Methodological Bases of Creation and Development of a New Type of Natural and Technical Systems of Multipurpose Water Use in Urban Areas

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Abstract. In the development of the class of natural-technical systems (NTS) "Natural Environment-Object of Activity-Population" ("NE-OA-P") on the use of water resources in the multifaceted types of economic and other activities, giving the results of theoretical studies of a specialized type "NTS" in where the component "PS" means the natural water environment (NWE) of a water body as a source of the multi-purpose water supply system (MWS) of the objects of urban households, settlements, enterprises of the fuel and energy complex (TPP, HES, NPP); Under the "OA" water intake technological complex (WITC) is considered, which includes various for the functional purpose of hydraulic structures (HS) and devices for ensuring the selection of estimated water flow (Qm³/s) with an environmentally safe level of protection of the water environment of the water body in the zones of influence of the WITC and the functional work of the treatment facilities in the composition of the MWS; under the component "P is considered MWS that provides water of normative quality to specific water consumers and water users. The methodological basis in creation of new type NTS "NWE-WITC-MWS" considers the system analysis and the approach which is based on concept of "System". The methodology for creating and developing this type is based on 4 axiomatic conditions: (1) existence as a fundamental characteristic; (2) a multitude of structural formations; (3) unity, as the relationship between natural technogenic components; (4) sufficiency of the initial material for an assessment of an ecological condition of water environment oNWE-WITC-MWS ".

1. Introduction
The system regularity is considered in a basis of the functioning of the NTS "NWE-WITC-MWS", which is based on a combination of two opposite tendencies that determine the dualism in the processes of transformation of energy forms. At the present stage of social development, both at the level of the global system "Nature-Society-Man", and at the level of regional and local basin geosystems, there are many areas of knowledge that serve the diversity of economic activities (EA),
one of the most important is the use of water resources. Systemic consideration of the processes of vital activity of society at all hierarchical levels of the Earth’s biosphere is characterized by a certain limitation in natural resources, including water resources, in limiting conditions for further development. The modern paradigm of society development has given rise to a number of 10 global problems, of which the most important are the first three problems of Energy, Water, Nutrition, without solution of which it is impossible to solve other 7 important problems, including Ecology, in fourth place. This condition of development of society necessitates the creation and development of new scientific methodological approaches to improve the technology of using natural resources, including water, which are formed within the spatial limits of basin geosystems of inland water bodies (rivers, lakes) [1,3,5].

A specific feature of the social role of science in modern conditions is the orientation of scientific knowledge in general and the creation of more effective technology for the use of natural resources, including water.

Applicable for the branch science on the use of water resources in various types of EA industries, and particularly in the MWS of urban facilities, settlements, fuel and energy complex enterprises (TPP, HES, NPP), the most acceptable is the application of system analysis in the creation of new or improved existing design-construction solutions with the provision of ES level of protection of the water environment of the water body in the zones of influence of "WITC".

The methodological basis for the creation and development of a new type of NTS "NWE-WITC-MWS" is the system analysis and the system approach, which are based on the central concept "System", which priority is traced in Aristotle, and the basis of the generalized theory of systems is Hegel's ideas, in which the whole is considered as something more than the sum of parts where the whole determines the nature of the parts, and the parts cannot be known outside the whole. For the considering type of NTS "NWE-WITC-MWS" the parts are represented in the form of natural and technogenic components ("NWE", "WITC", "MWS") and the elements included in them which are in constant inter-linkage, interaction and interrelations (III) among themselves in the functioning processes. Consequently, for the considered type of "EA" the concept “System” is relevant in the scientific and practical sense, related to the creation and development of the methodology of a specialized type of NTS "NWE-WITC-MWS" (Fig. 1).

![Figure 1](image)

**Figure 1.** Model III between the components of the NTS "NWE-WITC-MWS" of urban facilities, settlements, industrial and agricultural enterprises.

### 2. Materials and Methods

The natural component of the “NWE” of the system under consideration includes the natural water environment of the water body, from which carried out the selection of calculated water flow \((Q, \text{m}^3/\text{s})\) is taken by the water intake technological complex (WITC). The technogenic component "WITC" includes in its composition various on functional purpose constructively designed solutions for ES level of protection of the water environment of the water body in its impact zones. The main and
necessary constructive solutions, as evidenced by the results of research, are: fish protection devices (FPD); protection devices from bottom and suspended silts; protection devices against aquatic vegetation and Dreissena; devices for the formation of the necessary hydraulic structure of the water flow in the leading part of the water intake windows, etc., accompanying to ensure the normative quality of the water supplied to the MWS. The technogenic component "MWS" provides transportation (delivery) of water to specific water users (general population, enterprise, etc.) \cite{4,7,8}.

To create the basis for the methodology of the specialized type of NTS "NWE-WITC-MWS", the prerequisites of the theoretical value are considered: methodology with the identified axiomatic prerequisites and rules of inference in their formation. So, for the considered NTS "NWE-WITC-MWS" the following axiomatic conditions are chosen: -existence, many structural formations, unity and sufficiency.

The conditions for the existence of the NTS "NWE-WITC-MWS" as a fundamental characteristic are determined by the flow of substance, energy and information (SEI), in the space and time of the WITC influence zones.

The condition is the set of structural formations (biotic, abiotic) components and technogenic components in the form of WITC and MWS.

The condition of unity determines the III between the components of the system, due to which a new property for them and their aggregate arises - additive, nonadditive, additive - nonadditive, which have a functional meaning in their importance.

The sufficiency condition is understood in the sense of the adequacy of the number of natural, laboratory and theoretical studies of the processes of IIIs of technogenic components with natural components in the considered NTS "NWE-WITC-MWS"\cite{6,10,15}.

3. Results
In the study of the FM NTS "NWE-WITC-MWS", an important method is the analogy and physical modeling of the “III” processes of constructive solutions of the WITC with a water flow in the active zone of influence, for example, providing protection against ingress of juvenile fish into the MWS. The method of analogy, in its essence, is based on the equivalence between two systems, each of which can be real or abstract.

For the NTS "NWE-WITC-MWS" two requirements are important:

Fundamentals of methodology should include existing methodological developments; its terms and concepts should be interpreted in more narrow fields of water management sciences;

Fundamentals of methodology should be scientific in the sense that its concepts and its language should be uniquely determined, and the basic foundation of FM-NTS "NWE-WITC-MWS" should be such that its conclusions are of practical value in researching existing and emerging NTS "NWE-WITC-MWS", FM-NTS "NWE-WITC-MWS", according to the results of the research, should have the following properties:

- FM-NTS "NWE-WITC-MWS" are built on the basic concept of "System", where abstract and physical models can be considered;
- FM-NTS "NWE-WITC-MWS" should use the achievement in abstract areas of mathematics;
- FM-NTS "NWE-WITC-MWS" is a field of scientific research related to the study of the “III” processes of natural and technogenic components among themselves in the composition of operating full-scale systems and their laboratory models at a given scale of physical modeling.

Proceeding from the concept of "System" given by L. Bertha Lanf and the analysis of other concepts "System" for the considered specialized type of NTS "NWE-WITC-MWS" acceptable, there will be a concept where under the system there are many components with T elements in them, in which the relation R is implemented with the given property P.

Material formation in the form of "WITC" is in constant “III” with material formations of "NWE" of the water object, introducing certain changes in the intensity of the flow of the SEI flows in the zones of influence. The exchange of flows SEI between the "WITC" and "NWE" causes research related to the field of "Enhancement" of material education. If the exchange of flows SEI is not
considered, the research belongs to the sphere of "Structure" of material education "WITC". Synthesis of the opposite categories "Behavior" and "Structure" determines the relativity of the concept of "System".

In the system study of the “III” processes between the "WITC", and "NWE" and "MWS" systems approach with its characteristics (integrity, completeness, etc.) and the stage of research are used. So, at the first stage of system analysis, a qualitative description of the “WITC” with its integral properties is performed. At the second stage, a more abstract level of analysis is performed, where the main task is to substantiate the integral properties of the system under consideration [12-20].

The notions of "System" and "Systemic approach" are integral concepts: the system element; Environment; component and structure of the component; model of the system; matter; energy; entropy; feedback, on the basis of which FM-NTS "NWE-WITC-MWS" is considered, analysis and synthesis of this type of systems. In FM-NTS "NWE-WITC-MWS" under the element of the system, a non-divisible constructive formation in the composition of "WITC", for example, FPD, etc., is adopted.

4. Conclusions
System analysis, system synthesis in FM research and design of the NTS "NWE-WITC-MWS" cause itself applied science, which is aimed at the abiotic ES level of protection of the water environment of the water body in the zones of influence "WITC", with "III", it with "NWE "and "MWS", to achieve the goal related to the vital needs of the municipal economy in drinking water supply, as well as industrial enterprises.

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