**Development of an analysis tool for the evaluation of processes in the asset management of water distribution systems**

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## Abstract

Management of assets consists of a large number of individual processes. These include e.g. data collection, data analysis and the implementation of a suitable and asset-specific maintenance strategy. A large number of German and international regulations (e.g. DVGW, ISO, DIN) contain content relevant guidelines and information to implement a technical asset management strategy for water distribution systems. Based on these regulations, processes, data, management ratios and methods in the asset management of pipelines are defined as a „best- practice“. On this basis, a structured and comprehensible methodology for analysing and evaluating the current AM of a water utility company is carried out. As a result, optimization potential can be demonstrated, e.g.: The condition data usage can be optimized, better and more efficient inspection methods are proposed. The analysis tool is based on the German regulations, but the methodology can basically be transferred to other nations/regulations.

**Keywords:** management of assets, water distribution, Best-Practice, analysis-tool

# 1. Introduction

The German water supply industry consists of a large number of small to medium-sized network operators [1]. Their level of implementation and understanding of management of assets has a wide range. Especially smaller water supply units tend to have a lower degree of maturity. Reasons for this are:

- Limited human resources
- Difficulties in implementing complex functional separations such as asset owners and asset managers
- low competence and capacity to develop own approaches
- less budget to finance high-priced external consulting

These structural conditions are countered by a tendency towards increasing cost pressure, which increases the need for structured asset management of water distribution systems.

Therefore it is important to identify proven processes (“best-practice”) in the management of assets. The entire water supply sector can thus be provided with an improved understanding. Furthermore, existing specifications in technical standards and regulations are concretized and operationalized for practical implementation.

A DVGW[1] research project (W201743) was carried out to identify relevant rules and regulations on the subject of management of assets and to define the “best practice” [2]. The research pursued the object to develop practical hints for a better understanding of the asset management of water supply plants. Therefore the contents of ISO standards 24516-1 [3], 24516-2 [4] and the existing DVGW regulations were analysed. The developed information and hints were compared with the implementation status of several practical partners. Standards 24516-1 and 24516-2 specify the definitions of ISO 55000 [5] and the general organizational requirements according to ISO 50001 [6].

To determine the differences between the theoretical rules and the practical implementation within water companies, an extensive questionnaire was provided. A process model for the complex management of assets was developed for the elaboration of the questionnaire. It was used to enable a systematic identification of the asset management with the selected practice partners of the project. Following questions could be answered:

- Which (sub-)processes define the management of assets?
- What kind of data is generated?
- Which data is collected? (Quantity, Quality)
- Which analyses methods are used to generate information and knowledge?
- Are there any tools referring to the analysis-methods?
- How are decisions made?

The research project was completed in December 2018 and forms the content basis for the development of the analysis tool.

[1] Note: German Technical and Scientific Association for Gas and Water; Deutscher Verein des Gas- und Wasserfaches e.V. – technisch wissenschaftlicher Verein (DVGW)

## 2. Basics of tool development

A general applicable process model of technical plant management was developed for the various water supply plants. The best practice was defined on the basis of this process model using questionnaires with nine practical partners. These investigations (answers of the questionnaires) form the basis for the development of the TAM analysis tool. Figure 1 shows the workflow of the tool development.

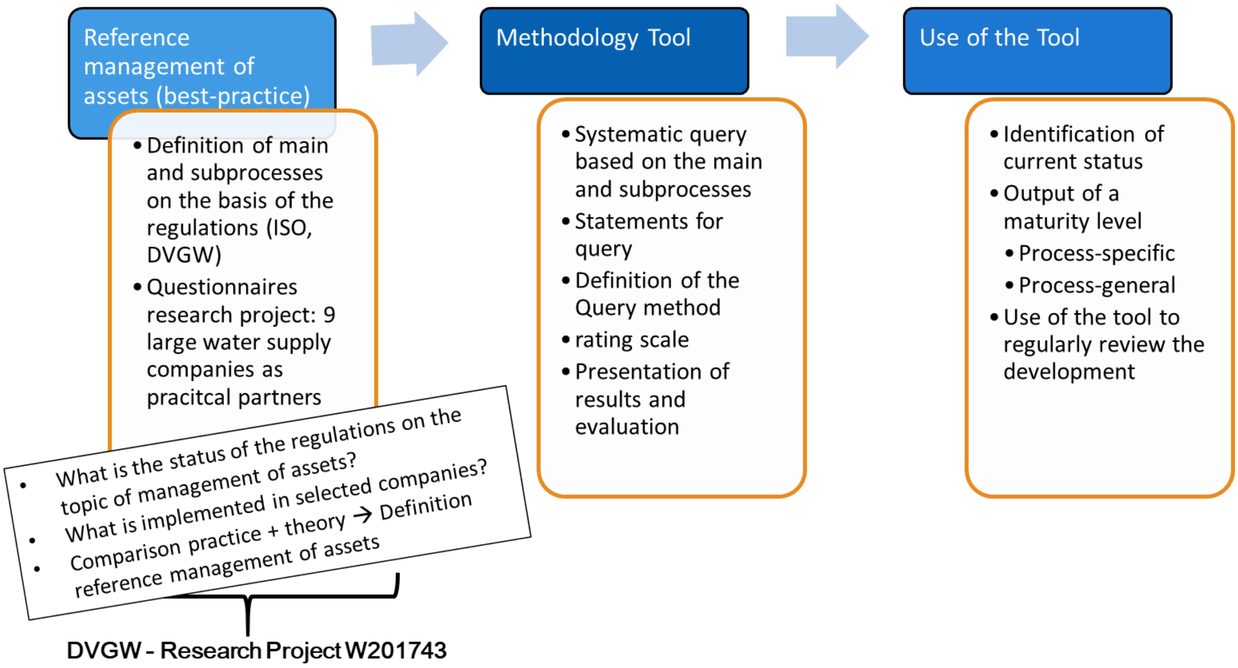


**Figure 1: Workflow of the tool development**

### 2.1 Definition of processes

The process model consists of interconnected sub-processes of the data flow (figure 2). Data is generated, received, processed and converted within the asset management. Strategic specifications through planning processes provide feedback to the other sub-processes. In this abstract form, asset management can be interpreted as a purely information technology system.

Data is acquired in different work steps ("investigation processes"). These steps are divided into planning, construction, operation and maintenance. Data types are divided into inventory, structural environmental, condition and failure data.

Data are collected, processed and converted ("support process") in different data storages (databases) after the investigation process. These include handwritten notes, GIS-Applications, NIS-Applications, digital databases or analogue planning. The data are subsequently evaluated in order to generate the IT basis for processes and strategies of plant management ("evaluation processes"). The elements "data gathering" and "data storage/evaluation" are separate processes within the data flow model, which must to be structured, planned and operated.

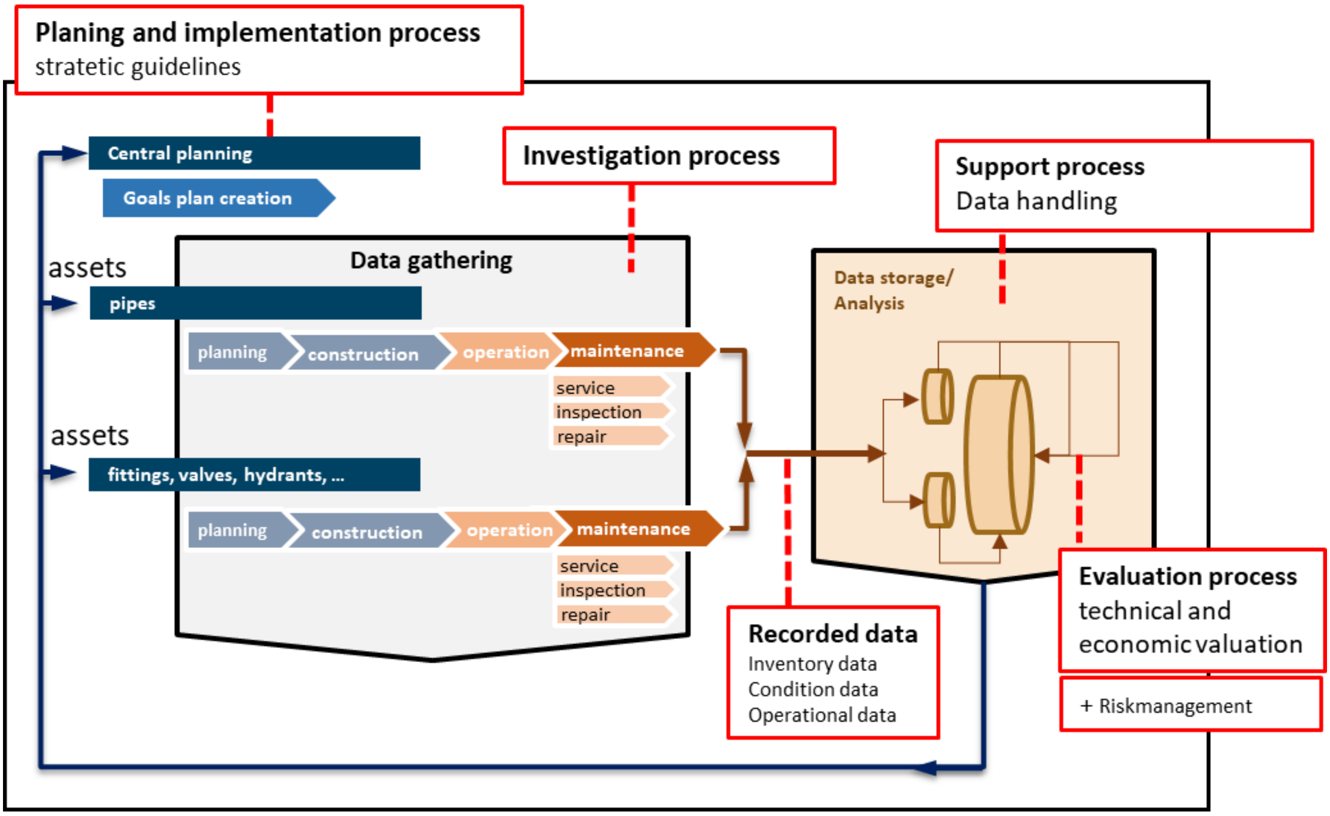


**Figure 2: Generic data flow model "management of assets" for water supply systems**

The process structure in plant management is defined in ISO 24516-1 by the terms *investigation*, *assessment (Evaluation process)*, *planning* and *implementation*. The defined data flow model is thus based on the standard and provides an enhanced model for practical implementation.

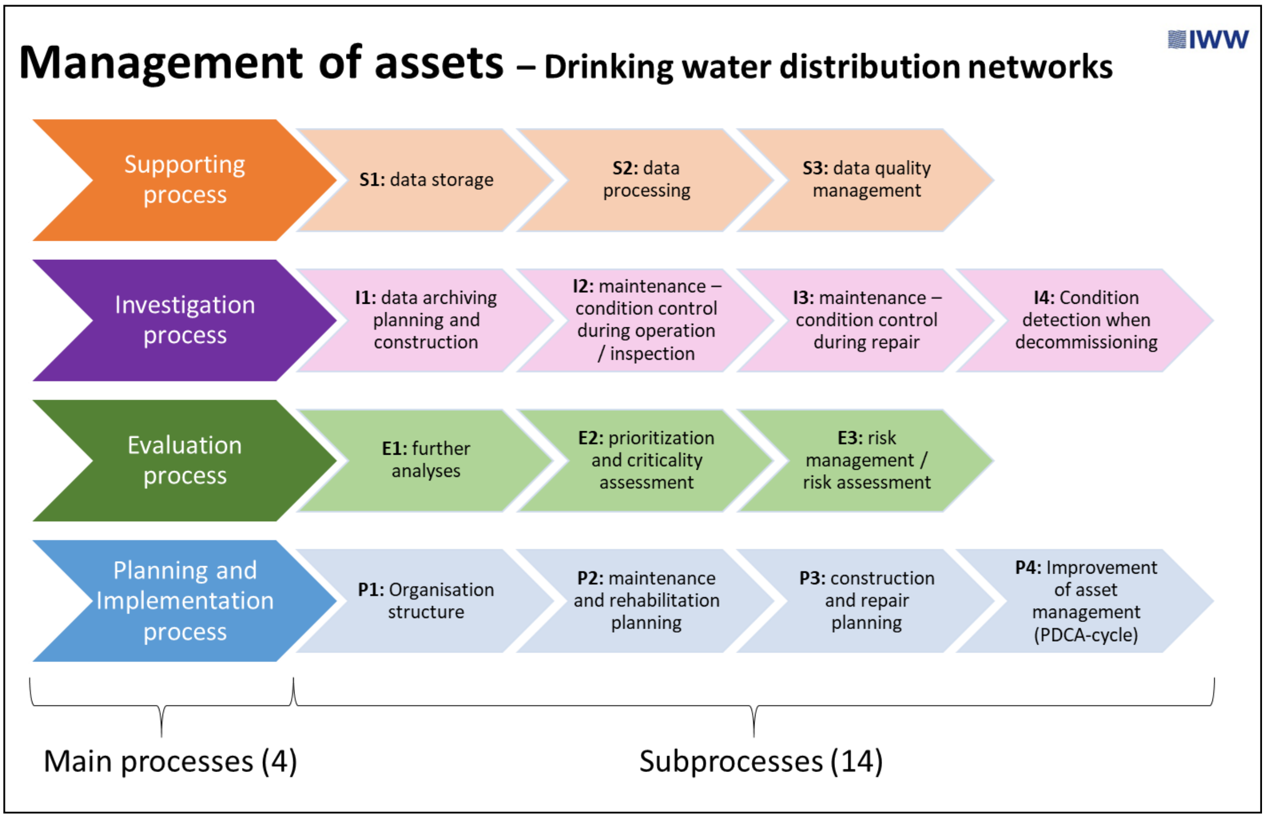


**Figure 3: Representation of all processes used in the analysis tool**

Figure 3 shows the further composition, which contains four main processes. These main processes are specified into a total of 14 sub-processes. This subdivision support a sufficient and precise analysis of the implemented asset management. A Further accuracy or depth level reduces the user-friendliness of the analysis tool.

## 2.2 Best-Practice in management of assets

The results of the DVGW research project "Tools for Technical Plant Management" [2] were used as the data basis to define a reference for the management of assets of water distribution plants (so-called “best practice”). Nine large water supply companies presented their status and practices by means of a comprehensive questionnaire. The nine participating water supply companies generally have an advanced status because of their seize within the water economy

A quantitative evaluation of the answers was methodically carried out (consensus of the individual water supply companies). The replies were compared with the acknowledged rules of technology and the State of the Art.

The existing DVGW rules and regulations already define a whole series of methods and management ratios for (primarily condition-oriented) maintenance for the plant group lines (or line objects) within the framework of work sheets and leaflets. For example descriptions for damage statistics, reliability and prognosis models, decision aids for rehabilitation planning are provided. For example management ratios are described for water losses and damage rates. This facilitates the generally valid representation of the sub-processes in plant management. In addition to the sheet

W 403 (M) [7], a well-equipped guideline, the information is available in many different places.

Table 1 shows the best-practice in a strongly summarized form

**Table 1: Best-practice in management of assets for water distribution systems [2]**

| |
|---|
| **Support process** |
| - Data management: digital<br>- Data processing: via specialist databases, ERP systems, geoinformation systems, network information systems and computer network models<br>- Data quality assurance: through operating and recording instructions as well as plausibility checks |
| **Investigation process** |
| - Recording method: manual analog or manual digital and automated digital<br>- Scope and depth of detail: according to DVGW W 402 [8] worksheet<br>- Data supplementation by company-specific requirements<br>- Data quality: Data collection on the basis of operating and collection instructions (e.g. forms, checkbox forms)<br>- Inspection periods: mainly in accordance with the requirements of DVGW Code of Practice W 400-3-B1 [9] and the codes of practice DVGW GW 19-1 [10] and DVGW GW 19-2 [11]<br>  - Continuous: e.g. flow, pressure, cathodic corrosion protection measurements<br>  - Regular: e.g. due to failure rates and/or water losses<br>  - Event-oriented: in the event of supply disruptions and special operating conditions (e.g. shut-offs/forced positions in parts of the pipeline network) |
| **Evaluation process** |
| - Risk-oriented evaluation procedures: Probability of occurrence multiplied by extent of damage<br>- Condition assessment and prioritisation<br>- Inclusion of specific requirements and use of synergies in maintenance (e.g. coordination with road construction authorities or other utility companies)<br>- Methods: damage statistics, hazard and risk assessment, forecast models, damage rates incl. ageing function, economic feasibility studies<br>- Success control by means of key figures: Technical figures: technical remaining life time, failure rates, water losses, rehabilitation rates, redundancies<br>- Economic figures: specific construction costs, maintenance costs, damage costs, operating costs, depreciation period, (re-)investment rate |
| **Planning and implementation process** |
| - Maintenance strategy: Inspection strategy ( preventive and condition-oriented)<br>- Concretisation: Priority-oriented maintenance<br>- Rehabilitation Strategy: "Derivation from Mathematical Distribution Functions"<br>- Company-specific strategies (individual, methodically adapted strategies)<br>- Further development/improvement of the TAM is reactive:<br>- Adjustment of the maintenance and rehabilitation strategy<br>- Determination of the remediation, renewal and repair procedures<br>- Using the PDCA Cycle |

## 3. Tool Implementation

The main objective of the analysis tool is to identify the performance level of a water supply company in comparison to best practice in the industry (chapter 2.2). Summarized it is a comparison between the actual state and the target state. Following sub-goals are carefully worded:

- Identification of company-specific weaknesses and strengths
- Suggestions to focus strategic development for the thematic occupation with the topic and by taking into account holistic approaches to the management of assets
- Creating the need to optimize operational activities

The analysis tool cannot be used to support specific recommended course of actions. The tool facilitates the technical introduction to the topic. However, the professional reading of specialist literature and rules is not replaced by the sole use of the tool. The tool does not replace any management consultancy or consulting activity due to the complexity and individuality of the work processes in a water supply company.

### 3.1 Definition of profiles – Main- and sub-processes

The theoretical basis of the analysis tool is formed by the definition of main and sub-processes of the management of assets (Figure 3). A profile is stored in the tool for each main- and sub-process. The profile describes each process with the same feature classes:

- **Description:** Brief description of the process in brief
- **Technical rules and regulations:** Reference to relevant contents of the rules and regulations
- **Necessity:** Classification of the process in the global understanding of the asset management
- **Objective / Result:** Brief Description of the Process Goal
- **Time expenditure / Interval**: Time classification or specification of an interval if applicable.
- **Contact person:** Contact person / person responsible for the process in the company

As an example, Figure 4 shows the profile for process S1 (data storage).

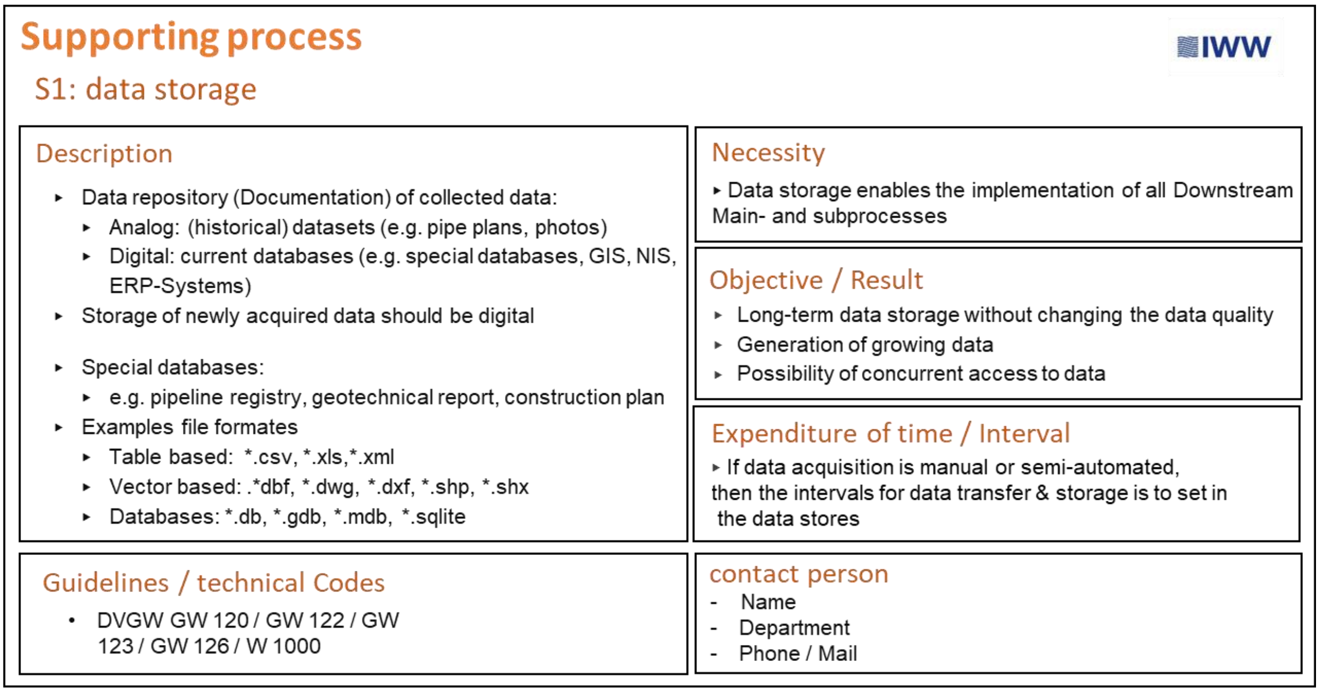


**Figure 4: Structure of the profiles using the example of Process S1 data storage**

The profiles are stored in the tool and can be called up directly during the query. Therefore the profiles take place as a guideline and ease the understanding of the whole topic.

### 3.2 Definition of the level of maturity

The tool is Excel-based and coded using Visual Basic Application (VBA). The tool is developed in cooperation with a practical partner (medium-sized water supply company).

For each of the defined 14 sub-processes, between 6 and 12 statements are provided, which query process implementation within the company. Figure 5 shows statements as an example of the sub-process “S1 data storage”.

The individual statements define on the one hand the maturity level of the respective process. On the other hand the user recognizes the different topic aspects which are part of an individual sub-process by means of the statements.

A Likert scale is used as a four-point answer scale [12]. Due to the evenness of the number “four” the user of the application is forced to choose the level of agreement or disagreement.

| | **Support Process** **S1: data storage** | agree 1 | 2 | 3 | disagree 4 |
|---|---|---|---|---|---|
| 1. | The company operates state-of-the-art hardware (data storage systems). | ○ | ○ | ● | ○ |
| 2. | The network documentation for pipelines, installations and fittings is digital. (e.g. plans, construction plans see DVGW GW 120). | ○ | ○ | ○ | ● |
| 3. | The data memory is a specialized database without georeferencing. (e.g. computer network models, ERP systems, digital accounting etc.). | ● | ○ | ○ | ○ |
| 4. | GIS databases are used as data storage. (e.g. real estate, traffic routes, tree cadastre, etc.): ArcGIS ©, ALKIS ®, QuantumGIS ®). | ○ | ○ | ○ | ● |
| 5. | NIS databases are used as data storage. (e.g. line management, equipment etc.): PRO NIS ©, GEONIS ©, IP Water ©). | ○ | ○ | ○ | ● |
| 6. | The access possibilities to data memories are regulated on the basis of an authorization concept. (e.g. protection against accidental modification or deletion of data). | ○ | ○ | ● | ○ |
| 7. | Backups are regularly generated from the current database. (e.g. hard disks, cloud storage, RDX cassettes etc.). | ○ | ○ | ● | ○ |
| 8. | Employees are trained in the possible sensitivity of data (to third parties). | ○ | ○ | ○ | ● |

**Figure 5: Theses to define the level of maturity of sub-process "S1 data storage"**

The maturity level is output specifically for each sub-process and summed up for all main processes. The maturity level is visualized with a seven-level system (A-G), which is already established in another subject area [13]. A colour coding supports the classification visually (Figure 6).

| **Evaluation** | | L1 | L2 | L3 | L4 | Level of maturity |
|---|---|---|---|---|---|---|
| **Supporting process** | | 1 | 0 | 7 | 10 | B |
| S1 | Data storage | 1 | | 3 | 4 | C |
| S2 | Data processing | | | 1 | 4 | A |
| S3 | Data quality management | | | 3 | 2 | B |
| **Investigation process** | | 3 | 4 | 6 | 18 | B |
| I1 | data archiving planning and construction | | 2 | 1 | 4 | B |
| I2 | maintenance – condition control during operation / inspection | 2 | | 2 | 6 | C |
| I3 | maintenance – condition control during repair | 1 | 2 | 2 | 5 | C |
| I4 | Condition detection when decommissioning | | | 1 | 3 | A |
| **Evaluation process** | | 11 | 5 | 3 | 7 | E |
| E1 | further analyses | 5 | | 1 | 4 | E |
| E2 | prioritization and criticality assessment | 5 | 2 | 1 | | G |
| E3 | risk management / risk assessment | 1 | 3 | 1 | 3 | D |
| **Planning and implementation process** | | 1 | 5 | 2 | 18 | B |
| P1 | Organisation structure | | 1 | | 2 | B |
| P2 | maintenance and rehabilitation planning | 1 | 3 | | 6 | C |
| P3 | construction and repair planning | | 1 | | 4 | B |
| P4 | Improvement of asset management | | | 2 | 6 | A |

**Figure 6: Representation the level of maturity after use of the analysing-tool**

## 4. Conclusion

The development of the tool is nearly completed. A further goal is the spreading of the tool in the target group. In principle a qualitative as well as a quantitative use of the tool is possible.

The analysis tool can be used to make quantitative statements on the current status of plant management in the water supply sector when using and anonymously passing on data. A prerequisite for this is a statistically sufficiently large group of participants.

Operational managers can use the tool to check the quality of the existing asset management. As a result the processes within the company can be improved and an increased understanding of the involved processes can be achieved.

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