



Urban Subsurface Planning and Management Week, SUB-URBAN 2017, 13-16 March 2017,  
Bucharest, Romania

## Improvement of the Water Infrastructure in Central Moldova

Eduard Dinet<sup>a</sup>, Gabriel Racoviteanu<sup>a</sup>, Alexandru Jercan<sup>a\*</sup>

<sup>a</sup>*Technical University of Civil Engineering, B-dul Lacul Tei, no. 124, Sector 2, Bucharest, 020396, Romania*

---

### Abstract

Selection of the optimum solution for drinking water supply is very difficult operation, considering the constraints generated by presence of many factors which influence the selection process. In order to select the optimal solution multi-criterial analyses have to be performed, considering technical, institutional, environmental and financial aspects for each analyzed option. Such an analysis was carried out for the development of a water supply system for all localities of two rayons, Calarasi and Straseni, located in the central area of the Republic of Moldova.

© 2017 The Authors. Published by Elsevier Ltd.

Peer-review under responsibility of the scientific committee of the Urban Subsurface Planning and Management Week.

*Keywords:* option analyses, water supply, transmission pipe;

---

### 1. Introduction

The main problem identified in the Central Moldova is the poor raw water quality. Existing studies indicate that the localities in Central Moldova use generally groundwater sources for drinking water supply which are polluted and hence improper for drinking water (exceeding levels of hydrogen sulphide, ammonia as well as fluoride and boron). In order to assure the consumers with drinking water which comply EU Directive 98/83/EC requirements, the proper treatment of these polluted groundwater sources is disproportionately complicated and expensive.

In this situation, were identified all available sources in the area and an option analyses was developed in order to select the most suitable source to supply the consumers from all localities of the rayons Calarasi and Straseni with safe drinking water.

---

\* Corresponding author. Tel.: +40-212-423-595; fax: +40-212-423-595.

*E-mail address:* [edi@utcb.ro](mailto:edi@utcb.ro)

## 2. The Method Used In the Evaluation of the Source Selection

### 2.1. Available Water Sources and Water Quality

The project area is presented in the next figure. Available sources in the area are: Nistru River, Prut River Micauti wellfield. The project area and the available water sources are presented in the next figure.

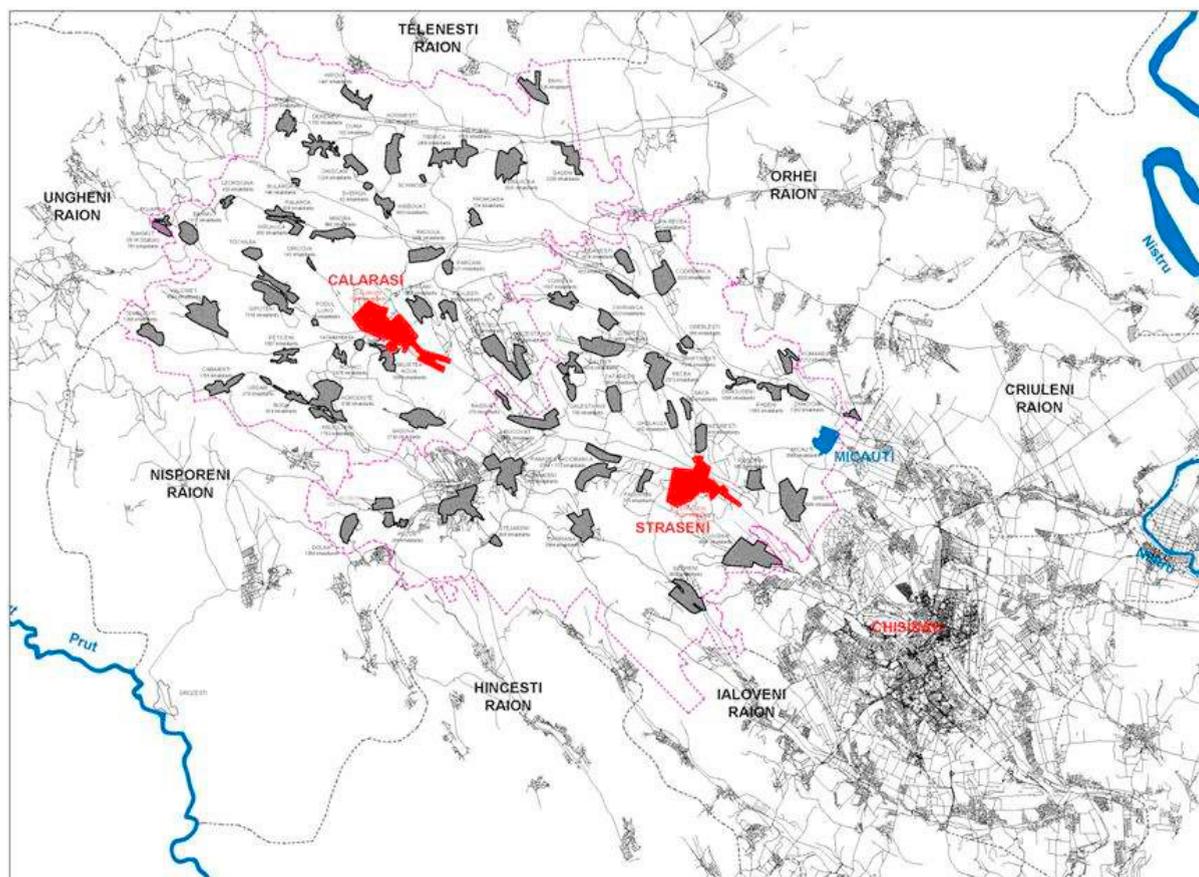


Fig. 1. Project area and available water sources.

The **Nistru River** is actually used as raw water source for Chisinau Town. The water is treated in the Drinking Water Treatment Plant (DWTP) Chisinau and is distributed to the consumers from Chisinau Town. The analyses of drinking water performed in the period 2013 – 2016 reveal the good quality of drinking water in Chisinau.

Also, an assessment of the production capacities from Chisinau reveals the excess capacity of the plant. The existing treatment capacity represents about 45% of the total capacity of the plant. In physical terms, the available excess flow in Chisinau represents more than 63.0 Mil. m<sup>3</sup>/year, while the necessary flow to supply the Rayons Straseni and Calarasi is around 10.0 Mil. m<sup>3</sup>/year ( $315.89 \text{ l/s} \times 86,400 \text{ sec/day} \times 1/1,000 \text{ l/m}^3 \times 365 \text{ days/year} = 9.96 \text{ Mil. m}^3/\text{year}$ ).

In conclusion, Chisinau DWTP has sufficient capacity to provide the necessary drinking water quantities to Calarasi and Straseni Rayons at the quality requested by the regulations.

The **Prut River** is another available source. According to the raw water quality analyses, the Prut River is a highly polluted source and the raw water quality exceeds A3 Category according to 75/440/EEC Directive and Moldavian GD 890/2013. The main parameters which exceed the limits are iron, oxidability and COD.

In this situation an advanced treatment is required provide a drinking water with quality according to Directive CE 98/83/EC. According to the raw water quality, the proposed treatment scheme is presented in the next figure.

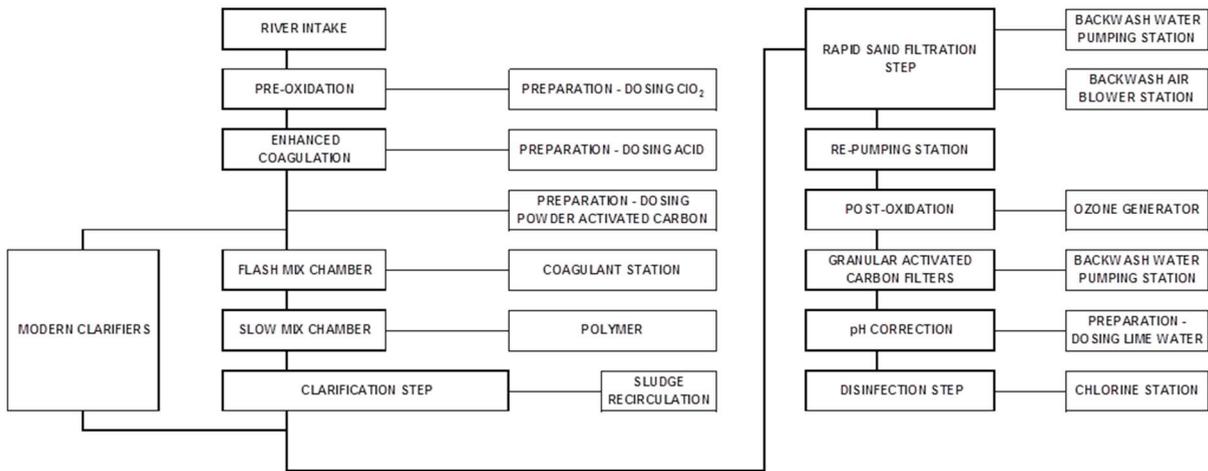


Fig. 2. The proposed technological scheme for the Prut River treatment.

A short description of the adopted processes is presented in the following:

- Powder activated carbon injection as a mitigation measure against accidental pollution;
- Pre-oxidation with chlorine dioxide against organic compounds but also as a measure against algal development;
- Enhanced coagulation – as a measure for lowering the Tri-Halo-Methane Formation Potential (THMFP);
- Coagulation-flocculation with corresponding chemical reagents in rapid and slow mix chambers;
- Clarification using lamella clarifiers and sludge recirculation;
- Rapid sand filtration;
- Final polishing consisting of ozone post-oxidation and adsorption on granular activated carbon filters;
- pH correction using lime water;
- Final disinfection using electro-chlorination (sodium hypochlorite), in order to provide the necessary residual chlorine dose.

**Micauti groundwater source** is currently used as drinking water source for Straseni town but also for some rural localities (Micauti, Sireti). The quality of groundwater abstracted from Micauti source is good is compliant with the Directive CE 98/83/EC.

The main problem of this source is availability of the water quantity. The evaluation of the water reserves indicated that the source can assure only 100 l/s in safe conditions.

## 2.2. Water Demand Calculation

The actual average consumptions of water for domestic customers in the project area are very low (44-45 l/capita, day), compared to the average consumption in Central and Eastern Europe. Furthermore an increase of specific flows was considered mainly determined by the increase of the prosperity of the population, while the level of commercial losses will decrease as a result of completion of new infrastructure and the increase of the accuracy of water metering as well as due to a better commercial management of water sales.

The water demand has been determined using the local norms (SNiP 2.04.02-84). According the prescriptions of the standard, the specific water consumptions considered in the calculation is: 160 l/capita, day – house connection in urban area and 125 l/capita, day – house connection in rural area.

Table 1. Summary of future water demand for the year 2045.

No.	Description	Unit	Straseni Rayon		Calarasi Rayon	
			Urban	Rural	Urban	Rural
1	No. of inhabitants	no.	21,023	71,050	15,840	62,276
2	Per-capita demand	l/c,d	160.00	125.00	160.00	125.00
3	Institutional demand	l/c,d	3.84	2.82	5.18	2.93
4	Commercial demand	l/c,d	5.39	0.75	3.39	0.75
5	Total average demand	l/c,d	169.23	128.57	168.57	128.68
6	Daily average demand	m <sup>3</sup> /d	3,557.69	9,134.83	2,670.17	8,013.55
7	Real Water Losses	m <sup>3</sup> /d	1,163	881	809	798
8	Total Water Demand including Water Losses	m <sup>3</sup> /d	4,720.69	10,015.83	3,479.17	8,811.55

Intake, water treatment plant, pumping stations, transmission mains and water reservoirs was calculated using the Daily Peak Demand which is 400 l/s for both rayons.

### 2.3. Options Regarding the Selection of the Water Source

Considering the existing situation and the available water sources an option analyses was developed in order to select the most suitable source to supply the consumers with safe drinking water in the area. The analysed options are presented in the following.

#### 2.3.1. Option 1 – Treated Water from Chisinau DWTP

In Option 1 the centralised Straseni – Calarasi WSS will be developed using the treated water produced in the Chisinau DWTP. The drinking water is provided from Chisinau distribution system, from the existing pipe with diameter of DN 1000 mm, through an intersection chamber located at in the area of the Gura Vaii and Mircesti streets intersection.

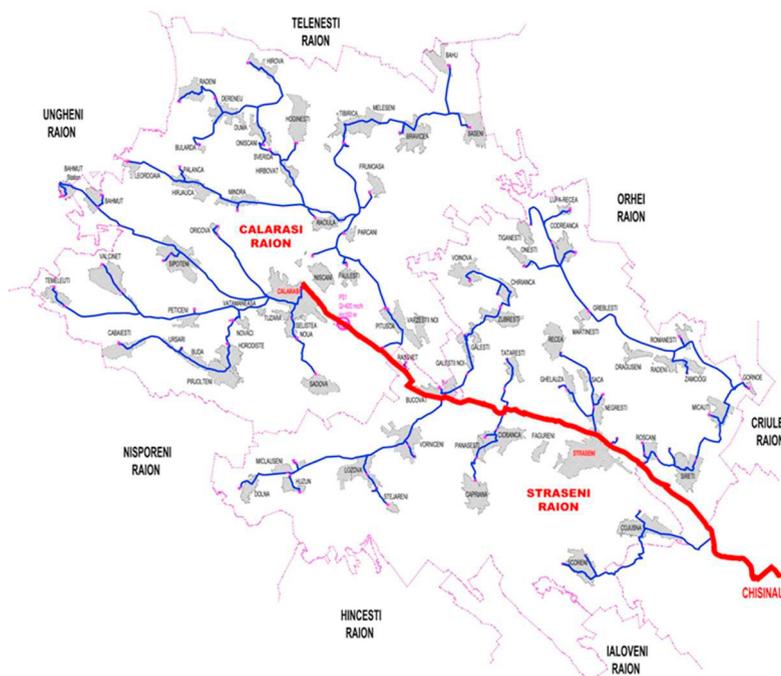


Fig. 3. General layout of the main transmission pipe Chisinau - Straseni - Bucovat - Calarasi and secondary transmission pipes – Option 1.

From the injection point is proposed a main transmission pipe which will follow public domain on the route: Chisinau – Sireti – Straseni – Ciobanca – Bucovat – Rassvet – Calarasi.

From the intersection chamber in Chisinau the drinking water is transported through 48.53 km of main pipes with diameters of DN 700 mm, L=19.56 km, DN 600 mm, L=13.73 km, DN 500 mm, L=7.45 km, DN 400 mm, L=7.04 km and DN 355 mm, L=0.75 km. Considering the existing pressure in Chisinau, the ground levels and the headlosses on the transmission pipes, one pumping stations are provided on the main transmission pipe.

The secondary transmission pipes will transport the water from the main transmission system to all localities in the project area. The secondary transmission systems consist of 331.79 km of pipes and 28 pumping stations.

### 2.3.2. Option 2 – Treated Water From New Prut DWTP

For Option 2, the centralised Straseni – Calarasi WSS will be developed using the treated water provided from Prut River, treated in a new DWTP and main transmission pipes Prut - Micleuseni - Vorniceni - Calarasi and Vorniceni – Straseni and secondary transmission pipes systems for all localities.

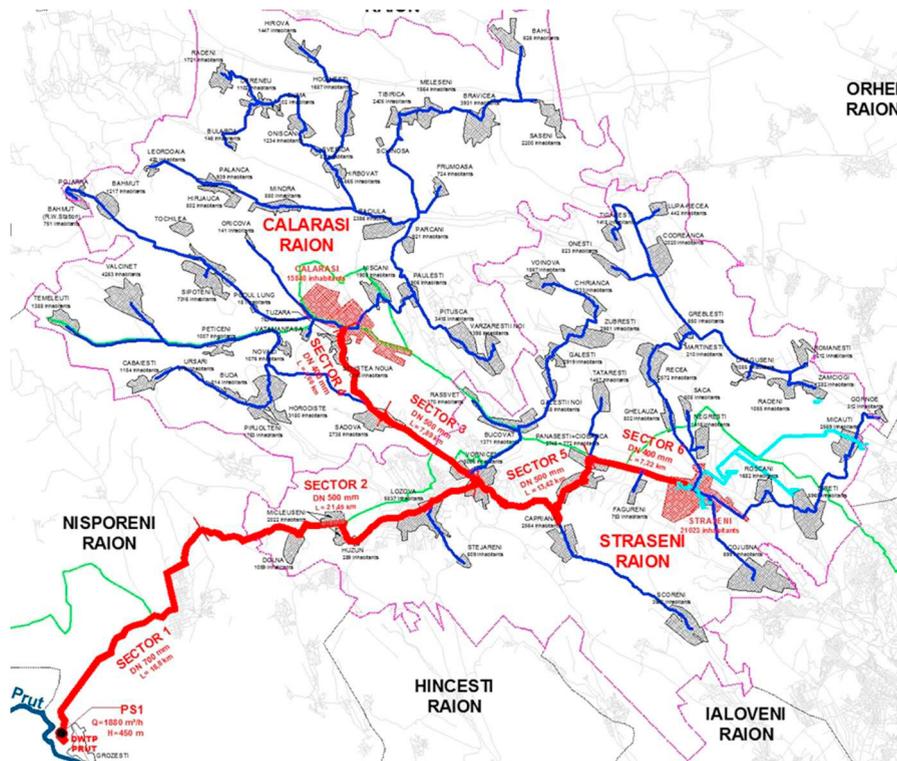


Fig. 4. General layout of the main transmission pipe Prut DWTP - Micleuseni - Vorniceni - Calarasi and Vorniceni – Straseni and secondary transmission pipes – Option 2.

In this option, the New Prut DWTP is located on the Prut river bank near Grozesti locality and is provided with the treatment scheme presented before. The raw water is provided from a new surface water intake, located near the Prut DWTP. The drinking water from the new Prut DWTP will be pumped through a main transmission pipe following the public roads on the route: Prut DWTP (Grozesti) – Micleuseni – Lozova – Vorniceni. From Vorniceni this main pipe will be divided into 2 main branches, the first on the route Vorniceni – Sadova – Calarasi and the second on the route Vorniceni – Capriana - Panasesti – Straseni. In this option the main transmission pipe has 75.19 km and consists of the following diameters: DN 600 mm, L=18.80 km, DN 500 mm, L=29.35 km, DN 400 mm, L=6.41 km, DN 500 mm, L=13.42 km and DN 400 mm, L=7.22 km.

Considering the ground levels and the headlosses on the transmission pipes, one pumping station located in Prut DWTP is required for entire main transport system.

The secondary transmission pipes systems consist of 292.18 km of pipes and 13 pumping stations.

### 2.3.3. Option 3 – Treated Water from Micauti Wellfield

In Option 3, the centralised Straseni – Calarasi WSS will be developed using the treated water provided by the existing Micauti groundwater source. The problem of this source is the raw water quantity. In this condition, a safe operation of this source, in terms of water quantities, requires a permanent re-charge of the aquifer from an external source, to be considered for supply of all localities from both rayons Calarasi and Straseni.

The potential available source, which can provide the necessary water quantity for aquifer recharge is Nistru River. In order to inject a proper water quality into the aquifer the raw water from Nistru River requires a treatment.

The proposed treatment consists of the coagulation–flocculation and clarification processes followed by a rapid sand filtration (the classic drinking water treatment scheme). Also, a transmission pipe for aquifer recharge DN 500 mm, L=26.78 km, facilities for recharge of the aquifer at Micauti Wellfield, rehabilitation of 10 existing wells and 42 new wells, new reservoir and disinfection plant are required.

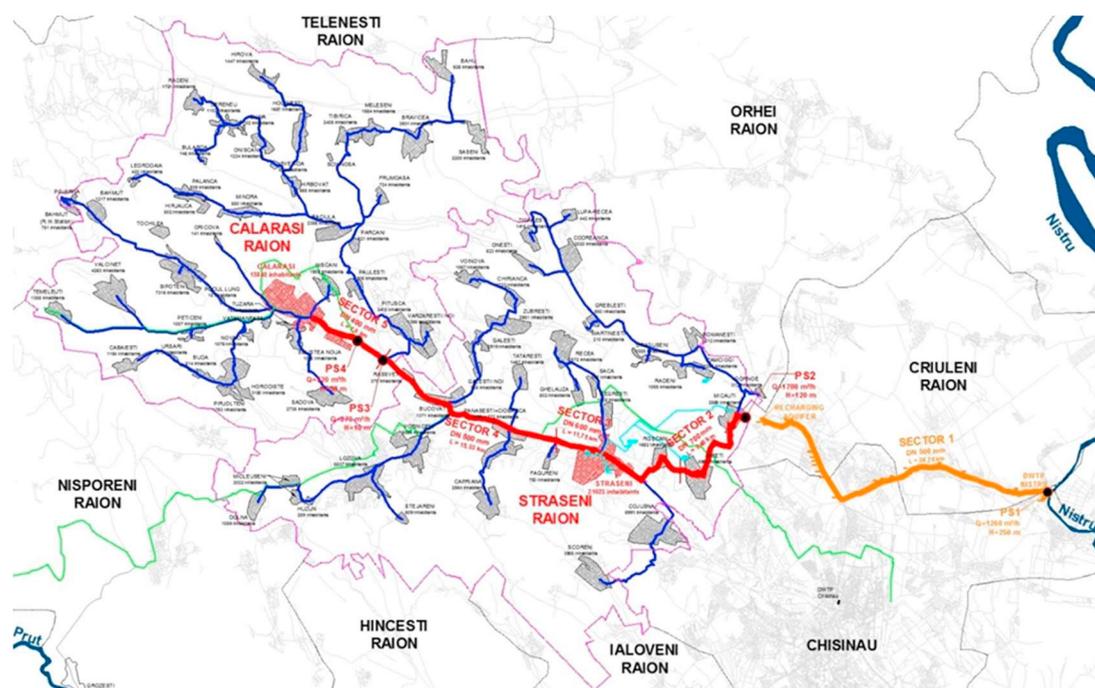


Fig. 5. General layout of the main transmission pipe Nistru DWTP - Micauti - Straseni - Bucovat – Calarasi and secondary transmission pipes – Option 3.

The drinking water provided from Micauti Wellfield is pumped through a main transmission pipe following the public roads on the route: Micauti – Sireti - Roscani – Straseni – Panasesti – Bucovat – Rassvet – Calarasi. In this option the main transmission pipe has a length of 43.55 km and consists of the following diameters DN 700 mm, L=9.48 km, DN 600 mm, L=11.75 km, DN 500 mm, L=15.32 km, DN 400 mm, L=7.00 km. Considering the ground levels and the headloss on the transmission pipes, 3 pumping stations are provided on the main transmission pipe.

The secondary transmission pipes systems consist of 291.01 km of pipes and 32 pumping stations.

### 2.3.4. Option 4 – Local Water Treatment

In this option, the use of decentralised drinking water systems is analysed. The conclusions regarding the groundwater quality shows that the groundwater is highly polluted. The deeper aquifers have very variable water qualities. The groundwater is anaerobic and shows elevated levels of fluoride ( $F^-$ ), boron (B), iron (Fe), hydrogen sulphide ( $H_2S$ ), ammonium ( $NH_4^+$ ), dissolved organic carbon (DOC), and sulphate ( $SO_4^{2-}$ ).

The above mentioned contaminants are natural (geogenic) and can be treated only by reverse osmosis. Thus in this option local treatment requires the use of reverse osmosis treatment plants, except Strasen Town where the existing good water source Micauti is kept.

In this type of treatment, the water is pumped through a semipermeable membrane resulting in two streams; permeate with low concentration of salts (low TDS) and brine, a stream with a high concentration of salts (high TDS). As a result of the low TDS on permeate, the system has a bypass valve in order to blend the permeate stream with filtered water. The option has important disadvantages related to the environmental impact, determined by the concentrate solution from the RO process for drinking water preparation which has to be safely removed.

### 3. Results and Discussions

#### 3.1. Comparative Analyse of the Options – Technical Assessments

All analysed options comply with the EU Directive 98/83/EC for the quality of water intended for human consumption. Options 1, 2 and 3 consist of centralised water supply systems for Strasen and Calarasi while a decentralised system is foreseen in Option 4.

All before mentioned options have been analysed identifying their respective advantages and disadvantages which are presented in the next table.

Table 2. Summary of the advantages and disadvantages of the considered options.

	<b>Option 1</b> <b>Treated water from Chisinau</b>	<b>Option 2</b> <b>Treated water from New Prut DWTP</b>	<b>Option 3</b> <b>Treated water from Micauti Wellfield</b>	<b>Option 4</b> <b>Local treatment using reverse osmose</b>
<b>ADVANTAGES</b>	No treatment needed, only re-chlorination		No treatment needed, only re-chlorination	No long water transfer
	Sufficient source	Sufficient source		
	Less land purchase			
	Low investment cost		Lower operating cost	Lower investment cost
	No very large pumping stations	Low number of secondary pumping stations		
	Low requirements on qualified personal needed			
<b>DISADVANTAGES</b>	Large pumping stations on main pipe	Requires new DWTP	Insufficient source	Extremely high operating cost
	Higher operation cost than Option 3	Highest investment cost	High investment cost	Handling a large number of chemicals
		Highest operating cost	Necessary aquifer recharge	Large number of plants
		Large pumping station	Water treatment for aquifer recharge	Special treatment for concentrate
		Land property on the route of the transmission pipe and for the DWTP	Large pumping stations	High pollution risk related to concentrate from treatment
		Land property on the route of the transmission pipe and for the DWTP	Land property for the DWTPs	
	Large number of qualified personnel needed		Large number of qualified personnel needed	High requirements on qualified personnel

The assessment of advantages and disadvantages results in the selection of Option 1 as preferred technical options. Considering technical point of view the selected option is Option 1- Treated water provided from Chisinau DWTP, main transmission pipe Chisinau - Strasen - Bucovat - Calarasi and secondary transmission pipes for all localities.

### 3.2. Comparative Analyse of the Options – Institutional Assessments

The main institutional elements that could affect the implementation and future operation of the water and wastewater systems are similar for all options and are not affecting the decision process.

### 3.3. Comparative Analyse of the Options – Environmental Impact Assessments

From the environmental point of view, the minimum impact will derive in the proposed Option 1, while the other options will determine higher effects on the environment.

### 3.4. Comparative Analyse of the Options – Financial Assessments

The financial comparison of the options was made considering indicators Net Present Value (NPV) and Dynamic Prime Costs (DPC) for each option. The results of the indicators, considering the discount rate of 4% are presented in the following table.

Table 3. Net Present Value (NPV) and Dynamic Prime Costs (DPC) [in Euro] -water sources.

Total water system options analysis (4% discount rate)	Option 1	Option 2	Option 3	Option 4
Net Present Value of investment components (NPVi)	30,785,891	51,430,811	42,789,138	20,200,013
Net Present Value of operating costs (NPVo&m)	40,827,775	35,134,916	35,731,768	225,203,194
Net Present Value of invoiced quantities (NPVq)	63,259,667	63,259,667	63,259,667	63,259,667
Net Present Value of investment + operation (NPVt)	<b>71,613,666</b>	<b>86,565,726</b>	<b>78,520,906</b>	<b>245,403,206</b>
Dynamic Prime Costs (DPCi) - investment	0.487	0.813	0.676	0.319
Dynamic Prime Costs (DPCo&m) -operating costs	0.645	0.555	0.565	3.560
Dynamic Prime Costs (DPCt) -investment + operating costs	<b>1.132</b>	<b>1.368</b>	<b>1.241</b>	<b>3.879</b>

The option generating the lowest Net Present Value considering both investment and O&M costs and the lowest Dynamic Prime Costs regardless of the applied discount rate is Option 1.

## 4. Results and Discussions

Considering the previous conclusions from the technical, environmental impact and financial point of view, the most feasible option for long term sustainability of potable water supply is **Option 1 - Treated water provided from Chisinau DWTP, main transmission pipe Chisinau - Straseni - Bucovat - Calarasi and secondary transmission pipes for all localities.**

## References

- [1] CES Consulting Engineers Salzgitter GmbH - Improvement Of Water Infrastructure In Central Moldova - Consulting Services for the Feasibility Study Regarding Extension of the Transmission Pipe Chisinau-Straseni-Calarasi - Feasibility Study, December 2016.
- [2] Government of Moldova – Strategy for Water Supply and Sanitation (2014-2028), Governmental Decision 199/20.03.2014.
- [3] United Nations, Department of Economic and Social Affairs, Population Division (2015) – World Population Prospects: The 2015 Revision, DVD Edition.
- [4] USSR State Committee for Construction – Building Regulations – Water Supply. Exterior Network and Structures, SNiP 2.04.02-84 \*, Moscow 1986.
- [5] Government of Moldova, Ministry of Construction and Territorial Development – Feasibility Study “Improving and extension of water supply and sanitation services in the town of Straseni”, GOPA - Gesellschaft für Organisation, Planung und Ausbildung mbH – Eptisa Servicios de Ingeniera S.L. - Integration Environment & Energy GmbH – Kommunalkredit Public Consulting GmbH – Oxford Policy Management Ltd., published by GIZ in 2015.
- [6] Government of Moldova, Ministry of Construction and Territorial Development – Feasibility Study “Improving and extension of water supply and sanitation services in the town of Calarasi”, GOPA - Gesellschaft für Organisation, Planung und Ausbildung mbH – Eptisa Servicios de Ingeniera S.L. - Integration Environment & Energy GmbH – Kommunalkredit Public Consulting GmbH – Oxford Policy Management Ltd., published by GIZ in 2015.
- [7] Department of Constructions and Territorial Development - “Water Supply of Localities in Straseni and Calarasi Rayons from Chisinau Water Intake”, IPROCUM, 2005.