevo to Botunetz (Gravity)	Surface water	7824	14.05
Lesnovska River	River uptake	6804	12.22
Matitza River	River uptake	600	1.08
	Sum	22224	39.91
Reused industrial water for the fresh water cycle			
Hvostohraniliste	Settling Pond	1776	3.19
Sgurootval	Settling Pond	132	0.24
WWTPIRW to Botunetz	Treated waste water	20592	36.98
	Sum	22500	40.41
	Total	**55680**	**100.00**

Table 1: Fresh industrial water sources (average yearly) in $1000m^3$.

Table 1 shows the average yearly fresh water volumes required by the Kremikovtzi plant, along with the different water sources providing them. Although currently reused water amounts to 40% of all fresh water needs, the overall objective is to raise this percentage, while at the same time decrease the overall fresh water needs, by reducing water losses at the turnover cycles.

Other objectives include the study of potential scenarios for improved water management in normal, dry and very dry years, by simulating hierarchically potential stoppage for operational units and dry out, or reduced availability for various water sources. Additionally improved water management should aim at reducing lower quality excess (treated) waste water releases to the river.

It is obvious that the system is too complex for casually simulating operating scenarios, especially if the parameters of each scenario are to be understood and worked out by stakeholders (i.e. no mathematical modelling experts). Conceptual modelling and SDM proved to be the best working tool for achieving this purpose.

5. Conceptual model

The Kremikovtzi plant water supply system conceptual model has been developed using the stocks (compartments), directed arrows (flows) and converters, as described in section 3. It has been built gradually and interactively, with the groups of “experts” from UNEXE, RWTH and UACEG and “stakeholders” exchanging information and improving it. The final version (AQUASTRESS 2006a) is shown in Figure 5. It was completed in its final form in October 2006.

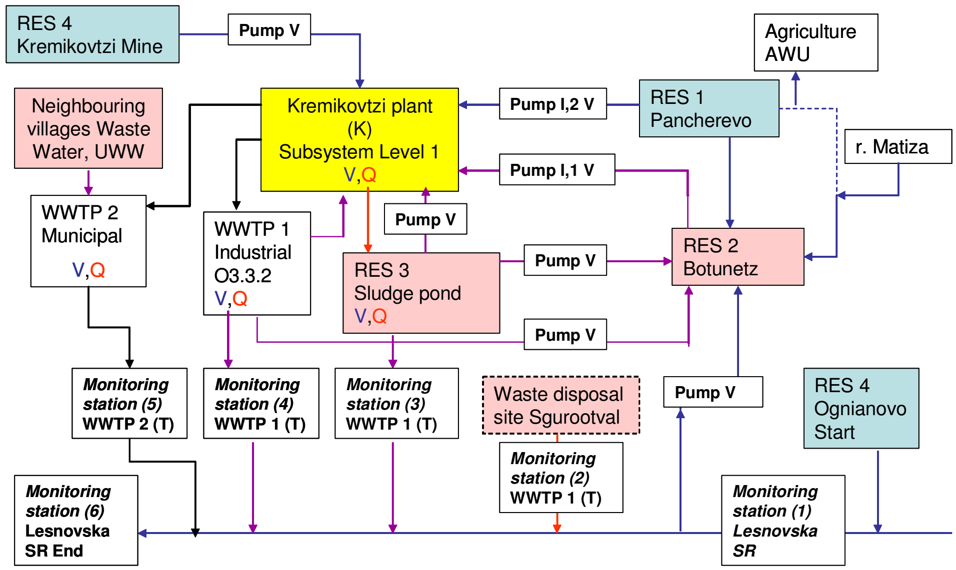

Figure 5: Conceptual model of the Kremikovtzi plant water system

Although the conceptual model refers to the schematic layout of the system, presented in Figure 4, it displays a different image, bringing forward the system component interactions, feedbacks and loops.

A central system component/compartment can be seen at the centre of the diagram, i.e. the Kremikovtzi industrial plant itself. The plant consists of several independent process units, operating in parallel, with different water demands. In the water supply system conceptual model they are combined as a single water user. However the detailed analysis of this internal subsystem has been performed separately (Dimova et al, 2007), and has been taken into consideration for the final SDM model of the system, presented in the following sections of this report.

Coloured components in Figure 5 represent clean and waste water sources (reservoirs), while the dotted line around Sgurootvaal pond denotes uncertainties (at the time) as to the functional role of this specific component (which have been defined at a later stage, when the SDM model was built).

It should also be mentioned that monitoring stations appear at the conceptual model, since they practically define the system boundaries, and will be useful for the numerical implementation and evaluation of the subsequent quantitative SDM model.

6. SDM model

6.1 Initial and intermediate SDM models

SDM modelling for the Kremikovtzi water supply system has been carried out using the SIMILE (Muetzelfeldt & Massheder 2003) and the VENSIM (www.vensim.com) visual environments.

There are two different types of fresh industrial water supplied to Kremikovtzi. The first type consists of higher quality clean fresh industrial water, required throughout the plant for specific processes (it will be conventionally called WQ1), while the second type of fresh industrial water is of lower quality, containing partly clean fresh water, and partly treated waste water from the industrial water treatment plant (WWTP ITW) or the sludge ponds, conventionally called WQ2.

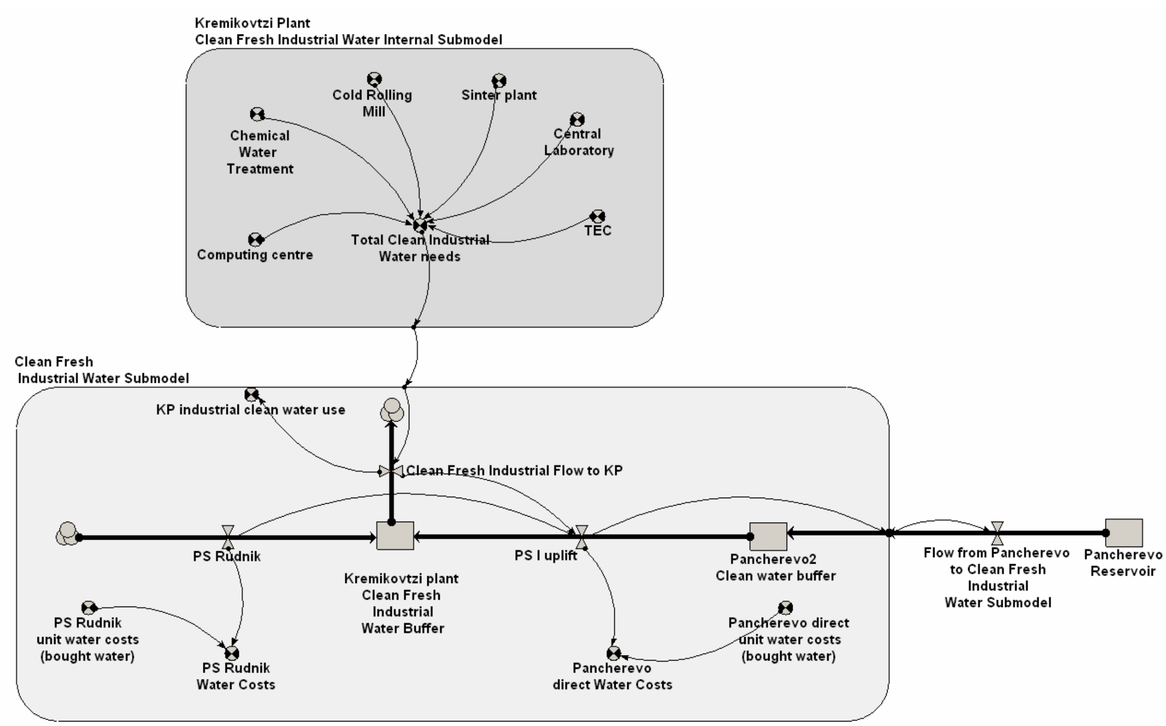

Figure 6: Kremikovtzi: System Dynamics Model for higher quality clean fresh industrial water system at an intermediate stage

Since mixture of the two types of fresh water is unlikely to happen, it has been decided initially to simulate the Kremikovtzi industrial water supply system by breaking it into two separate models, i.e. the fresh clean higher quality water system-WQ1 (Fig. 6), providing about 20% of the fresh water needs (Table 1), and the fresh lower quality one-WQ2 (80% of water needs), the latter including wastewater treatment plants and water reuse (Fig. 7). The two Figures 6 and 7 show respectively the SDM models for WQ1 and WQ2, as they were in May 2007, at an intermediate stage, in the development of the model. Apart from these versions, there have been previous versions of the SDM model (November 2006), which have been gradually improved over the months (Vamvakeridou-Lyroudia et al, 2007).

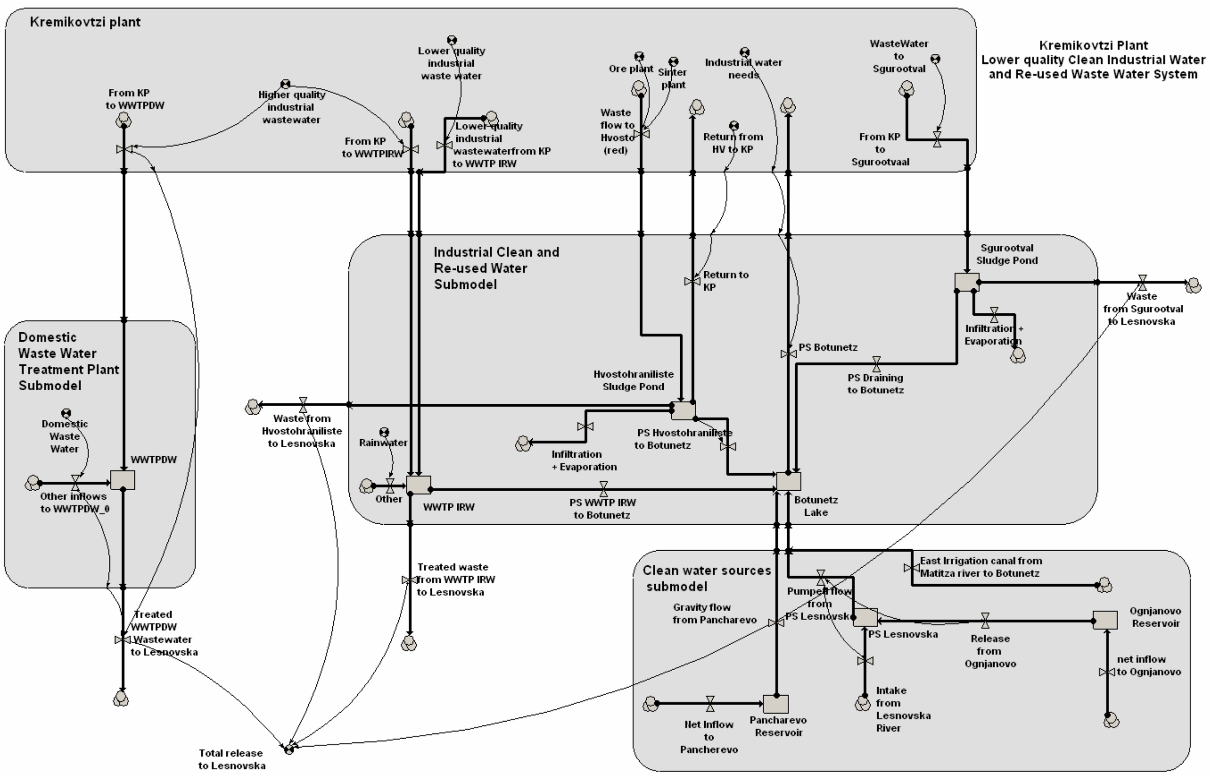

Figure 7: Kremikovtzi: System Dynamics Model for lower quality clean fresh industrial water system and recycled water at an intermediate stage

However the two water systems are interconnected, since waste water flow (and consequently water reuse) is partly determined by the total water demand at the higher quality water system. The initial connected SDM model has been developed using the VENSIM visual environment, again in November 2006 (Figure 8). The different colours of the system components at this Figure (Fig. 8) denote the different types of water/waste water, i.e. blue for the higher quality fresh industrial water, pink for the lower quality fresh industrial water and red for the waste water.

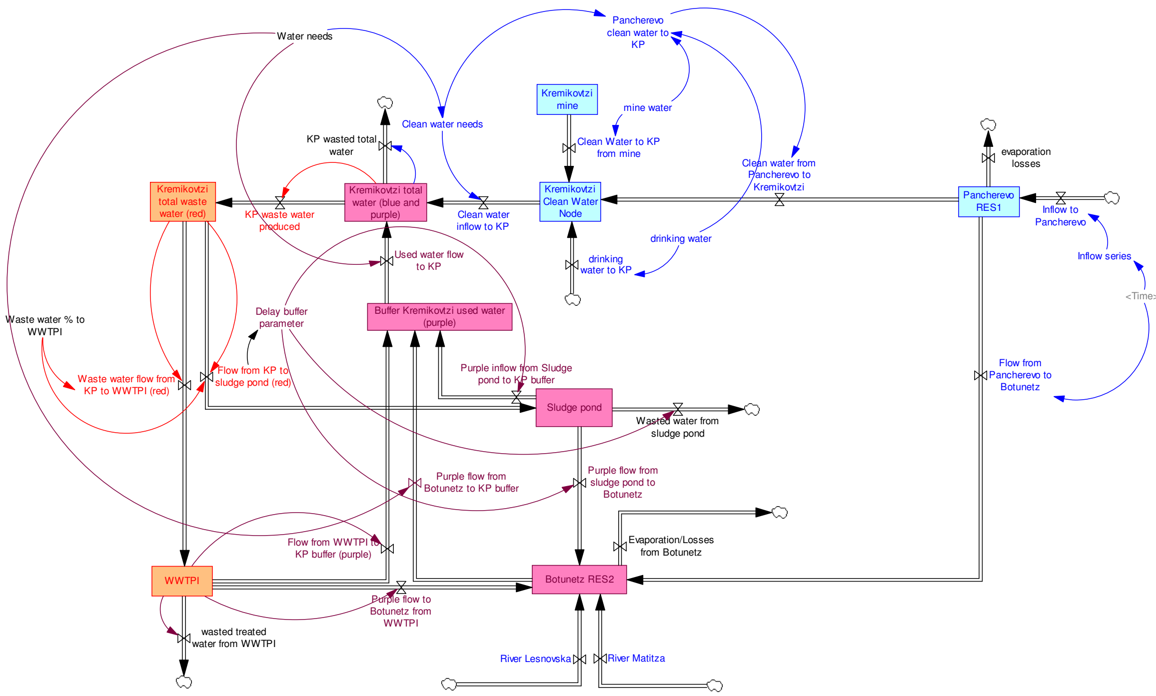

Figure 8: Interconnected SDM, using the VENSIM visual environment at an intermediate stage (November 2006)

6.2 Causal loop diagram

The causal loop SDM diagram for the Kremikovtzi plant water system is presented in Figure 9. It shows all system entities (stocks, variables, parameters and flows), together with their respective interconnections and interactions, in a qualitative way. This diagram has been drawn using the VENSIM© software tool (www.vensim.com). The causal loop SDM diagram and model will be uploaded at the Centre for Water Systems, University of Exeter website (www.ex.ac.uk/cws) from January 2008, with free access.

According to causal loop SDM semantics, in this diagram, arrows with positive (+) or negative (-) sign close to the arrowhead represent positive/negative directed influence respectively between two entities, if all other entities are assumed to be constant. For instance, if “External inflows from Iskar dam” increase, then the status (volume) of “PANCHEREVO RESERVOIR” will increase (improve), hence the positive sign to the arrowhead connecting these two entities. By contrast, if water demands for “Other users” increase, the status (volume) of “PANCHEREVO RESERVOIR” will decrease, i.e. the sign of the arrowhead connecting them is negative.

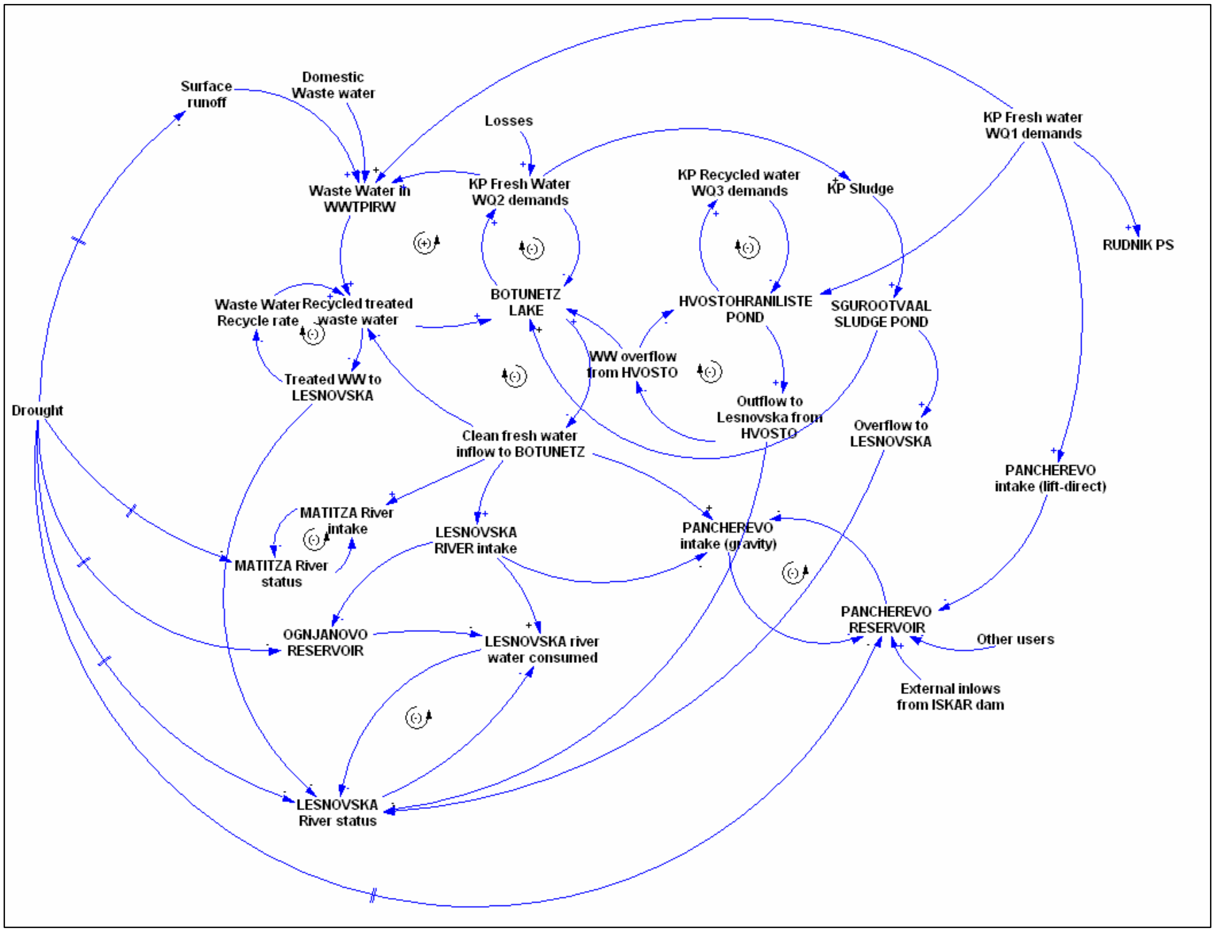

Figure 9: Causal loop diagram for Kremikovtzi water system

In a similar way, loops in the diagram are assigned positive (+) or negative (-) polarity. For example, if “LESNOVSKA river water consumed” increases (i.e. if more water is taken from the river), the “LESNOVSKA river status” (available/remaining water flow) will decrease (-). Any decrease of the “LESNOVSKA river status” means that less water will be available for uptake, i.e. it will reduce the entity “LESNOVSKA river water consumed”. It is obvious that these two entities (“LESNOVSKA river status” and “LESNOVSKA river water consumed”) interact with each other. In causal loop semantics, this means that they form a loop with negative (-) polarity, because they affect each other negatively.

The causal diagram may contain, as is the case with Kremikovtzi, also indirect influences. They are denoted with a broken influence arrow (╫) on the diagram. The “drought” is such an indirect influence element. It influences other entities (e.g. rainfall and surface runoff) indirectly, by affecting their properties. During the numerical implementation of the model (quantitative SDM), these entities are taken into consideration by adopting and running different scenarios. By including them at the causal loop diagram, the engineer/end user has the opportunity to study and graphically represent their impact conceptually.

Although causal loops diagrams can only give a qualitative image of the system and its interconnections, by studying and deciphering those, end users and stakeholders can make and check assumptions about influences among entities, feed back mechanisms and degrees of complexity (loops/trees). Results and conclusions drawn out of the causal loop diagram affect the development of the quantitative lead to the development

With the use of the causal loop model, tree-like diagrams, showing causalities for various entities can be drawn. In this report, some representative causality trees are shown (it is impossible to include them all, because the system is complex with many entities and interactions), while all of them, for each and all entities of the causal SDM model, can be produced by running the model.

For each entity in the Kremikovtzi causal loop model, two different causality trees can be drawn. The first, called “causes tree” represents the entity in question as the end of the tree and includes all the elements (entities) that influence it. The second tree-like diagram, called “uses tree” has the entity in question at its head, and shows all other entities influenced by it.

For example, Figure 10 shows the “causes” tree for Botunetz, while Figure 11 shows respectively the “uses” for the same entity (Botunetz lake).

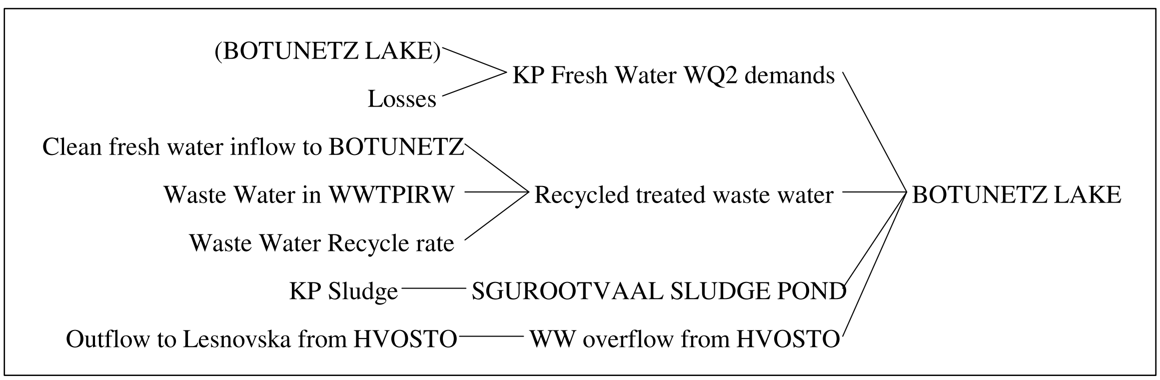

Figure 10: “Causes” diagram for Botunetz Lake entity

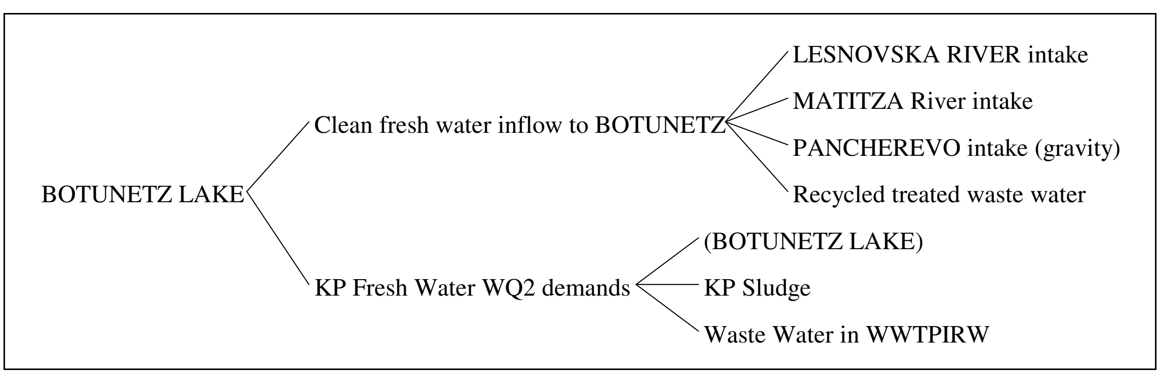

Figure 11: “Uses” diagram for Botunetz Lake entity

In all causal tree diagrams entities in parenthesis, i.e. (BOTUNETZ LAKE) in Figure 11, denote that this entity appears (at least) twice in the tree, and is therefore contained in a loop, as indeed can be seen in the causal loop model presented in Figure 9.

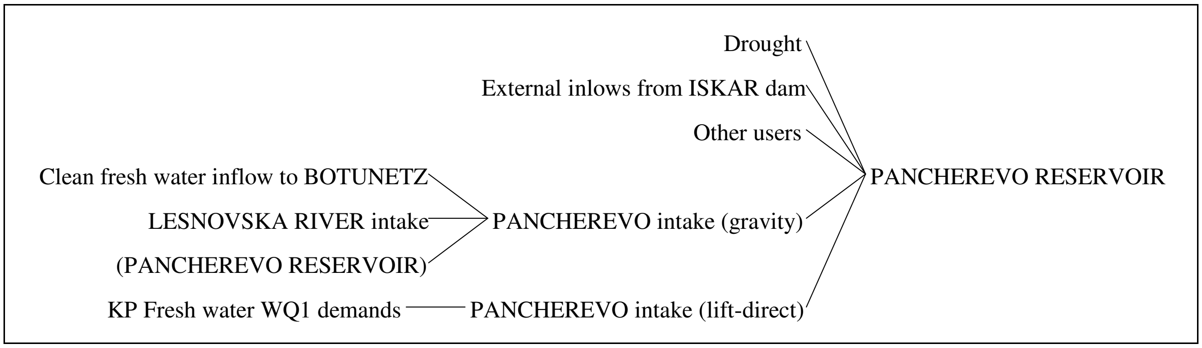

Figure 12: “Causes” tree for Pancherevo reservoir.

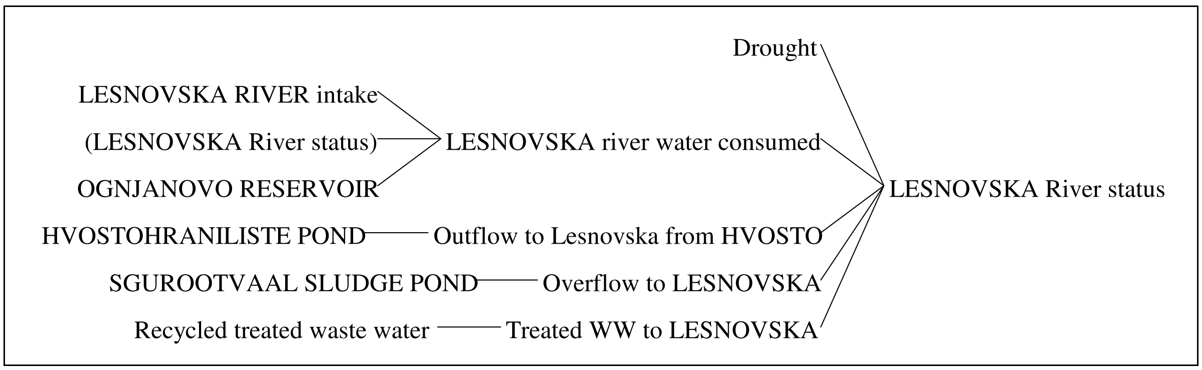

Figure 13: “Causes” tree for Lesnovska river.

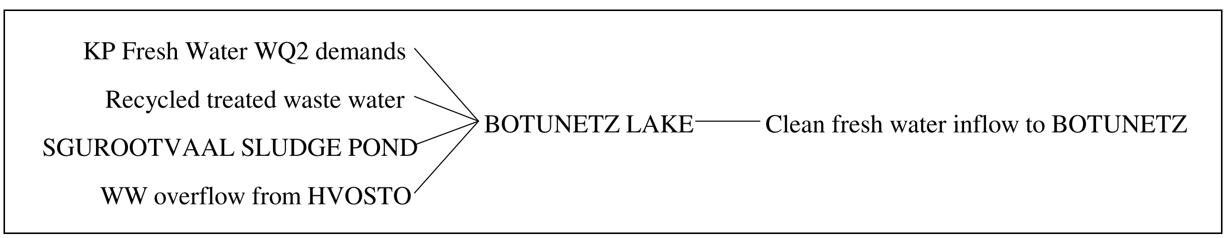

Figure 14: “Causes” tree for “clean fresh water to Botunetz” entity

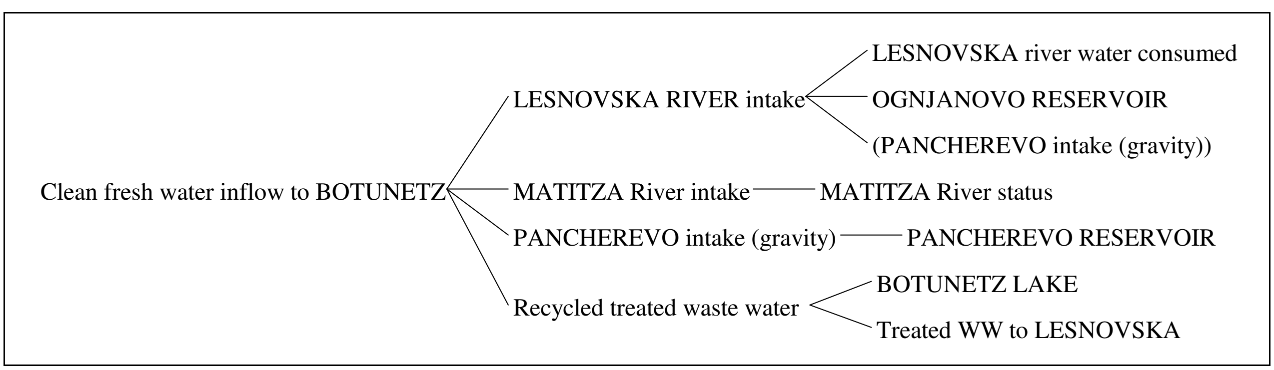

Figure 15: “Uses” tree for “clean fresh water to Botunetz” entity

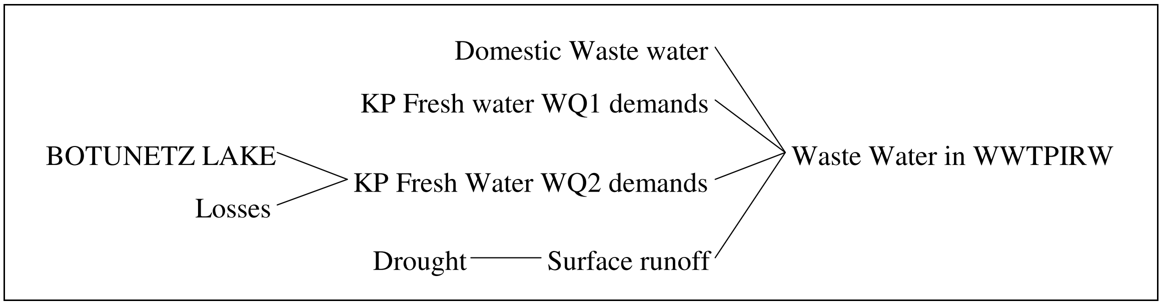

Figure 16:“Causes” tree for “Waste water in WWTPIRW” (waste water treatment plant)

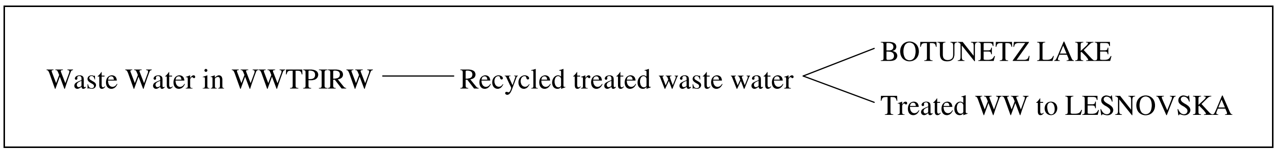

Figure 17: “Uses” tree for “Waste water in WWTPIRW” (waste water treatment plant)

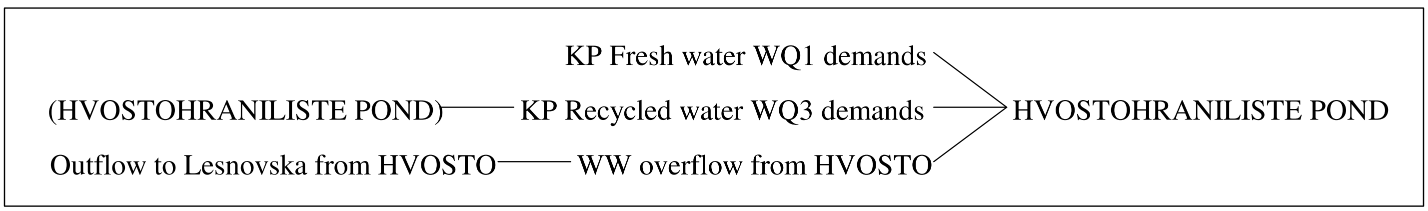

Figure 18:“Causes” tree for “Hvostohraniliste sludge pond”

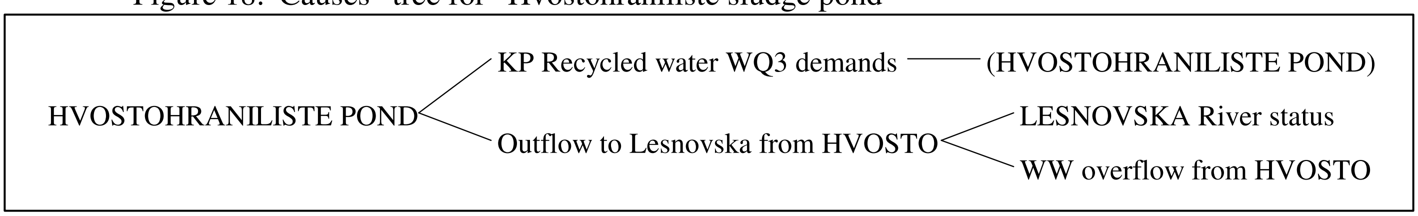

Figure 19: “Uses” tree for “Hvostohraniliste sludge pond”

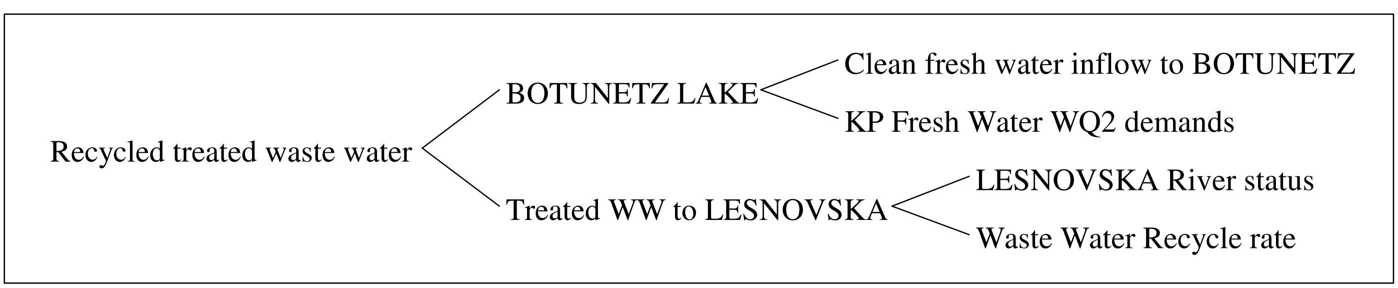

Figure 20:“Causes” tree for “recycled treated waste water”

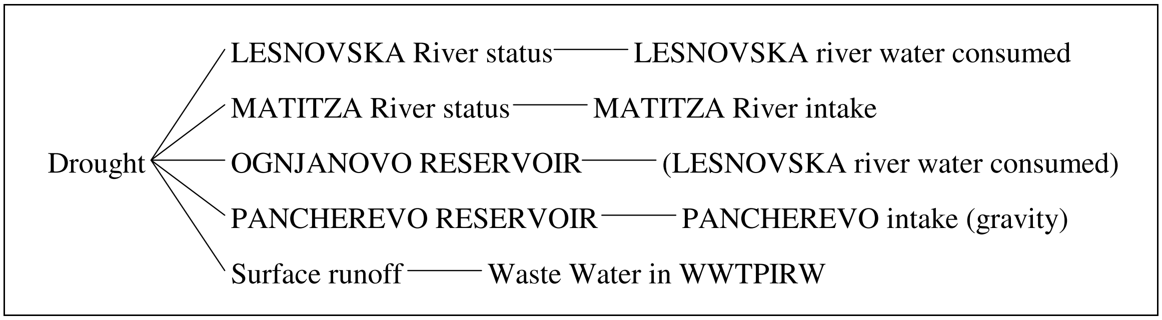

Figure 21:"Causes" tree for "drought", an entity that indirectly (through scenarios) affects other system elements

6.3 Final SDM model

The SDM model for the Kremikovtzi plant water system has been further developed and finalised in the summer of 2007 (June/July), after a last meeting between experts (UNEXE, RWTH, UACEG) and stakeholders (Sofia, 21-22 June 2007).

The final version is richer in detail. Each internal unit of the plant has been simulated separately, the system as a whole has been interconnected into one model, while several parameters have been added, in order to simulate complicated operating conditions.

The total SDM model is presented in Figure 22. In January 2008, this model will be uploaded at the Centre for Water Systems, University of Exeter website (www.ex.ac.uk/cws), with free access.

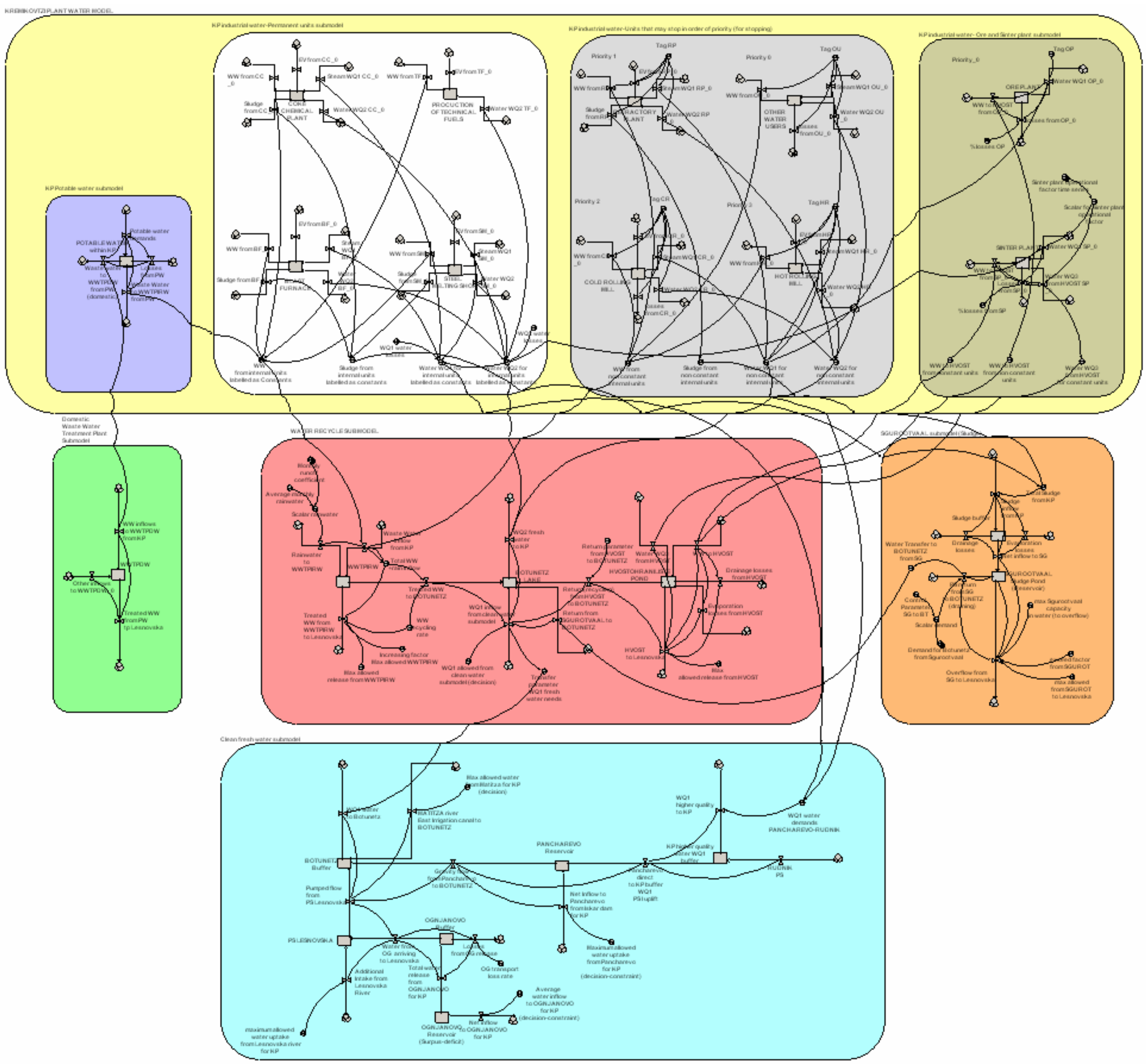

Figure 22: Final complete SDM model for Kremikovtzi plant-Total view

The final SDM consists of interconnected submodels. The lower submodel (in blue) represents the "fresh water sources" submodel. The middle row red submodel refers to "recycling", the orange middle row submodel to the right, simulates the Sgurootvaal pond, the green middle row submodel to the left stands for the WWTPDW plant (Domestic water treatment plant), while the whole upper row submodel (yellow) simulates the various Kremikovtzi plant industrial units and water demand points (internal units submodel).

The submodel for the internal units, consists in turn of four sub-submodels (from left to right): The potable water submodel to the left (blue), the submodel for the constant units (white) (i.e. units that may not stop under "very dry" scenarios, the non-constant units submodel (grey), and finally the Ore plant/Sinter plant submodel (brown) to the right end, simulating the units that connect to Hvostohraniliste pond.

Due to the large number of model components and parameters, it is impossible to present the whole model as a single graph with larger fonts in this report. Therefore in the following figures, each submodel will be shown separately, so as to ensure that all legends are legible.

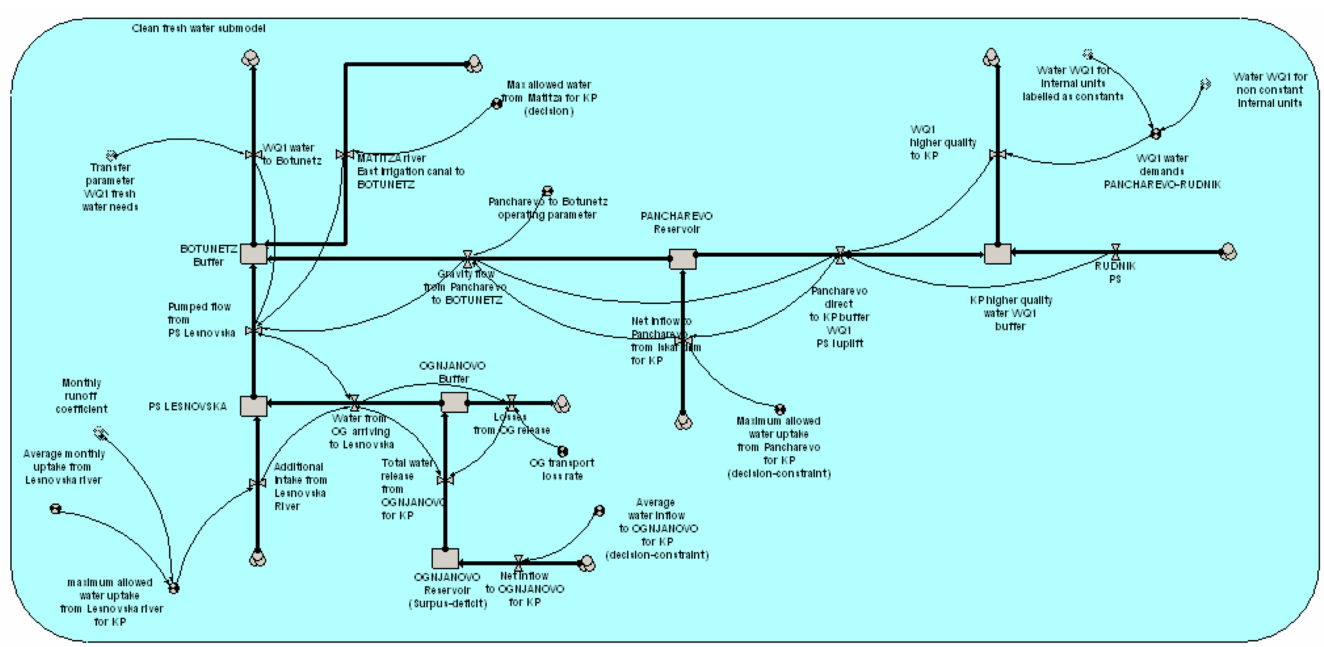

Figure 23: SDM model for Kremikovtzi plant-Clean fresh water submodel

The clean fresh water submodel is presented in Figure 23. The stocks for the two reservoirs Ognjanovo and Pancharevo can be seen, as well as the uptake from Lesnovska (PS LESNOVSKA). Rudnik and Matitza are presented as flows, while the Botunetz buffer and the higher quality buffer are needed for computational reasons. This submodel is controlled by demand, i.e. water demands from the Kremikovtzi plant are transferred through transfer parameters from the other submodels.

The Pancharevo reservoir is constantly connected to the KP higher quality buffer, while its connection to the Botunetz lake buffer is controlled by an operating parameter, which may be turned on/off, according to the scenario examined.

It is worth mentioning that the inflows to the Pancherevo stock simulated within the SDM are not the actual inflows of the Pancherevo reservoir, because of the special role of Pancharevo within the actual Kremikovtzi system: Indeed Pancharevo also supplies with clean fresh water the Thermoelectrical plant (TEC), which is a major consumer of WQ1 fresh water. However TEC is not owned by the Kremikovtzi company-it is a separate consumer, whose needs and operational modes are not included in this case study. Accordingly it cannot be included to the SDM, or the scenarios. Therefore the "inflows" into Pancharevo modelled in the SDM, actually represent the maximum allowed water for the Kremikovtzi plant from this reservoir. In the same way, Ognjanovo inflows represent in reality the maximum allowed water to be taken out of Ognjanovo for Kremikovtzi, and are based on measurements in the period 2000-2006 (Dimova et al, 2007)

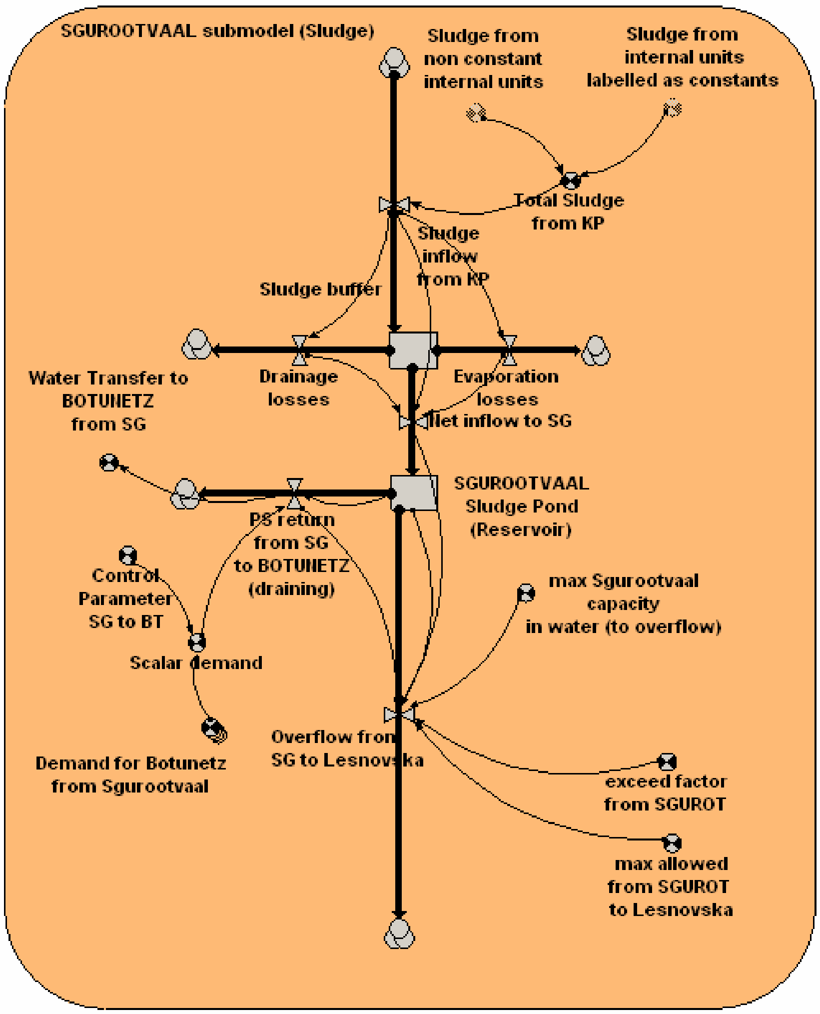

Figure 24: The Sgurootvaal sludge pond submodel

The Sgurootvaal sludge pond submodel is presented in Figure 24. Sludge enters this submodel both from the constant and non-constant industrial units of the Kremikovtzi plant. Evaporation and drainage losses, which are propotional to the inflow are simulated through a buffer, while the pond stock (in the middle of the diagram) overflows to Lesnovska. Overflows are controlled by the capacity of the pond, the maximum allowed releases from the pond and an exceed factor, which can be set by the user at will, in order to overcome the maximum release constraint.

Although there is a connection for waste water overflowing also to Botunetz, in all scenarios examined during this study, the control parameter has been set to off mode, i.e.

returns from Sgurootvaal to Btunetz are not allowed, because of the low quality of the waste water contained in the pond.

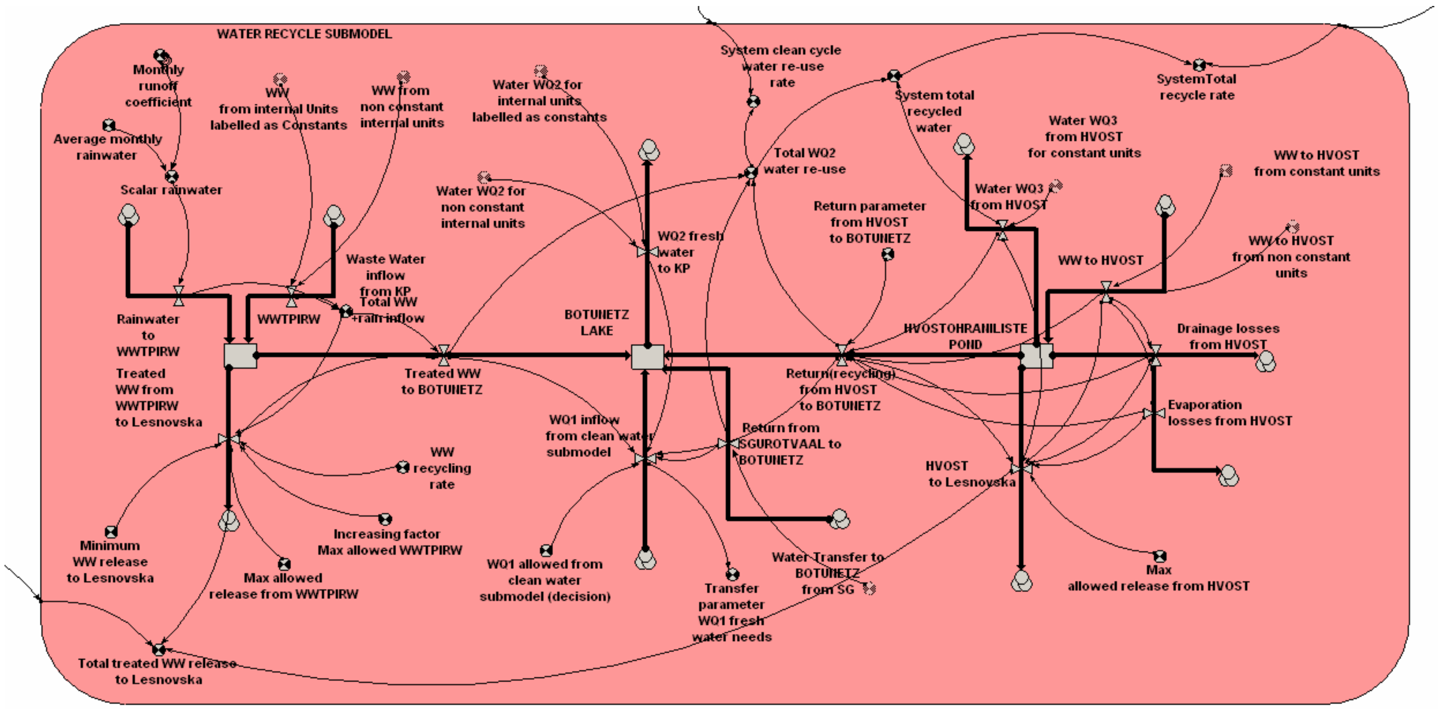

Figure 25: The water recycle submodel

The water recycle and re-use submodel is presented in Figure 25. It should be noted that this submodel is the core of the whole model, i.e. the most important submodel, on which most scenarios will differentiate, resulting in different recycling rates, recycled water use etc.

There are three stocks in it, each representing respectively the WWTPIRW, the Botunetz lake and the Hvostohraniliste pond.

WWTPIRW receives waste water from surface runoff (rainwater) and the plant internal units. Domestic waste water, which also reaches WWTPIRW from the potable water subsystem, is included in the “WW from internal units labelled as constants” parameter. From WWTPIRW treated waste water either returns to Botunetz for recycling, or is being released to the river Lesnovska. Releases to Lesnovska are controlled by 3 parameters set by the user: (a) waste water recycling rate – a major decision parameter (b) the minimum treated waste water release to Lesnovska – sustaining minimum releases to the river in “very dry” scenarios and (c) maximum allowed releases – which can be overcome by the “increasing factor” parameter.

The Hvostohraniliste pond receives waste water from the ore and sinter plant (internal units submodel), and returns WQ3 (lowest quality treated waste water) to them. After evaporation and drainage losses are estimated, waste water may either be released to Lesnovska, or return to Botunetz for recycling in "dry" and "very dry" scenarios, controlled by an on/off return parameter.

Botunetz lake is the main stock/element of the whole system, providing fresh water of lower quality (WQ2) to the Kremikovtzi plant internal units. The amount of water returning to the plant from Botunetz is controlled by the demands of the internal units submodel. Botunetz receives clean fresh water (WQ1 quality) from the fresh water submodel, treated waste water from WWTPIRW and (potentially) treated waste water from Hvostohraniliste (should the scenario allow it). Botunetz could also potentially receive waste water overflows from Sgurootvaal – the link exists in the model, although it is not an acceptable operational condition for any of the scenarios examined.

Apart from calculating all the flows in and out of the submodel stocks, the model calculates also some additional useful parameters: The total waste water releases to Lesnovska, the total volume of lower fresh water WQ2 used by the system, the system total clean cycle water re-use rate (as the ratio between the total WQ2 fresh water used in the units and the total clean water needs (WQ1 and WQ2), and the overall system recycle rate (where all recycling – including returns from Hvostohraniliste directly to the plant) are taken into account. The latter is a main parameter characterising the various scenarios examined. It should be mentioned that, generally speaking, the total recycling rate is much lower than the recycle rate for WWTPIRW set by the user. For instance in some "very dry" scenarios, where the WWTPIRW recycling rate is set to 95%, the actual overall recycling rate for the system does not exceed 60%. This is due to the fact, that whatever happens, come internal units will need clean fresh water of the highest quality (WQ1), mainly for steam production, which cannot be reduced.

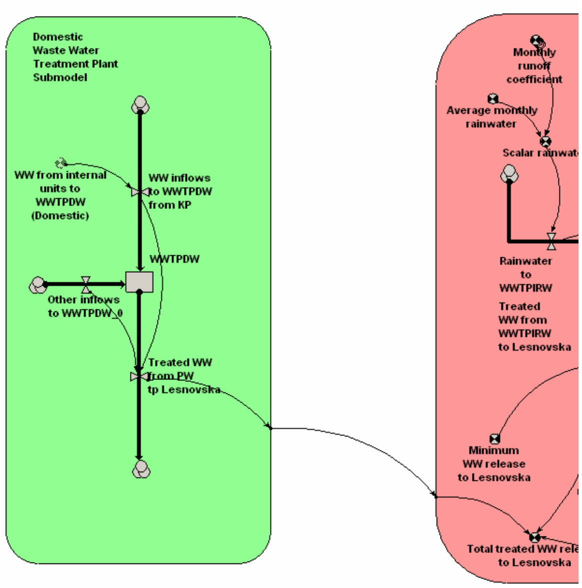

Figure 26: The domestic waste water treatment plant submodel

The Waste Water Treatment Plant for Domectic Water is shown in Figure 26. This is the smallest of submodels and has only been included in the SDM for the industrial water in order to compute accurately the total releases of treated waste water to Lesnovska, represented by the connecting arrow to the water reuse submodel.

The following submodels are all part of the Kremikovtzi internal units submodel, shown in Figure 22.

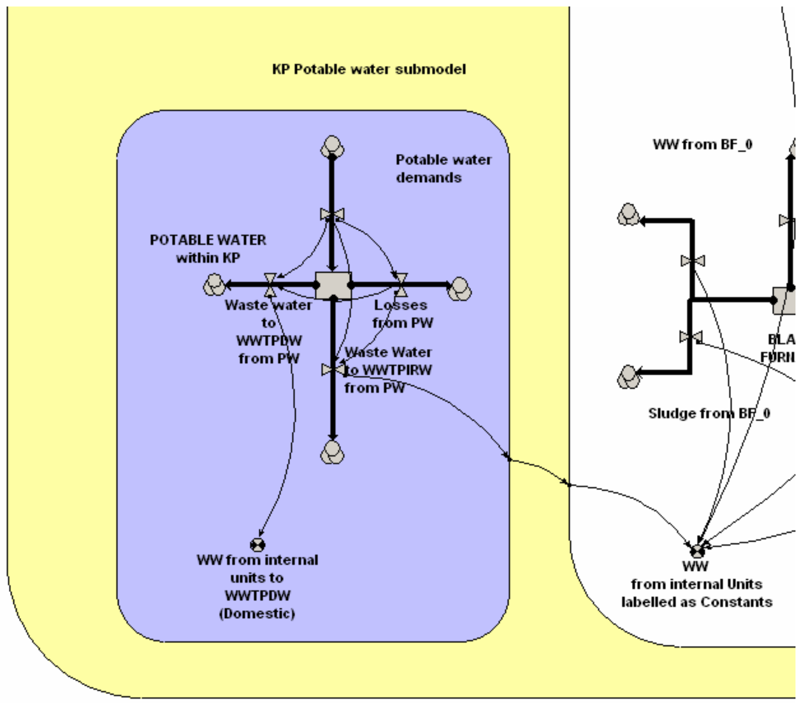

Figure 27: The potable water submodel

The potable water submodel has only been included in the SDM of the Kremikovtzi industrial water system for similar reasons, as the WWTPDW submodel, i.e.in order to simulate the part of potable waste water (50%) which is treated by the WWTPIRW, which is represented by the arrow connecting this submodel to the "internal units labelles as constants" submodel. Water losses for potable water are estimated at 10%, thus meaning that 90% of the potable water quantity ends up as waste water at the WWTPDW or the WWTPIRW.

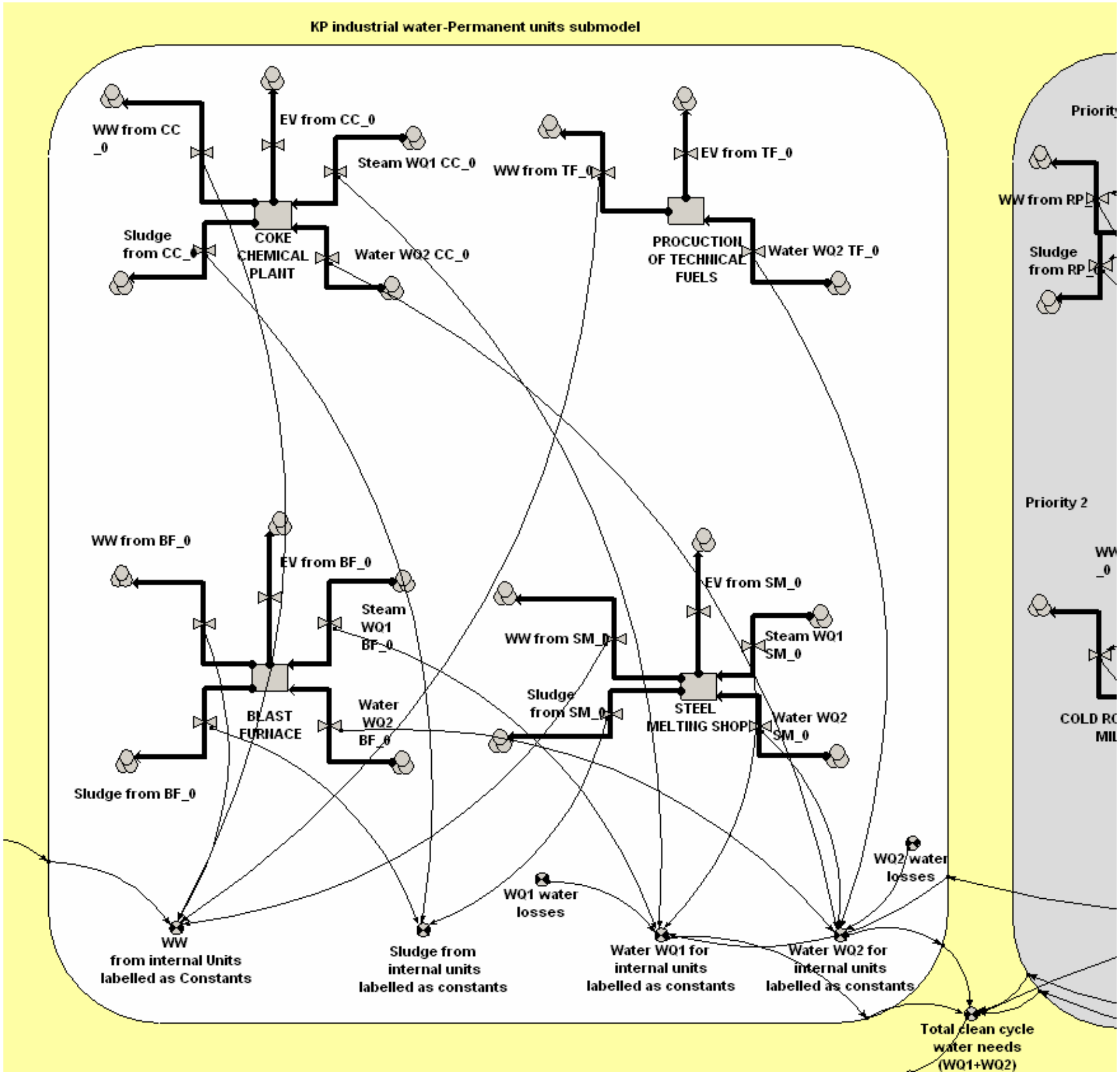

Figure 28: The submodel for the internal units labelled as constant (or permanent)

The submodel for the Kremikovtzi internal units labelles as constant (or permanent) is shown in Figure 28. These units are the coke chemical plant, the blast furnace, the steel melting shop and the unit for the production of technical fuels. These units should continue operating normally even at the worst "very dry" conditions scenario.

For each unit, fresh water demands for water of higher quality (WQ1), fresh water demands for water of lower quality (WQ2), waste water (WW) directed to WWTPIRW and sludge, directed to Sgurootvaal are simulated as inflows and outflows. Numerical values for each flow have been based on previous work within AQUASTRESS (Dimova et al, 2007).

Apart from the needs of these four units, the submodel contains the parameters simulating water losses both for WQ1 and WQ2. It is also connected to the potable water submodel (Figure 27) from which the waste water produced by the potable water system, directedto the WWTPIRW, is defined.

Total water needs in WQ1 and WQ2 water, together with the waste water and sludge produced from these units are directed as demand parameters to the clean fresh water (Figure 23), the water recycle (Figure 25) and the sludge submodel (Figure 24) respectively. They are also taken into account for the calculation of the "total clean water cycle water needs" of the system, which in turn is used to estimate, as it has already been mentioned, the system recycling rates.

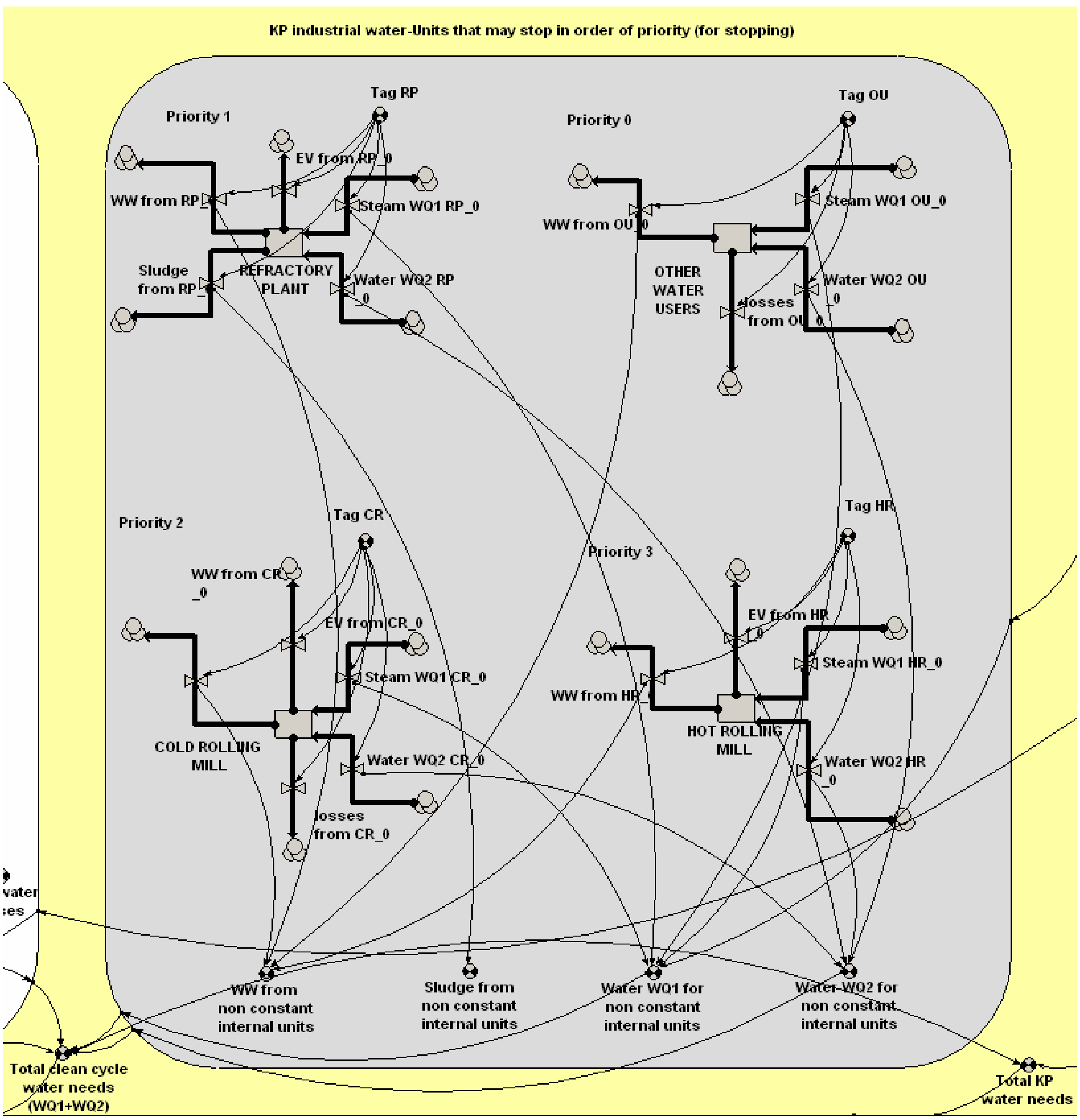

Figure 29: The submodel for the internal units labelled as non-constant (or non-permanent)

The submodel for the non-constant internal units, i.e. the industrial units that can stop in case of insufficient water (“very dry” year conditions) is presented in Figure 29. There are 4 non-constant industrial units, with different priority regarding potential stoppage, according to information provided by the local stakeholders.

The unit labelled “Other water users”, refers to external users using water supplied by the Kremikovtzi water system. Water supply to this unit will be the first to stop in case of emergency (Priority 0). The unit “Refractory plant” (Priority 1) comes next, followed by the unit “Cold Rolling Mill” (Priority 2), while the unit “Hot Rolling Mill” will be the last to stop (Priority 3).

Consequently, in order to simulate all possible combinations for the operation of this particular subsystem, 4 different scenarios have been examined, as it is described in the section about scenarios:

(1) Stopping the unit with Priority 0
(2) Stopping the units with Priorities 0 and 1
(3) Stopping the units with Priorities 0, 1 and 2
(4) Stopping all units (Priorities 0, 1, 2 and 3)

In order to enable the on/off operation of each unit within the SDM at the user’s will, each unit in this submodel has been assigned a “Tag” parameter, shown in Figure 29. This “Tag” parameter may only take the values 0 (unit off) or 1(unit on). Every inflow/outflow from each industrial unit is always multiplied by this tag parameter. Consequently, by simply turning from on to off (and vice versa) each tag, the user may simulate any desired combination. Total water demands and total waste water and sludge produced by this submodel will vary accordingly, affecting the other submodels (clean water, water recycle and sludge). Hence the parameters at the bottom of the submodel diagram refer to numerical parameters transferred to the other submodels.

As was the case with the constant units submodel, all numerical values for inflow/outflows have been based on previous work within AQUASTRESS (Dimova et al, 2007).

Finally, the ore plant and sinter plant units have been simulated using a different submodel, presented in Figure 30. The main reason for separating these two industrial units from the rest is, that they direct their waste water to the Hvostohraniliste pond, part of which returns (is being recycled) to this submodel as fresh water of the lowest quality (WQ3).

The Ore plant is a non-constant unit with high priority in stoppage (Priority 0). The sinter plant, however has a very different mode of operation: Its operational capacity (and consequently water supply and waste water production) can be gradually reduced by 1/6 (operational capacity 5/6), 2/6 (operational capacity 4/6) or ultimately by 3/6 (operational capacity 3/6).

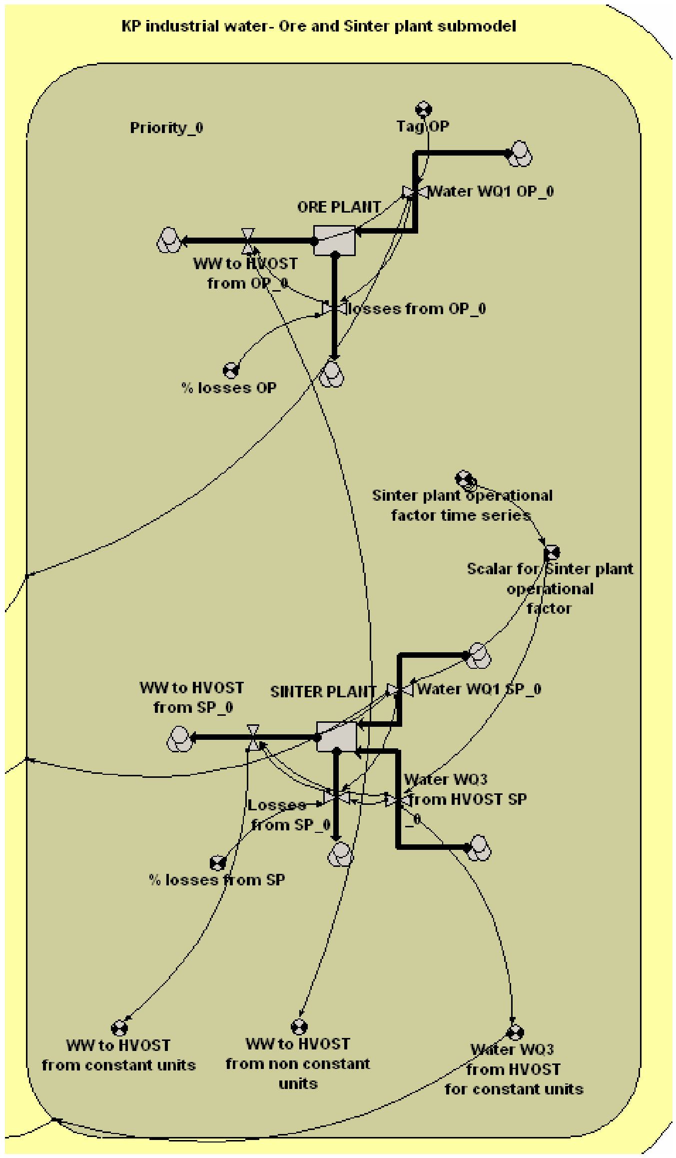

Figure 30: Ore and Sinter plant submodel

Consequently the ore plant has a "Tag" parameter, like all non-constant units, while the operational mode of the sinter plant is being determined by a time series, defining the operational capacity.

Numerical values for the losses both at the Ore plant and the Sinter plant have been determined during the development of the SDM, by conferring with the stakeholders.

7. Water demands and waste water production

7.1. Industrial units

The water demands for each industrial unit within the Kremikvotzi plant have been based on a separate analysis performed by RWTH and UACEG (Galina et al, 2007, Tarnacki et al, 2007). For the purposes of SDM, water demands have been differentiated into three different categories as follows:

The first category comprises fresh industrial water of higher quality, which will be consequently labelled as WQ1 (Water Quality 1). WQ1 comes to the plant units directly through Pancharevo reservoir (pumping) and/or the Rudnik boreholes to the various units.

The second category comprises water demands directed to the plant units through the Botunetz lake. Since fresh industrial water (by Pancharevo, Ognjanovo, Lesnovska and Matitza), as well as treated waste water (by WWTPIRW) are both directed to the Botunetz lake, water quality is expected to be different (lower), and will be consequently labelled and referred to as WQ2.

The third category comprises waste water recycled to the plant through the Hvostohraniliste pond, where water quality is even lower and will consequently be labelled WQ3.

Water demands for each unit are shown in Table 2. In this Table waste water produced by each unit is also presented, as well as losses due mainly to evaporation.

Moreover each industrial unit is assigned a label, according to the mode of operation. Ths units labelled as “constant” are not allowed to stop, even at the worst scenarios. Non constant units are assigned a label (0, 1, 2, 3) according to the hierarchy (priority) for stopping them. In this way units labelled as “0” will be the first to stop in case of water shortage, flowed by units labelled as “1” etc. If a unit “stops”, then the relative water demands and waste water produced are taken as zero.

The pattern for the sinter plant is special and does not fall in any of the above categories. Specifically for the sinter plant gradual reduction may take place, in case of water shortage: The plant may reduce its water demands by 1/6 (operating at 5/6 of its capacity), 2/6 (operating at 4/6 of its capacity) or by 3/6 (operating at 3/6 of its capacity). In each case waste water produced by the sinter plant is relatively reduced.

General water losses within the system, as well as water losses for the sinter plant and the ore plant have been estimated and taken into consideration for the SDM. They are also shown in the same table (Table 2).

Waste water from the industrial units is directed to the WWTPIRW (Waste Water Treatment Plant for Industrial and Rainwater), except sludge, which is directed to the

Sgurootvaal sludge pond and waste water from the Sinter and Ore plant, which is directed to the Hvostohranilste sludge pond..

The Kremikovtzi potable water system is separate from the industrial water system, but generates on average 390 x 1000m^3/month of waste water, 50% of which are directed to the WWTPIRW and the rest to the WWTPDW (Waste water treatment plant for Domestic Water). The losses in this system are considered to be 10%, i.e. waste water is considered to be 90% of the potable water demands.

KREMIKOVTZI PLANT UNITS	TYPE	LOSSES (%)	FRESH WATER WQ2	STEAM WQ1	EVAP. LOSSES	OTHER LOSSES	WASTE WATER SLUDGE	WASTE WATER PHENOLS	WASTE WATER FROM WQ1	WASTE WATER FROM WQ2	WASTE WATER TOTAL
			1000m3 month	1000m3 month	1000m3 month	1000m3 month	1000m3 month	1000m3 month	1000m3 month	1000m3 month	1000m3 month
BLAST FURNACE	CONSTANT		607	39	182	0	66	0	35	363	398
STEEL MELTING SHOP	CONSTANT		405	152	74	0	124	0	137	222	359
COKE CHEMICAL PLANT	CONSTANT		347	81	219	0	48	39	72	50	122
PRODUCTION OF TECHNICAL FUELS	CONSTANT		460	0	404	0	0	0	0	56	56
OTHER WATER USERS	STOP(0)		499	70	0	256	0	0	63	250	313
REFRACTORY PLANT	STOPS (1)		96	49	5	0	12	0	44	84	128
COLD ROLLING MILL	STOPS(2)		207	50	46	41	0	0	46	124	170
HOT ROLLING MILL	STOPS(3)		598	66	135	0	0	0	59	470	529
UNACCOUNTABLE LOSSES/LEAKAGE		0.01553	50								
UNACCOUNTABLE LOSSES/STEAM		0.155		93							
TOTAL INTERNAL UNITS			**3269**	**600**	**1065**	**440**	**250**	**39**	**456**	**1619**	**2075**

ORE/SINTER PLANT		% LOSSES	FRESH WATER WQ2	WATER WQ1	FROM HVOSTO WQ3	OTHER LOSSES	TOTAL WATER DEMAND	WW TO HVOSTO
ORE PLANT	STOP (0)	0.153	0	153	0	23.3	153	129.6
SINTER PLANT	CONSTANT SPECIAL	0.048	0	187	493	32.4	680	648.0
TOTAL ORE/SINTER PLANT				**340**	**493**	**55.7**	**833**	**777.6**

Table 2: Water demands, losses and waste water produced at each internal unit of Kremikovtzi plant

7.2 Rainfall-Surface runoff

The average surface runoff due to rainfall at the Kremikovtzi plant area, which is directed to the WWTPIRW was taken to be 419 x 10^3 m^3/month (Dimova et al, 2007).

The seasonal pluvial fluctuation factor has been based on the mean average monthly rainfall statistical data given at the WMO website (www.worldweather.org) for the region of Sofia. It is shown in Table 3 (Column 5)

	Months	Mean Monthly Rainfall (mm)	Monthly factor (%)	Average fluctuation factor
(1)	(2)	(3)	(4)	(5)
1	January	28	4.9037	0.5884
2	February	31	5.4291	0.6515
3	March	38	6.6550	0.7986
4	April	51	8.9317	1.0718
5	May	73	12.7846	1.5342
6	June	75	13.1349	1.5762
7	July	63	11.0333	1.3240
8	August	51	8.9317	1.0718
9	September	38	6.6550	0.7986
10	October	35	6.1296	0.7356
11	November	48	8.4063	1.0088
12	December	40	7.0053	0.8406
Total		571	100	
Mean monthly average		47.58		

Table 3: Rain seasonal average distribution (Source: World Meteorological Organization)

The same seasonal factor has been taken into consideration for modelling the water uptake from the Lesnovska river, i.e. the water flowing in the river naturally, not the water released from Ognjanovo reservoir. In this case the following assumption has been made: The mean maximum monthly water uptake from Lesnovska is determined as a separate constraint for each scenario (see next section) as the 1/12 of the maximum annual uptake allowed. This water quantity is consequently modified monthly, according to the factors shown in Table 3 (Column 5).

For example, if the maximum annual uptake allowed from Lesnovska is set at 2400 x 10^3 m^3/year, the mean monthly uptake is 200 x 10^3 m^3/month, which in turn gives the following monthly maximum water uptake quantities: For January 200 x 0.5884 = 117.68 x 10^3 m^3/month, for February 200 x 0.6515 = 130.30 x 10^3 m^3/month, etc.

This assumption has been adopted in order to simulate seasonal fluctuations to the river flow availability in a more realistic way for the different operational scenarios under consideration. Although it is not strictly speaking accurate in hydrological terms, because delayed flow due to snow-melting is ignored, it is considered to be accurate enough for the purpose of SDM modelling of the system as a whole.

The mean average surface runoff from the Kremikovtzi area considered as inflows to WWTPIRW is set to 419 x 1000m^3/month (Dimova et al, 2007).

8. Operational conditions and scenarios

8.1. Water availability from different sources

All numerical values for mean average water availability from different sources are based on the numerical values and analysis performed by the water balance study (Dimova et al, 2007).

- Mean average water uptake from Matitza is set to 50 x 1000m^3/month for normal year conditions, and equal to zero for "dry" and "very dry" year conditions.
- Mean average water availability from Rudnik is set to 313 x 1000m^3/month.
- Mean average inflow to Ognjanovo reservoir, to be used for Kremikovtzi is set to 580 x 1000m^3/month.
- Mean average water uptake from Lesnovska should not exceed 500 x 1000m^3/month under normal conditions and "dry year" conditions, and 200 x 1000m^3/month under "very dry year" conditions. However, uptakes from Lesnovska for normal and "dry year" conditions should be as low as possible.
- Mean average water uptake from Pancharevo should not exceed 1300 x 1000m^3/month, under normal conditions, but is considered to be reduced under "dry" and "very dry" year conditions, as described in detail in the Scenarios section that follows.

Water losses have been taken into consideration as follows:

- Evaporation losses from Hvostohraniliste pond are set to 4% of inflow
- Drainage losses from Hvostohraniliste pond are set to 6% of inflow
- Evaporation losses from Sgurootvaal pond are set to 4% of inflow
- Drainage losses from Sgurootvaal pond are set to 6% of inflow
- Transport losses from Ognjanovo through Lesnovska are set to 20% of water releases from Ognjanovo.

8.2 Scenarios

Simulation scenarios for the Kremikovtzi plant SDM have been organised in three groups, along the following guidelines:

Group 1: scenarios labelled as “normal year” conditions.
Group 2: scenarios labelled as “dry year” conditions
Group 3: scenarios labelled as “very dry year” conditions.

8.2.1.Group 1: Normal year scenarios

For normal operating conditions all industrial units are operating normally. Rainfall is considered to be average, whereas for the water sources limits and constraints adhere to the numerical values presented in the previous section about water availability.

Furthermore it is not allowed to return waste water from Hvostohraniliste and Sgurootvaal ponds to Botunetz lake.

In total 5 different operational scenarios have been generated using these conditions with the SDM model, with the following characteristics (Table 4):

Scenario	1.1	1.2	1.3	1.4	1.5
Recycling rate (WWTPIRW)	70%	65%	60%/A	60%/B	75%
Restrictions to Lesnovska uptake	285	330	453	503	150
Pancharevo reservoir	1200	1250	1300	1250	1200
Ognjanovo volume ($1000m^3$)	25000	25000	25000	25000	25000
Net inflow to Ognjanovo for KP	580	580	580	580	580
Surface runoff average	419	419	419	419	419
Recycled WW average	1878.8	1744.6	1610.4	1610.4	2013.0

Table 4: Normal year operational scenarios and parameters in $1000m^3$/month

Scenario 4 represents the actual operational conditions for Kremikovtzi. As it can be seen in Table 4 the other scenarios include different recycling rates and/or different operational conditions for Lesnovska/Pancharevo. Thus scenario 1.3 has the same recycling rate as Scenario 1.4 (60%), but uptakes from Lesnovska are reduced, while releases from Pancharevo are increased.

The last row at the table represents a numerical result from the simulation, i.e. the average WW recycled to Botunetz. In all scenarios the initial volume at Ognjanovo reservoir (25000 x $1000m^3$) is kept constant throughout the simulation.

8.2.2. Group 2: “dry year” scenarios

Assumptions for “dry year” conditions can be summarized as follows:

- All industrial units operate as normal (i.e. normal water demands)
- Recycling rate for WWTPIRW is set to 90%
- Pancharevo releases are restricted to 1200 x $1000m^3$/month.
- Pancharevo releases to Botunetz stop (i.e. no WQ2 water from Pancharevo)
- Matitza uptakes stop (equal to zero)

- Lesnovska uptakes are limited to 500 x 1000m^3/month
- Rain/Surface runoff: 50% of normal, affecting:
  - Rainwater inflows/surface runoff to WWTPIRW, which are set to 50% of normal (i.e. 419*0.50=209.50 x 1000m^3/month)
  - Inflows to Ognjanevo reservoir. Although these inflows have not been entered directly as input to the SDM model, they are taken into consideration as follows: The Ognjanovo water inflows "dedicated" to Kremikovtzi are set to 50% of normal (i.e. 580*0.50=290 x 1000m^3/month). Any water in excess of this preset constraint are assumed to come out of the Ognjanovo reserves, the objective of the simulation being to minimize the total decrease of the aforementioned reserves within a dry year.

There are two scenarios in this group, as shown in Table 5

Scenario	2.1	2.2
Recycling rate (WWTPIRW)	90%	90%
Restrictions to Lesnovska uptake	500	500
Pancharevo reservoir	1200	1200
Ognjanovo volume reduction (in 1000m3/year)	5276.1	2302.3
Net inflow to Ognjanovo for KP	290	290
Surface runoff average	209.5	209.5
Return to Botunetz from Hvostohraniliste	0	206.5
Recycled WW average	2227.1	2227.1

Table 5: "Dry year" operational scenarios and parameters in 1000m^3/month

In the first scenario (2.1) there are no returns from Hvostohraniliste to Botunetz, while in the second scenario (2.2) excess water from Hvostohraniliste returns to Botunetz. Consequently the reduction in the water volume in Ognjanovo is reduced.

<u>8.2.3. Group 3: "very dry year" scenarios</u>.

Assumptions for very dry scenarios can be summarized as follows:
- WWTPIRW set for a target recycling rate of 95% (Condition 1)
- Total treated waste water releases to Lesnovska (apart from sludge) should be at least 60 l/s (i.e. 155.5≈160 x 1000m^3/month). (Condition 2).

These two conditions/constraints, clearly contradicting each other, have both been entered to the model with the following priority: Condition 2 should be maintained before Condition 1, unless the total water demands from Ognjanovo exceed 4000 x 1000m^3/month. Should this happen, hierarchy is reversed and Condition 1 takes precedence over Condition 2.

Rain/Surface runoff: 25% of normal, affecting:
- Rainwater inflows/surface runoff to WWTPIRW, which are set to 25% of normal (i.e. 419*0.25=104.75 x 1000m^3/month) (Condition 3)

- Inflows to Ognjanovo reservoir. Although these inflows have not been entered directly as input to the SDM model, they are taken into consideration as follows: The Ognjanovo water inflows "dedicated" to Kremikovtzi are set to 25% of normal (i.e. 580*0.25=145 x 1000m^3/month). Any water in excess of this preset constraint are assumed to come out of the Ognjanovo reserves, the objective of the simulation being to minimize the total decrease of the aforementioned reserves within a very dry year. (Condition 4)

- Matitza uptake stop (equal to zero) (Condition 5)
- Lesnovska uptakes are limited to 200 x 1000m^3/month (Condition 6)
- Excessive waste water from Hvostohraniliste returns to Botunetz (Condition 7)
- Water uptake from Pancharevo reservoir should not exceed 300 x 1000m^3/month (Condition 8)
- Priority for water releases from Pancharevo: It will be supplying WQ1 for steam through direct uplifting to Kremikovtzi. (Condition 9)
- If water needed for Condition 7 is less than the preset upper limit (300 x 1000m^3/month), any excessive water may be directed to Botunetz to be use as WQ2. (Condition 10).

It should be mentioned that Condition 10 was not initially proposed by the stakeholders. Indeed it was initially proposed that Pancharevo would simply stop supplying Botunetz in dry and very dry years. However, by simulating the system through the SDM model, it became apparent that there was occasionally some water available (out of the 300 x 1000m^3/month allowed) after the WQ1 needs had been satisfied, which could be directed to Botunetz, thus relieving uptakes from Lesnovska. Obviously this condition leads to different operational scenarios (Variation B), when applicable (Table 6)

According to the above conditions, and the various combinations and priorities for industrial units (as described in the water demands section), 16 different scenarios have been simulated, run and examined, as presented in the following Table:

Scenario	Variation	Description
3.1		All units operate
3.2		Ore plant (OP) stops
3.3		OP + Other water users (OWU) stop (Priority 0)
3.4		OP + OWU + Refractory plant (RF) stop (Priorities 0,1)
3.5		OP + OWU + RF + Cold rolling mill (CR) stop (Priorities 0,1,2)
3.6A	Variation A	OP + all non constant units stop (Priorities 0,1,2,3)
3.6B	Variation B	OP + units with priorities 0,1,2,3 stop + Pancherevo excess to Botunetz
3.7.1A	Variation A	OP + all non constant units stop (Priorities 0,1,2,3) + Sinter plant (SP) reduced to 5/6 of capacity
3.7.2A	Variation A	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 4/6 of capacity
3.7.3A	Variation A	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 3/6 of capacity
3.7.1B	Variation B	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 5/6 of capacity + Pancherevo excess to Botunetz
3.7.2B	Variation B	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 4/6 of capacity + Pancherevo excess to Botunetz
3.7.3B	Variation B	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 4/6 of capacity + Pancherevo excess to Botunetz
3.8.1		OP stops + Sinter plant (SP) reduced to 5/6 of capacity. All other units operate
3.8.2		OP stops + Sinter plant (SP) reduced to 4/6 of capacity. All other units operate
3.8.3		OP stops + Sinter plant (SP) reduced to 3/6 of capacity. All other units operate

Table 6: Scenarios for “very dry” year conditions

9. Results and conclusions

All runs and simulations for the Kremikovtzi plant water system SDM have been performed using a monthly time step.

Detailed results and tables are included in Appendices A, B and C for the "normal", "dry" and "very dry" scenarios respectively. Due to the significant number of variables, parameters and system components involved, it is impossible (and unnecessary) to print out numerical values for all of them; this report is already long enough, even by including selected outputs, after careful consideration.

Therefore only significant and characteristic numerical results, showing all the important information have been selected for hard print and inclusion to this report. Anyway, by running the model, which, as it has already been mentioned, will be available at the CWS (UNEXE) website (www.ex.ac.uk/cws) since January 2008, any SDM scenario can be reproduced and studied at will.

Selected tables of results have been organized as follows: For each group of scenarios (A,B or C), the following tables exist in the Appendices:

- Clean fresh water of higher quality WQ1 subsystem – Pancherevo/Rudnik
- Sgurootvaal sludge pond subsystem
- Hvostohraniliste pond subsystem
- Clean fresh water to Botunetz subsystem :Ognjanovo – Lesnovska – Matitza – Pancharevo to Botunetz (analytic monthly tables for each scenario and comparative table with average values)
- WWTPIRW subsystem (analytic monthly tables for each scenario and comparative table with average values)
- Botunetz lake subsystem (analytic monthly tables for each scenario and comparative table with average values)
- Total system water needs, releases to Lesnovska and recycling rates (analytic monthly tables for each scenario and comparative table with average values)

By studying the results the following conclusions can be drawn:

For "normal year" scenarios, it is possible to increase the system total recycling rate from 44.4% (today) to 53.8% (or the clean fresh water-not taking into account Hvostohraniliste) from 38.3% to 47.8%, by increasing the recycling rate at the WWTPIRW from 60% to 75%, saving on average ≈400 x 10^3 m^3/month of fresh clean water from Ognjanovo and Pancharevo.

The "dry year" scenarios show that it is possible to keep all units operating normally on "dry year" conditions (rainfall and surface runoff 50% of normal), if the recycling rate at WWTPIRW is set to 90%. The system total recycling rates will be 62.2% or 57.9%, depending on whether excess waste water from Hvostohraniliste will return to Botunetz or not, respectively. In both cases the final water volume in Ognjanovo will be less than the initial starting volume of 25000 x 10^3 m^3 (19724 x 10^3 m^3 and 22698 x 10^3 m^3 respectively), as shown in Table B11. However, it will be above 21000 x 10^3 m^3 (i.e. deficit less than 4000 x 10^3 m^3) if waste water from Hvostohraniliste is recycled to Botunetz.

The most interesting results come from the "very dry" year scenarios (rainfall and surface runoff at 25% or normal). On the whole, these scenarios, based on successive stoppage of various units offer the chance to the stakeholders and end-users to study and decide on the impact of different operational policies in case of (very) limited water resources. Apart from this general conclusion, there are two additional points worth mentioning:

A. The first remark is based on the analytic results presented in Tables C5-C20, and the comparative average values presented in Table C21. Even if all (or most) of the non-constant industrial units stop, it is not possible to avoid decreases in the reserve water volume (deficits) for Ognjanovo reservoir. It is even not possible to limit the deficit to less than 4000 x 10^3 m^3/year, unless excessive water from Pancharevo (at the scenarios, where this is possible, i.e. when the WQ1 needs are less than the 300 x 10^3 m^3/month allocated to KP from Pancharevo) are directed to Botunetz (Scenarios 3.6B and 3.7.xB) (Figure 31).

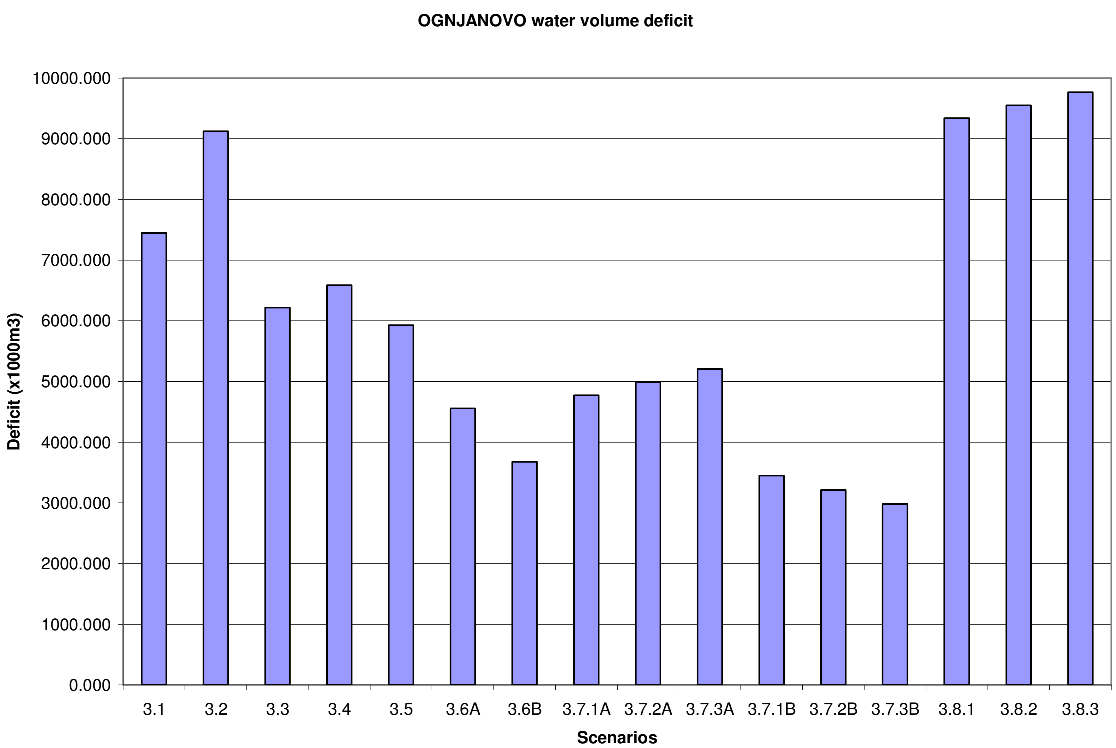

Figure 31: Annual water deficit at Ognjanovo for "very dry" year scenarios

B. The second remark refers again to the same graph shown in Figure 31, and the system total fresh water needs and water recycling rate, shown in Table C53.

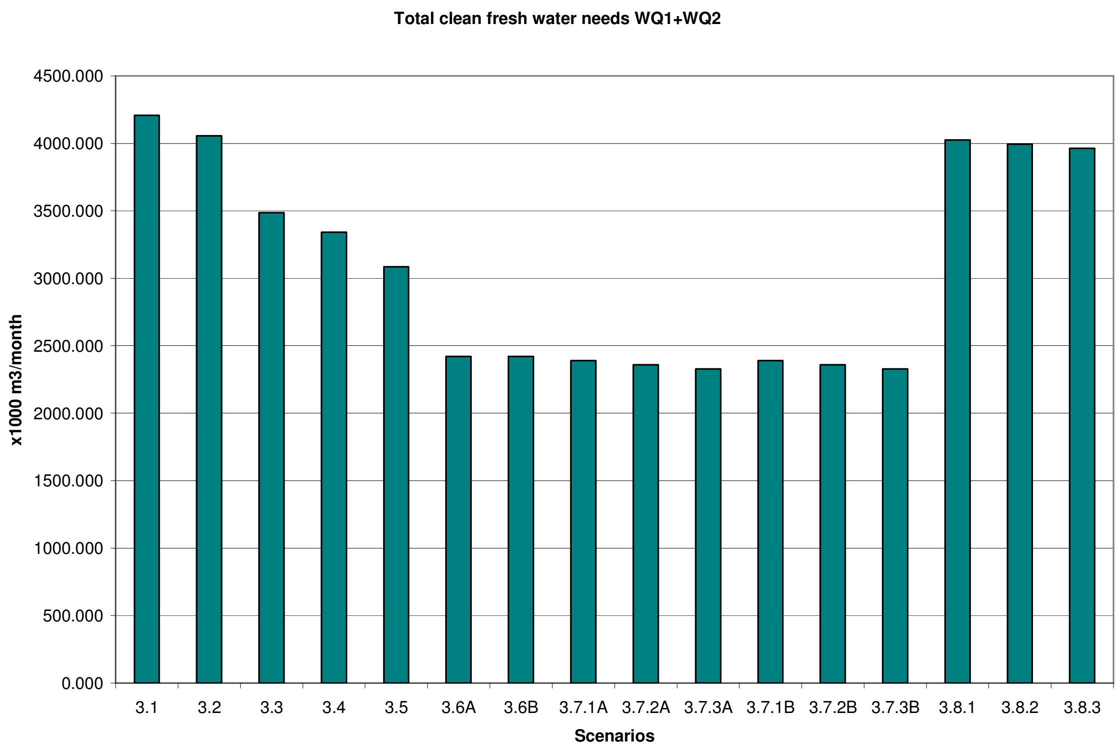

Figure 32: Average clean fresh water needs for the "very dry" year scenarios

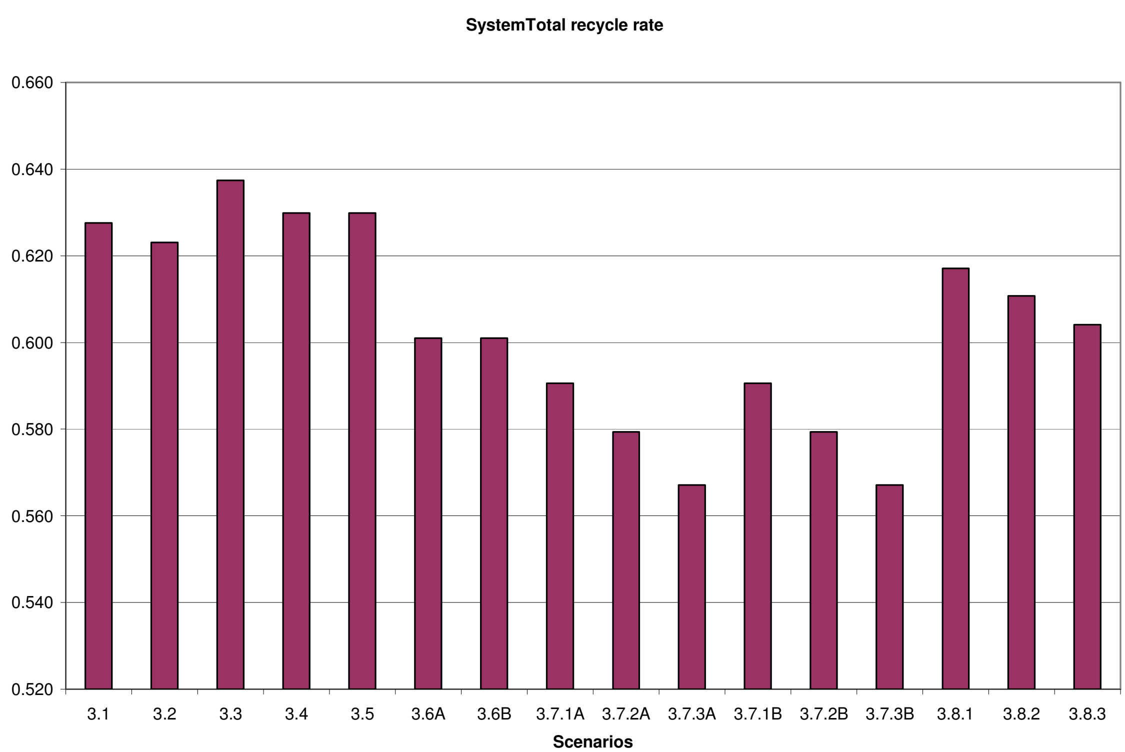

Figure 33: System total water recycling rate for "very dry" year scenarios

It is clearly shown, that despite stopping various industrial units and practically recycling everything (apart from Sgurootvaal sludge), the needs for fresh water are still above 2300 x 10^3 m^3/month (Figure 32) and the system total recycling rate cannot get higher than 63% (Figure 33). In fact the recycling rate slightly decreases, as more and more units stop. The reason for this is that by stopping the units, there is not enough waste water produced in the plant (which could potentially be recycled), while the units labelled as "constant", still need fresh clean water to operate.

Acknowledgments

The research presented in this paper was funded by the EC FP6 project AQUASTRESS, IP grant 511231. The authors would like to acknowledge the assistance provided by other AQUASTRESS partners from RWTH (Katharina Tarnacki, Thomas Wintgens and Thomas Melin) and UACEG (Galina Dimova and Irina Ribarova). They would also like to thank the authorities of Kremikovtzi Ltd, Botunetz, Sofia, Bulgaria for their cooperation and Mr. Nikolai Savov, in particular, for the data provided and his personal assistance.

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Appendix A

Normal year scenarios

	WWTPIRW recycling rate	Water WQ1 for constant units	Water WQ1 for non-constant units	Total WQ1 demands	Rudnik PS	Pancharevo direct to KP	Maximum allowed water uptake from Pancharevo	Gravity flow from Pancharevo to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
1.1	70%	552.072	387.928	940	313	627	1200	573
1.2	65%	552.072	387.928	940	313	627	1250	623
1.3	60%	552.072	387.928	940	313	627	1300	673
1.4	60%	552.072	387.928	940	313	627	1250	623
1.5	75%	552.072	387.928	940	313	627	1200	573

Table A1: Higher water quality WQ1 demands and flows for normal year scenarios

Month	Simulation Time step	Sludge from non constant units	Sludge from constant units	Sludge inflow from KP	Drainage losses	Evaporation losses	Net inflow to Sgurootvaal	Sgurootvaal sludge pond	PS return from SG to Botunetz	Overflow from SG to Lesnovska	Max allowed overflow to Lesnovska
				x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
Jan	0	12	277	289	17.34	11.56	260.1	600	0	237.5	237.5
Feb	1	12	277	289	17.34	11.56	260.1	622.6	0	237.5	237.5
March	2	12	277	289	17.34	11.56	260.1	645.2	0	237.5	237.5
April	3	12	277	289	17.34	11.56	260.1	667.8	0	237.5	237.5
May	4	12	277	289	17.34	11.56	260.1	690.4	0	237.5	237.5
June	5	12	277	289	17.34	11.56	260.1	713	0	237.5	237.5
July	6	12	277	289	17.34	11.56	260.1	735.6	0	237.5	237.5
Aug	7	12	277	289	17.34	11.56	260.1	758.2	0	237.5	237.5
Sept	8	12	277	289	17.34	11.56	260.1	780.8	0	237.5	237.5
Oct	9	12	277	289	17.34	11.56	260.1	803.4	0	237.5	237.5
Nov	10	12	277	289	17.34	11.56	260.1	826	0	237.5	237.5
Dec	11	12	277	289	17.34	11.56	260.1	848.6	0	237.5	237.5
Jan	12	12	277	289	17.34	11.56	260.1	871.2	0	237.5	237.5
							Excess	**271.2**			

Table A2: Sgurootvaal sludge pond subsystem for all normal year scenarios

WW to HVOST from constant units	WW to HVOST from non constant units	WW to HVOST	Drainage losses	Evaporation	Return parameter 0/1	Return (recycling)	Water WQ3 to KP from HVOST	HVOST to Lesnovska	Max allowed release from HVOST
x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
648	129.6	777.6	46.656	31.104	0	0	493.328	206.512	354.17

Table A3: Hvostohraniliste sludge pond subsystem for all normal year scenarios

70%	Recycle rate										
Months	Timestep	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir surplus-deficit	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1510.910	50	573	887.910	167.706	720.204	144.041	864.245	25000.000	580
Feb	1	1492.418	50	573	869.418	185.674	683.744	136.749	820.493	24715.755	580
March	2	1449.271	50	573	826.271	227.601	598.670	119.734	718.404	24475.262	580
April	3	1369.140	50	573	746.140	305.464	440.676	88.135	528.811	24336.858	580
May	4	1233.534	50	573	610.534	437.233	173.301	34.660	207.961	24388.047	580
June	5	1221.206	50	573	598.206	449.212	148.994	29.799	178.793	24760.086	580
July	6	1295.173	50	573	672.173	377.338	294.835	58.967	353.802	25161.293	580
Aug	7	1369.140	50	573	746.140	305.464	440.676	88.135	528.811	25387.491	580
Sept	8	1449.271	50	573	826.271	227.601	598.670	119.734	718.404	25438.680	580
Oct	9	1467.763	50	573	844.763	209.632	635.131	127.026	762.157	25300.276	580
Nov	10	1387.632	50	573	764.632	287.496	477.136	95.427	572.563	25118.119	580
Dec	11	1436.943	50	573	813.943	239.580	574.363	114.873	689.236	25125.556	580
Jan	12	1510.910	50	573	887.910	167.706	720.204	144.041	864.245	25016.320	580
Average		1390.200			767.200	285.000	482.200	96.440	578.640		

Table A4: Scenario 1.1 Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Recycling rate 70% at WWTPIRW

70%	Recycle rate										
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1125.000	1140	2265	246.557	2511.557	1051.170	753.467	0.700	0.000	1758.0898
Feb	1	1125.000	1140	2265	272.974	2537.974	1051.170	761.392	0.700	0.000	1776.5816
March	2	1125.000	1140	2265	334.613	2599.613	1051.170	779.884	0.700	0.000	1819.7291
April	3	1125.000	1140	2265	449.086	2714.086	1051.170	814.226	0.700	0.000	1899.8601
May	4	1125.000	1140	2265	642.809	2907.809	1051.170	872.343	0.700	0.000	2035.4664
June	5	1125.000	1140	2265	660.420	2925.420	1051.170	877.626	0.700	0.000	2047.7942
July	6	1125.000	1140	2265	554.753	2819.753	1051.170	845.926	0.700	0.000	1973.8271
Aug	7	1125.000	1140	2265	449.086	2714.086	1051.170	814.226	0.700	0.000	1899.8601
Sept	8	1125.000	1140	2265	334.613	2599.613	1051.170	779.884	0.700	0.000	1819.7291
Oct	9	1125.000	1140	2265	308.196	2573.196	1051.170	771.959	0.700	0.000	1801.2373
Nov	10	1125.000	1140	2265	422.669	2687.669	1051.170	806.301	0.700	0.000	1881.3683
Dec	11	1125.000	1140	2265	352.224	2617.224	1051.170	785.167	0.700	0.000	1832.0569
Jan	12	1125.000	1140	2265	246.557	2511.557	1051.170	753.467	0.700	0.000	1758.0898
Average					419.000	2684.000		805.200			1878.800

Table A5: Scenario 1.1 WWTPIRW . Recycling rate 70% at WWTPIRW

70%	Recycle rate									
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400	3269	0.000	1758.090	0.000	1510.910	1510.910	1000.000
Feb	1	1869.000	1400	3269	0.000	1776.582	0.000	1492.418	1492.418	1000.000
March	2	1869.000	1400	3269	0.000	1819.729	0.000	1449.271	1449.271	1000.000
April	3	1869.000	1400	3269	0.000	1899.860	0.000	1369.140	1369.140	1000.000
May	4	1869.000	1400	3269	0.000	2035.466	0.000	1233.534	1233.534	1000.000
June	5	1869.000	1400	3269	0.000	2047.794	0.000	1221.206	1221.206	1000.000
July	6	1869.000	1400	3269	0.000	1973.827	0.000	1295.173	1295.173	1000.000
Aug	7	1869.000	1400	3269	0.000	1899.860	0.000	1369.140	1369.140	1000.000
Sept	8	1869.000	1400	3269	0.000	1819.729	0.000	1449.271	1449.271	1000.000
Oct	9	1869.000	1400	3269	0.000	1801.237	0.000	1467.763	1467.763	1000.000
Nov	10	1869.000	1400	3269	0.000	1881.368	0.000	1387.632	1387.632	1000.000
Dec	11	1869.000	1400	3269	0.000	1832.057	0.000	1436.943	1436.943	1000.000
Jan	12	1869.000	1400	3269	0.000	1758.090	0.000	1510.910	1510.910	1000.000
Average						1878.800		1390.200	1390.200	

Table A6: Scenario 1.1 Botunetz lake . Recycling rate 70% at WWTPIRW

70%	Recycle rate											
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4209.000	4702.328	2511.557	1758.090	0.700	1758.090	0.418	493.328	2251.418	0.479	1149.979
Feb	1	4209.000	4702.328	2537.974	1776.582	0.700	1776.582	0.422	493.328	2269.910	0.483	1157.904
March	2	4209.000	4702.328	2599.613	1819.729	0.700	1819.729	0.432	493.328	2313.057	0.492	1176.396
April	3	4209.000	4702.328	2714.086	1899.860	0.700	1899.860	0.451	493.328	2393.188	0.509	1210.738
May	4	4209.000	4702.328	2907.809	2035.466	0.700	2035.466	0.484	493.328	2528.794	0.538	1268.855
June	5	4209.000	4702.328	2925.420	2047.794	0.700	2047.794	0.487	493.328	2541.122	0.540	1274.138
July	6	4209.000	4702.328	2819.753	1973.827	0.700	1973.827	0.469	493.328	2467.155	0.525	1242.438
Aug	7	4209.000	4702.328	2714.086	1899.860	0.700	1899.860	0.451	493.328	2393.188	0.509	1210.738
Sept	8	4209.000	4702.328	2599.613	1819.729	0.700	1819.729	0.432	493.328	2313.057	0.492	1176.396
Oct	9	4209.000	4702.328	2573.196	1801.237	0.700	1801.237	0.428	493.328	2294.565	0.488	1168.471
Nov	10	4209.000	4702.328	2687.669	1881.368	0.700	1881.368	0.447	493.328	2374.696	0.505	1202.813
Dec	11	4209.000	4702.328	2617.224	1832.057	0.700	1832.057	0.435	493.328	2325.385	0.495	1181.679
Jan	12	4209.000	4702.328	2511.557	1758.090	0.700	1758.090	0.418	493.328	2251.418	0.479	1149.979
Average				2684.000	1878.800		1878.800	0.446	493.328	2372.128	0.504	1201.712

Table A7: Scenario 1.1 Total system water needs, releases to Lesnovska and recycling rates. Recycling rate 70% at WWTPIRW

65%	Recycle rate										
Months	Timestep	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir surplus-deficit	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1636.488	50	623	963.488	217.723	745.765	149.153	894.918	25000.000	580
Feb	1	1619.317	50	623	946.317	241.051	705.266	141.053	846.320	24685.082	580
March	2	1579.252	50	623	906.252	295.482	610.770	122.154	732.924	24418.763	580
April	3	1504.844	50	623	831.844	396.567	435.277	87.055	522.332	24265.839	580
May	4	1378.924	50	623	705.924	567.636	138.288	27.658	165.946	24323.507	580
June	5	1367.477	50	623	694.477	583.187	111.289	22.258	133.547	24737.561	580
July	6	1436.161	50	623	763.161	489.877	273.283	54.657	327.940	25184.013	580
Aug	7	1504.844	50	623	831.844	396.567	435.277	87.055	522.332	25436.074	580
Sept	8	1579.252	50	623	906.252	295.482	610.770	122.154	732.924	25493.742	580
Oct	9	1596.423	50	623	923.423	272.154	651.268	130.254	781.522	25340.818	580
Nov	10	1522.015	50	623	849.015	373.240	475.775	95.155	570.930	25139.296	580
Dec	11	1567.804	50	623	894.804	311.033	583.771	116.754	700.525	25148.365	580
Jan	12	1636.488	50	623	963.488	217.723	745.765	149.153	894.918	25027.840	580
Average		1524.400			851.400	370.000	481.400	96.280	577.680		

Table A8: Scenario 1.2 Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Recycling rate 65% at WWTPIRW

65%	Recycle rate										
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1125.000	1140	2265	246.557	2511.557	1051.170	879.045	0.650	0	1632.512
Feb	1	1125.000	1140	2265	272.974	2537.974	1051.170	888.291	0.650	0	1649.6829
March	2	1125.000	1140	2265	334.613	2599.613	1051.170	909.865	0.650	0	1689.7484
April	3	1125.000	1140	2265	449.086	2714.086	1051.170	949.930	0.650	0	1764.1558
May	4	1125.000	1140	2265	642.809	2907.809	1051.170	1017.733	0.650	0	1890.0759
June	5	1125.000	1140	2265	660.420	2925.420	1051.170	1023.897	0.650	0	1901.5232
July	6	1125.000	1140	2265	554.753	2819.753	1051.170	986.914	0.650	0	1832.8395
Aug	7	1125.000	1140	2265	449.086	2714.086	1051.170	949.930	0.650	0	1764.1558
Sept	8	1125.000	1140	2265	334.613	2599.613	1051.170	909.865	0.650	0	1689.7484
Oct	9	1125.000	1140	2265	308.196	2573.196	1051.170	900.619	0.650	0	1672.5775
Nov	10	1125.000	1140	2265	422.669	2687.669	1051.170	940.684	0.650	0	1746.9849
Dec	11	1125.000	1140	2265	352.224	2617.224	1051.170	916.029	0.650	0	1701.1957
Jan	12	1125.000	1140	2265	246.557	2511.557	1051.170	879.045	0.650	0	1632.512
Average					419.000	2684.000		939.400			1744.600

Table A9: Scenario 1.2 WWTPIRW . Recycling rate 65% at WWTPIRW

65%	Recycle rate									
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400	3269	0.000	1632.512	0.000	1636.488	1636.488	1000.000
Feb	1	1869.000	1400	3269	0.000	1649.683	0.000	1619.317	1619.317	1000.000
March	2	1869.000	1400	3269	0.000	1689.748	0.000	1579.252	1579.252	1000.000
April	3	1869.000	1400	3269	0.000	1764.156	0.000	1504.844	1504.844	1000.000
May	4	1869.000	1400	3269	0.000	1890.076	0.000	1378.924	1378.924	1000.000
June	5	1869.000	1400	3269	0.000	1901.523	0.000	1367.477	1367.477	1000.000
July	6	1869.000	1400	3269	0.000	1832.840	0.000	1436.161	1436.161	1000.000
Aug	7	1869.000	1400	3269	0.000	1764.156	0.000	1504.844	1504.844	1000.000
Sept	8	1869.000	1400	3269	0.000	1689.748	0.000	1579.252	1579.252	1000.000
Oct	9	1869.000	1400	3269	0.000	1672.578	0.000	1596.423	1596.423	1000.000
Nov	10	1869.000	1400	3269	0.000	1746.985	0.000	1522.015	1522.015	1000.000
Dec	11	1869.000	1400	3269	0.000	1701.196	0.000	1567.804	1567.804	1000.000
Jan	12	1869.000	1400	3269	0.000	1632.512	0.000	1636.488	1636.488	1000.000
Average						1744.600		1524.400	1524.400	

Table A10: Scenario 1.2 Botunetz lake . Recycling rate 65% at WWTPIRW

65%	Recycle rate											
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4209.000	4702.328	2511.557	1632.512	0.650	1632.512	0.388	493.328	2125.840	0.452	1275.557
Feb	1	4209.000	4702.328	2537.974	1649.683	0.650	1649.683	0.392	493.328	2143.011	0.456	1284.803
March	2	4209.000	4702.328	2599.613	1689.748	0.650	1689.748	0.402	493.328	2183.076	0.464	1306.377
April	3	4209.000	4702.328	2714.086	1764.156	0.650	1764.156	0.419	493.328	2257.484	0.480	1346.442
May	4	4209.000	4702.328	2907.809	1890.076	0.650	1890.076	0.449	493.328	2383.404	0.507	1414.245
June	5	4209.000	4702.328	2925.420	1901.523	0.650	1901.523	0.452	493.328	2394.851	0.509	1420.409
July	6	4209.000	4702.328	2819.753	1832.840	0.650	1832.840	0.436	493.328	2326.168	0.495	1383.426
Aug	7	4209.000	4702.328	2714.086	1764.156	0.650	1764.156	0.419	493.328	2257.484	0.480	1346.442
Sept	8	4209.000	4702.328	2599.613	1689.748	0.650	1689.748	0.402	493.328	2183.076	0.464	1306.377
Oct	9	4209.000	4702.328	2573.196	1672.578	0.650	1672.578	0.397	493.328	2165.906	0.461	1297.131
Nov	10	4209.000	4702.328	2687.669	1746.985	0.650	1746.985	0.415	493.328	2240.313	0.476	1337.196
Dec	11	4209.000	4702.328	2617.224	1701.196	0.650	1701.196	0.404	493.328	2194.524	0.467	1312.541
Jan	12	4209.000	4702.328	2511.557	1632.512	0.650	1632.512	0.388	493.328	2125.840	0.452	1275.557
Average				2684.000	1744.600		1744.600	0.415	493.328	2237.928	0.476	1335.912

Table A11: Scenario 1.2 Total system water needs, releases to Lesnovska and recycling rates. Recycling rate 65% at WWTPIRW

60% A	Recycle rate										
Months	Timestep	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir surplus-deficit	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1762.066	50	673	1039.066	266.564	772.502	154.500	927.002	25000.000	580
Feb	1	1746.216	50	673	1023.216	295.124	728.091	145.618	873.710	24652.998	580
March	2	1709.232	50	673	986.232	361.765	624.467	124.893	749.360	24359.288	580
April	3	1640.549	50	673	917.549	485.527	432.021	86.404	518.426	24189.928	580
May	4	1524.315	50	673	801.315	694.970	106.344	21.269	127.613	24251.502	580
June	5	1513.748	50	673	790.748	714.011	76.737	15.348	92.085	24703.889	580
July	6	1577.148	50	673	854.148	599.769	254.379	50.876	305.255	25191.804	580
Aug	7	1640.549	50	673	917.549	485.527	432.021	86.404	518.426	25466.549	580
Sept	8	1709.232	50	673	986.232	361.765	624.467	124.893	749.360	25528.123	580
Oct	9	1725.082	50	673	1002.082	333.205	668.877	133.776	802.653	25358.763	580
Nov	10	1656.399	50	673	933.399	456.967	476.432	95.286	571.718	25136.110	580
Dec	11	1698.666	50	673	975.666	380.806	594.860	118.972	713.832	25144.392	580
Jan	12	1762.066	50	673	1039.066	266.564	772.502	154.500	927.002	25010.560	580
Average		1658.600			935.600	453.000	482.600	96.520	579.120		

Table A12: Scenario 1.3 Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Recycling rate 60% at WWTPIRW

60% B	Recycle rate										
Months	Timestep	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir surplus-deficit	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1762.066	50	623	1089.066	295.986	793.080	158.616	951.696	25000.000	580
Feb	1	1746.216	50	623	1073.216	327.699	745.517	149.103	894.620	24628.304	580
March	2	1709.232	50	623	1036.232	401.695	634.537	126.907	761.444	24313.684	580
April	3	1640.549	50	623	967.549	539.117	428.431	85.686	514.117	24132.239	580
May	4	1524.315	50	623	851.315	771.678	79.637	15.927	95.564	24198.122	580
June	5	1513.748	50	623	840.748	792.820	47.928	9.586	57.514	24682.558	580
July	6	1577.148	50	623	904.148	665.969	238.180	47.636	285.816	25205.044	580
Aug	7	1640.549	50	623	967.549	539.117	428.431	85.686	514.117	25499.228	580
Sept	8	1709.232	50	623	1036.232	401.695	634.537	126.907	761.444	25565.111	580
Oct	9	1725.082	50	623	1052.082	369.983	682.100	136.420	818.520	25383.667	580
Nov	10	1656.399	50	623	983.399	507.405	475.994	95.199	571.193	25145.147	580
Dec	11	1698.666	50	623	1025.666	422.837	602.828	120.566	723.394	25153.954	580
Jan	12	1762.066	50	623	1089.066	295.986	793.080	158.616	951.696	25010.560	580
Average		1658.600			985.600	503.000	482.600	96.520	579.120		

Table A13: Scenario 1.4 Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Recycling rate 60% at WWTPIRW

60%A-B	Recycle rate										
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1125.000	1140	2265	246.557	2511.557	1051.170	1004.623	0.600	0.000	1506.9342
Feb	1	1125.000	1140	2265	272.974	2537.974	1051.170	1015.190	0.600	0.000	1522.7842
March	2	1125.000	1140	2265	334.613	2599.613	1051.170	1039.845	0.600	0.000	1559.7678
April	3	1125.000	1140	2265	449.086	2714.086	1051.170	1051.170	0.600	0.000	1628.4515
May	4	1125.000	1140	2265	642.809	2907.809	1051.170	1051.170	0.600	34.464	1744.6855
June	5	1125.000	1140	2265	660.420	2925.420	1051.170	1051.170	0.600	146.418	1755.2522
July	6	1125.000	1140	2265	554.753	2819.753	1051.170	1051.170	0.600	265.416	1691.8518
Aug	7	1125.000	1140	2265	449.086	2714.086	1051.170	1051.170	0.600	342.147	1628.4515
Sept	8	1125.000	1140	2265	334.613	2599.613	1051.170	1039.845	0.600	376.612	1559.7678
Oct	9	1125.000	1140	2265	308.196	2573.196	1051.170	1029.279	0.600	376.612	1543.9177
Nov	10	1125.000	1140	2265	422.669	2687.669	1051.170	1051.170	0.600	376.612	1612.6014
Dec	11	1125.000	1140	2265	352.224	2617.224	1051.170	1046.890	0.600	400.509	1570.3345
Jan	12	1125.000	1140	2265	246.557	2511.557	1051.170	1004.623	0.600	400.509	1506.9342
Average					419.000	2684.000		1040.224			1610.400

Table A14: Scenarios 1.3 and 1.4 WWTPIRW . Recycling rate 60% at WWTPIRW

60%A-B	Recycle rate									
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400	3269	0.000	1506.934	0.000	1762.066	1762.066	1000.000
Feb	1	1869.000	1400	3269	0.000	1522.784	0.000	1746.216	1746.216	1000.000
March	2	1869.000	1400	3269	0.000	1559.768	0.000	1709.232	1709.232	1000.000
April	3	1869.000	1400	3269	0.000	1628.452	0.000	1640.549	1640.549	1000.000
May	4	1869.000	1400	3269	0.000	1744.686	0.000	1524.315	1524.315	1000.000
June	5	1869.000	1400	3269	0.000	1755.252	0.000	1513.748	1513.748	1000.000
July	6	1869.000	1400	3269	0.000	1691.852	0.000	1577.148	1577.148	1000.000
Aug	7	1869.000	1400	3269	0.000	1628.452	0.000	1640.549	1640.549	1000.000
Sept	8	1869.000	1400	3269	0.000	1559.768	0.000	1709.232	1709.232	1000.000
Oct	9	1869.000	1400	3269	0.000	1543.918	0.000	1725.082	1725.082	1000.000
Nov	10	1869.000	1400	3269	0.000	1612.601	0.000	1656.399	1656.399	1000.000
Dec	11	1869.000	1400	3269	0.000	1570.335	0.000	1698.666	1698.666	1000.000
Jan	12	1869.000	1400	3269	0.000	1506.934	0.000	1762.066	1762.066	1000.000
Average						1610.400		1658.600	1658.600	

Table A15: Scenarios 1.3 and 1.4 Botunetz lake . Recycling rate 60% at WWTPIRW

60%A-B	Recycle rate											
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4209.000	4702.328	2511.557	1506.934	0.600	1506.934	0.358	493.328	2000.262	0.425	1401.135
Feb	1	4209.000	4702.328	2537.974	1522.784	0.600	1522.784	0.362	493.328	2016.112	0.429	1411.702
March	2	4209.000	4702.328	2599.613	1559.768	0.600	1559.768	0.371	493.328	2053.096	0.437	1436.357
April	3	4209.000	4702.328	2714.086	1628.452	0.600	1628.452	0.387	493.328	2121.780	0.451	1447.682
May	4	4209.000	4702.328	2907.809	1744.686	0.600	1744.686	0.415	493.328	2238.014	0.476	1447.682
June	5	4209.000	4702.328	2925.420	1755.252	0.600	1755.252	0.417	493.328	2248.580	0.478	1447.682
July	6	4209.000	4702.328	2819.753	1691.852	0.600	1691.852	0.402	493.328	2185.180	0.465	1447.682
Aug	7	4209.000	4702.328	2714.086	1628.452	0.600	1628.452	0.387	493.328	2121.780	0.451	1447.682
Sept	8	4209.000	4702.328	2599.613	1559.768	0.600	1559.768	0.371	493.328	2053.096	0.437	1436.357
Oct	9	4209.000	4702.328	2573.196	1543.918	0.600	1543.918	0.367	493.328	2037.246	0.433	1425.791
Nov	10	4209.000	4702.328	2687.669	1612.601	0.600	1612.601	0.383	493.328	2105.929	0.448	1447.682
Dec	11	4209.000	4702.328	2617.224	1570.335	0.600	1570.335	0.373	493.328	2063.663	0.439	1443.402
Jan	12	4209.000	4702.328	2511.557	1506.934	0.600	1506.934	0.358	493.328	2000.262	0.425	1401.135
Average				2684.000	1610.400		1610.400	0.383	493.328	2103.728	0.447	1436.736

Table A16: Scenarios 1.3 and 1.4 Total system water needs, releases to Lesnovska and recycling rates. Recycling rate 60% at WWTPIRW

75%	Recycle rate										
Months	Timestep	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir surplus-deficit	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1385.332	50	573	762.332	88.266	674.066	134.813	808.879	25000.000	580
Feb	1	1365.520	50	573	742.520	97.723	644.796	128.959	773.756	24771.121	580
March	2	1319.290	50	573	696.290	119.790	576.500	115.300	691.801	24577.365	580
April	3	1233.436	50	573	610.436	160.771	449.665	89.933	539.598	24465.564	580
May	4	1088.143	50	573	465.143	230.123	235.021	47.004	282.025	24505.966	580
June	5	1074.935	50	573	451.935	236.427	215.507	43.102	258.609	24803.942	580
July	6	1154.185	50	573	531.185	198.599	332.586	66.517	399.104	25125.333	580
Aug	7	1233.436	50	573	610.436	160.771	449.665	89.933	539.598	25306.229	580
Sept	8	1319.290	50	573	696.290	119.790	576.500	115.300	691.801	25346.631	580
Oct	9	1339.103	50	573	716.103	110.333	605.770	121.154	726.924	25234.831	580
Nov	10	1253.248	50	573	630.248	151.314	478.935	95.787	574.722	25087.907	580
Dec	11	1306.082	50	573	683.082	126.095	556.987	111.398	668.385	25093.185	580
Jan	12	1385.332	50	573	762.332	88.266	674.066	134.813	808.879	25004.800	580
Average		1256.000			633.000	150.000	483.000	96.600	579.600		

Table A17: Scenario 1.5 Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Recycling rate 75% at WWTPIRW

75%	Recycle rate										
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1125.000	1140	2265	246.557	2511.557	1051.170	627.889	0.750	0	1883.6677
Feb	1	1125.000	1140	2265	272.974	2537.974	1051.170	634.493	0.750	0	1903.4803
March	2	1125.000	1140	2265	334.613	2599.613	1051.170	649.903	0.750	0	1949.7097
April	3	1125.000	1140	2265	449.086	2714.086	1051.170	678.522	0.750	0	2035.5644
May	4	1125.000	1140	2265	642.809	2907.809	1051.170	726.952	0.750	0	2180.8568
June	5	1125.000	1140	2265	660.420	2925.420	1051.170	731.355	0.750	0	2194.0652
July	6	1125.000	1140	2265	554.753	2819.753	1051.170	704.938	0.750	0	2114.8148
Aug	7	1125.000	1140	2265	449.086	2714.086	1051.170	678.522	0.750	0	2035.5644
Sept	8	1125.000	1140	2265	334.613	2599.613	1051.170	649.903	0.750	0	1949.7097
Oct	9	1125.000	1140	2265	308.196	2573.196	1051.170	643.299	0.750	0	1929.8971
Nov	10	1125.000	1140	2265	422.669	2687.669	1051.170	671.917	0.750	0	2015.7518
Dec	11	1125.000	1140	2265	352.224	2617.224	1051.170	654.306	0.750	0	1962.9181
Jan	12	1125.000	1140	2265	246.557	2511.557	1051.170	627.889	0.750	0	1883.6677
Average					419.000	2684.000	1051.170	671.000			2013.000

Table A18: Scenario 1.5 WWTPIRW . Recycling rate 75% at WWTPIRW

75%	Recycle rate									
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400	3269	0.000	1883.668	0.000	1385.332	1385.332	1000.000
Feb	1	1869.000	1400	3269	0.000	1903.480	0.000	1365.520	1365.520	1000.000
March	2	1869.000	1400	3269	0.000	1949.710	0.000	1319.290	1319.290	1000.000
April	3	1869.000	1400	3269	0.000	2035.564	0.000	1233.436	1233.436	1000.000
May	4	1869.000	1400	3269	0.000	2180.857	0.000	1088.143	1088.143	1000.000
June	5	1869.000	1400	3269	0.000	2194.065	0.000	1074.935	1074.935	1000.000
July	6	1869.000	1400	3269	0.000	2114.815	0.000	1154.185	1154.185	1000.000
Aug	7	1869.000	1400	3269	0.000	2035.564	0.000	1233.436	1233.436	1000.000
Sept	8	1869.000	1400	3269	0.000	1949.710	0.000	1319.290	1319.290	1000.000
Oct	9	1869.000	1400	3269	0.000	1929.897	0.000	1339.103	1339.103	1000.000
Nov	10	1869.000	1400	3269	0.000	2015.752	0.000	1253.248	1253.248	1000.000
Dec	11	1869.000	1400	3269	0.000	1962.918	0.000	1306.082	1306.082	1000.000
Jan	12	1869.000	1400	3269	0.000	1883.668	0.000	1385.332	1385.332	1000.000
Average						2013.000		1256.000	1256.000	

Table A19: Scenario 1.5 Botunetz lake . Recycling rate 75% at WWTPIRW

75%	Recycle rate											
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4209.000	4702.328	2511.557	1883.668	0.750	1883.668	0.448	493.328	2376.996	0.506	1024.401
Feb	1	4209.000	4702.328	2537.974	1903.480	0.750	1903.480	0.452	493.328	2396.808	0.510	1031.006
March	2	4209.000	4702.328	2599.613	1949.710	0.750	1949.710	0.463	493.328	2443.038	0.520	1046.415
April	3	4209.000	4702.328	2714.086	2035.564	0.750	2035.564	0.484	493.328	2528.892	0.538	1075.034
May	4	4209.000	4702.328	2907.809	2180.857	0.750	2180.857	0.518	493.328	2674.185	0.569	1123.464
June	5	4209.000	4702.328	2925.420	2194.065	0.750	2194.065	0.521	493.328	2687.393	0.572	1127.867
July	6	4209.000	4702.328	2819.753	2114.815	0.750	2114.815	0.503	493.328	2608.143	0.555	1101.450
Aug	7	4209.000	4702.328	2714.086	2035.564	0.750	2035.564	0.484	493.328	2528.892	0.538	1075.034
Sept	8	4209.000	4702.328	2599.613	1949.710	0.750	1949.710	0.463	493.328	2443.038	0.520	1046.415
Oct	9	4209.000	4702.328	2573.196	1929.897	0.750	1929.897	0.459	493.328	2423.225	0.515	1039.811
Nov	10	4209.000	4702.328	2687.669	2015.752	0.750	2015.752	0.479	493.328	2509.080	0.534	1068.429
Dec	11	4209.000	4702.328	2617.224	1962.918	0.750	1962.918	0.466	493.328	2456.246	0.522	1050.818
Jan	12	4209.000	4702.328	2511.557	1883.668	0.750	1883.668	0.448	493.328	2376.996	0.506	1024.401
Average				2684.000	2013.000		2013.000	0.478	493.328	2506.328	0.533	1067.512

Table A20: Scenario 1.5 Total system water needs, releases to Lesnovska and recycling rates. Recycling rate 75% at WWTPIRW

Average values											
Scenario	WWTPIRW recycling rate	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status at the end of the period	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
1.1	70%	1390.200	50.000	573.000	767.200	285.000	482.200	96.440	578.640	25016.320	580.000
1.2	65%	1524.400	50.000	623.000	851.400	370.000	481.400	96.280	577.680	25027.840	580.000
1.3	60% A	1658.600	50.000	673.000	935.600	453.000	482.600	96.520	579.120	25010.560	580.000
1.4	60% B	1658.600	50.000	623.000	985.600	503.000	482.600	96.520	579.120	25010.560	580.000
1.5	75%	1256.000	50.000	573.000	633.000	150.000	483.000	96.600	579.600	25004.800	580.000

Table A21: Normal year scenarios Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Average values

Average values											
Scenario	WWTPIRW recycling rate	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status at the end of the period	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
1.1	70%	1125.000	1140.000	2265.000	419.000	2684.000	1051.170	805.200	0.700	0.000	1878.800
1.2	65%	1125.000	1140.000	2265.000	419.000	2684.000	1051.170	939.400	0.650	0.000	1744.600
1.3 & 1.4	60%	1125.000	1140.000	2265.000	419.000	2684.000	1051.170	1040.224	0.600	400.509	1610.400
1.5	75%	1125.000	1140.000	2265.000	419.000	2684.000	1051.170	671.000	0.750	0.000	2013.000

Table A22: Normal year scenarios WWTPIRW . Average values

Average values										
Scenario	WWTPIRW recycling rate	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
1.1	70%	1869.000	1400.000	3269.000	0.000	1878.800	0.000	1390.200	1390.200	1000.000
1.2	65%	1869.000	1400.000	3269.000	0.000	1744.600	0.000	1524.400	1524.400	1000.000
1.3 & 1.4	60%	1869.000	1400.000	3269.000	0.000	1610.400	0.000	1658.600	1658.600	1000.000
1.5	75%	1869.000	1400.000	3269.000	0.000	2013.000	0.000	1256.000	1256.000	1000.000

Table A23: Normal year scenarios Botunetz lake . Average values

Average values												
Scenario	WWTPIRW recycling rate	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
1.1	70%	4209.000	4702.328	2684.000	1878.800	0.700	1878.800	0.446	493.328	2372.128	0.504	1201.712
1.2	65%	4209.000	4702.328	2684.000	1744.600	0.650	1744.600	0.415	493.328	2237.928	0.476	1335.912
1.3 & 1.4	60%	4209.000	4702.328	2684.000	1610.400	0.600	1610.400	0.383	493.328	2103.728	0.447	1436.736
1.5	75%	4209.000	4702.328	2684.000	2013.000	0.750	2013.000	0.478	493.328	2506.328	0.533	1067.512

Table A24: Normal year scenarios Total system water needs, releases to Lesnovska and recycling rates. Average values

Appendix B

“Dry year” scenarios

Scenario	WWTPIRW recycling rate	Water WQ1 for constant units	Water WQ1 for non-constant units	Total WQ1 demands	Rudnik PS	Pancharevo direct to KP	Maximum allowed water uptake from Pancharevo	Gravity flow from Pancharevo to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
2.1	90%	552.072	387.928	940	313	627	1200	0
2.2	90%	552.072	387.928	940	313	627	1200	0

Table B1: Higher water quality WQ1 demands and flows for dry year scenarios

Month	Simulation Time step	Sludge from non constant units	Sludge from constant units	Sludge inflow from KP	Drainage losses	Evaporation losses	Net inflow to Sgurootvaal	Sgurootvaal sludge pond	PS return from SG to Botunetz	Overflow from SG to Lesnovska	Max allowed overflow to Lesnovska
				x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
Jan	0	12	277	289	17.34	11.56	260.1	600	0	237.5	237.5
Feb	1	12	277	289	17.34	11.56	260.1	622.6	0	237.5	237.5
March	2	12	277	289	17.34	11.56	260.1	645.2	0	237.5	237.5
April	3	12	277	289	17.34	11.56	260.1	667.8	0	237.5	237.5
May	4	12	277	289	17.34	11.56	260.1	690.4	0	237.5	237.5
June	5	12	277	289	17.34	11.56	260.1	713	0	237.5	237.5
July	6	12	277	289	17.34	11.56	260.1	735.6	0	237.5	237.5
Aug	7	12	277	289	17.34	11.56	260.1	758.2	0	237.5	237.5
Sept	8	12	277	289	17.34	11.56	260.1	780.8	0	237.5	237.5
Oct	9	12	277	289	17.34	11.56	260.1	803.4	0	237.5	237.5
Nov	10	12	277	289	17.34	11.56	260.1	826	0	237.5	237.5
Dec	11	12	277	289	17.34	11.56	260.1	848.6	0	237.5	237.5
Jan	12	12	277	289	17.34	11.56	260.1	871.2	0	237.5	237.5
							Excess	**271.2**			

Table B2: Sgurootvaal sludge pond subsystem for all dry year scenarios

Scenario	WW to HVOST from constant units	WW to HVOST from non constant units	WW to HVOST	Drainage losses	Evaporation	Return parameter 0/1	Return (recycling)	Water WQ3 to KP from HVOST	HVOST to Lesnovska	Max allowed release from HVOST
	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
2.1	648	129.6	777.6	46.656	31.104	0	0	493.328	206.512	354.17
2.2	648	129.6	777.6	46.656	31.104	1	206.512	493.328	0	354.17

Table B3: Hvostohraniliste sludge pond subsystem for all dry year scenarios

90%	Recycle rate		All scenarios								
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1125.000	1140	2265	123.279	2388.279	1051.170	238.828	0.900	0.000	2149.4506
Feb	1	1125.000	1140	2265	136.487	2401.487	1051.170	240.149	0.900	0.000	2161.3382
March	2	1125.000	1140	2265	167.307	2432.307	1051.170	243.231	0.900	0.000	2189.0758
April	3	1125.000	1140	2265	224.543	2489.543	1051.170	248.954	0.900	0.000	2240.5886
May	4	1125.000	1140	2265	321.405	2586.405	1051.170	258.641	0.900	0.000	2327.7641
June	5	1125.000	1140	2265	330.210	2595.210	1051.170	259.521	0.900	0.000	2335.6891
July	6	1125.000	1140	2265	277.377	2542.377	1051.170	254.238	0.900	0.000	2288.1389
Aug	7	1125.000	1140	2265	224.543	2489.543	1051.170	248.954	0.900	0.000	2240.5886
Sept	8	1125.000	1140	2265	167.307	2432.307	1051.170	243.231	0.900	0.000	2189.0758
Oct	9	1125.000	1140	2265	154.098	2419.098	1051.170	241.910	0.900	0.000	2177.1883
Nov	10	1125.000	1140	2265	211.335	2476.335	1051.170	247.634	0.900	0.000	2228.7011
Dec	11	1125.000	1140	2265	176.112	2441.112	1051.170	244.111	0.900	0.000	2197.0009
Jan	12	1125.000	1140	2265	123.279	2388.279	1051.170	238.828	0.900	0.000	2149.4506
Average		1125.000	1140.000	2265.000	209.500	2474.500	1051.170	247.450	0.900	0.000	2227.050

Table B4: WWTPIRW for all dry year scenarios. WWTPIRW recycling rate set at 90%

90%	Recycle rate		No return from Hvostohraniliste								
Months	Timestep	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir surplus-deficit	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1119.549	0	0	1119.549	294.221	825.329	165.066	990.395	25000.000	290
Feb	1	1107.662	0	0	1107.662	325.744	781.918	156.384	938.301	24299.606	290
March	2	1079.924	0	0	1079.924	399.300	680.625	136.125	816.750	23651.305	290
April	3	1028.411	0	0	1028.411	500.000	528.411	105.682	634.094	23124.555	290
May	4	941.236	0	0	941.236	500.000	441.236	88.247	529.483	22780.461	290
June	5	933.311	0	0	933.311	500.000	433.311	86.662	519.973	22540.978	290
July	6	980.861	0	0	980.861	500.000	480.861	96.172	577.033	22311.005	290
Aug	7	1028.411	0	0	1028.411	500.000	528.411	105.682	634.094	22023.972	290
Sept	8	1079.924	0	0	1079.924	399.300	680.625	136.125	816.750	21679.878	290
Oct	9	1091.812	0	0	1091.812	367.776	724.036	144.807	868.843	21153.129	290
Nov	10	1040.299	0	0	1040.299	500.000	540.299	108.060	648.359	20574.285	290
Dec	11	1071.999	0	0	1071.999	420.315	651.684	130.337	782.021	20215.927	290
Jan	12	1119.549	0	0	1119.549	294.221	825.329	165.066	990.395	19723.906	290
Average		1041.950	0.000	0.000	1041.950	433.888	608.062	121.612	729.675		290.000

Table B5: Scenario 2.1 Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Recycling rate 90% at WWTPIRW

90% Recycle rate			No return from Hvostohraniliste							
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400	3269	0.000	2149.451	0.000	1119.549	1119.549	1000.000
Feb	1	1869.000	1400	3269	0.000	2161.338	0.000	1107.662	1107.662	1000.000
March	2	1869.000	1400	3269	0.000	2189.076	0.000	1079.924	1079.924	1000.000
April	3	1869.000	1400	3269	0.000	2240.589	0.000	1028.411	1028.411	1000.000
May	4	1869.000	1400	3269	0.000	2327.764	0.000	941.236	941.236	1000.000
June	5	1869.000	1400	3269	0.000	2335.689	0.000	933.311	933.311	1000.000
July	6	1869.000	1400	3269	0.000	2288.139	0.000	980.861	980.861	1000.000
Aug	7	1869.000	1400	3269	0.000	2240.589	0.000	1028.411	1028.411	1000.000
Sept	8	1869.000	1400	3269	0.000	2189.076	0.000	1079.924	1079.924	1000.000
Oct	9	1869.000	1400	3269	0.000	2177.188	0.000	1091.812	1091.812	1000.000
Nov	10	1869.000	1400	3269	0.000	2228.701	0.000	1040.299	1040.299	1000.000
Dec	11	1869.000	1400	3269	0.000	2197.001	0.000	1071.999	1071.999	1000.000
Jan	12	1869.000	1400	3269	0.000	2149.451	0.000	1119.549	1119.549	1000.000
Average		1869.000	1400.000	3269.000	0.000	2227.050	0.000	1041.950	1041.950	1000.000

Table B6: Scenario 2.1 Botunetz lake. Recycling rate 90% at WWTPIRW

90%	Recycle rate		No return from Hvostohraniliste									
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4209.000	4702.328	2388.279	2149.451	0.900	2149.451	0.511	493.328	2642.779	0.562	635.340
Feb	1	4209.000	4702.328	2401.487	2161.338	0.900	2161.338	0.514	493.328	2654.666	0.565	636.661
March	2	4209.000	4702.328	2432.307	2189.076	0.900	2189.076	0.520	493.328	2682.404	0.570	639.743
April	3	4209.000	4702.328	2489.543	2240.589	0.900	2240.589	0.532	493.328	2733.917	0.581	645.466
May	4	4209.000	4702.328	2586.405	2327.764	0.900	2327.764	0.553	493.328	2821.092	0.600	655.153
June	5	4209.000	4702.328	2595.210	2335.689	0.900	2335.689	0.555	493.328	2829.017	0.602	656.033
July	6	4209.000	4702.328	2542.377	2288.139	0.900	2288.139	0.544	493.328	2781.467	0.592	650.750
Aug	7	4209.000	4702.328	2489.543	2240.589	0.900	2240.589	0.532	493.328	2733.917	0.581	645.466
Sept	8	4209.000	4702.328	2432.307	2189.076	0.900	2189.076	0.520	493.328	2682.404	0.570	639.743
Oct	9	4209.000	4702.328	2419.098	2177.188	0.900	2177.188	0.517	493.328	2670.516	0.568	638.422
Nov	10	4209.000	4702.328	2476.335	2228.701	0.900	2228.701	0.530	493.328	2722.029	0.579	644.146
Dec	11	4209.000	4702.328	2441.112	2197.001	0.900	2197.001	0.522	493.328	2690.329	0.572	640.623
Jan	12	4209.000	4702.328	2388.279	2149.451	0.900	2149.451	0.511	493.328	2642.779	0.562	635.340
Average		4209.000	4702.328	2474.500	2227.050	0.900	2227.050	0.529	493.328	2720.378	0.579	643.962

Table B7: Scenario 2.1 Total system water needs, releases to Lesnovska and recycling rates. Recycling rate 90% at WWTPIRW

90% Recycle rate			Returns from Hvostohraniliste								
Months	Timestep	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir surplus-deficit	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	913.037	0	0	913.037	294.221	618.817	123.763	742.580	25000.000	290
Feb	1	901.150	0	0	901.150	325.744	575.406	115.081	690.487	24547.420	290
March	2	873.412	0	0	873.412	399.300	474.113	94.823	568.935	24146.933	290
April	3	821.899	0	0	821.899	500.000	321.899	64.380	386.279	23867.998	290
May	4	734.724	0	0	734.724	500.000	234.724	46.945	281.669	23771.719	290
June	5	726.799	0	0	726.799	500.000	226.799	45.360	272.159	23780.050	290
July	6	774.349	0	0	774.349	500.000	274.349	54.870	329.219	23797.892	290
Aug	7	821.899	0	0	821.899	500.000	321.899	64.380	386.279	23758.673	290
Sept	8	873.412	0	0	873.412	399.300	474.113	94.823	568.935	23662.393	290
Oct	9	885.300	0	0	885.300	367.776	517.524	103.505	621.029	23383.458	290
Nov	10	833.787	0	0	833.787	500.000	333.787	66.757	400.544	23052.429	290
Dec	11	865.487	0	0	865.487	420.315	445.172	89.034	534.206	22941.885	290
Jan	12	913.037	0	0	913.037	294.221	618.817	123.763	742.580	22697.679	290
Average		835.438	0.000	0.000	835.438	433.888	401.550	80.310	481.860		290.000

Table B8: Scenario 2.2 Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Recycling rate 90% at WWTPIRW

90%	Recycle rate		Returns from Hvostohraniliste							
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400	3269	206.512	2149.451	0.000	913.037	913.037	1000.000
Feb	1	1869.000	1400	3269	206.512	2161.338	0.000	901.150	901.150	1000.000
March	2	1869.000	1400	3269	206.512	2189.076	0.000	873.412	873.412	1000.000
April	3	1869.000	1400	3269	206.512	2240.589	0.000	821.899	821.899	1000.000
May	4	1869.000	1400	3269	206.512	2327.764	0.000	734.724	734.724	1000.000
June	5	1869.000	1400	3269	206.512	2335.689	0.000	726.799	726.799	1000.000
July	6	1869.000	1400	3269	206.512	2288.139	0.000	774.349	774.349	1000.000
Aug	7	1869.000	1400	3269	206.512	2240.589	0.000	821.899	821.899	1000.000
Sept	8	1869.000	1400	3269	206.512	2189.076	0.000	873.412	873.412	1000.000
Oct	9	1869.000	1400	3269	206.512	2177.188	0.000	885.300	885.300	1000.000
Nov	10	1869.000	1400	3269	206.512	2228.701	0.000	833.787	833.787	1000.000
Dec	11	1869.000	1400	3269	206.512	2197.001	0.000	865.487	865.487	1000.000
Jan	12	1869.000	1400	3269	206.512	2149.451	0.000	913.037	913.037	1000.000
Average		1869.000	1400.000	3269.000	206.512	2227.050	0.000	835.438	835.438	1000.000

Table B9: Scenario 2.2 Botunetz lake. Recycling rate 90% at WWTPIRW

90%	Recycle rate		Returns from Hvostohraniliste									
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4209.000	4702.328	2388.279	2149.451	0.900	2355.963	0.560	493.328	2849.291	0.606	428.828
Feb	1	4209.000	4702.328	2401.487	2161.338	0.900	2367.850	0.563	493.328	2861.178	0.609	430.149
March	2	4209.000	4702.328	2432.307	2189.076	0.900	2395.588	0.569	493.328	2888.916	0.614	433.231
April	3	4209.000	4702.328	2489.543	2240.589	0.900	2447.101	0.581	493.328	2940.429	0.625	438.954
May	4	4209.000	4702.328	2586.405	2327.764	0.900	2534.276	0.602	493.328	3027.604	0.644	448.641
June	5	4209.000	4702.328	2595.210	2335.689	0.900	2542.201	0.604	493.328	3035.529	0.646	449.521
July	6	4209.000	4702.328	2542.377	2288.139	0.900	2494.651	0.593	493.328	2987.979	0.635	444.238
Aug	7	4209.000	4702.328	2489.543	2240.589	0.900	2447.101	0.581	493.328	2940.429	0.625	438.954
Sept	8	4209.000	4702.328	2432.307	2189.076	0.900	2395.588	0.569	493.328	2888.916	0.614	433.231
Oct	9	4209.000	4702.328	2419.098	2177.188	0.900	2383.700	0.566	493.328	2877.028	0.612	431.910
Nov	10	4209.000	4702.328	2476.335	2228.701	0.900	2435.213	0.579	493.328	2928.541	0.623	437.634
Dec	11	4209.000	4702.328	2441.112	2197.001	0.900	2403.513	0.571	493.328	2896.841	0.616	434.111
Jan	12	4209.000	4702.328	2388.279	2149.451	0.900	2355.963	0.560	493.328	2849.291	0.606	428.828
Average		4209.000	4702.328	2474.500	2227.050	0.900	2433.562	0.578	493.328	2926.890	0.622	437.450

Table B10: Scenario 2.2 Total system water needs, releases to Lesnovska and recycling rates. Recycling rate 90% at WWTPIRW

Average values											
Scenario	WWTPIRW recycling rate	WQ1 water	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status at the end of the period	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
2.1	90%	1041.95	0.000	0.000	1041.950	433.888	608.062	121.612	729.675	19723.906	290.000
2.2	90%	835.438	0.000	0.000	835.438	433.888	401.550	80.310	481.860	22697.679	290.000

Table B11: Dry year scenarios Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Average values

Average values										
Scenario	WWTPIRW recycling rate	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
2.1	90%	1869.000	1400.000	3269.000	0.000	2227.050	0.000	1041.950	1041.950	1000.000
2.2	90%	1869.000	1400.000	3269.000	206.512	2227.050	0.000	835.438	835.438	1000.000

Table B11: Dry year scenarios Botunetz lake. Average values

Average values													
Scenario	WWTPIRW recycling rate	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
2.1	90%	4209.000	4702.328	2474.500	2227.050	0.900	2227.050	0.529	493.328	2720.378	0.579	643.962
2.2	90%	4209.000	4702.328	2474.500	2227.050	0.900	2433.562	0.578	493.328	2926.890	0.622	437.450

Table B12: Dry year scenarios Total system water needs, releases to Lesnovska and recycling rates. Average values

Appendix C

"Very dry year" scenarios

Scenario	Variation	Description
3.1		All units operate
3.2		Ore plant (OP) stops
3.3		OP + Other water users (OWU) stop (Priority 0)
3.4		OP + OWU + Refractory plant (RF) stop (Priorities 0,1)
3.5		OP + OWU + RF + Cold rolling mill (CR) stop (Priorities 0,1,2)
3.6A	Variation A	OP + all non constant units stop (Priorities 0,1,2,3)
3.6B	Variation B	OP + units with priorities 0,1,2,3 stop + Pancherevo excess to Botunetz
3.7.1A	Variation A	OP + all non constant units stop (Priorities 0,1,2,3) + Sinter plant (SP) reduced to 5/6 of capacity
3.7.2A	Variation A	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 4/6 of capacity
3.7.3A	Variation A	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 3/6 of capacity
3.7.1B	Variation B	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 5/6 of capacity + Pancherevo excess to Botunetz
3.7.2B	Variation B	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 4/6 of capacity + Pancherevo excess to Botunetz
3.7.3B	Variation B	OP + all non constant units stop (Priorities 0,1,2,3) + SP reduced to 4/6 of capacity + Pancherevo excess to Botunetz
3.8.1		OP stops + Sinter plant (SP) reduced to 5/6 of capacity. All other units operate
3.8.2		OP stops + Sinter plant (SP) reduced to 4/6 of capacity. All other units operate
3.8.3		OP stops + Sinter plant (SP) reduced to 3/6 of capacity. All other units operate

Table C1: Scenarios for “very dry” year conditions

Scenario	Stopping units	Water WQ1 for constant units	Water WQ1 for non-constant units	Total WQ1 demands	Rudnik PS	Pancharevo direct to KP	PANCHAREVO reservoir surpus/deficit at the end of the period	Maximum allowed water uptake from Pancharevo	Gravity flow from Pancharevo to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month	x 1000 m3/month
3.1	All on	552.072	387.928	940.000	313.000	627.000	-3924.000	300.000	0.000
3.2	OP	552.072	235.000	787.072	313.000	474.072	-2088.864	300.000	0.000
3.3	OP +(0)	552.072	165.000	717.072	313.000	404.072	-1248.864	300.000	0.000
3.4	OP+(0,1)	552.072	116.000	668.072	313.000	355.072	-660.864	300.000	0.000
3.5	OP+(0,1,2)	552.072	66.000	618.072	313.000	305.072	-60.864	300.000	0.000
3.6A	OP+(0,1,2,3)	552.072	0.000	552.072	313.000	239.072	731.136	300.000	0.000
3.6B	OP+(0,1,2,3)	552.072	0.000	552.072	313.000	239.072	0.000	300.000	60.928
3.7.1A	OP+(0,1,2,3)+SP(5/6)	520.893	0.000	520.893	313.000	207.893	1105.280	300.000	0.000
3.7.2A	OP+(0,1,2,3)+SP(4/6)	489.715	0.000	489.715	313.000	176.715	1479.424	300.000	0.000
3.7.3A	OP+(0,1,2,3)+SP(3/6)	458.536	0.000	458.536	313.000	145.536	1853.568	300.000	0.000
3.7.1B	OP+(0,1,2,3)+SP(5/6)	520.893	0.000	520.893	313.000	207.893	0.000	300.000	92.107
3.7.2B	OP+(0,1,2,3)+SP(4/6)	489.715	0.000	489.715	313.000	176.715	0.000	300.000	123.285
3.7.3B	OP+(0,1,2,3)+SP(3/6)	458.536	0.000	458.536	313.000	145.536	0.000	300.000	154.464
3.8.1	OP+SP(5/6)	520.893	235.000	755.893	313.000	442.893	-1714.720	300.000	0.000
3.8.2	OP+SP(4/6)	489.715	235.000	724.715	313.000	411.715	-1340.576	300.000	0.000
3.8.3	OP+SP(3/6)	458.536	235.000	693.536	313.000	380.536	-966.432	300.000	0.000

Table C2: Higher water quality WQ1 demands and flows for “very dry” year scenarios- Pancharevo reservoir status

Scenario	Stopping units	Sludge from non constant units	Sludge from constant units	Sludge inflow from KP	Drainage losses	Evaporation losses	Net inflow to Sgurootvaal	Sgurootvaal sludge pond excess	PS return from SG to Botunetz	Overflow from SG to Lesnovska	Max allowed overflow to Lesnovska
				x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
3.1	All on	12	277	289	17.34	11.56	260.1	271.2	0	237.5	237.5
3.2	OP	12	277	289	17.34	11.56	260.1	271.2	0	237.5	237.5
3.3	OP +(0)	12	277	289	17.34	11.56	260.1	271.2	0	237.5	237.5
3.4	OP+(0,1)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.5	OP+(0,1,2)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.6A	OP+(0,1,2,3)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.6B	OP+(0,1,2,3)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.7.1A	OP+(0,1,2,3)+SP(5/6)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.7.2A	OP+(0,1,2,3)+SP(4/6)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.7.3A	OP+(0,1,2,3)+SP(3/6)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.7.1B	OP+(0,1,2,3)+SP(5/6)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.7.2B	OP+(0,1,2,3)+SP(4/6)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.7.3B	OP+(0,1,2,3)+SP(3/6)	0	277	277	16.62	11.08	249.3	141.6	0	237.5	237.5
3.8.1	OP+SP(5/6)	12	277	289	17.34	11.56	260.1	271.2	0	237.5	237.5
3.8.2	OP+SP(4/6)	12	277	289	17.34	11.56	260.1	271.2	0	237.5	237.5
3.8.3	OP+SP(3/6)	12	277	289	17.34	11.56	260.1	271.2	0	237.5	237.5

Table C3: Sgurootvaal sludge pond subsystem for all “very dry” year scenarios- Sgurootvaal pond status (excess)

Scenario	Stopping units	WW to HVOST from constant units	WW to HVOST from non constant units	WW to HVOST	Drainage losses	Evaporation	Return parameter 0/1	Return (recycling) to BOTUNETZ	Water WQ3 to KP from HVOST	HVOST to Lesnovska	Max allowed release from HVOST
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
3.1	All on	648.000	129.600	777.600	46.656	31.104	1	206.512	493.328	0.000	354.170
3.2	OP	648.000	0.000	648.000	38.880	25.920	1	89.872	493.328	0.000	354.170
3.3	OP +(0)	648.000	0.000	648.000	38.880	25.920	1	89.872	493.328	0.000	354.170
3.4	OP+(0,1)	648.000	0.000	648.000	38.880	25.920	1	89.872	493.328	0.000	354.170
3.5	OP+(0,1,2)	648.000	0.000	648.000	38.880	25.920	1	89.872	493.328	0.000	354.170
3.6A	OP+(0,1,2,3)	648.000	0.000	648.000	38.880	25.920	1	89.872	493.328	0.000	354.170
3.6B	OP+(0,1,2,3)	648.000	0.000	648.000	38.880	25.920	1	89.872	493.328	0.000	354.170
3.7.1A	OP+(0,1,2,3)+SP(5/6)	540.000	0.000	540.000	32.400	21.600	1	74.893	411.107	0.000	354.170
3.7.2A	OP+(0,1,2,3)+SP(4/6)	432.000	0.000	432.000	25.920	17.280	1	59.915	328.885	0.000	354.170
3.7.3A	OP+(0,1,2,3)+SP(3/6)	324.000	0.000	324.000	19.440	12.960	1	44.936	246.664	0.000	354.170
3.7.1B	OP+(0,1,2,3)+SP(5/6)	540.000	0.000	540.000	32.400	21.600	1	74.893	411.107	0.000	354.170
3.7.2B	OP+(0,1,2,3)+SP(4/6)	432.000	0.000	432.000	25.920	17.280	1	59.915	328.885	0.000	354.170
3.7.3B	OP+(0,1,2,3)+SP(3/6)	324.000	0.000	324.000	19.440	12.960	1	44.936	246.664	0.000	354.170
3.8.1	OP+SP(5/6)	540.000	0.000	540.000	32.400	21.600	1	74.893	411.107	0.000	354.170
3.8.2	OP+SP(4/6)	432.000	0.000	432.000	25.920	17.280	1	59.915	328.885	0.000	354.170
3.8.3	OP+SP(3/6)	324.000	0.000	324.000	19.440	12.960	1	44.936	246.664	0.000	354.170

Table C4: Hvostohraniliste sludge pond subsystem for all “very dry” year scenarios- Returns from Hvostohraniliste to Botunetz

3.1	All on		95%	Recycle rate							
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	852.181	0.000	0.000	852.181	117.688	734.493	146.899	881.391	25000.000	200.000
Feb	1	845.907	0.000	0.000	845.907	130.298	715.609	143.122	858.731	24263.609	200.000
March	2	831.267	0.000	0.000	831.267	159.720	671.548	134.310	805.857	23549.878	200.000
April	3	804.080	0.000	0.000	804.080	200.000	604.080	120.816	724.896	22889.021	200.000
May	4	758.071	0.000	0.000	758.071	200.000	558.071	111.614	669.685	22309.125	200.000
June	5	753.888	0.000	0.000	753.888	200.000	553.888	110.778	664.666	21784.440	200.000
July	6	778.984	0.000	0.000	778.984	200.000	578.984	115.797	694.781	21264.774	200.000
Aug	7	804.080	0.000	0.000	804.080	200.000	604.080	120.816	724.896	20714.993	200.000
Sept	8	831.267	0.000	0.000	831.267	159.720	671.548	134.310	805.857	20135.097	200.000
Oct	9	837.541	0.000	0.000	837.541	147.110	690.431	138.086	828.517	19474.240	200.000
Nov	10	810.354	0.000	0.000	810.354	200.000	610.354	122.071	732.425	18790.723	200.000
Dec	11	827.085	0.000	0.000	827.085	168.126	658.959	131.792	790.750	18203.298	200.000
Jan	12	852.181	0.000	0.000	852.181	117.688	734.493	146.899	881.391	17557.547	200.000
Average		811.225	0.000	0.000	811.225	173.555	637.670	127.534	765.204		200.000

Table C5: Very dry year scenario 3.1. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows.

3.2	OP stops		95%	Recycle rate							
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	968.821	0.000	0.000	968.821	117.688	851.133	170.227	1021.359	25000.000	200.000
Feb	1	962.547	0.000	0.000	962.547	130.298	832.249	166.450	998.699	24123.641	200.000
March	2	947.907	0.000	0.000	947.907	159.720	788.188	157.638	945.825	23269.942	200.000
April	3	920.720	0.000	0.000	920.720	200.000	720.720	144.144	864.864	22469.117	200.000
May	4	874.711	0.000	0.000	874.711	200.000	674.711	134.942	809.653	21749.253	200.000
June	5	870.528	0.000	0.000	870.528	200.000	670.528	134.106	804.634	21084.600	200.000
July	6	895.624	0.000	0.000	895.624	200.000	695.624	139.125	834.749	20424.966	200.000
Aug	7	920.720	0.000	0.000	920.720	200.000	720.720	144.144	864.864	19735.217	200.000
Sept	8	947.907	0.000	0.000	947.907	159.720	788.188	157.638	945.825	19015.353	200.000
Oct	9	954.181	0.000	0.000	954.181	147.110	807.071	161.414	968.485	18214.528	200.000
Nov	10	926.994	0.000	0.000	926.994	200.000	726.994	145.399	872.393	17391.043	200.000
Dec	11	943.725	0.000	0.000	943.725	168.126	775.599	155.120	930.718	16663.650	200.000
Jan	12	968.821	0.000	0.000	968.821	117.688	851.133	170.227	1021.359	15877.931	200.000
Average		927.865	0.000	0.000	927.865	173.555	754.310	150.862	905.172		200.000

Table C6: Very dry year scenario 3.2. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.3	OP +(0) stops		**95%**	Recycle rate							
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	767.171	0.000	0.000	767.171	117.688	649.483	129.897	779.379	25000.000	200.000
Feb	1	760.897	0.000	0.000	760.897	130.298	630.599	126.120	756.719	24365.621	200.000
March	2	746.257	0.000	0.000	746.257	159.720	586.538	117.308	703.845	23753.902	200.000
April	3	719.070	0.000	0.000	719.070	200.000	519.070	103.814	622.884	23195.057	200.000
May	4	673.061	0.000	0.000	673.061	200.000	473.061	94.612	567.673	22717.173	200.000
June	5	668.878	0.000	0.000	668.878	200.000	468.878	93.776	562.654	22294.500	200.000
July	6	693.974	0.000	0.000	693.974	200.000	493.974	98.795	592.769	21876.846	200.000
Aug	7	719.070	0.000	0.000	719.070	200.000	519.070	103.814	622.884	21429.077	200.000
Sept	8	746.257	0.000	0.000	746.257	159.720	586.538	117.308	703.845	20951.193	200.000
Oct	9	752.531	0.000	0.000	752.531	147.110	605.421	121.084	726.505	20392.348	200.000
Nov	10	725.344	0.000	0.000	725.344	200.000	525.344	105.069	630.413	19810.843	200.000
Dec	11	742.075	0.000	0.000	742.075	168.126	573.949	114.790	688.738	19325.430	200.000
Jan	12	767.171	0.000	0.000	767.171	117.688	649.483	129.897	779.379	18781.691	200.000
Average		726.215	0.000	0.000	726.215	173.555	552.660	110.532	663.192		200.000

Table C7: Very dry year scenario 3.3. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.4	OP +(0, 1) stops		95%	Recycle rate							
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	792.771	0.000	0.000	792.771	117.688	675.083	135.017	810.099	25000.000	200.000
Feb	1	786.497	0.000	0.000	786.497	130.298	656.199	131.240	787.439	24334.901	200.000
March	2	771.857	0.000	0.000	771.857	159.720	612.138	122.428	734.565	23692.462	200.000
April	3	744.670	0.000	0.000	744.670	200.000	544.670	108.934	653.604	23102.897	200.000
May	4	698.661	0.000	0.000	698.661	200.000	498.661	99.732	598.393	22594.293	200.000
June	5	694.478	0.000	0.000	694.478	200.000	494.478	98.896	593.374	22140.900	200.000
July	6	719.574	0.000	0.000	719.574	200.000	519.574	103.915	623.489	21692.526	200.000
Aug	7	744.670	0.000	0.000	744.670	200.000	544.670	108.934	653.604	21214.037	200.000
Sept	8	771.857	0.000	0.000	771.857	159.720	612.138	122.428	734.565	20705.433	200.000
Oct	9	778.131	0.000	0.000	778.131	147.110	631.021	126.204	757.225	20115.868	200.000
Nov	10	750.944	0.000	0.000	750.944	200.000	550.944	110.189	661.133	19503.643	200.000
Dec	11	767.675	0.000	0.000	767.675	168.126	599.549	119.910	719.458	18987.510	200.000
Jan	12	792.771	0.000	0.000	792.771	117.688	675.083	135.017	810.099	18413.051	200.000
Average		751.815	0.000	0.000	751.815	173.555	578.260	115.652	693.912		200.000

Table C8: Very dry year scenario 3.4. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.5	OP +(0,1,2) stops		95%	Recycle rate							
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	747.271	0.000	0.000	747.271	117.688	629.583	125.917	755.499	25000.000	200.000
Feb	1	740.997	0.000	0.000	740.997	130.298	610.699	122.140	732.839	24389.501	200.000
March	2	726.357	0.000	0.000	726.357	159.720	566.638	113.328	679.965	23801.662	200.000
April	3	699.170	0.000	0.000	699.170	200.000	499.170	99.834	599.004	23266.697	200.000
May	4	653.161	0.000	0.000	653.161	200.000	453.161	90.632	543.793	22812.693	200.000
June	5	648.978	0.000	0.000	648.978	200.000	448.978	89.796	538.774	22413.900	200.000
July	6	674.074	0.000	0.000	674.074	200.000	474.074	94.815	568.889	22020.126	200.000
Aug	7	699.170	0.000	0.000	699.170	200.000	499.170	99.834	599.004	21596.237	200.000
Sept	8	726.357	0.000	0.000	726.357	159.720	566.638	113.328	679.965	21142.233	200.000
Oct	9	732.631	0.000	0.000	732.631	147.110	585.521	117.104	702.625	20607.268	200.000
Nov	10	705.444	0.000	0.000	705.444	200.000	505.444	101.089	606.533	20049.643	200.000
Dec	11	722.175	0.000	0.000	722.175	168.126	554.049	110.810	664.858	19588.110	200.000
Jan	12	747.271	0.000	0.000	747.271	117.688	629.583	125.917	755.499	19068.251	200.000
Average		706.315	0.000	0.000	706.315	173.555	532.760	106.552	639.312		200.000

Table C9: Very dry year scenario 3.5. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.6.A	OP +(0,1,2,3) stops		95%	Recycle rate							
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	651.821	0.000	0.000	651.821	117.688	534.133	106.827	640.959	25000.000	200.000
Feb	1	645.547	0.000	0.000	645.547	130.298	515.249	103.050	618.299	24504.041	200.000
March	2	630.907	0.000	0.000	630.907	159.720	471.188	94.238	565.425	24030.742	200.000
April	3	603.720	0.000	0.000	603.720	200.000	403.720	80.744	484.464	23610.317	200.000
May	4	557.711	0.000	0.000	557.711	200.000	357.711	71.542	429.253	23270.853	200.000
June	5	553.528	0.000	0.000	553.528	200.000	353.528	70.706	424.234	22986.600	200.000
July	6	578.624	0.000	0.000	578.624	200.000	378.624	75.725	454.349	22707.366	200.000
Aug	7	603.720	0.000	0.000	603.720	200.000	403.720	80.744	484.464	22398.017	200.000
Sept	8	630.907	0.000	0.000	630.907	159.720	471.188	94.238	565.425	22058.553	200.000
Oct	9	637.181	0.000	0.000	637.181	147.110	490.071	98.014	588.085	21638.128	200.000
Nov	10	609.994	0.000	0.000	609.994	200.000	409.994	81.999	491.993	21195.043	200.000
Dec	11	626.725	0.000	0.000	626.725	168.126	458.599	91.720	550.318	20848.050	200.000
Jan	12	651.821	0.000	0.000	651.821	117.688	534.133	106.827	640.959	20442.731	200.000
Average		610.865	0.000	0.000	610.865	173.555	437.310	87.462	524.772		200.000

Table C10: Very dry year scenario 3.6.A. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.6.B	OP +(0,1,2,3) stops		**95%** Recycle rate								
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	651.821	0.000	60.928	590.893	117.688	473.205	94.641	567.845	25000.000	200.000
Feb	1	645.547	0.000	60.928	584.619	130.298	454.321	90.864	545.185	24577.155	200.000
March	2	630.907	0.000	60.928	569.979	159.720	410.260	82.052	492.312	24176.969	200.000
April	3	603.720	0.000	60.928	542.792	200.000	342.792	68.558	411.351	23829.658	200.000
May	4	557.711	0.000	60.928	496.783	200.000	296.783	59.357	356.139	23563.307	200.000
June	5	553.528	0.000	60.928	492.600	200.000	292.600	58.520	351.120	23352.168	200.000
July	6	578.624	0.000	60.928	517.696	200.000	317.696	63.539	381.235	23146.048	200.000
Aug	7	603.720	0.000	60.928	542.792	200.000	342.792	68.558	411.351	22909.812	200.000
Sept	8	630.907	0.000	60.928	569.979	159.720	410.260	82.052	492.312	22643.462	200.000
Oct	9	637.181	0.000	60.928	576.253	147.110	429.143	85.829	514.972	22296.150	200.000
Nov	10	609.994	0.000	60.928	549.066	200.000	349.066	69.813	418.879	21926.179	200.000
Dec	11	626.725	0.000	60.928	565.797	168.126	397.671	79.534	477.205	21652.299	200.000
Jan	12	651.821	0.000	60.928	590.893	117.688	473.205	94.641	567.845	21320.094	200.000
Average		610.865	0.000	60.928	549.937	173.555	376.382	75.276	451.659		200.000

Table C11: Very dry year scenario 3.6.B. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.7.1.A	OP +(0,1,2,3) stops+SP(5/6)			**95%**	Recycle rate						
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	666.799	0.000	0.000	666.799	117.688	549.111	109.822	658.933	25000.000	200.000
Feb	1	660.525	0.000	0.000	660.525	130.298	530.228	106.046	636.273	24486.067	200.000
March	2	645.886	0.000	0.000	645.886	159.720	486.166	97.233	583.400	23994.794	200.000
April	3	618.699	0.000	0.000	618.699	200.000	418.699	83.740	502.439	23556.394	200.000
May	4	572.690	0.000	0.000	572.690	200.000	372.690	74.538	447.227	23198.955	200.000
June	5	568.507	0.000	0.000	568.507	200.000	368.507	73.701	442.208	22896.728	200.000
July	6	593.603	0.000	0.000	593.603	200.000	393.603	78.721	472.323	22599.520	200.000
Aug	7	618.699	0.000	0.000	618.699	200.000	418.699	83.740	502.439	22272.197	200.000
Sept	8	645.886	0.000	0.000	645.886	159.720	486.166	97.233	583.400	21914.758	200.000
Oct	9	652.160	0.000	0.000	652.160	147.110	505.050	101.010	606.060	21476.359	200.000
Nov	10	624.973	0.000	0.000	624.973	200.000	424.973	84.995	509.967	21015.299	200.000
Dec	11	641.703	0.000	0.000	641.703	168.126	473.577	94.716	568.293	20650.332	200.000
Jan	12	666.799	0.000	0.000	666.799	117.688	549.111	109.822	658.933	20227.039	200.000
Average		625.844	0.000	0.000	625.844	173.555	452.289	90.458	542.747		200.000

Table C12: Very dry year scenario 3.7.1.A. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.7.2.A	OP +(0,1,2,3) stops+SP(4/6)			**95%**	Recycle rate						
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	681.778	0.000	0.000	681.778	117.688	564.090	112.818	676.908	25000.000	200.000
Feb	1	675.504	0.000	0.000	675.504	130.298	545.206	109.041	654.248	24468.092	200.000
March	2	660.865	0.000	0.000	660.865	159.720	501.145	100.229	601.374	23958.845	200.000
April	3	633.677	0.000	0.000	633.677	200.000	433.677	86.736	520.413	23502.471	200.000
May	4	587.668	0.000	0.000	587.668	200.000	387.668	77.534	465.202	23127.058	200.000
June	5	583.486	0.000	0.000	583.486	200.000	383.486	76.697	460.183	22806.856	200.000
July	6	608.582	0.000	0.000	608.582	200.000	408.582	81.716	490.298	22491.674	200.000
Aug	7	633.677	0.000	0.000	633.677	200.000	433.677	86.736	520.413	22146.376	200.000
Sept	8	660.865	0.000	0.000	660.865	159.720	501.145	100.229	601.374	21770.963	200.000
Oct	9	667.139	0.000	0.000	667.139	147.110	520.028	104.006	624.034	21314.589	200.000
Nov	10	639.951	0.000	0.000	639.951	200.000	439.951	87.990	527.942	20835.555	200.000
Dec	11	656.682	0.000	0.000	656.682	168.126	488.556	97.711	586.267	20452.613	200.000
Jan	12	681.778	0.000	0.000	681.778	117.688	564.090	112.818	676.908	20011.346	200.000
Average		640.823	0.000	0.000	640.823	173.555	467.268	93.454	560.721		200.000

Table C13: Very dry year scenario 3.7.2.A. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.7.3.A	OP +(0,1,2,3) stops+SP(3/6)			**95%**	Recycle rate						
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	696.757	0.000	0.000	696.757	117.688	579.069	115.814	694.882	25000.000	200.000
Feb	1	690.483	0.000	0.000	690.483	130.298	560.185	112.037	672.222	24450.118	200.000
March	2	675.843	0.000	0.000	675.843	159.720	516.124	103.225	619.348	23922.896	200.000
April	3	648.656	0.000	0.000	648.656	200.000	448.656	89.731	538.387	23448.548	200.000
May	4	602.647	0.000	0.000	602.647	200.000	402.647	80.529	483.176	23055.160	200.000
June	5	598.464	0.000	0.000	598.464	200.000	398.464	79.693	478.157	22716.984	200.000
July	6	623.560	0.000	0.000	623.560	200.000	423.560	84.712	508.272	22383.827	200.000
Aug	7	648.656	0.000	0.000	648.656	200.000	448.656	89.731	538.387	22020.555	200.000
Sept	8	675.843	0.000	0.000	675.843	159.720	516.124	103.225	619.348	21627.168	200.000
Oct	9	682.117	0.000	0.000	682.117	147.110	535.007	107.001	642.009	21152.819	200.000
Nov	10	654.930	0.000	0.000	654.930	200.000	454.930	90.986	545.916	20655.811	200.000
Dec	11	671.661	0.000	0.000	671.661	168.126	503.535	100.707	604.242	20254.895	200.000
Jan	12	696.757	0.000	0.000	696.757	117.688	579.069	115.814	694.882	19795.653	200.000
Average		655.801	0.000	0.000	655.801	173.555	482.246	96.449	578.696		200.000

Table C14: Very dry year scenario 3.7.3.A. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.7.1.B	OP +(0,1,2,3) stops+SP(5/6)			95%	Recycle rate						
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	666.799	0.000	92.107	574.693	117.688	457.004	91.401	548.405	25000.000	200.000
Feb	1	660.525	0.000	92.107	568.419	130.298	438.121	87.624	525.745	24596.595	200.000
March	2	645.886	0.000	92.107	553.779	159.720	394.060	78.812	472.872	24215.850	200.000
April	3	618.699	0.000	92.107	526.592	200.000	326.592	65.318	391.911	23887.978	200.000
May	4	572.690	0.000	92.107	480.583	200.000	280.583	56.117	336.699	23641.067	200.000
June	5	568.507	0.000	92.107	476.400	200.000	276.400	55.280	331.680	23449.368	200.000
July	6	593.603	0.000	92.107	501.496	200.000	301.496	60.299	361.795	23262.688	200.000
Aug	7	618.699	0.000	92.107	526.592	200.000	326.592	65.318	391.911	23045.893	200.000
Sept	8	645.886	0.000	92.107	553.779	159.720	394.060	78.812	472.872	22798.982	200.000
Oct	9	652.160	0.000	92.107	560.053	147.110	412.943	82.589	495.532	22471.111	200.000
Nov	10	624.973	0.000	92.107	532.866	200.000	332.866	66.573	399.439	22120.579	200.000
Dec	11	641.703	0.000	92.107	549.597	168.126	381.471	76.294	457.765	21866.140	200.000
Jan	12	666.799	0.000	92.107	574.693	117.688	457.004	91.401	548.405	21553.375	200.000
Average		625.844	0.000	92.107	533.737	173.555	360.182	72.036	432.219		200.000

Table C15: Very dry year scenario 3.7.1.B. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.7.2.B	OP +(0,1,2,3) stops+SP(4/6)		**95%**	Recycle rate							
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	681.778	0.000	123.285	558.493	117.688	440.804	88.161	528.965	25000.000	200.000
Feb	1	675.504	0.000	123.285	552.219	130.298	421.921	84.384	506.305	24616.035	200.000
March	2	660.865	0.000	123.285	537.579	159.720	377.860	75.572	453.432	24254.730	200.000
April	3	633.677	0.000	123.285	510.392	200.000	310.392	62.078	372.471	23946.298	200.000
May	4	587.668	0.000	123.285	464.383	200.000	264.383	52.877	317.259	23718.828	200.000
June	5	583.486	0.000	123.285	460.200	200.000	260.200	52.040	312.240	23546.568	200.000
July	6	608.582	0.000	123.285	485.296	200.000	285.296	57.059	342.355	23379.328	200.000
Aug	7	633.677	0.000	123.285	510.392	200.000	310.392	62.078	372.471	23181.973	200.000
Sept	8	660.865	0.000	123.285	537.579	159.720	377.860	75.572	453.432	22954.502	200.000
Oct	9	667.139	0.000	123.285	543.853	147.110	396.743	79.349	476.092	22646.071	200.000
Nov	10	639.951	0.000	123.285	516.666	200.000	316.666	63.333	379.999	22314.979	200.000
Dec	11	656.682	0.000	123.285	533.397	168.126	365.271	73.054	438.325	22079.980	200.000
Jan	12	681.778	0.000	123.285	558.493	117.688	440.804	88.161	528.965	21786.655	200.000
Average		640.823	0.000	123.285	517.537	173.555	343.982	68.796	412.779		200.000

Table C16: Very dry year scenario 3.7.2.B. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.7.3.B	OP +(0,1,2,3) stops+SP(3/6)			95%	Recycle rate						
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	696.757	0.000	154.464	542.293	117.688	424.605	84.921	509.525	25000.000	200.000
Feb	1	690.483	0.000	154.464	536.019	130.298	405.721	81.144	486.865	24635.475	200.000
March	2	675.843	0.000	154.464	521.379	159.720	361.660	72.332	433.992	24293.610	200.000
April	3	648.656	0.000	154.464	494.192	200.000	294.192	58.838	353.031	24004.618	200.000
May	4	602.647	0.000	154.464	448.183	200.000	248.183	49.637	297.819	23796.587	200.000
June	5	598.464	0.000	154.464	444.000	200.000	244.000	48.800	292.800	23643.768	200.000
July	6	623.560	0.000	154.464	469.096	200.000	269.096	53.819	322.915	23495.968	200.000
Aug	7	648.656	0.000	154.464	494.192	200.000	294.192	58.838	353.031	23318.053	200.000
Sept	8	675.843	0.000	154.464	521.379	159.720	361.660	72.332	433.992	23110.022	200.000
Oct	9	682.117	0.000	154.464	527.653	147.110	380.543	76.109	456.652	22821.030	200.000
Nov	10	654.930	0.000	154.464	500.466	200.000	300.466	60.093	360.559	22509.379	200.000
Dec	11	671.661	0.000	154.464	517.197	168.126	349.071	69.814	418.885	22293.819	200.000
Jan	12	696.757	0.000	154.464	542.293	117.688	424.605	84.921	509.525	22019.935	200.000
Average		655.801	0.000	154.464	501.337	173.555	327.782	65.556	393.339		200.000

Table C17: Very dry year scenario 3.7.3.B. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.8.1	OP stops+SP(5/6)		95%	Recycle rate							
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	983.799	0.000	0.000	983.799	117.688	866.111	173.222	1039.333	25000.000	200.000
Feb	1	977.525	0.000	0.000	977.525	130.298	847.228	169.446	1016.673	24105.667	200.000
March	2	962.886	0.000	0.000	962.886	159.720	803.166	160.633	963.800	23233.994	200.000
April	3	935.699	0.000	0.000	935.699	200.000	735.699	147.140	882.839	22415.194	200.000
May	4	889.690	0.000	0.000	889.690	200.000	689.690	137.938	827.627	21677.355	200.000
June	5	885.507	0.000	0.000	885.507	200.000	685.507	137.101	822.608	20994.728	200.000
July	6	910.603	0.000	0.000	910.603	200.000	710.603	142.121	852.723	20317.120	200.000
Aug	7	935.699	0.000	0.000	935.699	200.000	735.699	147.140	882.839	19609.397	200.000
Sept	8	962.886	0.000	0.000	962.886	159.720	803.166	160.633	963.800	18871.558	200.000
Oct	9	969.160	0.000	0.000	969.160	147.110	822.050	164.410	986.460	18052.759	200.000
Nov	10	941.973	0.000	0.000	941.973	200.000	741.973	148.395	890.367	17211.299	200.000
Dec	11	958.703	0.000	0.000	958.703	168.126	790.577	158.116	948.693	16465.932	200.000
Jan	12	983.799	0.000	0.000	983.799	117.688	866.111	173.222	1039.333	15662.239	200.000
Average		942.844	0.000	0.000	942.844	173.555	769.289	153.858	923.147		200.000

Table C18: Very dry year scenario 3.8.1. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.8.2	OP stops+SP(4/6)			**95%**	Recycle rate						
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	998.778	0.000	0.000	998.778	117.688	881.090	176.218	1057.308	25000.000	200.000
Feb	1	992.504	0.000	0.000	992.504	130.298	862.206	172.441	1034.648	24087.692	200.000
March	2	977.865	0.000	0.000	977.865	159.720	818.145	163.629	981.774	23198.045	200.000
April	3	950.677	0.000	0.000	950.677	200.000	750.677	150.136	900.813	22361.271	200.000
May	4	904.668	0.000	0.000	904.668	200.000	704.668	140.934	845.602	21605.458	200.000
June	5	900.486	0.000	0.000	900.486	200.000	700.486	140.097	840.583	20904.856	200.000
July	6	925.582	0.000	0.000	925.582	200.000	725.582	145.116	870.698	20209.274	200.000
Aug	7	950.677	0.000	0.000	950.677	200.000	750.677	150.136	900.813	19483.576	200.000
Sept	8	977.865	0.000	0.000	977.865	159.720	818.145	163.629	981.774	18727.763	200.000
Oct	9	984.139	0.000	0.000	984.139	147.110	837.028	167.406	1004.434	17890.989	200.000
Nov	10	956.951	0.000	0.000	956.951	200.000	756.951	151.390	908.342	17031.555	200.000
Dec	11	973.682	0.000	0.000	973.682	168.126	805.556	161.111	966.667	16268.213	200.000
Jan	12	998.778	0.000	0.000	998.778	117.688	881.090	176.218	1057.308	15446.546	200.000
Average		957.823	0.000	0.000	957.823	173.555	784.268	156.854	941.121		200.000

Table C19: Very dry year scenario 3.8.2. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

3.8.3	OP stops+SP(3/6)			95%	Recycle rate						
Months	Timestep	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status	Average water inflow toOgnjanovo for KP (decision-constraint)
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3/month
Jan	0	1013.757	0.000	0.000	1013.757	117.688	896.069	179.214	1075.282	25000.000	200.000
Feb	1	1007.483	0.000	0.000	1007.483	130.298	877.185	175.437	1052.622	24069.718	200.000
March	2	992.843	0.000	0.000	992.843	159.720	833.124	166.625	999.748	23162.096	200.000
April	3	965.656	0.000	0.000	965.656	200.000	765.656	153.131	918.787	22307.348	200.000
May	4	919.647	0.000	0.000	919.647	200.000	719.647	143.929	863.576	21533.560	200.000
June	5	915.464	0.000	0.000	915.464	200.000	715.464	143.093	858.557	20814.984	200.000
July	6	940.560	0.000	0.000	940.560	200.000	740.560	148.112	888.672	20101.427	200.000
Aug	7	965.656	0.000	0.000	965.656	200.000	765.656	153.131	918.787	19357.755	200.000
Sept	8	992.843	0.000	0.000	992.843	159.720	833.124	166.625	999.748	18583.968	200.000
Oct	9	999.117	0.000	0.000	999.117	147.110	852.007	170.401	1022.409	17729.219	200.000
Nov	10	971.930	0.000	0.000	971.930	200.000	771.930	154.386	926.316	16851.811	200.000
Dec	11	988.661	0.000	0.000	988.661	168.126	820.535	164.107	984.642	16070.495	200.000
Jan	12	1013.757	0.000	0.000	1013.757	117.688	896.069	179.214	1075.282	15230.853	200.000
Average		972.801	0.000	0.000	972.801	173.555	799.246	159.849	959.096		200.000

Table C20: Very dry year scenario 3.8.3. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows

Scenario	Fresh water needs for Botunetz (WQ1)	MATITZA river to Botunetz	Gravity flow from Pancharevo to BOTUNETZ	Pumped flow from PS Lesnovska	Additional intake from Lesnovska river	Water from OG arriving to Lesnovska	Losses from OG release	Total water release from OGNJANOVO for KP	OGNJANOVO reservoir status at the end of the period	OGNJANOVO water volume deficit	Average water inflow toOgnjanovo for KP (decision-constraint)
	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3	x 1000 m3	x 1000 m3/month
3.1	811.225	0.000	0.000	811.225	173.555	637.670	127.534	765.204	17557.547	-7442.453	145.000
3.2	927.865	0.000	0.000	927.865	173.555	754.310	150.862	905.172	15877.931	-9122.069	145.000
3.3	726.215	0.000	0.000	726.215	173.555	552.660	110.532	663.192	18781.691	-6218.309	145.000
3.4	751.815	0.000	0.000	751.815	173.555	578.260	115.652	693.912	18413.051	-6586.949	145.000
3.5	706.315	0.000	0.000	706.315	173.555	532.760	106.552	639.312	19068.251	-5931.749	145.000
3.6A	610.865	0.000	0.000	610.865	173.555	437.310	87.462	524.772	20442.731	-4557.269	145.000
3.6B	610.865	0.000	60.928	549.937	173.555	376.382	75.276	451.659	21320.094	-3679.906	145.000
3.7.1A	625.844	0.000	0.000	625.844	173.555	452.289	90.458	542.747	20227.039	-4772.961	145.000
3.7.2A	640.823	0.000	0.000	640.823	173.555	467.268	93.454	560.721	20011.346	-4988.654	145.000
3.7.3A	655.801	0.000	0.000	655.801	173.555	482.246	96.449	578.696	19795.653	-5204.347	145.000
3.7.1B	625.844	0.000	92.107	533.737	173.555	360.182	72.036	432.219	21553.375	-3446.625	145.000
3.7.2B	640.823	0.000	123.285	517.537	173.555	343.982	68.796	412.779	21786.655	-3213.345	145.000
3.7.3B	655.801	0.000	154.464	501.337	173.555	327.782	65.556	393.339	22019.935	-2980.065	145.000
3.8.1	942.844	0.000	0.000	942.844	173.555	769.289	153.858	923.147	15662.239	-9337.761	145.000
3.8.2	957.823	0.000	0.000	957.823	173.555	784.268	156.854	941.121	15446.546	-9553.454	145.000
3.8.3	972.801	0.000	0.000	972.801	173.555	799.246	159.849	959.096	15230.853	-9769.147	145.000

Table C21: Comparative for very dry year scenarios. Ognjanovo, Lesnovska, Matitza and Pancherevo to Botunetz flows. Average values

3.1	All on	95%	Recycle rate
3.2	OP stops	95%	Recycle rate
3.8	OP stops + SP reduced	95%	Recycle rate

Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3	x 1000 m3/month
Jan	0	1125.000	1140.000	2265.000	61.639	2326.639	1051.170	116.332	0.950	0.000	2210.3073
Feb	1	1125.000	1140.000	2265.000	68.243	2333.243	1051.170	116.662	0.950	0.000	2216.5813
March	2	1125.000	1140.000	2265.000	83.653	2348.653	1051.170	117.433	0.950	0.000	2231.2206
April	3	1125.000	1140.000	2265.000	112.272	2377.272	1051.170	118.864	0.950	0.000	2258.4079
May	4	1125.000	1140.000	2265.000	160.702	2425.702	1051.170	121.285	0.950	0.000	2304.4172
June	5	1125.000	1140.000	2265.000	165.105	2430.105	1051.170	121.505	0.950	0.000	2308.5998
July	6	1125.000	1140.000	2265.000	138.688	2403.688	1051.170	120.184	0.950	0.000	2283.5039
Aug	7	1125.000	1140.000	2265.000	112.272	2377.272	1051.170	118.864	0.950	0.000	2258.4079
Sept	8	1125.000	1140.000	2265.000	83.653	2348.653	1051.170	117.433	0.950	0.000	2231.2206
Oct	9	1125.000	1140.000	2265.000	77.049	2342.049	1051.170	117.103	0.950	0.000	2224.9466
Nov	10	1125.000	1140.000	2265.000	105.667	2370.667	1051.170	118.533	0.950	0.000	2252.1339
Dec	11	1125.000	1140.000	2265.000	88.056	2353.056	1051.170	117.653	0.950	0.000	2235.4032
Jan	12	1125.000	1140.000	2265.000	61.639	2326.639	1051.170	116.332	0.950	0.000	2210.3073
Average		1125.000	1140.000	2265.000	104.750	2369.750	1051.170	118.488	0.950	0.000	2251.263

Table C22: Very dry year scenarios 3.1, 3.2, 3.8.1, 3.8.2 and 3.8.3. WWTPIRW

3.3	OP + (0) stops		**95%**	Recycle rate							
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3	x 1000 m3/month
Jan	0	1125.000	827.000	1952.000	61.639	2013.639	1051.170	100.682	0.950	0.000	1912.9573
Feb	1	1125.000	827.000	1952.000	68.243	2020.243	1051.170	101.012	0.950	0.000	1919.2313
March	2	1125.000	827.000	1952.000	83.653	2035.653	1051.170	101.783	0.950	0.000	1933.8706
April	3	1125.000	827.000	1952.000	112.272	2064.272	1051.170	103.214	0.950	0.000	1961.0579
May	4	1125.000	827.000	1952.000	160.702	2112.702	1051.170	105.635	0.950	0.000	2007.0672
June	5	1125.000	827.000	1952.000	165.105	2117.105	1051.170	105.855	0.950	0.000	2011.2498
July	6	1125.000	827.000	1952.000	138.688	2090.688	1051.170	104.534	0.950	0.000	1986.1539
Aug	7	1125.000	827.000	1952.000	112.272	2064.272	1051.170	103.214	0.950	0.000	1961.0579
Sept	8	1125.000	827.000	1952.000	83.653	2035.653	1051.170	101.783	0.950	0.000	1933.8706
Oct	9	1125.000	827.000	1952.000	77.049	2029.049	1051.170	101.453	0.950	0.000	1927.5966
Nov	10	1125.000	827.000	1952.000	105.667	2057.667	1051.170	102.883	0.950	0.000	1954.7839
Dec	11	1125.000	827.000	1952.000	88.056	2040.056	1051.170	102.003	0.950	0.000	1938.0532
Jan	12	1125.000	827.000	1952.000	61.639	2013.639	1051.170	100.682	0.950	0.000	1912.9573
Average		1125.000	827.000	1952.000	104.750	2056.750	1051.170	102.838	0.950	0.000	1953.913

Table C23: Very dry year scenario 3.3. WWTPIRW

3.4	OP + (0,1) stops	95%	Recycle rate								
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3	x 1000 m3/month
Jan	0	1125.000	699.000	1824.000	61.639	1885.639	1051.170	94.282	0.950	0.000	1791.3573
Feb	1	1125.000	699.000	1824.000	68.243	1892.243	1051.170	94.612	0.950	0.000	1797.6313
March	2	1125.000	699.000	1824.000	83.653	1907.653	1051.170	95.383	0.950	0.000	1812.2706
April	3	1125.000	699.000	1824.000	112.272	1936.272	1051.170	96.814	0.950	0.000	1839.4579
May	4	1125.000	699.000	1824.000	160.702	1984.702	1051.170	99.235	0.950	0.000	1885.4672
June	5	1125.000	699.000	1824.000	165.105	1989.105	1051.170	99.455	0.950	0.000	1889.6498
July	6	1125.000	699.000	1824.000	138.688	1962.688	1051.170	98.134	0.950	0.000	1864.5539
Aug	7	1125.000	699.000	1824.000	112.272	1936.272	1051.170	96.814	0.950	0.000	1839.4579
Sept	8	1125.000	699.000	1824.000	83.653	1907.653	1051.170	95.383	0.950	0.000	1812.2706
Oct	9	1125.000	699.000	1824.000	77.049	1901.049	1051.170	95.053	0.950	0.000	1805.9966
Nov	10	1125.000	699.000	1824.000	105.667	1929.667	1051.170	96.483	0.950	0.000	1833.1839
Dec	11	1125.000	699.000	1824.000	88.056	1912.056	1051.170	95.603	0.950	0.000	1816.4532
Jan	12	1125.000	699.000	1824.000	61.639	1885.639	1051.170	94.282	0.950	0.000	1791.3573
Average		1125.000	699.000	1824.000	104.750	1928.750	1051.170	96.438	0.950	0.000	1832.313

Table C24: Very dry year scenario 3.4. WWTPIRW

3.5	OP + (0,1,2) stops		95% Recycle rate								
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3	x 1000 m3/month
Jan	0	1125.000	529.000	1654.000	61.639	1715.639	1051.170	85.782	0.950	0.000	1629.8573
Feb	1	1125.000	529.000	1654.000	68.243	1722.243	1051.170	86.112	0.950	0.000	1636.1313
March	2	1125.000	529.000	1654.000	83.653	1737.653	1051.170	86.883	0.950	0.000	1650.7706
April	3	1125.000	529.000	1654.000	112.272	1766.272	1051.170	88.314	0.950	0.000	1677.9579
May	4	1125.000	529.000	1654.000	160.702	1814.702	1051.170	90.735	0.950	0.000	1723.9672
June	5	1125.000	529.000	1654.000	165.105	1819.105	1051.170	90.955	0.950	0.000	1728.1498
July	6	1125.000	529.000	1654.000	138.688	1792.688	1051.170	89.634	0.950	0.000	1703.0539
Aug	7	1125.000	529.000	1654.000	112.272	1766.272	1051.170	88.314	0.950	0.000	1677.9579
Sept	8	1125.000	529.000	1654.000	83.653	1737.653	1051.170	86.883	0.950	0.000	1650.7706
Oct	9	1125.000	529.000	1654.000	77.049	1731.049	1051.170	86.553	0.950	0.000	1644.4966
Nov	10	1125.000	529.000	1654.000	105.667	1759.667	1051.170	87.983	0.950	0.000	1671.6839
Dec	11	1125.000	529.000	1654.000	88.056	1742.056	1051.170	87.103	0.950	0.000	1654.9532
Jan	12	1125.000	529.000	1654.000	61.639	1715.639	1051.170	85.782	0.950	0.000	1629.8573
Average		1125.000	529.000	1654.000	104.750	1758.750	1051.170	87.938	0.950	0.000	1670.813

Table C25: Very dry year scenario 3.5. WWTPIRW

3.6	OP + (0,1,2,3) stops			**95%**	Recycle rate						
3.7	OP + (0,1,2,3) stops + SP reduced			**95%**	Recycle rate						
Months	Timestep	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Max allowed release to Lesnovska from WWTPIRW	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	WWTPIRW status	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3	x 1000 m3/month
Jan	0	1125.000	0.000	1125.000	61.639	1186.639	1051.170	59.332	0.950	0.000	1127.3073
Feb	1	1125.000	0.000	1125.000	68.243	1193.243	1051.170	59.662	0.950	0.000	1133.5813
March	2	1125.000	0.000	1125.000	83.653	1208.653	1051.170	60.433	0.950	0.000	1148.2206
April	3	1125.000	0.000	1125.000	112.272	1237.272	1051.170	61.864	0.950	0.000	1175.4079
May	4	1125.000	0.000	1125.000	160.702	1285.702	1051.170	64.285	0.950	0.000	1221.4172
June	5	1125.000	0.000	1125.000	165.105	1290.105	1051.170	64.505	0.950	0.000	1225.5998
July	6	1125.000	0.000	1125.000	138.688	1263.688	1051.170	63.184	0.950	0.000	1200.5039
Aug	7	1125.000	0.000	1125.000	112.272	1237.272	1051.170	61.864	0.950	0.000	1175.4079
Sept	8	1125.000	0.000	1125.000	83.653	1208.653	1051.170	60.433	0.950	0.000	1148.2206
Oct	9	1125.000	0.000	1125.000	77.049	1202.049	1051.170	60.103	0.950	0.000	1141.9466
Nov	10	1125.000	0.000	1125.000	105.667	1230.667	1051.170	61.533	0.950	0.000	1169.1339
Dec	11	1125.000	0.000	1125.000	88.056	1213.056	1051.170	60.653	0.950	0.000	1152.4032
Jan	12	1125.000	0.000	1125.000	61.639	1186.639	1051.170	59.332	0.950	0.000	1127.3073
Average		1125.000	0.000	1125.000	104.750	1229.750	1051.170	61.488	0.950	0.000	1168.263

Table C26: Very dry year scenarios 3.6.A, 3.6.B, 3.7.1A, 3.7.2A, 3.7.3A, 3.7.1B, 3.7.2B, 3.7.3B. WWTPIRW

Scenario	Stopping units	WW from constant units	WW from non-constant units	Waste Water from KP	Rainwater to WWTPIRW	Total WW+rain inflow	Treated WW from WWTPIRW to Lesnovska	WW recycling rate	Treated WW to Botunetz
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
3.1	All on	1125.000	1140.000	2265.000	104.750	2369.750	118.488	0.950	2251.263
3.2	OP	1125.000	1140.000	2265.000	104.750	2369.750	118.488	0.950	2251.263
3.3	OP +(0)	1125.000	827.000	1952.000	104.750	2056.750	102.838	0.950	1953.913
3.4	OP+(0,1)	1125.000	699.000	1824.000	104.750	1928.750	96.438	0.950	1832.313
3.5	OP+(0,1,2)	1125.000	529.000	1654.000	104.750	1758.750	87.938	0.950	1670.813
3.6A	OP+(0,1,2,3)	1125.000	0.000	1125.000	104.750	1229.750	61.488	0.950	1168.263
3.6B	OP+(0,1,2,3)	1125.000	0.000	1125.000	104.750	1229.750	61.488	0.950	1168.263
3.7.1A	OP+(0,1,2,3)+SP(5/6)	1125.000	0.000	1125.000	104.750	1229.750	61.488	0.950	1168.263
3.7.2A	OP+(0,1,2,3)+SP(4/6)	1125.000	0.000	1125.000	104.750	1229.750	61.488	0.950	1168.263
3.7.3A	OP+(0,1,2,3)+SP(3/6)	1125.000	0.000	1125.000	104.750	1229.750	61.488	0.950	1168.263
3.7.1B	OP+(0,1,2,3)+SP(5/6)	1125.000	0.000	1125.000	104.750	1229.750	61.488	0.950	1168.263
3.7.2B	OP+(0,1,2,3)+SP(4/6)	1125.000	0.000	1125.000	104.750	1229.750	61.488	0.950	1168.263
3.7.3B	OP+(0,1,2,3)+SP(3/6)	1125.000	0.000	1125.000	104.750	1229.750	61.488	0.950	1168.263
3.8.1	OP+SP(5/6)	1125.000	1140.000	2265.000	104.750	2369.750	118.488	0.950	2251.263
3.8.2	OP+SP(4/6)	1125.000	1140.000	2265.000	104.750	2369.750	118.488	0.950	2251.263
3.8.3	OP+SP(3/6)	1125.000	1140.000	2265.000	104.750	2369.750	118.488	0.950	2251.263

Table C27: Comparative for very dry year scenarios. WWTPIRW. Average values

3.1	All on		95%	Recycle rate						
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400.000	3269.000	206.512	2210.307	0.000	852.181	852.181	1000.000
Feb	1	1869.000	1400.000	3269.000	206.512	2216.581	0.000	845.907	845.907	1000.000
March	2	1869.000	1400.000	3269.000	206.512	2231.221	0.000	831.267	831.267	1000.000
April	3	1869.000	1400.000	3269.000	206.512	2258.408	0.000	804.080	804.080	1000.000
May	4	1869.000	1400.000	3269.000	206.512	2304.417	0.000	758.071	758.071	1000.000
June	5	1869.000	1400.000	3269.000	206.512	2308.600	0.000	753.888	753.888	1000.000
July	6	1869.000	1400.000	3269.000	206.512	2283.504	0.000	778.984	778.984	1000.000
Aug	7	1869.000	1400.000	3269.000	206.512	2258.408	0.000	804.080	804.080	1000.000
Sept	8	1869.000	1400.000	3269.000	206.512	2231.221	0.000	831.267	831.267	1000.000
Oct	9	1869.000	1400.000	3269.000	206.512	2224.947	0.000	837.541	837.541	1000.000
Nov	10	1869.000	1400.000	3269.000	206.512	2252.134	0.000	810.354	810.354	1000.000
Dec	11	1869.000	1400.000	3269.000	206.512	2235.403	0.000	827.085	827.085	1000.000
Jan	12	1869.000	1400.000	3269.000	206.512	2210.307	0.000	852.181	852.181	1000.000
Average		1869.000	1400.000	3269.000	206.512	2251.263	0.000	811.225	811.225	1000.000

Table C28: Very dry year scenario 3.1. Botunetz lake inflows/outflows

3.2	OP stops		95%	Recycle rate						
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400.000	3269.000	89.872	2210.307	0.000	968.821	968.821	1000.000
Feb	1	1869.000	1400.000	3269.000	89.872	2216.581	0.000	962.547	962.547	1000.000
March	2	1869.000	1400.000	3269.000	89.872	2231.221	0.000	947.907	947.907	1000.000
April	3	1869.000	1400.000	3269.000	89.872	2258.408	0.000	920.720	920.720	1000.000
May	4	1869.000	1400.000	3269.000	89.872	2304.417	0.000	874.711	874.711	1000.000
June	5	1869.000	1400.000	3269.000	89.872	2308.600	0.000	870.528	870.528	1000.000
July	6	1869.000	1400.000	3269.000	89.872	2283.504	0.000	895.624	895.624	1000.000
Aug	7	1869.000	1400.000	3269.000	89.872	2258.408	0.000	920.720	920.720	1000.000
Sept	8	1869.000	1400.000	3269.000	89.872	2231.221	0.000	947.907	947.907	1000.000
Oct	9	1869.000	1400.000	3269.000	89.872	2224.947	0.000	954.181	954.181	1000.000
Nov	10	1869.000	1400.000	3269.000	89.872	2252.134	0.000	926.994	926.994	1000.000
Dec	11	1869.000	1400.000	3269.000	89.872	2235.403	0.000	943.725	943.725	1000.000
Jan	12	1869.000	1400.000	3269.000	89.872	2210.307	0.000	968.821	968.821	1000.000
Average		1869.000	1400.000	3269.000	89.872	2251.263	0.000	927.865	927.865	1000.000

Table C29: Very dry year scenario 3.2. Botunetz lake inflows/outflows

3.3	OP + (0) stops		95% Recycle rate							
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	901.000	2770.000	89.872	1912.957	0.000	767.171	767.171	1000.000
Feb	1	1869.000	901.000	2770.000	89.872	1919.231	0.000	760.897	760.897	1000.000
March	2	1869.000	901.000	2770.000	89.872	1933.871	0.000	746.257	746.257	1000.000
April	3	1869.000	901.000	2770.000	89.872	1961.058	0.000	719.070	719.070	1000.000
May	4	1869.000	901.000	2770.000	89.872	2007.067	0.000	673.061	673.061	1000.000
June	5	1869.000	901.000	2770.000	89.872	2011.250	0.000	668.878	668.878	1000.000
July	6	1869.000	901.000	2770.000	89.872	1986.154	0.000	693.974	693.974	1000.000
Aug	7	1869.000	901.000	2770.000	89.872	1961.058	0.000	719.070	719.070	1000.000
Sept	8	1869.000	901.000	2770.000	89.872	1933.871	0.000	746.257	746.257	1000.000
Oct	9	1869.000	901.000	2770.000	89.872	1927.597	0.000	752.531	752.531	1000.000
Nov	10	1869.000	901.000	2770.000	89.872	1954.784	0.000	725.344	725.344	1000.000
Dec	11	1869.000	901.000	2770.000	89.872	1938.053	0.000	742.075	742.075	1000.000
Jan	12	1869.000	901.000	2770.000	89.872	1912.957	0.000	767.171	767.171	1000.000
Average		1869.000	901.000	2770.000	89.872	1953.913	0.000	726.215	726.215	1000.000

Table C30: Very dry year scenario 3.3. Botunetz lake inflows/outflows

3.4	OP + (0,1) stops		95% Recycle rate							
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	805.000	2674.000	89.872	1791.357	0.000	792.771	792.771	1000.000
Feb	1	1869.000	805.000	2674.000	89.872	1797.631	0.000	786.497	786.497	1000.000
March	2	1869.000	805.000	2674.000	89.872	1812.271	0.000	771.857	771.857	1000.000
April	3	1869.000	805.000	2674.000	89.872	1839.458	0.000	744.670	744.670	1000.000
May	4	1869.000	805.000	2674.000	89.872	1885.467	0.000	698.661	698.661	1000.000
June	5	1869.000	805.000	2674.000	89.872	1889.650	0.000	694.478	694.478	1000.000
July	6	1869.000	805.000	2674.000	89.872	1864.554	0.000	719.574	719.574	1000.000
Aug	7	1869.000	805.000	2674.000	89.872	1839.458	0.000	744.670	744.670	1000.000
Sept	8	1869.000	805.000	2674.000	89.872	1812.271	0.000	771.857	771.857	1000.000
Oct	9	1869.000	805.000	2674.000	89.872	1805.997	0.000	778.131	778.131	1000.000
Nov	10	1869.000	805.000	2674.000	89.872	1833.184	0.000	750.944	750.944	1000.000
Dec	11	1869.000	805.000	2674.000	89.872	1816.453	0.000	767.675	767.675	1000.000
Jan	12	1869.000	805.000	2674.000	89.872	1791.357	0.000	792.771	792.771	1000.000
Average		1869.000	805.000	2674.000	89.872	1832.313	0.000	751.815	751.815	1000.000

Table C31: Very dry year scenario 3.4. Botunetz lake inflows/outflows

3.5	OP + (0,1,2) stops		95%	Recycle rate						
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	598.000	2467.000	89.872	1629.857	0.000	747.271	747.271	1000.000
Feb	1	1869.000	598.000	2467.000	89.872	1636.131	0.000	740.997	740.997	1000.000
March	2	1869.000	598.000	2467.000	89.872	1650.771	0.000	726.357	726.357	1000.000
April	3	1869.000	598.000	2467.000	89.872	1677.958	0.000	699.170	699.170	1000.000
May	4	1869.000	598.000	2467.000	89.872	1723.967	0.000	653.161	653.161	1000.000
June	5	1869.000	598.000	2467.000	89.872	1728.150	0.000	648.978	648.978	1000.000
July	6	1869.000	598.000	2467.000	89.872	1703.054	0.000	674.074	674.074	1000.000
Aug	7	1869.000	598.000	2467.000	89.872	1677.958	0.000	699.170	699.170	1000.000
Sept	8	1869.000	598.000	2467.000	89.872	1650.771	0.000	726.357	726.357	1000.000
Oct	9	1869.000	598.000	2467.000	89.872	1644.497	0.000	732.631	732.631	1000.000
Nov	10	1869.000	598.000	2467.000	89.872	1671.684	0.000	705.444	705.444	1000.000
Dec	11	1869.000	598.000	2467.000	89.872	1654.953	0.000	722.175	722.175	1000.000
Jan	12	1869.000	598.000	2467.000	89.872	1629.857	0.000	747.271	747.271	1000.000
Average		1869.000	598.000	2467.000	89.872	1670.813	0.000	706.315	706.315	1000.000

Table C32: Very dry year scenario 3.5. Botunetz lake inflows/outflows

3.6	OP + (0,1,2,3) stops			95%	Recycle rate					
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	0.000	1869.000	89.872	1127.307	0.000	651.821	651.821	1000.000
Feb	1	1869.000	0.000	1869.000	89.872	1133.581	0.000	645.547	645.547	1000.000
March	2	1869.000	0.000	1869.000	89.872	1148.221	0.000	630.907	630.907	1000.000
April	3	1869.000	0.000	1869.000	89.872	1175.408	0.000	603.720	603.720	1000.000
May	4	1869.000	0.000	1869.000	89.872	1221.417	0.000	557.711	557.711	1000.000
June	5	1869.000	0.000	1869.000	89.872	1225.600	0.000	553.528	553.528	1000.000
July	6	1869.000	0.000	1869.000	89.872	1200.504	0.000	578.624	578.624	1000.000
Aug	7	1869.000	0.000	1869.000	89.872	1175.408	0.000	603.720	603.720	1000.000
Sept	8	1869.000	0.000	1869.000	89.872	1148.221	0.000	630.907	630.907	1000.000
Oct	9	1869.000	0.000	1869.000	89.872	1141.947	0.000	637.181	637.181	1000.000
Nov	10	1869.000	0.000	1869.000	89.872	1169.134	0.000	609.994	609.994	1000.000
Dec	11	1869.000	0.000	1869.000	89.872	1152.403	0.000	626.725	626.725	1000.000
Jan	12	1869.000	0.000	1869.000	89.872	1127.307	0.000	651.821	651.821	1000.000
Average		1869.000	0.000	1869.000	89.872	1168.263	0.000	610.865	610.865	1000.000

Table C33: Very dry year scenarios 3.6A and 3.6.B. Botunetz lake inflows/outflows

3.7.1	OP + (0,1,2,3) stops + SP (5/6)			95%	Recycle rate					
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	0.000	1869.000	74.893	1127.307	0.000	666.799	666.799	1000.000
Feb	1	1869.000	0.000	1869.000	74.893	1133.581	0.000	660.525	660.525	1000.000
March	2	1869.000	0.000	1869.000	74.893	1148.221	0.000	645.886	645.886	1000.000
April	3	1869.000	0.000	1869.000	74.893	1175.408	0.000	618.699	618.699	1000.000
May	4	1869.000	0.000	1869.000	74.893	1221.417	0.000	572.690	572.690	1000.000
June	5	1869.000	0.000	1869.000	74.893	1225.600	0.000	568.507	568.507	1000.000
July	6	1869.000	0.000	1869.000	74.893	1200.504	0.000	593.603	593.603	1000.000
Aug	7	1869.000	0.000	1869.000	74.893	1175.408	0.000	618.699	618.699	1000.000
Sept	8	1869.000	0.000	1869.000	74.893	1148.221	0.000	645.886	645.886	1000.000
Oct	9	1869.000	0.000	1869.000	74.893	1141.947	0.000	652.160	652.160	1000.000
Nov	10	1869.000	0.000	1869.000	74.893	1169.134	0.000	624.973	624.973	1000.000
Dec	11	1869.000	0.000	1869.000	74.893	1152.403	0.000	641.703	641.703	1000.000
Jan	12	1869.000	0.000	1869.000	74.893	1127.307	0.000	666.799	666.799	1000.000
Average		1869.000	0.000	1869.000	74.893	1168.263	0.000	625.844	625.844	1000.000

Table C34: Very dry year scenarios 3.7.1.A and 3.7.1.B. Botunetz lake inflows/outflows

3.7.2	OP + (0,1,2,3) stops + SP (4/6)			95%	Recycle rate					
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	0.000	1869.000	59.915	1127.307	0.000	681.778	681.778	1000.000
Feb	1	1869.000	0.000	1869.000	59.915	1133.581	0.000	675.504	675.504	1000.000
March	2	1869.000	0.000	1869.000	59.915	1148.221	0.000	660.865	660.865	1000.000
April	3	1869.000	0.000	1869.000	59.915	1175.408	0.000	633.677	633.677	1000.000
May	4	1869.000	0.000	1869.000	59.915	1221.417	0.000	587.668	587.668	1000.000
June	5	1869.000	0.000	1869.000	59.915	1225.600	0.000	583.486	583.486	1000.000
July	6	1869.000	0.000	1869.000	59.915	1200.504	0.000	608.582	608.582	1000.000
Aug	7	1869.000	0.000	1869.000	59.915	1175.408	0.000	633.677	633.677	1000.000
Sept	8	1869.000	0.000	1869.000	59.915	1148.221	0.000	660.865	660.865	1000.000
Oct	9	1869.000	0.000	1869.000	59.915	1141.947	0.000	667.139	667.139	1000.000
Nov	10	1869.000	0.000	1869.000	59.915	1169.134	0.000	639.951	639.951	1000.000
Dec	11	1869.000	0.000	1869.000	59.915	1152.403	0.000	656.682	656.682	1000.000
Jan	12	1869.000	0.000	1869.000	59.915	1127.307	0.000	681.778	681.778	1000.000
Average		1869.000	0.000	1869.000	59.915	1168.263	0.000	640.823	640.823	1000.000

Table C35: Very dry year scenarios 3.7.2.A and 3.7.2.B. Botunetz lake inflows/outflows

3.7.3	OP + (0,1,2,3) stops + SP (3/6)			95%	Recycle rate					
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	0.000	1869.000	44.936	1127.307	0.000	696.757	696.757	1000.000
Feb	1	1869.000	0.000	1869.000	44.936	1133.581	0.000	690.483	690.483	1000.000
March	2	1869.000	0.000	1869.000	44.936	1148.221	0.000	675.843	675.843	1000.000
April	3	1869.000	0.000	1869.000	44.936	1175.408	0.000	648.656	648.656	1000.000
May	4	1869.000	0.000	1869.000	44.936	1221.417	0.000	602.647	602.647	1000.000
June	5	1869.000	0.000	1869.000	44.936	1225.600	0.000	598.464	598.464	1000.000
July	6	1869.000	0.000	1869.000	44.936	1200.504	0.000	623.560	623.560	1000.000
Aug	7	1869.000	0.000	1869.000	44.936	1175.408	0.000	648.656	648.656	1000.000
Sept	8	1869.000	0.000	1869.000	44.936	1148.221	0.000	675.843	675.843	1000.000
Oct	9	1869.000	0.000	1869.000	44.936	1141.947	0.000	682.117	682.117	1000.000
Nov	10	1869.000	0.000	1869.000	44.936	1169.134	0.000	654.930	654.930	1000.000
Dec	11	1869.000	0.000	1869.000	44.936	1152.403	0.000	671.661	671.661	1000.000
Jan	12	1869.000	0.000	1869.000	44.936	1127.307	0.000	696.757	696.757	1000.000
Average		1869.000	0.000	1869.000	44.936	1168.263	0.000	655.801	655.801	1000.000

Table C36: Very dry year scenarios 3.7.3.A and 3.7.3.B. Botunetz lake inflows/outflows

3.8.1	OP + SP (5/6)			**95%**	Recycle rate					
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400.000	3269.000	74.893	2210.307	0.000	983.799	983.799	1000.000
Feb	1	1869.000	1400.000	3269.000	74.893	2216.581	0.000	977.525	977.525	1000.000
March	2	1869.000	1400.000	3269.000	74.893	2231.221	0.000	962.886	962.886	1000.000
April	3	1869.000	1400.000	3269.000	74.893	2258.408	0.000	935.699	935.699	1000.000
May	4	1869.000	1400.000	3269.000	74.893	2304.417	0.000	889.690	889.690	1000.000
June	5	1869.000	1400.000	3269.000	74.893	2308.600	0.000	885.507	885.507	1000.000
July	6	1869.000	1400.000	3269.000	74.893	2283.504	0.000	910.603	910.603	1000.000
Aug	7	1869.000	1400.000	3269.000	74.893	2258.408	0.000	935.699	935.699	1000.000
Sept	8	1869.000	1400.000	3269.000	74.893	2231.221	0.000	962.886	962.886	1000.000
Oct	9	1869.000	1400.000	3269.000	74.893	2224.947	0.000	969.160	969.160	1000.000
Nov	10	1869.000	1400.000	3269.000	74.893	2252.134	0.000	941.973	941.973	1000.000
Dec	11	1869.000	1400.000	3269.000	74.893	2235.403	0.000	958.703	958.703	1000.000
Jan	12	1869.000	1400.000	3269.000	74.893	2210.307	0.000	983.799	983.799	1000.000
Average		1869.000	1400.000	3269.000	74.893	2251.263	0.000	942.844	942.844	1000.000

Table C37: Very dry year scenario 3.8.1. Botunetz lake inflows/outflows

3.8.2	OP + SP (4/6)			95%	Recycle rate					
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400.000	3269.000	59.915	2210.307	0.000	998.778	998.778	1000.000
Feb	1	1869.000	1400.000	3269.000	59.915	2216.581	0.000	992.504	992.504	1000.000
March	2	1869.000	1400.000	3269.000	59.915	2231.221	0.000	977.865	977.865	1000.000
April	3	1869.000	1400.000	3269.000	59.915	2258.408	0.000	950.677	950.677	1000.000
May	4	1869.000	1400.000	3269.000	59.915	2304.417	0.000	904.668	904.668	1000.000
June	5	1869.000	1400.000	3269.000	59.915	2308.600	0.000	900.486	900.486	1000.000
July	6	1869.000	1400.000	3269.000	59.915	2283.504	0.000	925.582	925.582	1000.000
Aug	7	1869.000	1400.000	3269.000	59.915	2258.408	0.000	950.677	950.677	1000.000
Sept	8	1869.000	1400.000	3269.000	59.915	2231.221	0.000	977.865	977.865	1000.000
Oct	9	1869.000	1400.000	3269.000	59.915	2224.947	0.000	984.139	984.139	1000.000
Nov	10	1869.000	1400.000	3269.000	59.915	2252.134	0.000	956.951	956.951	1000.000
Dec	11	1869.000	1400.000	3269.000	59.915	2235.403	0.000	973.682	973.682	1000.000
Jan	12	1869.000	1400.000	3269.000	59.915	2210.307	0.000	998.778	998.778	1000.000
Average		1869.000	1400.000	3269.000	59.915	2251.263	0.000	957.823	957.823	1000.000

Table C38: Very dry year scenario 3.8.2. Botunetz lake inflows/outflows

3.8.3	OP + SP (3/6)			**95%**	Recycle rate					
Months	Timestep	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel	BOTUNETZ Lake status
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3
Jan	0	1869.000	1400.000	3269.000	44.936	2210.307	0.000	1013.757	1013.757	1000.000
Feb	1	1869.000	1400.000	3269.000	44.936	2216.581	0.000	1007.483	1007.483	1000.000
March	2	1869.000	1400.000	3269.000	44.936	2231.221	0.000	992.843	992.843	1000.000
April	3	1869.000	1400.000	3269.000	44.936	2258.408	0.000	965.656	965.656	1000.000
May	4	1869.000	1400.000	3269.000	44.936	2304.417	0.000	919.647	919.647	1000.000
June	5	1869.000	1400.000	3269.000	44.936	2308.600	0.000	915.464	915.464	1000.000
July	6	1869.000	1400.000	3269.000	44.936	2283.504	0.000	940.560	940.560	1000.000
Aug	7	1869.000	1400.000	3269.000	44.936	2258.408	0.000	965.656	965.656	1000.000
Sept	8	1869.000	1400.000	3269.000	44.936	2231.221	0.000	992.843	992.843	1000.000
Oct	9	1869.000	1400.000	3269.000	44.936	2224.947	0.000	999.117	999.117	1000.000
Nov	10	1869.000	1400.000	3269.000	44.936	2252.134	0.000	971.930	971.930	1000.000
Dec	11	1869.000	1400.000	3269.000	44.936	2235.403	0.000	988.661	988.661	1000.000
Jan	12	1869.000	1400.000	3269.000	44.936	2210.307	0.000	1013.757	1013.757	1000.000
Average		1869.000	1400.000	3269.000	44.936	2251.263	0.000	972.801	972.801	1000.000

Table C39: Very dry year scenario 3.8.3. Botunetz lake inflows/outflows

Scenario	Stopping units	Water WQ2 for constant units	Water WQ2 for non-constant units	WQ2 fresh water for KP	Return (recycling) from HVOST to BOTUNETZ	Treated WW to Botunetz	Return from Sgurootvaal to BOTUNETZ	WQ1 inflow to Botunetz from clean water submodel	Transfer parameter WQ1 fresh water from clean water submodel
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month
3.1	All on	1869.000	1400.000	3269.000	206.512	2251.263	0.000	811.225	811.225
3.2	OP	1869.000	1400.000	3269.000	89.872	2251.263	0.000	927.865	927.865
3.3	OP +(0)	1869.000	901.000	2770.000	89.872	1953.913	0.000	726.215	726.215
3.4	OP+(0,1)	1869.000	805.000	2674.000	89.872	1832.313	0.000	751.815	751.815
3.5	OP+(0,1,2)	1869.000	598.000	2467.000	89.872	1670.813	0.000	706.315	706.315
3.6A	OP+(0,1,2,3)	1869.000	0.000	1869.000	89.872	1168.263	0.000	610.865	610.865
3.6B	OP+(0,1,2,3)	1869.000	0.000	1869.000	89.872	1168.263	0.000	610.865	610.865
3.7.1A	OP+(0,1,2,3)+SP(5/6)	1869.000	0.000	1869.000	74.893	1168.263	0.000	625.844	625.844
3.7.2A	OP+(0,1,2,3)+SP(4/6)	1869.000	0.000	1869.000	59.915	1168.263	0.000	640.823	640.823
3.7.3A	OP+(0,1,2,3)+SP(3/6)	1869.000	0.000	1869.000	44.936	1168.263	0.000	655.801	655.801
3.7.1B	OP+(0,1,2,3)+SP(5/6)	1869.000	0.000	1869.000	74.893	1168.263	0.000	625.844	625.844
3.7.2B	OP+(0,1,2,3)+SP(4/6)	1869.000	0.000	1869.000	59.915	1168.263	0.000	640.823	640.823
3.7.3B	OP+(0,1,2,3)+SP(3/6)	1869.000	0.000	1869.000	44.936	1168.263	0.000	655.801	655.801
3.8.1	OP+SP(5/6)	1869.000	1400.000	3269.000	74.893	2251.263	0.000	942.844	942.844
3.8.2	OP+SP(4/6)	1869.000	1400.000	3269.000	59.915	2251.263	0.000	957.823	957.823
3.8.3	OP+SP(3/6)	1869.000	1400.000	3269.000	44.936	2251.263	0.000	972.801	972.801

Table C40: Comparative for very dry year scenarios. Botunetz lake inflows/outflows. Average values

3.1	All on		95%	Recycle rate								
Months	Time step	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4209.000	4702.328	2326.639	2210.307	0.950	2416.819	0.574	493.328	2910.147	0.619	306.332
Feb	1	4209.000	4702.328	2333.243	2216.581	0.950	2423.093	0.576	493.328	2916.421	0.620	306.662
March	2	4209.000	4702.328	2348.653	2231.221	0.950	2437.733	0.579	493.328	2931.061	0.623	307.433
April	3	4209.000	4702.328	2377.272	2258.408	0.950	2464.920	0.586	493.328	2958.248	0.629	308.864
May	4	4209.000	4702.328	2425.702	2304.417	0.950	2510.929	0.597	493.328	3004.257	0.639	311.285
June	5	4209.000	4702.328	2430.105	2308.600	0.950	2515.112	0.598	493.328	3008.440	0.640	311.505
July	6	4209.000	4702.328	2403.688	2283.504	0.950	2490.016	0.592	493.328	2983.344	0.634	310.184
Aug	7	4209.000	4702.328	2377.272	2258.408	0.950	2464.920	0.586	493.328	2958.248	0.629	308.864
Sept	8	4209.000	4702.328	2348.653	2231.221	0.950	2437.733	0.579	493.328	2931.061	0.623	307.433
Oct	9	4209.000	4702.328	2342.049	2224.947	0.950	2431.459	0.578	493.328	2924.787	0.622	307.103
Nov	10	4209.000	4702.328	2370.667	2252.134	0.950	2458.646	0.584	493.328	2951.974	0.628	308.533
Dec	11	4209.000	4702.328	2353.056	2235.403	0.950	2441.915	0.580	493.328	2935.243	0.624	307.653
Jan	12	4209.000	4702.328	2326.639	2210.307	0.950	2416.819	0.574	493.328	2910.147	0.619	306.332
Average		4209.000	4702.328	2369.750	2251.263	0.950	2457.775	0.584	493.328	2951.103	0.628	308.488

Table C41: Scenario 3.1 Total system water needs, releases to Lesnovska and recycling rates.

3.2	OP stops		95%	Recycle rate								
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4056.072	4549.400	2326.639	2210.307	0.950	2300.179	0.567	493.328	2793.507	0.614	306.332
Feb	1	4056.072	4549.400	2333.243	2216.581	0.950	2306.453	0.569	493.328	2799.781	0.615	306.662
March	2	4056.072	4549.400	2348.653	2231.221	0.950	2321.093	0.572	493.328	2814.421	0.619	307.433
April	3	4056.072	4549.400	2377.272	2258.408	0.950	2348.280	0.579	493.328	2841.608	0.625	308.864
May	4	4056.072	4549.400	2425.702	2304.417	0.950	2394.289	0.590	493.328	2887.617	0.635	311.285
June	5	4056.072	4549.400	2430.105	2308.600	0.950	2398.472	0.591	493.328	2891.800	0.636	311.505
July	6	4056.072	4549.400	2403.688	2283.504	0.950	2373.376	0.585	493.328	2866.704	0.630	310.184
Aug	7	4056.072	4549.400	2377.272	2258.408	0.950	2348.280	0.579	493.328	2841.608	0.625	308.864
Sept	8	4056.072	4549.400	2348.653	2231.221	0.950	2321.093	0.572	493.328	2814.421	0.619	307.433
Oct	9	4056.072	4549.400	2342.049	2224.947	0.950	2314.819	0.571	493.328	2808.147	0.617	307.103
Nov	10	4056.072	4549.400	2370.667	2252.134	0.950	2342.006	0.577	493.328	2835.334	0.623	308.533
Dec	11	4056.072	4549.400	2353.056	2235.403	0.950	2325.275	0.573	493.328	2818.603	0.620	307.653
Jan	12	4056.072	4549.400	2326.639	2210.307	0.950	2300.179	0.567	493.328	2793.507	0.614	306.332
Average		4056.072	4549.400	2369.750	2251.263	0.950	2341.135	0.577	493.328	2834.463	0.623	308.488

Table C42: Scenario 3.2 Total system water needs, releases to Lesnovska and recycling rates.

3.3	OP + (0) stops		95%	Recycle rate								
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	3487.072	3980.400	2013.639	1912.957	0.950	2002.829	0.574	493.328	2496.157	0.627	290.682
Feb	1	3487.072	3980.400	2020.243	1919.231	0.950	2009.103	0.576	493.328	2502.431	0.629	291.012
March	2	3487.072	3980.400	2035.653	1933.871	0.950	2023.743	0.580	493.328	2517.071	0.632	291.783
April	3	3487.072	3980.400	2064.272	1961.058	0.950	2050.930	0.588	493.328	2544.258	0.639	293.214
May	4	3487.072	3980.400	2112.702	2007.067	0.950	2096.939	0.601	493.328	2590.267	0.651	295.635
June	5	3487.072	3980.400	2117.105	2011.250	0.950	2101.122	0.603	493.328	2594.450	0.652	295.855
July	6	3487.072	3980.400	2090.688	1986.154	0.950	2076.026	0.595	493.328	2569.354	0.646	294.534
Aug	7	3487.072	3980.400	2064.272	1961.058	0.950	2050.930	0.588	493.328	2544.258	0.639	293.214
Sept	8	3487.072	3980.400	2035.653	1933.871	0.950	2023.743	0.580	493.328	2517.071	0.632	291.783
Oct	9	3487.072	3980.400	2029.049	1927.597	0.950	2017.469	0.579	493.328	2510.797	0.631	291.453
Nov	10	3487.072	3980.400	2057.667	1954.784	0.950	2044.656	0.586	493.328	2537.984	0.638	292.883
Dec	11	3487.072	3980.400	2040.056	1938.053	0.950	2027.925	0.582	493.328	2521.253	0.633	292.003
Jan	12	3487.072	3980.400	2013.639	1912.957	0.950	2002.829	0.574	493.328	2496.157	0.627	290.682
Average		3487.072	3980.400	2056.750	1953.913	0.950	2043.785	0.586	493.328	2537.113	0.637	292.838

Table C43: Scenario 3.3 Total system water needs, releases to Lesnovska and recycling rates.

3.4	OP + (0,1) stops		95%	Recycle rate								
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	3342.072	3835.400	1885.639	1791.357	0.950	1881.229	0.563	493.328	2374.557	0.619	284.282
Feb	1	3342.072	3835.400	1892.243	1797.631	0.950	1887.503	0.565	493.328	2380.831	0.621	284.612
March	2	3342.072	3835.400	1907.653	1812.271	0.950	1902.143	0.569	493.328	2395.471	0.625	285.383
April	3	3342.072	3835.400	1936.272	1839.458	0.950	1929.330	0.577	493.328	2422.658	0.632	286.814
May	4	3342.072	3835.400	1984.702	1885.467	0.950	1975.339	0.591	493.328	2468.667	0.644	289.235
June	5	3342.072	3835.400	1989.105	1889.650	0.950	1979.522	0.592	493.328	2472.850	0.645	289.455
July	6	3342.072	3835.400	1962.688	1864.554	0.950	1954.426	0.585	493.328	2447.754	0.638	288.134
Aug	7	3342.072	3835.400	1936.272	1839.458	0.950	1929.330	0.577	493.328	2422.658	0.632	286.814
Sept	8	3342.072	3835.400	1907.653	1812.271	0.950	1902.143	0.569	493.328	2395.471	0.625	285.383
Oct	9	3342.072	3835.400	1901.049	1805.997	0.950	1895.869	0.567	493.328	2389.197	0.623	285.053
Nov	10	3342.072	3835.400	1929.667	1833.184	0.950	1923.056	0.575	493.328	2416.384	0.630	286.483
Dec	11	3342.072	3835.400	1912.056	1816.453	0.950	1906.325	0.570	493.328	2399.653	0.626	285.603
Jan	12	3342.072	3835.400	1885.639	1791.357	0.950	1881.229	0.563	493.328	2374.557	0.619	284.282
Average		3342.072	3835.400	1928.750	1832.313	0.950	1922.185	0.575	493.328	2415.513	0.630	286.438

Table C44: Scenario 3.4 Total system water needs, releases to Lesnovska and recycling rates.

3.5	OP + (0,1,2) stops		95%	Recycle rate								
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	3085.072	3578.400	1715.639	1629.857	0.950	1719.729	0.557	493.328	2213.057	0.618	275.782
Feb	1	3085.072	3578.400	1722.243	1636.131	0.950	1726.003	0.560	493.328	2219.331	0.620	276.112
March	2	3085.072	3578.400	1737.653	1650.771	0.950	1740.643	0.564	493.328	2233.971	0.624	276.883
April	3	3085.072	3578.400	1766.272	1677.958	0.950	1767.830	0.573	493.328	2261.158	0.632	278.314
May	4	3085.072	3578.400	1814.702	1723.967	0.950	1813.839	0.588	493.328	2307.167	0.645	280.735
June	5	3085.072	3578.400	1819.105	1728.150	0.950	1818.022	0.589	493.328	2311.350	0.646	280.955
July	6	3085.072	3578.400	1792.688	1703.054	0.950	1792.926	0.581	493.328	2286.254	0.639	279.634
Aug	7	3085.072	3578.400	1766.272	1677.958	0.950	1767.830	0.573	493.328	2261.158	0.632	278.314
Sept	8	3085.072	3578.400	1737.653	1650.771	0.950	1740.643	0.564	493.328	2233.971	0.624	276.883
Oct	9	3085.072	3578.400	1731.049	1644.497	0.950	1734.369	0.562	493.328	2227.697	0.623	276.553
Nov	10	3085.072	3578.400	1759.667	1671.684	0.950	1761.556	0.571	493.328	2254.884	0.630	277.983
Dec	11	3085.072	3578.400	1742.056	1654.953	0.950	1744.825	0.566	493.328	2238.153	0.626	277.103
Jan	12	3085.072	3578.400	1715.639	1629.857	0.950	1719.729	0.557	493.328	2213.057	0.618	275.782
Average		3085.072	3578.400	1758.750	1670.813	0.950	1760.685	0.571	493.328	2254.013	0.630	277.938

Table C45: Scenario 3.5 Total system water needs, releases to Lesnovska and recycling rates.

3.6	OP + (0,1,2,3) stops			**95%**	Recycle rate							
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	2421.072	2914.400	1186.639	1127.307	0.950	1217.179	0.503	493.328	1710.507	0.587	249.332
Feb	1	2421.072	2914.400	1193.243	1133.581	0.950	1223.453	0.505	493.328	1716.781	0.589	249.662
March	2	2421.072	2914.400	1208.653	1148.221	0.950	1238.093	0.511	493.328	1731.421	0.594	250.433
April	3	2421.072	2914.400	1237.272	1175.408	0.950	1265.280	0.523	493.328	1758.608	0.603	251.864
May	4	2421.072	2914.400	1285.702	1221.417	0.950	1311.289	0.542	493.328	1804.617	0.619	254.285
June	5	2421.072	2914.400	1290.105	1225.600	0.950	1315.472	0.543	493.328	1808.800	0.621	254.505
July	6	2421.072	2914.400	1263.688	1200.504	0.950	1290.376	0.533	493.328	1783.704	0.612	253.184
Aug	7	2421.072	2914.400	1237.272	1175.408	0.950	1265.280	0.523	493.328	1758.608	0.603	251.864
Sept	8	2421.072	2914.400	1208.653	1148.221	0.950	1238.093	0.511	493.328	1731.421	0.594	250.433
Oct	9	2421.072	2914.400	1202.049	1141.947	0.950	1231.819	0.509	493.328	1725.147	0.592	250.103
Nov	10	2421.072	2914.400	1230.667	1169.134	0.950	1259.006	0.520	493.328	1752.334	0.601	251.533
Dec	11	2421.072	2914.400	1213.056	1152.403	0.950	1242.275	0.513	493.328	1735.603	0.596	250.653
Jan	12	2421.072	2914.400	1186.639	1127.307	0.950	1217.179	0.503	493.328	1710.507	0.587	249.332
Average		2421.072	2914.400	1229.750	1168.263	0.950	1258.135	0.520	493.328	1751.463	0.601	251.488

Table C46: Scenarios 3.6A and 3.6B Total system water needs, releases to Lesnovska and recycling rates.

3.7.1	OP + (0,1,2,3) stops + SP (5/6)			95%	Recycle rate							
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	2389.893	2801.000	1186.639	1127.307	0.950	1202.201	0.503	411.107	1613.307	0.576	249.332
Feb	1	2389.893	2801.000	1193.243	1133.581	0.950	1208.475	0.506	411.107	1619.581	0.578	249.662
March	2	2389.893	2801.000	1208.653	1148.221	0.950	1223.114	0.512	411.107	1634.221	0.583	250.433
April	3	2389.893	2801.000	1237.272	1175.408	0.950	1250.301	0.523	411.107	1661.408	0.593	251.864
May	4	2389.893	2801.000	1285.702	1221.417	0.950	1296.311	0.542	411.107	1707.417	0.610	254.285
June	5	2389.893	2801.000	1290.105	1225.600	0.950	1300.493	0.544	411.107	1711.600	0.611	254.505
July	6	2389.893	2801.000	1263.688	1200.504	0.950	1275.397	0.534	411.107	1686.504	0.602	253.184
Aug	7	2389.893	2801.000	1237.272	1175.408	0.950	1250.301	0.523	411.107	1661.408	0.593	251.864
Sept	8	2389.893	2801.000	1208.653	1148.221	0.950	1223.114	0.512	411.107	1634.221	0.583	250.433
Oct	9	2389.893	2801.000	1202.049	1141.947	0.950	1216.840	0.509	411.107	1627.947	0.581	250.103
Nov	10	2389.893	2801.000	1230.667	1169.134	0.950	1244.027	0.521	411.107	1655.134	0.591	251.533
Dec	11	2389.893	2801.000	1213.056	1152.403	0.950	1227.297	0.514	411.107	1638.403	0.585	250.653
Jan	12	2389.893	2801.000	1186.639	1127.307	0.950	1202.201	0.503	411.107	1613.307	0.576	249.332
Average		2389.893	2801.000	1229.750	1168.263	0.950	1243.156	0.520	411.107	1654.263	0.591	251.488

Table C47: Scenarios 3.7.1.A and 3.7.1.B Total system water needs, releases to Lesnovska and recycling rates

3.7.2	OP + (0,1,2,3) stops + SP (4/6)			95%	Recycle rate							
Months	Time step	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	2358.715	2687.600	1186.639	1127.307	0.950	1187.222	0.503	328.885	1516.107	0.564	249.332
Feb	1	2358.715	2687.600	1193.243	1133.581	0.950	1193.496	0.506	328.885	1522.381	0.566	249.662
March	2	2358.715	2687.600	1208.653	1148.221	0.950	1208.135	0.512	328.885	1537.021	0.572	250.433
April	3	2358.715	2687.600	1237.272	1175.408	0.950	1235.323	0.524	328.885	1564.208	0.582	251.864
May	4	2358.715	2687.600	1285.702	1221.417	0.950	1281.332	0.543	328.885	1610.217	0.599	254.285
June	5	2358.715	2687.600	1290.105	1225.600	0.950	1285.515	0.545	328.885	1614.400	0.601	254.505
July	6	2358.715	2687.600	1263.688	1200.504	0.950	1260.419	0.534	328.885	1589.304	0.591	253.184
Aug	7	2358.715	2687.600	1237.272	1175.408	0.950	1235.323	0.524	328.885	1564.208	0.582	251.864
Sept	8	2358.715	2687.600	1208.653	1148.221	0.950	1208.135	0.512	328.885	1537.021	0.572	250.433
Oct	9	2358.715	2687.600	1202.049	1141.947	0.950	1201.861	0.510	328.885	1530.747	0.570	250.103
Nov	10	2358.715	2687.600	1230.667	1169.134	0.950	1229.049	0.521	328.885	1557.934	0.580	251.533
Dec	11	2358.715	2687.600	1213.056	1152.403	0.950	1212.318	0.514	328.885	1541.203	0.573	250.653
Jan	12	2358.715	2687.600	1186.639	1127.307	0.950	1187.222	0.503	328.885	1516.107	0.564	249.332
Average		2358.715	2687.600	1229.750	1168.263	0.950	1228.177	0.521	328.885	1557.063	0.579	251.488

Table C48: Scenarios 3.7.2.A and 3.7.2.B Total system water needs, releases to Lesnovska and recycling rates

3.7.3	OP + (0,1,2,3) stops + SP (3/6)			95%	Recycle rate							
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	2327.536	2574.200	1186.639	1127.307	0.950	1172.243	0.504	246.664	1418.907	0.551	249.332
Feb	1	2327.536	2574.200	1193.243	1133.581	0.950	1178.517	0.506	246.664	1425.181	0.554	249.662
March	2	2327.536	2574.200	1208.653	1148.221	0.950	1193.157	0.513	246.664	1439.821	0.559	250.433
April	3	2327.536	2574.200	1237.272	1175.408	0.950	1220.344	0.524	246.664	1467.008	0.570	251.864
May	4	2327.536	2574.200	1285.702	1221.417	0.950	1266.353	0.544	246.664	1513.017	0.588	254.285
June	5	2327.536	2574.200	1290.105	1225.600	0.950	1270.536	0.546	246.664	1517.200	0.589	254.505
July	6	2327.536	2574.200	1263.688	1200.504	0.950	1245.440	0.535	246.664	1492.104	0.580	253.184
Aug	7	2327.536	2574.200	1237.272	1175.408	0.950	1220.344	0.524	246.664	1467.008	0.570	251.864
Sept	8	2327.536	2574.200	1208.653	1148.221	0.950	1193.157	0.513	246.664	1439.821	0.559	250.433
Oct	9	2327.536	2574.200	1202.049	1141.947	0.950	1186.883	0.510	246.664	1433.547	0.557	250.103
Nov	10	2327.536	2574.200	1230.667	1169.134	0.950	1214.070	0.522	246.664	1460.734	0.568	251.533
Dec	11	2327.536	2574.200	1213.056	1152.403	0.950	1197.339	0.514	246.664	1444.003	0.561	250.653
Jan	12	2327.536	2574.200	1186.639	1127.307	0.950	1172.243	0.504	246.664	1418.907	0.551	249.332
Average		2327.536	2574.200	1229.750	1168.263	0.950	1213.199	0.521	246.664	1459.863	0.567	251.488

Table C49: Scenarios 3.7.3.A and 3.7.3 B Total system water needs, releases to Lesnovska and recycling rates

3.8.1	OP + SP (5/6)			95%	Recycle rate								
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	4024.893	4436.000	2326.639	2210.307	0.950	2285.201	0.568	411.107	2696.307	0.608	306.332
Feb	1	4024.893	4436.000	2333.243	2216.581	0.950	2291.475	0.569	411.107	2702.581	0.609	306.662
March	2	4024.893	4436.000	2348.653	2231.221	0.950	2306.114	0.573	411.107	2717.221	0.613	307.433
April	3	4024.893	4436.000	2377.272	2258.408	0.950	2333.301	0.580	411.107	2744.408	0.619	308.864
May	4	4024.893	4436.000	2425.702	2304.417	0.950	2379.311	0.591	411.107	2790.417	0.629	311.285
June	5	4024.893	4436.000	2430.105	2308.600	0.950	2383.493	0.592	411.107	2794.600	0.630	311.505
July	6	4024.893	4436.000	2403.688	2283.504	0.950	2358.397	0.586	411.107	2769.504	0.624	310.184
Aug	7	4024.893	4436.000	2377.272	2258.408	0.950	2333.301	0.580	411.107	2744.408	0.619	308.864
Sept	8	4024.893	4436.000	2348.653	2231.221	0.950	2306.114	0.573	411.107	2717.221	0.613	307.433
Oct	9	4024.893	4436.000	2342.049	2224.947	0.950	2299.840	0.571	411.107	2710.947	0.611	307.103
Nov	10	4024.893	4436.000	2370.667	2252.134	0.950	2327.027	0.578	411.107	2738.134	0.617	308.533
Dec	11	4024.893	4436.000	2353.056	2235.403	0.950	2310.297	0.574	411.107	2721.403	0.614	307.653
Jan	12	4024.893	4436.000	2326.639	2210.307	0.950	2285.201	0.568	411.107	2696.307	0.608	306.332
Average		4024.893	4436.000	2369.750	2251.263	0.950	2326.156	0.578	411.107	2737.263	0.617	308.488

Table C50: Scenario 3.8.1.Total system water needs, releases to Lesnovska and recycling rates

3.8.2	OP + SP (4/6)			95%	Recycle rate							
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	3993.715	4322.600	2326.639	2210.307	0.950	2270.222	0.568	328.885	2599.107	0.601	306.332
Feb	1	3993.715	4322.600	2333.243	2216.581	0.950	2276.496	0.570	328.885	2605.381	0.603	306.662
March	2	3993.715	4322.600	2348.653	2231.221	0.950	2291.135	0.574	328.885	2620.021	0.606	307.433
April	3	3993.715	4322.600	2377.272	2258.408	0.950	2318.323	0.581	328.885	2647.208	0.612	308.864
May	4	3993.715	4322.600	2425.702	2304.417	0.950	2364.332	0.592	328.885	2693.217	0.623	311.285
June	5	3993.715	4322.600	2430.105	2308.600	0.950	2368.515	0.593	328.885	2697.400	0.624	311.505
July	6	3993.715	4322.600	2403.688	2283.504	0.950	2343.419	0.587	328.885	2672.304	0.618	310.184
Aug	7	3993.715	4322.600	2377.272	2258.408	0.950	2318.323	0.581	328.885	2647.208	0.612	308.864
Sept	8	3993.715	4322.600	2348.653	2231.221	0.950	2291.135	0.574	328.885	2620.021	0.606	307.433
Oct	9	3993.715	4322.600	2342.049	2224.947	0.950	2284.861	0.572	328.885	2613.747	0.605	307.103
Nov	10	3993.715	4322.600	2370.667	2252.134	0.950	2312.049	0.579	328.885	2640.934	0.611	308.533
Dec	11	3993.715	4322.600	2353.056	2235.403	0.950	2295.318	0.575	328.885	2624.203	0.607	307.653
Jan	12	3993.715	4322.600	2326.639	2210.307	0.950	2270.222	0.568	328.885	2599.107	0.601	306.332
Average		3993.715	4322.600	2369.750	2251.263	0.950	2311.177	0.579	328.885	2640.063	0.611	308.488

Table C51: Scenario 3.8.2.Total system water needs, releases to Lesnovska and recycling rates

3.8.3	OP + SP (3/6)			95%	Recycle rate							
Months	Timestep	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
Jan	0	3962.536	4209.200	2326.639	2210.307	0.950	2255.243	0.569	246.664	2501.907	0.594	306.332
Feb	1	3962.536	4209.200	2333.243	2216.581	0.950	2261.517	0.571	246.664	2508.181	0.596	306.662
March	2	3962.536	4209.200	2348.653	2231.221	0.950	2276.157	0.574	246.664	2522.821	0.599	307.433
April	3	3962.536	4209.200	2377.272	2258.408	0.950	2303.344	0.581	246.664	2550.008	0.606	308.864
May	4	3962.536	4209.200	2425.702	2304.417	0.950	2349.353	0.593	246.664	2596.017	0.617	311.285
June	5	3962.536	4209.200	2430.105	2308.600	0.950	2353.536	0.594	246.664	2600.200	0.618	311.505
July	6	3962.536	4209.200	2403.688	2283.504	0.950	2328.440	0.588	246.664	2575.104	0.612	310.184
Aug	7	3962.536	4209.200	2377.272	2258.408	0.950	2303.344	0.581	246.664	2550.008	0.606	308.864
Sept	8	3962.536	4209.200	2348.653	2231.221	0.950	2276.157	0.574	246.664	2522.821	0.599	307.433
Oct	9	3962.536	4209.200	2342.049	2224.947	0.950	2269.883	0.573	246.664	2516.547	0.598	307.103
Nov	10	3962.536	4209.200	2370.667	2252.134	0.950	2297.070	0.580	246.664	2543.734	0.604	308.533
Dec	11	3962.536	4209.200	2353.056	2235.403	0.950	2280.339	0.576	246.664	2527.003	0.600	307.653
Jan	12	3962.536	4209.200	2326.639	2210.307	0.950	2255.243	0.569	246.664	2501.907	0.594	306.332
Average		3962.536	4209.200	2369.750	2251.263	0.950	2296.199	0.579	246.664	2542.863	0.604	308.488

Table C52: Scenario 3.8.3.Total system water needs, releases to Lesnovska and recycling rates

Scenario	Stopping units	Total clean fresh water needs WQ1+WQ2	Total KP water needs	Total WW+rain inflow	Treated WW to Botunetz	WW recycling rate	Total WQ2 water re-use	System clean cycle water re-use rate	Water WQ3 from HVOST	System total recycled water	SystemTotal recycle rate	Total treated WW release to Lesnovska
		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month	x 1000 m3/month	x 1000 m3/month	x 1000 m3/month		x 1000 m3/month
3.1	All on	4209.000	4702.328	2369.750	2251.263	0.950	2457.775	0.584	493.328	2951.103	0.628	308.488
3.2	OP	4056.072	4549.400	2369.750	2251.263	0.950	2341.135	0.577	493.328	2834.463	0.623	308.488
3.3	OP +(0)	3487.072	3980.400	2056.750	1953.913	0.950	2043.785	0.586	493.328	2537.113	0.637	292.838
3.4	OP+(0,1)	3342.072	3835.400	1928.750	1832.313	0.950	1922.185	0.575	493.328	2415.513	0.630	286.438
3.5	OP+(0,1,2)	3085.072	3578.400	1758.750	1670.813	0.950	1760.685	0.571	493.328	2254.013	0.630	277.938
3.6A	OP+(0,1,2,3)	2421.072	2914.400	1229.750	1168.263	0.950	1258.135	0.520	493.328	1751.463	0.601	251.488
3.6B	OP+(0,1,2,3)	2421.072	2914.400	1229.750	1168.263	0.950	1258.135	0.520	493.328	1751.463	0.601	251.488
3.7.1A	OP+(0,1,2,3)+SP(5/6)	2389.893	2801.000	1229.750	1168.263	0.950	1243.156	0.520	411.107	1654.263	0.591	251.488
3.7.2A	OP+(0,1,2,3)+SP(4/6)	2358.715	2687.600	1229.750	1168.263	0.950	1228.177	0.521	328.885	1557.063	0.579	251.488
3.7.3A	OP+(0,1,2,3)+SP(3/6)	2327.536	2574.200	1229.750	1168.263	0.950	1213.199	0.521	246.664	1459.863	0.567	251.488
3.7.1B	OP+(0,1,2,3)+SP(5/6)	2389.893	2801.000	1229.750	1168.263	0.950	1243.156	0.520	411.107	1654.263	0.591	251.488
3.7.2B	OP+(0,1,2,3)+SP(4/6)	2358.715	2687.600	1229.750	1168.263	0.950	1228.177	0.521	328.885	1557.063	0.579	251.488
3.7.3B	OP+(0,1,2,3)+SP(3/6)	2327.536	2574.200	1229.750	1168.263	0.950	1213.199	0.521	246.664	1459.863	0.567	251.488
3.8.1	OP+SP(5/6)	4024.893	4436.000	2369.750	2251.263	0.950	2326.156	0.578	411.107	2737.263	0.617	308.488
3.8.2	OP+SP(4/6)	3993.715	4322.600	2369.750	2251.263	0.950	2311.177	0.579	328.885	2640.063	0.611	308.488
3.8.3	OP+SP(3/6)	3962.536	4209.200	2369.750	2251.263	0.950	2296.199	0.579	246.664	2542.863	0.604	308.488

Table C53: Comparative for very dry year scenarios. Total system water needs, releases to Lesnovska and recycling rates. Average values