Optimising processes of groundwater monitoring in the LGOM area

Groundwater monitoring is an immensely important source of up-to-date information about the amount of water resources available for economic use, its chemical composition and quality, as well as about the state of those components of the natural environment that are directly dependent on the groundwater. When looking at monitoring as an essential method for protection of water resources, it's noticeable that there is a significant level of complexity in it. This is the reason why process approach, which is being used in various branches of industry, has been used in this dissertation to describe and assess groundwater monitoring as it is conducted nowadays. Thanks to the use of process approach, the client is seen as the most important role, what drives adaptation of all operations towards satisfaction of his/her needs. Process improvement, which is part of the process approach, leads to modifications and adjustments of those processes within monitoring, which have been measured with the lowest scores for considered criteria (dominated processes). The research presented in this dissertation has been conducted based on the Legnicko-Glogowski Copper District, where groundwater monitoring is conducted since 1963 with the main purpose of tracking the influence of mining activities on hydrodynamic and hydrochemical conditions of the groundwater in that region.

The main goal of this dissertation is "to develop a process model of the groundwater monitoring based on the monitoring of the LGOM area and to indicate the processes for improvement". The analysis had been started with a literature review of both the groundwater monitoring and the process approach. The analysis covered also the source documentation as well as information obtained from participatory observation of the hydrodynamic and hydrochemical monitoring of groundwater in the area of Legnicko-Głogowski Copper District (case study).

As the first step of the analysis presented in the thesis, various types of network monitoring in the LGOM area have been characterised. This description includes measurement methodology, scope and frequency of testing, as well as methods of archiving, presentation and interpretation of the data. In the analysis of monitoring programs, three time periods have been distinguished (years 1973-2005, 2006-2010, and 2011-2014) and the differences in number of monitoring points, scope and frequency of testing have been considered for those periods. The detailed description of the current state of monitoring in the hydrogeological aspect, which has been constructed in the described process approach, became the starting point of the analysis in terms of the processes. Using the SIPOC models (Suppliers, Inputs, Processes, Outputs, Customers), the groundwater monitoring processes and relationships between them have been identified, as well as the deliverables and customers of each process. Modeling of processes in groundwater monitoring projects has also been carried out, what lead to producing five maps of current state that present actual process flow in a groundwater monitoring projects conducted in the analysed area, with attention to the structure of individual operations and interrelations between its elements.

In the next step of the analysis, three process parameters have been determined: duration of each process (CT_k), process cost (K_k), and process risk (R_k). These parameters allowed characterisation of the individual processes and, consequently, the entire project for two scenarios: pessimistic and most likely. The methods of calculating these parameters, both at the level of individual operations as well as the entire project, have also been presented in this dissertation. The first two parameters (duration of the process (CT_k) and process cost (K_k)) relate to the classical separation of parameters used in the literature, however a new perspective is taken in the approach and methods of

calculating these parameters. The third parameter, which is the process risk (R_k), so far has not been used in the process approach and it is author's original idea in the scope of this PhD dissertation.

The final stage of this thesis was to determine dominated processes, i.e. processes that should be selected as the first ones for improvement. Considering the specifics of the projects analysed in the dissertation, seven criteria have been chosen for this purpose:

- the duration of the main process for the most likely scenario (NPCTk),
- the duration of the main process for the pessimistic scenario (PCTk),
- the difference between the duration of the main process for both scenarios (ΔCTk),
- the costs of the main process for the most likely scenario (NPKk),
- the costs of the main process for the pessimistic scenario (PKk),
- the difference between the cost of the main process for both scenarios (ΔKk).
- risk value for the main process (Rk), which is the sum of the risk (Ri) of the constituent operations.

Based on those criteria and with the use of two different methods, ranking lists and weighted criteria method, the most dominated processes have been identified. Both methods indicated the same three processes ("logistics field measurements" – M.P.2 P.G.1, "inspection of measuring point" – M.P.2 P.G.2, "develop a plan for implementation of the project" – M.P.1 P.G.2) as the first ones to be improved. For these three selected processes, a detailed analysis of problems and their causes has been performed, which was followed by a proposal of solutions to improve current situation based on each criterion. Possible secondary risks, i.e. risks that can occur as a consequence of applying the proposed solutions, have been also identified. Additionally, an attempt to apply the process approach in hydrogeological context has been made, using the water level measurements as an example, and the results of this attempt have been presented in the dissertation.

The analysis carried out as part of the study leads to a conclusion that the process approach has great potential in identification of opportunities for improvement in the groundwater monitoring projects in the LGOM area and works very well in this context. The process model, which has been developed as part of this work, allows to improve project execution and project management practice in groundwater monitoring projects. Moreover, this model, combined with the prepared list of identified risks, can become a foundation for building a knowledge base of potential sources of problems in the course of groundwater monitoring projects and possible solutions to them.