Planning and Conception of Water Treatment Plants

PACIFIC

Environmental Technology

Content

1 Pacific Environmental Technology- Scope of service

1.1 Field of work

The team at "PACIFIC Environmental Technology" comprises constructional, electrical and process engineers, as well as hydrogeologists. Flexibility and a broad working spectrum, always with water at its focal point, distinguish the commitment of the employees today.

- Hydrogeology
- Hydromechanics
- Water resources planning
- Well design and construction
- Water transport
- Water treatment
- Water pumping
- Wastewater drainage
- Wastewater purification
- Rainwater management

The following chapters describe only an example. This is the way of complete consulting, planning and controlling with a focus on the phases of studies and rough draft planning.

1.2 Scope of Service

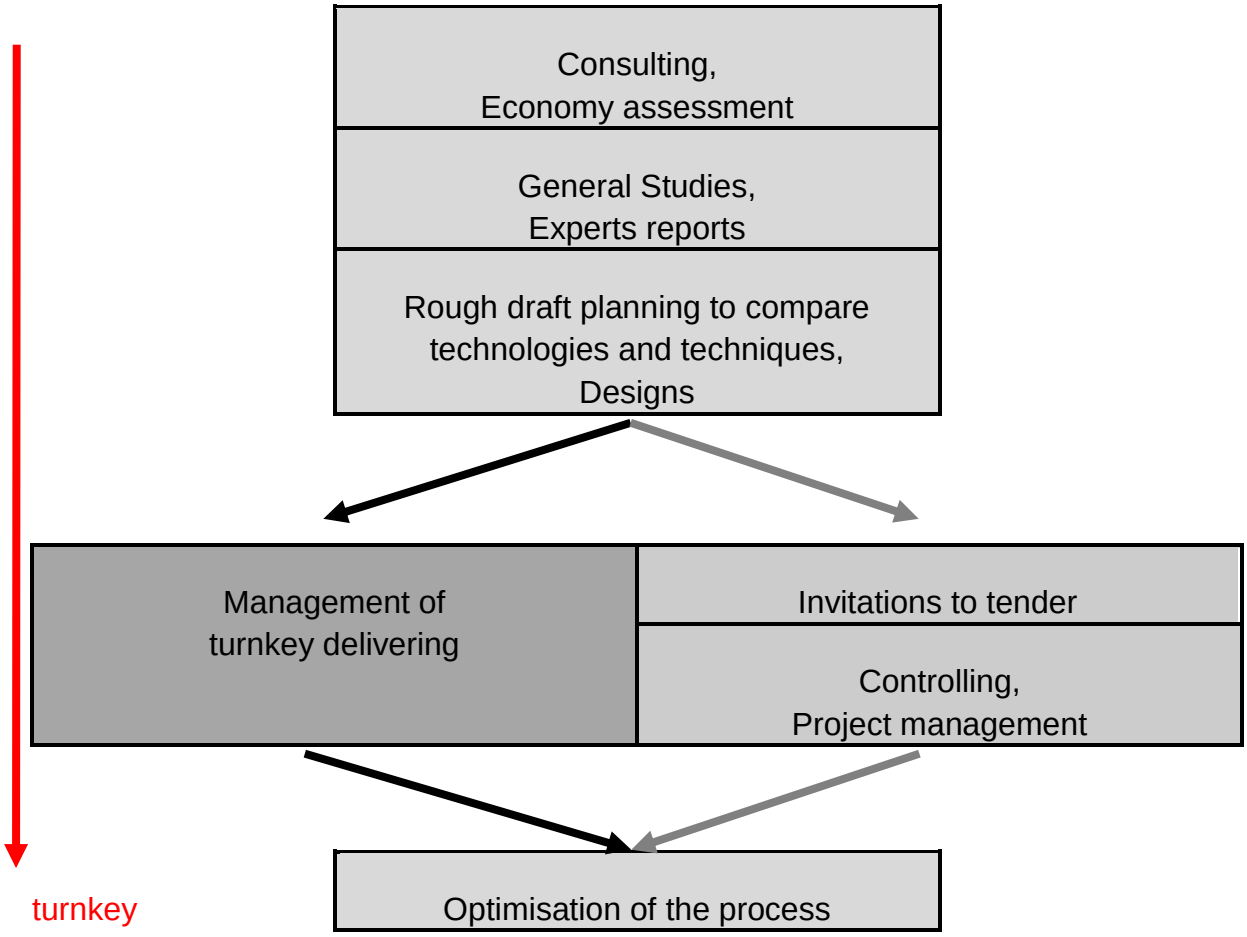

Table 1: Scope of service of "PACIFIC Environmental Technology"

2 Planning and Conception of Water Treatment Plants – explained using Drinking Water Treatment as an Example

2.1 Which Reasons occur to demand of an consultant

Various factors influence the quality of drinking water and the efficiency of water production, pumping, treatment and feeding into the mains water supply, as well as its transport to the consumer. These factors can be divided up into three categories.

Category A Ageing

Category B Changes to the original dimensioning.
If a water treatment plant is in operation, but its capacity is not sufficient, a decision has to be taken as to whether to expand it or build a new one.

Category C More detailed knowledge, modern technology

If there are problems with quality, the consistency of the water is compared to legal standards, laws and known values from the past, whereby a distinction has to be made concerning the source of the water

Ground Water		Surface Waters				
from loose rocks	from solid rocks	bank filtered	river water	lake water	brackish water	seawater

Table 2: Classification of Untreated Water according to Source

2.2 Studies, Consultancy, Expert Assessment

Irrespective of the cause of the water treatment problems, the water treatment plant should be subjected without fail to a full analysis /1/. During such an analysis certain aspects are usually brought to light which had previously gone unnoticed, but which have to be taken into consideration during modification work. If "PACIFIC Environmental Technology" perform the fundamental investigations, a multidisciplinary assessment is the result. Both Procedural, electrical and building technology aspects are analysed, as shown in illustration 1. The competence of a consultant is essentially based on the experience and specialisation of its employees. This multidiscipline mode of working makes it possible to take advantage of synergistic effects for the parallel solution of complex problems.

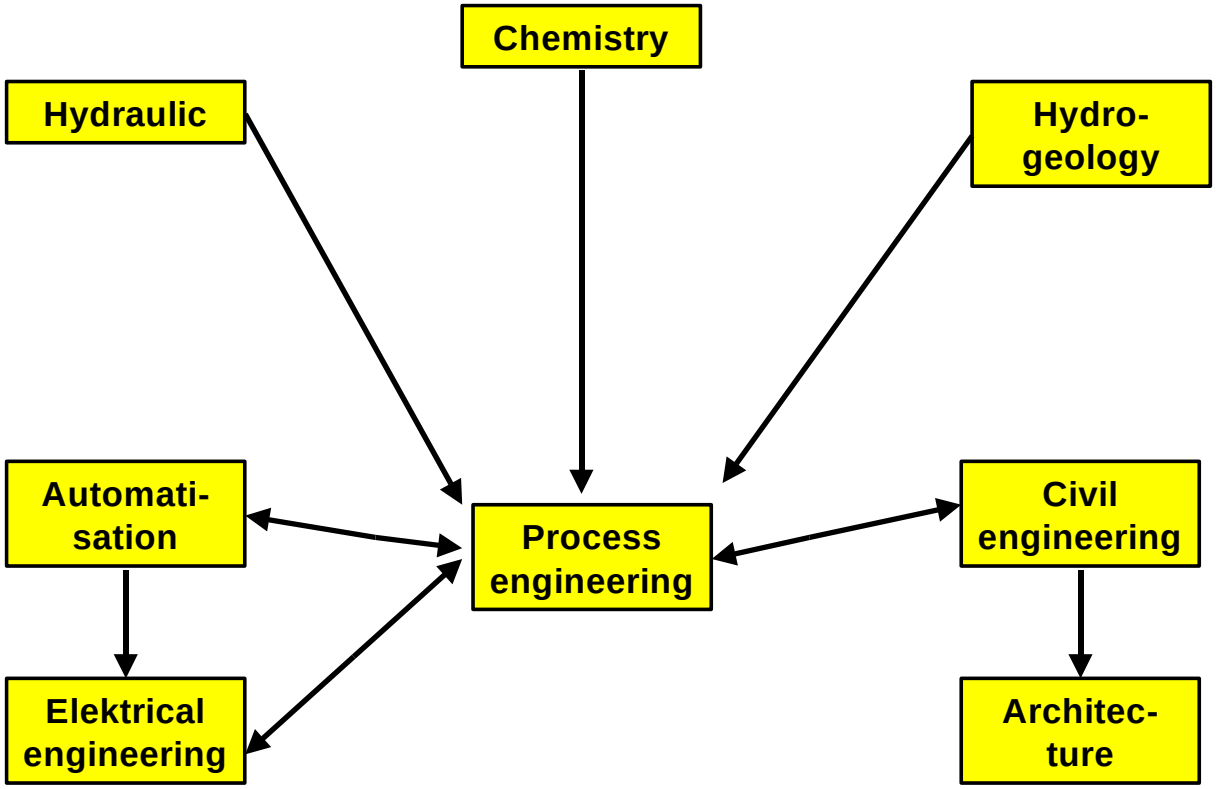

Illustration 1: Integral Planning

The centrepiece of analysis of the problem is complete theoretical reconstruction of the existing treatment steps, beginning with the constitution of the untreated water. As many untreated water analyses as possible showing development over many years should be used. In this way it is possible to obtain an idea of the trends involved.

After calculations of the mixed raw water streams, an evaluation of the chemical, biological and physical properties of the raw water has to be carried out. Then follows the examination of the existing water treatment plant in terms of its plausibility and functionality. Therefor the properties of the water also after each treatment step have to be compared with legal regulations relating to drinking water quality. In a similar manner, the relevant standards have to be taken into account.

The structural material of the treatment plant and the water production plant represents an important criterion for further considerations on redevelopment and strengthening.

2.3 Drawing up Concepts

At the start of this phase of processing, the necessity for changes to be made to the water treatment plant becomes apparent in most cases. This does not apply to projects which are based on financial motives.

The drawing up of a concept is particularly significant in cases of redevelopment and expansion work, where the creativity and skills of the planner play a large role. It is important to incorporate the existing materials as effectively as possible in the planning.

Meticulous preliminary analyses are a decisive factor in the overall success of any measures taken. It is well known that both the determination of the fundamental elements and the concept are dominating factors in the taking of decisions relating to cost-conscious building (see illustration 2). Through careful analysis and a well thought out concept it is possible for the intelligent planner to find the optimum plant and to limit the investment costs significantly by the avoidance of mistakes. This way of working allows an assessment of the quality of the firm of consulting engineers to be made.

This phase of processing is the "Know How" phase.

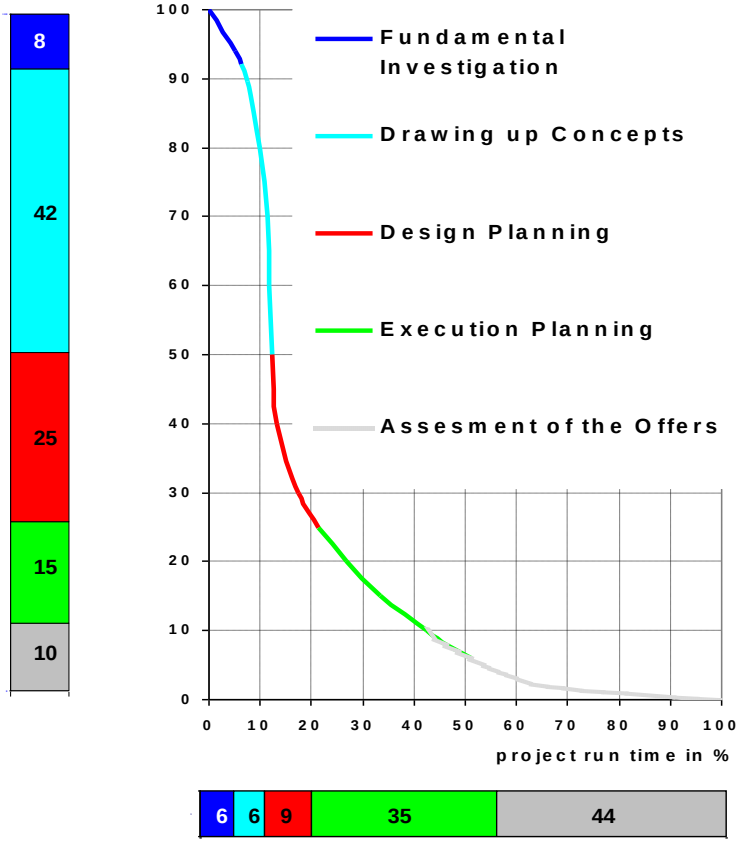

Illustration 2: Cost Influence in Relation to the Project Phases

Procedure for the Drafting of Concepts

When concepts are drawn up, the following tasks are involved:

1. Drawing up of a forecast of requirements
2. The assessment of previous characteristic supply values in order to determine the peak factors for the maximum daily consumption during the year. This is the basis for determining the dimensions of the water treatment processes.
3. The elaboration of all disruptive parameters from chemical water analyses, whereby an analysis alone is not sufficiently meaningful. Knowledge of the source of the water and potential for influencing its properties need to be considered.

4. The dependence of the individual treatment processes on chemical borderline conditions such as the pH value and the oxidation potential is ascertained, and a defined order built up (see **illustration 3)**. Here it is possible that one stage of the process may integrate several steps.

5. For the listing of the process chains involved in water treatment with several disruptive parameters, expert knowledge and experience of all relevant technologies and techniques are required.
   All technically meaningful concepts should be elucidated!
   Only a knowledge of all possible techniques and technologies guarantees that the best possible plant will be found (see illustrations 4 and 5).
   The specialists of "Pacific Environmental Technology" seek the optimal solution to each problem. In many cases their own developments and inventions are produced.

6. Hydraulic borderline conditions of the selected technologies are used as a basis for determining the structural requirements of the technology.

7. Each variation that is drawn up has to be optimised within the arrangement of the individual equipment used in the process.

8. Each variation is equipped with the necessary electrical technology. For the electrotechnical concept, the electrical consumer units determined by the process technology, together with the energy requirement and the synchrony, are important, as low-voltage, medium-voltage and also transformer plant have to be adapted to them. The requirements placed on the level of automation result from the process technology, but are also based on the operator's wishes.

9. Each variation lays down a space requirement for buildings which is dependent on the technology and the layout used.

10. It is possible to estimate the costs of investments from process technology, electrotechnology and components.

11. Calculation of the capital earnings and annuities from the current monetary conditions. In spite of the low level of accuracy, this calculation -- combined with the operating cost estimate -- mostly forms the basis for the decision.

12. The drawing up of the concept also includes planning of the pathways for pipe installations based on design drawings.

annoying parameter		treated with pH	CO_2	O_2	Technology Principle	effect on pH	CO_2	O_2	product
H_2S	Schwefelwasserstoff	+	-	+	physical, Gas exchange				SO_4
CH_4	Methan	+	-	+	physical, Gas exchange				CO_2
Fe++	Iron			+	biological, mechanical	-	+	-	$Fe(OH)_3$
Fe++	Iron	+	-	+	chemical, mechanical	-	+	-	$Fe(OH)_3$
DOC	Dissolved Organic Carbon				Sweep Coagulation	-	+		
NH_4	Ammonia	+	-	+	biological	-	+	- -	NO_2
NO_2	Nitrit	+	-	+	biological	-	+	- -	NO_3
$Ca(HCO_3)_2$	Hardness	+ $Ca(OH)_2$			chemical	+	-		$CaCO_3$
$Ca(HCO_3)_2$	Hardness	+ NaOH			chemical	+	-		$CaCO_3$, $NaHCO_3$
Mn+	Manganese	+	-	+	biological, mechanical	-	+	-	MnO_2
Mn+	Manganese	+	-	+	chemical, mechanical	-	+	-	MnO_2
DOC	Dissolved Organic Carbon				Sweep Coagulation	-	+		
Ca++, NO_3-, SO_4--, (Cl-)	**Hardness, Sulfat, Nitrat**				Ion exchange, Reverse Osmosis	- -	+ + +		
	Bacteria				**Ultra- and Microfiltration Disinfection, Ozon, UV**				**AOX, Bromat**
	Parasites				**Ultra- and Microfiltration**				
	Virus				**Ultra- and Microfiltration Disinfection, Ozon, UV**				**AOX, Bromat**
org. + anorg. Substances					**Ozon, Adsorption**				**AOX**

Illustration 3: The Order of Processes in Water Treatment

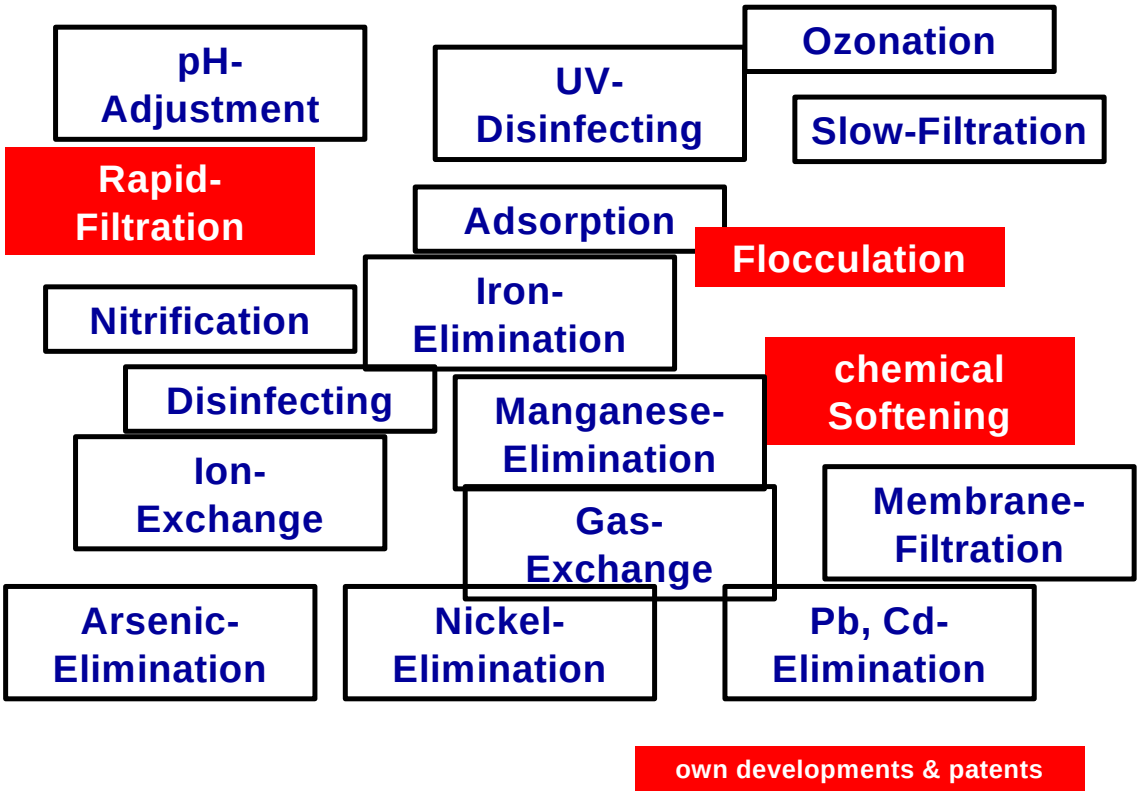

Illustration 4: Various Process Technologies for Water Treatment

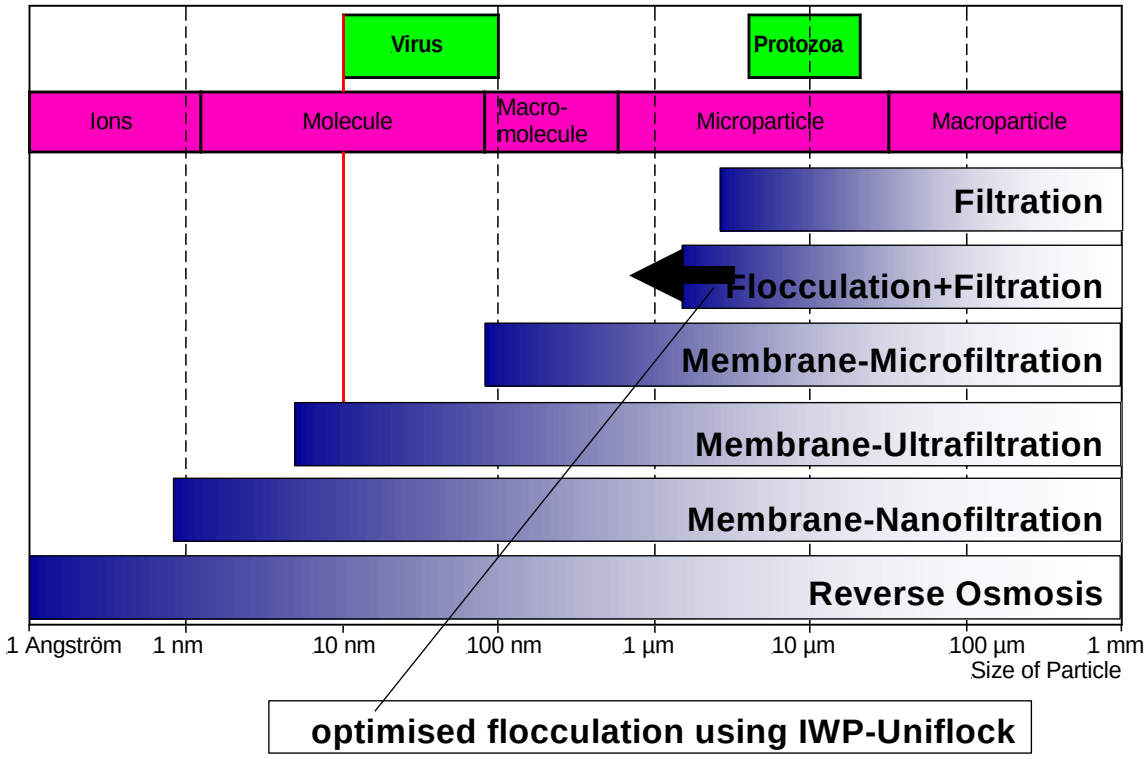

Illustration 5: Suitability of the Processes for the Retention of Particles

2.4 An Example of the Selection of Suitable Process Technologies and Techniques within the Framework of the Conception.

The Problem:

- Untreated water has to be turned into drinking water. This stems from a small storage reservoir. The amount of water flowing into the reservoir can increase rapidly during heavy rainfall. This results in high levels of turbidity.
- Pathogens have accumulated on the substances causing the turbidity.
- The water contains iron and manganese.
- The water is very soft, i.e. it has a low Ca and Mg concentration.
- The water contains excess carbon dioxide.
- From time to time the water contains increased concentrations of DOC (Dissolved Organic Carbon), and is therefore discoloured.

Possible Process Combinations:

process	rapid filtration	flocculation and filtration	optimized flocculation and filtration **IWP-Uniflock**	Ultra-Membran-filtration
elimination of particles	insufficient	sufficient	sufficient... excellent	excellent
reduction of DOC	insufficient	excellent	excellent	insufficient
elimination of iron	excellent	excellent	excellent	sufficient
elimination of manganese	excellent	excellent	excellent	sufficient
costs	low	medium	medium	high
problems	low effectiveness	difficult control		DOC→ Fouling

Table 3: Possible Process Combination for Particle Removal

The lack of space did not allow for slow Filtration.

Decision:

Installation of optimised Flocculation Filtration with Flocculation device "IWP-Uniflock" developed and patented by the firm of consulting engineers (see illustration 6).

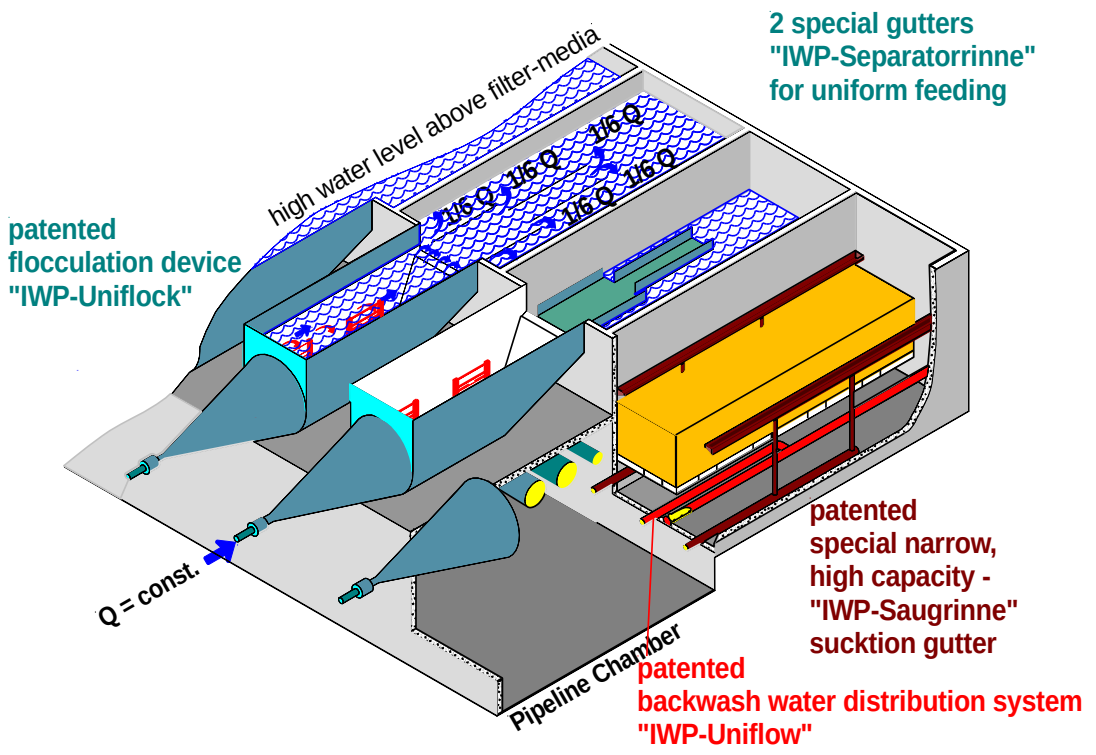

Illustration 6: Fundamental Diagram of the Flocculation Plant "IWP-Uniflock"

Operating Results:

The plant has been in running-in and optimisation operation since July 2001. The expectations prior to operation of the new type of flocculation plant are being more than met. The flow within the plant is very good and uniform. Energy input can be finely adjusted automatically. The amount of flocculant fed into the plant is regulated by the fully automatic control system.

Although no flocculant auxiliaries are used to produce macroflakes, filter resistance is the only limiting criterion for a filter run. The filtrate turbidity remains constant during a filter run, at an extremely low level of approx. **0.01 FNU** (see illustration 7). Such a filter run is able to produce more than 8000 m³ of drinking water. The removal of dissolved organic substances (measured by the Spectral Adsorption Coefficient SAC 254) is **92 - 94%**!

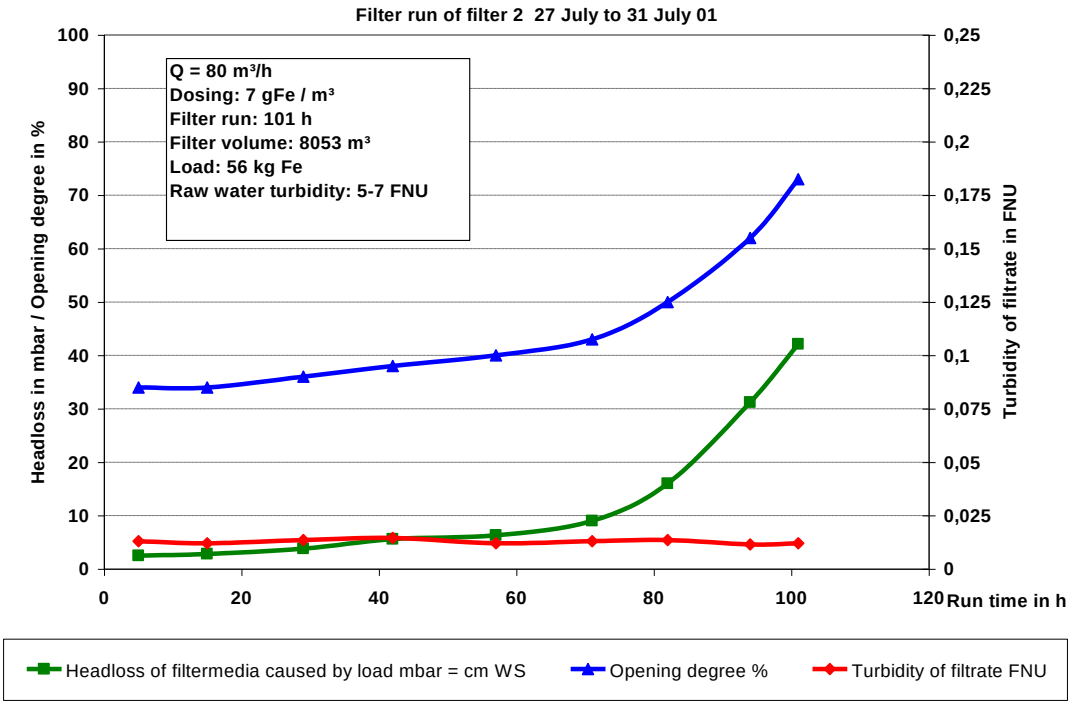

Illustration 7: Filter Discharge Turbidity and Filter Resistance of a Filter Run behind the novel Flocculation Plant 'IWP-Uniflock'

2.5 Design Planning

Design planning is performed on the basis of the concept, and therefore only contains one process variant.

During this phase the dimensions of machines, pipelines, fittings, etc., are worked out in detail. The peak factor for the maximum water consumption per hour (on the date of maximum consumption) during the year has to be determined. This determines the performance of the pure water pumping station. The water treatment plant can be designed for average water consumption per hour if a storage vessel is available.

In particular, the hydraulic calculation of the overall system and the resulting optimisations of the pipe diameters, shaped parts and fittings have a large effect on the overall planning and functionality.

This covers a large area of the innovative work. Illustration 8 shows (by using a cross section of a recently built Water Treatment Plant) the result of an intensive optimisation of the technique localisation inside of the facility.

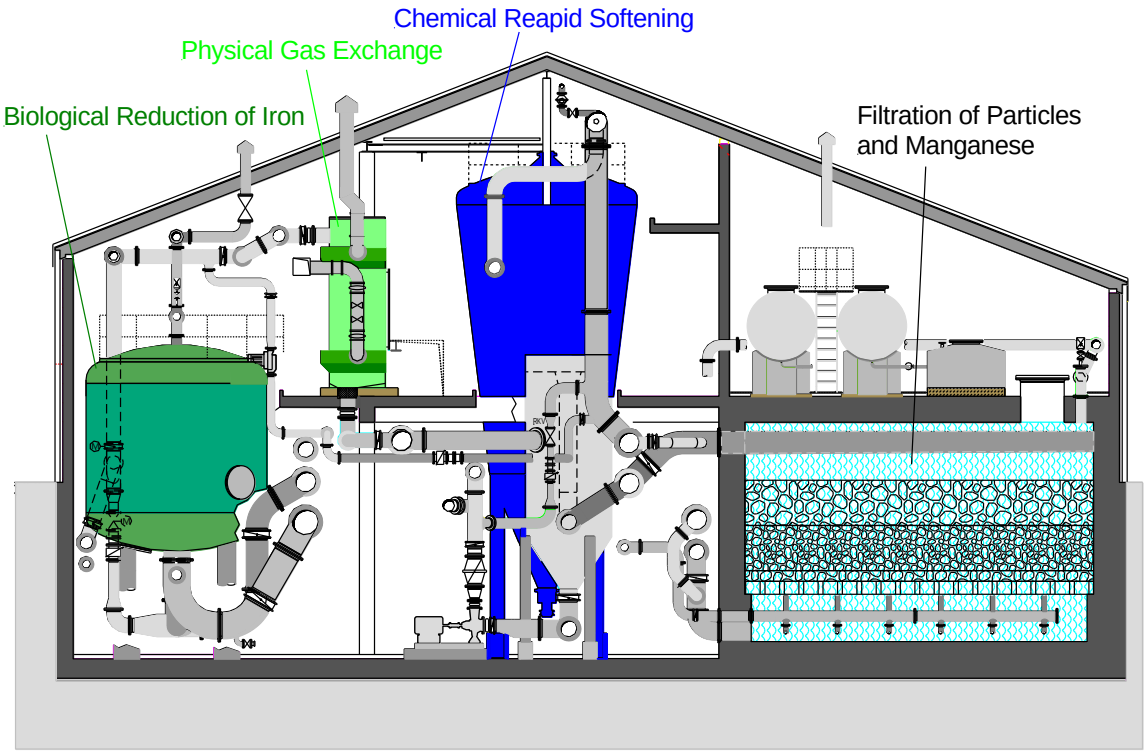

Illustration 8: Cross Section of a WTP with Biological Iron-Elimination, Physical Gas-Exchange, Chemical Rapid-Softening and Particle- and Manganese Filtration

Besides the main objective of converting untreated water to drinking water, design planning also determines peripheral fields and auxiliary techniques. These include:

1. the desired level of automation of the overall plant,
2. the storage of backwash water,
3. sludge liquor treatment,
4. sludge disposal and
5. clear water drainage or re-use

Moreover, the location of future plants is to be selected.

During design planning, a rough depiction of the pipe installation replaces that of pipeline pathways contained in the concept. Moreover, the list of specifications is drawn up. Elaboration of the list of specifications allows a calculation of the costs involved. By the use of current market prices in the detailed specification lists (the experts at "PACIFIC Environmental Technology" make use of prices submitted on a continuous basis for a high number of current projects) it is possible to achieve a high degree of accuracy.

2.6 Execution Planning

The essential aspect of this project phase is completion of the planning documents in accordance with the results of the design planning. This includes the incorporation of all dimensions and supplements as required by the offer to tender. Slot and breakthrough plans are drawn up. Installation of the process technology and the electrical equipment is now depicted and planned in detail. This makes it possible to draw up lists of fittings and measurement equipment. These are included in turn in the plant and function description -- an important basis for the work of the electrical firm involved.

The plant and function description produced by the planner represents a specification sheet showing all control and regulation processes. This is a process description forming the basis for the operation of the future plant, and has to be used by the electrical company for elaboration of a list of requirement specifications. This reflects the functional description with exact programme routines. This, too, is a focal aspect of the work of the planning engineer, who has to examine this list of requirement specifications to ensure it is correct and complete.

Functional descriptions as a form of the invitation to tender are based on the plant and function descriptions, and represent an opportunity to create competition in the submission of a tender.

2.7 Preparation and Involvement in the Awarding of the Contract

In the case of limited invitations to tender, the customer and consultants determine the group of potential tenderers.

In many cases of large-scale building projects, process technological and electrotechnical equipment, lots are drawn up which, owing to the complexity and specialist knowledge required, call for a limited invitation to tender. On the other hand, the finishing work is often the subject of a general invitation to tender in order that specialist firms located in the vicinity have a chance to participate. The lowest bidder is awarded the contract if it is evident that he is able to meet the technical requirements contained in the order.

2.8 Assessment of the Offers

Here the consultant can provide the following services:

- Assessment of adherence to the legal form, i.e. the required guarantees, demands and signatures.

- Assessment of the completeness of all requested work and services.
- All modified and supplementary offers that have been submitted have to be assessed from a technical and financial aspect.
- A recommendation that the work be commissioned is submitted to the customer.

2.9 Property Monitoring

The companies performing the work draw up detailed plans according to which the components are procured /2/. A check of these drawings and documents by the consultant and planner has to prevent mistakes occurring at an early a stage as possible.

Building supervision tasks are divided up into top supervisory tasks and building monitoring. The former include the giving of instructions and checking the overall project. They serve the purpose of realising the planning instructions both in terms of the function and the quality of the materials used. Many problems which the firms encounter as a result of mistakes (insufficient time, insufficient funds, incompetence) may quickly lead to disputes or reductions in functionality of the water treatment plant.

2.10 Running-in Operation, Process Optimisation

After a new water treatment plant has been created, all aggregates, pumps, control systems and regulators are put into operation. It is then usually found that many of the desired functions do not work in a satisfactory manner. Moreover, control circuits have to be adjusted, rotating speeds, flow rates, positions, etc. set and thoroughly tested. Here, too, "PACIFIC Environmental Technology" specialists provide expert help.

2.11 Guiding Principles for the Consultant and Planner

The engineering office

... provides expertise! - a mentally creative product

... organises a competition with respect to an invitation to tender!

... provides global, integral planning!

Literature

		page
/1/	Oesterle, E. und Koenigsdorff, R.: The interfaces are still not available. From liner to integral planning and building. Deutsches IngenieurBlatt, Vogel Baumedien GmbH, Berlin, S. 14, 6/2000.	5
/2/	Jung, C.: Outsourcing von Aufgaben des Projektmanagements. Wasserwirtschaft Zeitschrift für Wasser und Umwelt, Franckh-Kosmos Verlags-GmbH & Co., Stuttgart, S. 272, 6/2000.	16

Illustrations