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Identification of unusual high loads and infiltration water to the Waste Water Treatment Plant Lassee (Lower Austria)

Master Thesis to get the academic Double Degree

Master of Natural Resource Management and Ecological Engineering

Diplomingenieur

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Zusammenfassung

Die Kläranlage der Gemeinde Lassee in Niederösterreich hatte bereits über Jahre das Problem zu hoher Zulaufmengen und Frachtraten im Vergleich zu den Design Kriterien (3.700 EWG). Auffällig hohe Zulaufmengen hielten zum Teil über mehrere Wochen und Monate an und CSB-Frachten entsprechend Einwohnergleichwerten von über 6.000 EWG waren keine Seltenheit, mit Spitzenfrachten von über 13.000 EWG. Ziel dieser Arbeit war es, den oder die Gründe für diese hohen Werte zu finden. Speziell sollte geklärt werden, welchen Ursprungs die erhöhten Frachten sind und ob sie speziellen Wochentagen zugeordnet werden können. Die Methoden zur Klärung dieser Fragen waren die genaue Untersuchung der Kläranlagenprotokolle (Monatsberichte) von Januar 2004 bis April 2007, sowie eigene Messungen, Probenahmen und Laboranalysen des Abwassers, das die Pumpwerke (PW) durchfließt, zwecks lokaler Abgrenzung des/der problematischen Gebiete. Des weiteren wurden 14-tägige Zulaufproben der KA untersucht, um einen Wochengang zu ermitteln. Dafür wurden die Einwohnerzahlen und Betriebe in Lassee, sowie der nördlich liegenden Gemeinde Schönfeld, durch eine neue, genaue Zählung den acht PW zugeordnet. Diese Arbeit erforderte die Durchsicht der Indirekteinleiter gemäß der Indirekteinleiter-Verordnung (in Lassee) und möglicher anderer (industrieller) Einleiter gemäß dem WRG (in der BH Gänserndorf).

Die Zulaufwerte der Monatsberichte wurden sehr detailliert mit hydrographischen Daten verglichen, insbesondere mit den verzeichneten Regenereignissen (Meßstation Lassee), mit der Schneeschmelze und dem Grundwasserspiegel in der benachbarten Grundwasser-Meßstation ca. 2 km westlich von der KA. Unplausible Daten in den Monatsberichten konnten durch einen Vergleich mit den Stromrechnungen für die Ablaufpumpen ausgesondert werden. Zur besseren Bestimmung der weiteren Ursachen für den hohen Zulauf wurde der Regen aus der Datenmenge mit Hilfe der Methode des „Gleitenden Minimums“ eliminiert. Die Frachten der Monatsberichte wurden hinsichtlich der Übereinstimmung mit den Einwohnergleichwerten (PE) der Gemeinde verglichen. Die PE Werte zwischen den Frachten und dem Zulauf, sowie der Frachten untereinander wurden verglichen, insbesondere der organischen mit den anorganischen Frachten des Ammoniums und des Phosphors. Die Verhältnisse der Frachten untereinander sollten Aufschluß darüber geben, ob es sich eher um häusliches Abwasser oder um industrielles Abwasser handelt. Um eine realistische Umrechnung der Konzentrationen von mg/l in PE zu gewährleisten, sowie von P zu PO4-P und N zu NH4-N, wurde zu eigenen Laboranalysen auch Literatur hinzugezogen, die sich mit den Konzentrationen und Verhältnissen der ankommenden Frachten in vergleichbaren Kläranlagen befasst hat.

Die Messungen, Probenahmen und Laboranalysen wurden zwischen Mai und Juli 2007 durchgeführt. Die Durchflussmessungen der PW basierten auf Zählerablesungen der zugehörigen Pumpen. Die Umrechnung in Q(m^3/d) erfolgte durch Vergleichsmessungen mit einem Drucksensor, der die Wasserstandsänderungen in den jeweiligen PW registrierte. In Situ wurde des Weiteren die Leitfähigkeit und der pH gemessen. Die gemessenen Leitfähigkeiten wurden mit den theoretisch ermittelten Werten des Salzgehalts in menschlichen Ausscheidungen verglichen. Außer in den PW wurden die Leitfähigkeiten auch in einigen Brunnen Lassee´s gemessen. Die Proben wurden auf typische häusliche Abwasserparameter NH4-N, TKN, PH4-P, PO4-P, BOD5, COD, TOC, absetzbare und gelöste Stoffe, hin untersucht, des weiteren auf NO3-N, NO2-N, sowie auf die Summe der Kohlenwasserstoffe und die Schwermetalle Cr, Cd, Zn, Pb, Cu and Ni. Die Laboranalysen wurden an der Universität für Bodenkultur (BOKU) im Department für „Wasser, Atmosphere und Umwelt“ durchgeführt. Die Konzentrationen in mg/l konnten mit Hilfe der Durchflußmessungen in den PW in PE umgerechnet werden. Dies ermöglichte die Identifizierung des PW, in dem die Frachten im Vergleich mit den angeschlossenen PE zu hoch waren.

Die Ergebnisse zeigten, dass der periodisch anhaltende hohe Zulauf zur Kläranlage hauptsächlich durch Grundwassereintritt erklärt werden kann, ursächlich durch undichte Abwasserkanäle und zusätzlich durch eine Grundwassersanierung im Zentrum Lassee`s, wo seit 1993 eine Bepumpung von mindestens ~300m³/d stattfand. Dieses Grundwasser sollte an und für sich in den Regenwasserkanal abgepumpt werden, kam aber offensichtlich ins Abwassersystem, was durch Messungen in den Pumpstationen nachgewiesen werden konnte.

Der Grundwasserstand in Lassee kann so hoch sein, dass es in manchen Jahren nötig war, das Grundwasser in den Regenkanal abzupumpen, um Überschwemmungen zu verhindern. In der Untersuchung für die Jahre 2004 bis 2007 ergab der Vergleich zwischen dem Maximum des Grundwasserstands und dem Zulauf, dass alle Kanalstränge, die unterhalb 143m.ü.A liegen, von Grundwassereintritt betroffen sein konnten. Spitzenwerte im Zulauf von über 2.100m³/d konnten Regenereignissen zugeordnet werden. Neben dem Renovierungsbedarf des Kanalsystems deutet dies auch auf falsche Verbindungen zwischen dem Regen- und Abwasserkanalsystem hin.

Die höchsten Frachtraten wurden in der Pumpstation gefunden, an die die lokale Industrie angeschlossen ist. Die unterschiedliche Zusammensetzung des Abwassers in der Pumpstation schließt einen rein häuslichen Ursprung aus und zeigt, dass die Ursache für die Verschmutzung zum größten Teil in industriellen und so nicht genehmigten Einleitungen liegt. Hierbei entsprechen einer sehr variablen Zusammensetzung insbesondere die Abwässer, die durch das Ausleeren von Tankwagen und Speichern in die Pumpstation gelangen könnten. Gemäß den Monatsprotokollen der KA können außerdem ungewöhnlich hohe organische Frachten ungewöhnlich hohen Phosphorwerten zugeordnet werden. Zusammen mit dem zum Teil sehr niedrigen gemessenen pH Werten könnte dies ebenfalls auf die Abwässer der Gemüsefabrik hindeuten.

Abstract

The Waste Water Treatment Plant (WWTP) of Lassee had since several years the problem of too high inflow and loading rates compared to its design criteria (3700 PE). The remarkable exceedances of the inflow were lasting in some extent over periods of several weeks and COD loads equivalent to more than 5000 PE were not unusual, in some cases even reaching more than 13000PE. The goal of this work was to find the reasons for this high loads and infiltration water to the WWTP Lassee. The composition of the high loads as well as the allocation to special week days should be investigated to find the origin of the pollution. The methods to answer these questions were the thorough investigation of the WWTP monthly reports from January 2004 to April 2007 as well as own measurements, sampling and laboratory analysis of the waste water flowing through the pump stations in Lassee to locate the problematic area/s. Further 14d samples of the WWTP inflow were analyzed. A basic measure was to count and allocate new the inhabitants and locate industries in Lassee and Schönfeld north of Lassee, connected to the WWTP as well. To do this it was necessary to identify all possible indirect dischargers (IE) according to the permissions of the water law (WRG).

The inflow data of monthly reports were compared with hydrographical data, especially with the recorded rain events (in Lassee), with the snow melt and with the ground water table in the neighboring GW-measuring station ~2km west of the WWTP. After comparison with electricity bills of the outflow pumps not plausible data of the IDM monitoring were not considered any more. To identify better the reasons for the high inflow the "Moving Minimum Approach" was a good tool to eliminate the volume caused by rain. The loads recorded in the monthly reports were compared with each other and with the inflow in terms of personal equivalents (PE). Especially a comparison between the organic and inorganic loads as well as between ammonia and phosphorus could give a clue to domestic or industrial origin of pollution. To verify the conversion of concentrations (mg/l) to loads (PE) or (kg/d), as well as from P to PO4-P and N to NH4-N, besides own laboratory investigations literature data were used, in which the authors have investigated the loads and volumes of similar WWTP.

The own measurements, sampling and laboratory analysis were done between May and July 2007. The pump volume measurements of the pump stations are based on meter readings. The transfer to Q(m^3/d) was possible in comparison with a pressure gauge, installed in the pump stations, measuring the changes in pressure head. Further electrical conductivity (eC) and pH was measured online in the pump stations and in some wells. Recorded eC was compared then with the theoretical amount of salts excreted by the body. The samples taken of pump station waste water were analysed on the typical domestic waste water parameter NH4-N, TKN, NH4-N, PO4-P, BOD5, COD, TOC, settleable and suspended solids, as well as on NO3-N, NO2-N, the sum of hydrocarbons and the heavy metals Cr, Cd, Zn, Pb, Cu and Ni at the laboratory of the BOKU, Department for "Water, Atmosphere and Environment". The concentrations (mg/l) could be transferred to loads (PE) with the pumped volume estimations in the single pump stations (PW). This allowed the identification of the PW in which the loads were to high compared with the connected PE.

The high inflow volumes to the WWTP could be explained mainly by ground water infiltration. Two different types of infiltration could be distinguished: once through ruptured pipes and once by groundwater pumping due to a GW-remediation in the centre of Lassee, where since 1993 a volume of at least ~300m^3/d was pumped. The groundwater level in Lassee can be as high, that it was pumped in some years to the channel system to avoid inundations. The comparison between the inflow, the sewer elevations and the groundwater level resulted in the fact, that all sewer lying below 143m.ü.A could have been infiltrated in the years 2004 to 2007. Inflow peaks up to 2100m^3/d could be attributed to rain fall indicating wrong connections with rain channels and further more the need of sewer refurbishments.

The highest loading rates were found in that pump station where the local industry is connected to. The composition of the waste water pointed to other than domestic origin indicating that parts of the pollution are caused by industrial discharge. Unusual high organic loads according to the monthly reports corresponds with an unusual low NH4-N/PO4-P ratio <3. Together with sometimes high acidity this could fit with cannery waste water. Emptying of tanks from any kind of industrial polluter transported to and stored in Lassee could be the reason for the different composition of pollutants as well.

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1. Introduction

Infiltration water is commonly a very widespread problem of WWTPs with separated sewer system. It has most often its origin in damages of the often old sewer systems and wrong junctions of rain water channels or drainage systems. While advanced guidelines values for the emission of WWTP and out of it to the receiving water led to an improvement of the existing WWTPs and to the construction of new ones there were no additional environmental constraints for the improvement of the sewer systems. Monitoring of the sewers is only recommended to be undertaken every 5-10 years with inspection cameras. In rural communities this recommendation is seldom followed. In consequence the waste water and its pollutants are percolating into the groundwater. Other way round groundwater and rainwater running to the WWTP can cause serious problems in the treatment process.

Conventional waste water treatment plants like the one in Lassee have generally a high susceptibility of failures because of their technical equipment. Hydraulical overloading from rain or groundwater which infiltrates through moribund sewer systems or wrong connections aggravates the problem, because neither the plant nor its control instruments were designed for too high amounts, especially if overloading occurs over longer time scales. Conventional WWTPs need a lot of maintenance to make sure, that they work properly, but often specially in small communities this job is neglected.

In the biological treatment stage a high influx leads to an activated sludge discharge to the receiver and with that to a reduction of the involved microorganism in the biological treatment process. The “ecosystem” WWTP is disturbed and it takes a while to “rebuild” it. In this phase nitrification, denitrification and carbon degradation does not work properly because of the missing bacteria. Anyway, the emission concentrations to the receiver will still be in accordance with the legal decision due to the additional “pure” water amount of the precipitation or groundwater. But the intern sludge production will be disturbed.

In the design process of a WWTP infiltration water commonly is already considered with a factor of 25% to 100%. These factors consider also particularly the surface infiltration through drain covers.

Sometimes infiltration water cannot only be traced back to the “natural” reasons precipitation, snow melt and groundwater. Illegal dumps of polluted matter, of waste water with unknown composition are an even more serious problem and can damage the aquatic environment and the treatment system. The microorganism involved in the biological treatment stage, especially the nitrificants are very sensitive to pH and temperature. Not only illegal dumps can cause damages. If pretreatment facilities of small industries are not working properly and controls of it are missing or neglected, pollutants can easily enter the sewer system.

However, overall control is of course difficult. Waste water emission laws exist, but how they are followed is dependent on the responsible awareness of regional authorities and of the power of the municipality.

2. Goal

Since several years the municipality of Lassee has over longer periods unusual high inflow and loading rates to its Waste Water Treatment Plant (WWTP) compared to the design criteria of 3.700 PE. To find out the reasons the municipality where asking the University of Natural Resources and Applied Life Sciences (BOKU), Department for Water, Atmosphere and Environment, Institute of Sanitary Engineering and Water Pollution Control. This master thesis was initialized in April 2007.

To solve the problems a first step should be the analysis of the internal and external water quality data since January 2004. The investigation should continue with own investigations from April 2007 to the end of June 2007 and laboratory analysis of the sampled waste water.

The specific questions were as follows:

- Which part of the waste water is caused by infiltration water, either rain- or/and groundwater?
- Can local parts of the sewer network be identified for infiltration?
- What other reasons for infiltration exist in Lassee?
- Where are potential indirect dischargers located and who could cause higher inflows and loads?
- Can a correlation between the outliers of organic/nutrient loads and certain week days be identified?
- What is the correlation between the inflow and these parameters?
- What additionally laboratory parameters can be used to help to identify emissions of specific dischargers? (Additional to the chemical parameters normally used for domestic waste water control)

An important step in finding reasons for the high inflow was to compare the inflow data with rain and groundwater data, as well as occasionally to the snow melt and relate it to early spring time.

To evaluate the inflow and loads quantitative and locally the eight pumping stations (PW) had to be related to the accurate number of connected PE. That should help to localize the problematic areas. Potentially dischargers not listed by now should be identified.

A literature research for a comparison of consumption and discharge of the municipality people with other studies should further identify the domestic part of the waste water.

A further idea for isolating the domestic part of the waste water (to find out quantity and quality of infiltrated water) was to calculate the salt release of the inhabitants and set it in comparison to the salt content of the waste water.

A literature research for an indicator analysis should be done to find substances exclusively discharged by humans, which could help to identify actual illegal discharges in terms of industrial or domestic origin. In this caffeine and carbamacepine were considered.

To check possible dischargers the water right status and environmental legislation of the local industries should be actualized. An accurate knowledge of the flow system in the sewers, the dimensions of pumping stations and the depth of the sewers to compare it with groundwater had to be found out.

The break down of the computer system in April 07 suggests that the IDM flow meter could have been defect before as well. A comparison of Q with the electricity bills of the WWTP pumps should bring further conclusions.

The flows through the single pump stations (PW) should be detected over a 2 week period to ensure a correlation of pumping stations to the adjacent PE.

Further on the inflow of the WWTP sampling should be carried out over two weeks and analyzed in terms of nutrients and organic loads in the BOKU laboratory. Four PW should be analyzed to evaluate the household shares connected to these pump stations. Additionally some of these samples should be analyzed thoroughly on all nitrogen and phosphorus components as well as for heavy metals and hydrocarbons. All together 32 pumping station samples and 14 inflow samples were analyzed.

In parallel measurements of the online parameters electrical conductivity [mS/cm] (eC) and T [°C] in the particular pumping stations were done to co mpare them with the domestic salinity. Also pH was measured.

3. Theoretical background

3.1 Types and amounts of waste water

A general distinction of waste water is defined as follows (ATV-DVWK Klärwärter Taschenbuch, 2004):

- Domestic: waste water of private households, of municipal buildings like cleaning and canteens, of small business of similar kind as well as car washing and tourist features

- Municipal: waste water defined as every waste water channelled through the municipal sewer system

- Infiltration: water as an unwanted part of municipal waste water (mostly rain or groundwater)

- Industrial: waste water for cooling or production used water discharged either directly to a receiver (after own sewerage and treatment) or indirect discharge (discharge into the municipal sewerage) and then to a receiver. Receivers are rivers or the ocean.

In a sewer system these types of water flow either together in a combined system, where rain water and waste water are piped both to the WWTP or a separated system where the sewers for the rain water are build separately. Separated systems are preferable because precipitation water is only a hydraulic loading for the WWTP which has not to be cleaned. Anyway rain water cannot be avoided in the waste water sewerage due to e.g. necessary openings for oxygen in the manhole tops. Additionally precipitation water can infiltrate over wrong connections of the sewers and through cracks in the sewer.

Domestic waste water and rain water differs in its composition. While domestic waste water due to human activities contains mostly organic substances (from faeces and dishes, with pathogen bacteria) and to a lower part inorganic substances like salts, rain water is dominated by inorganic stuff with a higher amount of minerals and metals caused by runoffs from roofs and streets. Also rain water is more acidic in our times. Waste water also contains of course minerals and salts already covered by the used drinking water.

For the waste water treatment and the design of a WWTP the knowledge about the load and its composition and the distinction between suspended and dissolved, organic and inorganic substances, biologically degradable or not degradable, settleable and floating material is essential.

3.1.1 Suspended and dissolved solids

Treatment processes differ in their effectiveness to remove either dissolved or suspended pollutants. Solids passing a filter of a certain size are called dissolved (DS), the one held back, suspended solids (SS). To distinguish between each filter have a pore size as definition of 0.45µm in most countries. The total amount of solids is TS = SS + DS (C = X + S). C, X and S are common abbreviations in the following sense:

- C = Concentration of matter (mg/l)
- X = Suspended part of the matter (mg/l)
- S = Dissolved part of the matter (mg/l)

The differences between the TS before and after 2 hours settlement in the waste water are the settleable solids. Phosphorus, nitrogen and organic matter are oxygen depleting and have to be removed from water. Further P and N as fertilizers are causing eutrophication (Henze et al., 1996).

Some value: *In domestic waste water are around 1260 mg/l pollutants, approximately the half of it is dissolved and of the remaining 600mg/l SS approx. 400 mg/l are settleable. (Henze et al., 1996)*

3.1.2 Organic matter and its analysis

Because a measurement of each individual organic substance would be impossible an assessment is made over the oxygen demand during metabolism processes either by microorganisms (Biological Oxygen Demand BOD) or chemically (Chemical Oxygen Demand COD). Another assessment can be done by the analysis of the produced amount of CO_2 which is called TOC analysis. In average the composition of the organic matter is like $C_{18}H_{19}O_9N_1$. If organic matter is oxidized in water, CO_2 is released. Organic nitrogen is transformed into ammonium. There are more than 10 different methods to measure the organic matter by oxygen demand. In practice for treatment plants the 5-day BOD method is used. BOD5 measures the oxygen demand of microorganism for oxidation of carbon. The idea is that in the time of 5 days the major part of biodegradable organic matter will be oxidized. The consumed amount (g O_2/m^3) is measured and by the knowledge of the volume of polluted water the BOD in mg/l is calculated. The temperature for this process is standardized at 20℃. To avoid nitrification (and with it oxygen depletion) an inhibitor is added to the waste water sample. Fig. 3-1 shows the principles how the BOD is analyzed.

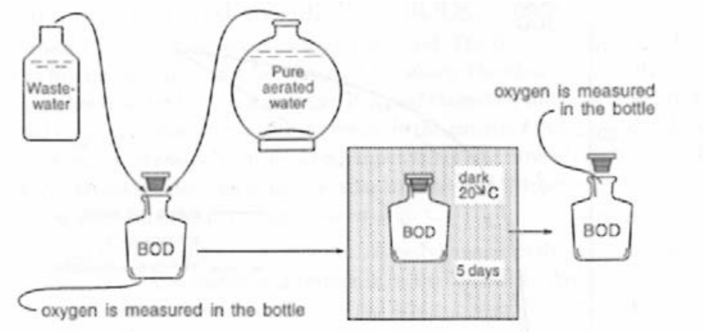

Fig. 3-1: Principles of BOD5-analysis [Henze et al., 1996]

In domestic waste water the COD lays typically twice above the BOD value. The COD test uses potassium dichromate for the oxidation process. It covers all different organic material including dissolved, suspended and easily biodegradable and biological inert material. The COD value is including the BOD. The COD analysis has the advantage to be carried out relatively fast but involves toxic chemicals. In the laboratory of treatment plants the analysis can be easily done with a "Lange-Photometer" like it is also used in the WWTP Lassee which is based on principles of photometry. Due to electrochemical reactions by light as the energy source concentrations can be made visible either in brightness or colour and determined by a defined colour range. A few ml of sample after proper mixing are filled in a cuvette together with the reactants.

The last method which shall be named to determine organic matter is the TOC value (Total organic carbon). The principle of analysis here is oxidation of organic matter to CO_2 through incineration. The production of CO_2 indicates the amount of carbon atoms in the sample (Henze et al., 1996).

Some values of discharge: *The design value for one inhabitant is measured in personal equivalent (PE). For the production of organic matter in terms of BOD_5 it is 60 g/PE*d and COD is 120 g/PE*d. 1 PE are e.g. as well washings of 1-5 kg or spilling of ½ l Milk or the production of 2 kg vegetable cans. Assuming a water waste of 300l/d (America) to 150 l/d (common european value) and person, municipal raw water has a concentration of 200-400mg/l BOD_5 (Henze et al., 1996).*

3.1.3 Nitrogen

In raw waste water nitrogen can be found as organic nitrogen and in urine or in beginning decomposition processes as inorganic ammonia. Ammonium is the biggest part of total nitrogen. Similar to organic matter nitrogen is divided into different fractions:

$$C_{TN} = S_{NOX} + S_{NH4-N} + S_{I,N} + X_{S,N} + X_{I,N}$$

where C_{TN} is total nitrogen (N_{ges})

S_{NOX} is nitrite and nitrate (NO_2-N, NO_3-N)

S_{NH4-N} is ammonia and ammonium (NH_4-N)

$S_{I,N}$ is dissolved inert organic nitrogen

$X_{S,N}$ is suspended easily degradable organic nitrogen

$X_{I,N}$ is suspended inert organic nitrogen

The organic parts of N in COD are differing. According to Henze et al. (1996) it is typically 0.12 – 0.24 * COD. The concentration of not biodegradable dissolved nitrogen $S_{I,N}$, also adsorbed by suspended solids, still remaining in the effluent may vary between 1 – 4 g N/m³ in municipal waste water. NH_4-N is with NH_3-N in equilibrium, it is an acid–base pair. Concentrations of NH_3 over 0.2mg/l in water are very toxic for fish.

To determine nitrogen in the influent and effluent of the waste water in small treatment plants usually only S_{NH4-N} and NO3-N is measured by photometrical methods. The nitrate amount in domestic waste water is approx. zero which means oxidation of ammonium by nitrification in the sewer system can be neglected. So C_{TN} can be approached with the formulas for the influent and the effluent (C_{COD}: Concentration COD)

$$C_{TN,\ inflow} = S_{NH4\text{-}N} + S_{I,N} + X_{S,N} + X_{I,N} = S_{NH4\text{-}N,\ inflow} + 0{,}04 \times CCOD\text{, in}$$

$$C_{TN,\ outflow} = S_{NH4\text{-}N} + S_{NOX} + S_{I,N} = S_{NH4\text{-}N,\ outflow} + S_{NOX,\ outflow} + 0{,}05 \times C_{COD,\ outflow}$$

The nitrogen difference in out- and inflow is bound in the settleable sludge.

Because of the instability of nitrite and its easily oxidation to nitrate by microorganism in the nitrification process, NO_3-N can be set as S_{NOX} and is together with NH_4-N representing $C_{TN,\ outflow}$. In the biological treatment stage of the WWTP the biological processes nitrification and denitrification are used, in which NH4-N is metabolized by microorganism under oxygen consumption to NO3-N (O_2 is added to the tanks) and under anoxic conditions NO3-N is reduced to gaseous N_2 (nitrogen cycle). Nitrification needs four times more oxygen as carbon oxidation. Also the organic part of nitrogen is transformed to ammonium in the aerobic stage. During nitrification the buffer capacity of water can be disturbed because this biochemical process is producing acid. That might inhibit the microbiological activity.

Another often used value for N-determination in domestic water is the Kjeldahl nitrogen TKN. The TKN is organic N plus NH4-N, but not the oxidized forms:

$$C_{TkN} = S_{NH4\text{-}N} + S_{I,N} + X_{S,N} + X_{I,N}$$

***Some values**: The design value in Austria for total nitrogen C_{TN} is 11g/PE*d (TKN). Approx. 2/3 of the influent nitrogen is in inorganic form NH4-N (Henze et al., 1996). Assuming a water waste of 300 to 150 l/d and person municipal raw water has an amount of 37 to 74 mg/l TKN.*

3.1.4 Phosphorus

The last very important nutrient which enters the waste water through faeces is phosphorus. As mentioned before it causes eutrophication, because phosphorus is a key element in forming biological structures and in this a strong fertilizer, especially in its inorganic form PO4-P. If it enters water at first algae will profit from it. The algae growth causes oxygen depletion. Phosphorus in detergents was a big problem in the 1970th, 1980th. Fortunately the emissions had to be reduced due to environmental laws. But there are still remaining concentrations in domestic used detergents and other cleaning agents. Industrial use can cause still very high concentrations.

Phosphorus is divided into the fractions:

$$C_{TP} = S_{PO4\text{-}P} + S_{p\text{-}P} + S_{org.P} + X_{org.P}$$

In the treatment plant the dissolved inorganic orthophosphate $S_{PO4\text{-}P}$ is measured (photometrical). C_{TP} can be assessed with a factor 1.3 of $S_{PO4\text{-}P.}$ ($S_{p\text{-}P}$ is dissolved inorganic polyphosphate and the rest org. P). In the WWTP phosphorus in its components is either dissolved or will be bound in biomass. Without an anaerobic stage in the WWTP treatment process the accumulation of P in biomass and with this the settlement as sludge is often not sufficient. Then P is usually precipitated chemically with iron (Henze et al., 1996).

***Some values**: The design value in Austria for total phosphorus C_{TP} is 1.8 g/PE*d. Assuming a water waste of 300 to 150 l/d and person municipal raw water has an amount of 6 - 12 mg/l*

3.2 Legislation in Austria for Municipal Waste Water Emissions

Emission Guidelines

In essence the emission regulations for waste water in Austria are related in the Water Act (Wasserrechtsgesetz WRG) from 1959. Due to the Waste Water Treatment Regulations of Austria the plants are divided into four classes depending on PE.

The definition is as follows (BGBl. Nr. 210/1996):

Size I	50 – 500 PE
Size II	500 – 5000 PE
Size III	5000 – 50000 PE
Size IV	>50000 PE

The minimum purification efficiency required in percent of inflow rates for all WWTP of more than 1000 PE is:

BOD5	> 95 %
COD	> 85 %
TOC	> 85 %

In Tab. 3-1 the guideline values for the effluents of all WWTP according to the waste water emission ordinances for domestic waste water and the permission for the WWTP Lassee, which is from the size of category II are shown.

Tab. 3-1: Emission ordinances for domestic waste water in general and for Lassee (self monitoring) (BGBl. Nr. 210/1996 STO067 Verordnung 1. AEV*)*

	I	II	III	IV	WWTP Lassee
BOD_5 (mg/l)	25	20	20	15	15
COD (mg/l)	90	75	75	75	75
TOC (mg/l)	30	25	25	25	
NH_4-N (mg/l)	10	5	5	5	3
P ges (mg/l)	-	2	1	1	1,5
N tot %			70% (>12℃)	70% (>12℃)	

Tab. 3-2: Minimum complexity and frequency of measurements, readings, investigations and interpretations for biological treatment plant in the frame of self-monitoring (BGBl. Nr. 210/1996 STO067 Verordnung 1. AEV)

Category II for 500 - 5.000PE			
Load	**Compulsory**	**Load/concentration**	**Compulsory**
Inflow (m³/d)	c	BOD_5-Inflow (mg/l)	m
Outflow (m³/d)	c	BOD_5-Inflow biology (mg/l)	w
Qmax (m³/h)	d	BOD_5-Inflow Load (kg/d)	m
Qmin	d	BOD_5-Outflow (mg/l)	m
T (℃)	w	Efficiency (%)	m
pH Inflow	2w	COD-Inflow (mg/l)	2m
pH Outflow	2w	COD-Inflow Load (kg/d)	2m
NH_4-N Inflow (mg/l)	2w	COD-Outflow (mg/l)	2m
NH_4-N Outflow (mg/l)	2w	Efficiency (%)	m
NO3-N-N Outflow (mg/l)	2w	Visibility Secondary Clarifier (cm)	d
Ges.-P Inflow Load (kg/d)	m	Settleable Solids (ml/l)	2w

c = continuously, d = daily, w = weekly, m= monthly

The WWTP Lassee is one of 642 municipal prosecuted WWTP over 2000 PE in Austria. In the following I will concentrate on regulations for WWTP of this type II.

An important issue of the regulations is the monitoring and investigation if the limit values are met. Here the Austrian law says that there shall be self-monitoring in periods as shown in Tab. 3-2. Additionally there shall be a monitoring for the same parameters by independent consultants once a year. This monitoring also contains a pollution control of the receiving water like in the case of the WWTP Lassee the small river Rußbach. Allowance for emission depends on the size of the receiver. The receivers are in most cases rivers and the emission of waste water is underlying the environmental legislation for emission to surface water.

The deadlines for the compulsory adoption of the actual valid Austrian emission values for WWTPs were:

- 1.1.2005 for PE 2000 to 15000
- 1.1.2007 for PE < 2000

If the permitted values are exceeded the water surveillance authority can order a short-term remediation (Ludwig, H., 1995).

Indirect Dischargers

Specific waste water emission ordinances (WRG-Nov. BGBl. I Nr. 74/1997) are laying down restrictions for waste water emission to the recipients/sewer lines from i.e. food production trade and industry, infrastructure, solid waste, livestock breeding, etc. One superior emission ordinance (General restriction of waste water emissions to the recipients/sewer lines) regulates the principle emission standards for a wide range of water pollution parameters (~40).

It also lists about seventy specific ordinances for different waste water sectors, which contain emission limits and a lot of specific internal measures for each waste water type (Haberl, 2006). In special cases a waste water treatment has to be realized in a „front–of-pipe“ way. Heavily polluted water has to be cleaned up to a certain amount before it can be channelled to the sewer system.

Small businesses and industries, i.e. restaurants, slaughterer and petrol stations, which need and transform water for their production process are mostly subject to the regulations for indirect discharge (IEV; BGBl. II Nr. 222/1998). The IEV is a part of the Water Act (WRG-Nov; BGBl. I Nr. 74/1997) and contains regulations for the emission to the municipal sewer system either if it’s the rain or waste water sewer. The ordinances are valid for each type of water which differs from domestic waste water. Especially if it can be toxic not only for the aquatic life but also for the microorganism of the biological treatment stage, like chemicals changing significant the pH. Nitrification bacteria belong to the most sensitive microorganism in the treatment cycle and are pH sensitive. Threshold values for industrial waste water for pH are 6.5 and 8.5 (9.5) and a temperature of 35°C.

Water right authorities are directly responsible for permission and controls of the discharge. In this case it is the BH Gänserndorf and for indirect discharger (IE) additional in first orders the municipality Lassee. For a wide range of industrial sectors like the chemical or food industry or generally said, always if the waste water exceeds threshold values defined in the IE ordinance, these industrial sectors become subject to the WRG. Exceeding rates in this case means, that the discharged amount of released water or dangerous load shall not exceed 1% of the daily permitted effluent of the WWTP.

The emission threshold values are defined in the IEV 1998 for more than 33 parameters like i.e. heavy metals, hydrocarbons, chloride, halogens and benzene and refer to a WWTP size of 1000 PE. Which chemical parameters in the waste water have to be analyzed depends on the type of business. The monitoring of the threshold values has to be organized and executed (Tab. 3-3), according to the polluter pay principle. The polluter has to report type and amount of waste water to the owner of the WWTP. This owner permits the discharge. Additionally the controls have to be reported at least every two years.

Tab. 3-3: Frequency requirements and type of controlling dependent on the amount of waste water

Q (m^3/d)	Monitoring by external engineers	Self monitoring	Type of Sampling
< 5	1 per 2 years		Grab Sample
5 - 50	1 per 1 years		Qualified Grab Sample
> 50	1 per 2 years	5 per 2 years	According to §4 AAEV BGBl. I Nr. 74/1997

It has to be reported also if an approval according to the WRG 1959 (BGBl. I Nr. 74/1997) would be necessary for the discharge.

The owner of the WWTP has the responsibility for the control of indirect discharges. The owner has the right to control at any time indirect dischargers, also on private premises. The owner has to inform at least once a year the Water Authority of exceeding limits and missing reports (Tab. 3-3) of indirect dischargers. The reports and information about emissions of indirect dischargers have to be send at least every three years to the water boards (since 2001). It is not allowed to infiltrate groundwater!

3.3 Design Loads for a WWTP

Once the inhabitants and water using facilities like trades, industries, restaurants and hotels of a municipality are clear an assessment of the PE is made, wherein every inhabitant P is equal to one PE and industrial or tourist places are assessed in PE by the amount of waste water discharge in 150l/d units. Sometimes also 100l/d or 200l/d is used as a consumption unit for 1 PE. For each PE and day the following loads are dedicated (like already mentioned in chapter 3.1):

Tab. 3-4: Design loads for a WWTP (ATW-DVWK-A 131, 1991)

Inflow (l/PE*d)	150
BOD5 (g/PE*d)	60
COD (g/ PE*d)	120
Nges (g/ PE*d)	11
Pges (g/ PE*d)	1.8

These are the basic values for the calculation of the volumes of the tanks of primary and secondary clarifier depending on the PE. Tank sizes and retention times of activated sludge have to be calculated in a way that the emission ordinances shown in Tab. 3-1 can be fulfilled.

The tank volumes, retention and oxidation times are estimated with these values to optimize settlement, nitrification and denitrification processes and digestion in the sludge tank.

As mentioned before in the design of a WWTP also infiltration water is considered and transformed in PE. For the calculation of the tanks a factor of additional PE between 25% and 100% is advised (ATV-DVWK-A 122, 1991).

3.4 The GW remediation in Lassee

In Lassee a groundwater remediation was initialized in 1993 after the pollution of the soil with chlorinated Hydrocarbons by a laundry on the premise Neustift 1 (mainly tetrachlorethene (PER)). Originally the pumped GW was supposed to be discharged into the rain water system but obviously it was flowing through the sewer (at least until July 2007) (see chapter 3.4).

Tetrachloroethenee (aliphatic chlorinated hydrocarbons) or PER is a chlorinated hydrocarbon like e.g. the former pestizide DDT. In substantial amounts it behaves like dense non aqueous phase liquids, liquids more dense then water (DNAPL). That means it is quite persistent in soil, because it has a limited solution capability. Tetrachloroethene is very volatile. In the presence of air and UV-light it decomposes to form the poisonous gas phosgene. Half–lives in air are in the order of a few days up to a week, in surface water they range between some days to weeks. Chlorinated hydrocarbons can cause hormon disruption to animals and damage to the central nervous system, even in lower doses, in humans also liver- and kidney damages (von der Perk, 2006).

The guideline value according to the “Grundwasserschwellenwert Verordnung” in Austria for PER concentration in groundwater is 0.01 mg/l, in surface water 0.1 mg/l (BGBl. Nr. 502/1991).

The polluted groundwater had more than 3.0 mg/l when starting the remediation. For the groundwater remediation existing wells on neighbor premises e.g. in Neustift 5 and a new drilled one in Neustift 1 were used starting 1993 after another measurement through soil air suction (1991) where big parts could be eliminated. Pumps in different depth should filter now the polluted water through a coal filter and discharge it into the rain water channels. The depression cone of the wells should stop spreading the pollution. In the beginning the pumped amount was over 470m³/d. Now three pumps are still in use: two in the well of Neustift 1 and one in Neustift 5. The treatment with activated carbon was stopped completely between1996 to 2002. The pumping tests of PER concentration shows oscillating values around 0.001 mg/l to 0.1 mg/l since several years. All information about the remediation was published by the remediation company GEOdata (2006).

3.5 Literature research

3.5.1 Literature research for comparison values of load concentrations

Different investigations have been made in the last years to find out, how existing WWTPs constructed in the described way are loaded in reality and how the design values do reflect the actual loads in the inflow of the WWTP. Also investigations in the domestic part of loads (households) have been made. In a project of municipal water management (Lindtner et al., 2002) data of 76 WWTP, size III, were collected and analyzed, supplemented by another study (Lindtner and Zessner, 2003). The study was initialized for hydrological and environmental purposes with the aim of load assessment in case data sets of WWTPs are incomplete. This statistical research considered only plausible data of WWTPs with known inhabitant values. The emphasis was the evaluation of phosphorus and nitrogen loads, only little is said about BOD and COD.

Concerning BOD loads the report says, that a comparison between real PE and designed PE show a great variance. In an investigation of frequency distribution 80% of the ratio PE(real)/PE (designed or admitted) were evaluated to be between 0.4 and 0.9 with an average of 0.64. Concerning inhabitant specific TOC loads 37g TOC/PE*d have been estimated in a number of different investigations (Pöpel, 1996) and (Lindtner et al., 2002). This is valid for 55g BOD5/PE*d, so it nearly meets the design value. Measurement series for the CSB/BSB5 ratio resulted in an average of 0.55. Fig. 3-1 shows the origin of the TOC in domestic waste water.

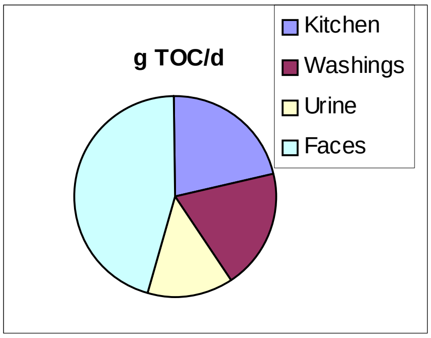

Fig. 3-2: Origin of TOC in domestic waste water [Pöpel, 1996]

Nitrogen loads in waste water are usual designed with values between 11 to 13g /PE*d, wherein only ~1g is not of direct human excretion. Phosphorus in waste water lies between 1.6 and 2.0 g P/PE*d and ~0.3 g is not of human origin (different countries, different values). Concerning the P and N assessment Lindtner and Zessner (2003) refer to an investigation of Andreottola et al. (1994). It shows the distribution of phosphorus and nitrogen in dependency of the ratio of real inhabitants and designed PE (E/EW). The investigation tries to distinguish between the domestic and industrial origin of nitrogen and phosphorus. From the distribution over the E/EW (P/PE) ratio Lindtner and Zessner (2003) estimate an average value here for the domestic part of P- load of 1.5g/P*d and N-load of 8.8g/P*d. The total average load is 11g N/PE*d and 1.6 gP/PE*d. To estimate ammonium from total nitrogen or more often vice versa a factor of 1.7 is normally used like already discussed before. This factor could be confirmed in the Lindtner and Zessner (2003) study in average (NH4-N/Nges = 0.57), wherein 80% of the WWTPs show a ratio distribution between 0.45 and 0.68. For phosphorus an PO4-P/Pges ratio of 0.64 was found in average. No influence of the temperature could be found for the ratio.

In Fig. 3-3 the distribution of N and P is shown. Grey background indicates values, which can be usually expected. Lower dashed line matches loads which can be expected without trade or industrial contribution. Straight line matches the regression. In Fig. 3-4 are growing distances between dispersing data pairs (N, P) indicating deviations of domestic WW ratio of N/P. These deviations could be connected to industrial dischargers. In the x-axis the P/PE ratio is plotted. The grey background shows the expected distribution of P and N.

For the ratio between N and P the studies found out typical values for mainly domestic waste water of N/P = 5.5 to 7.5 with an average of 6.5. If only dissolved P and ammonium measurements are available, values for NH4-N/PO4-P should lay proportionally between 4.9 and 6.7. Lindtner and Zessner (2003) say that outliers have its origin in indirect (industrial) dischargers, so this ratio is a good indicator for indirect dischargers, illegal or not and shall later on be used for comparison. Fig. 3-3 shows the relationships of nitrogen and phosphorus in some of the studied WWTP. Values are taken from Fig. 3-3.

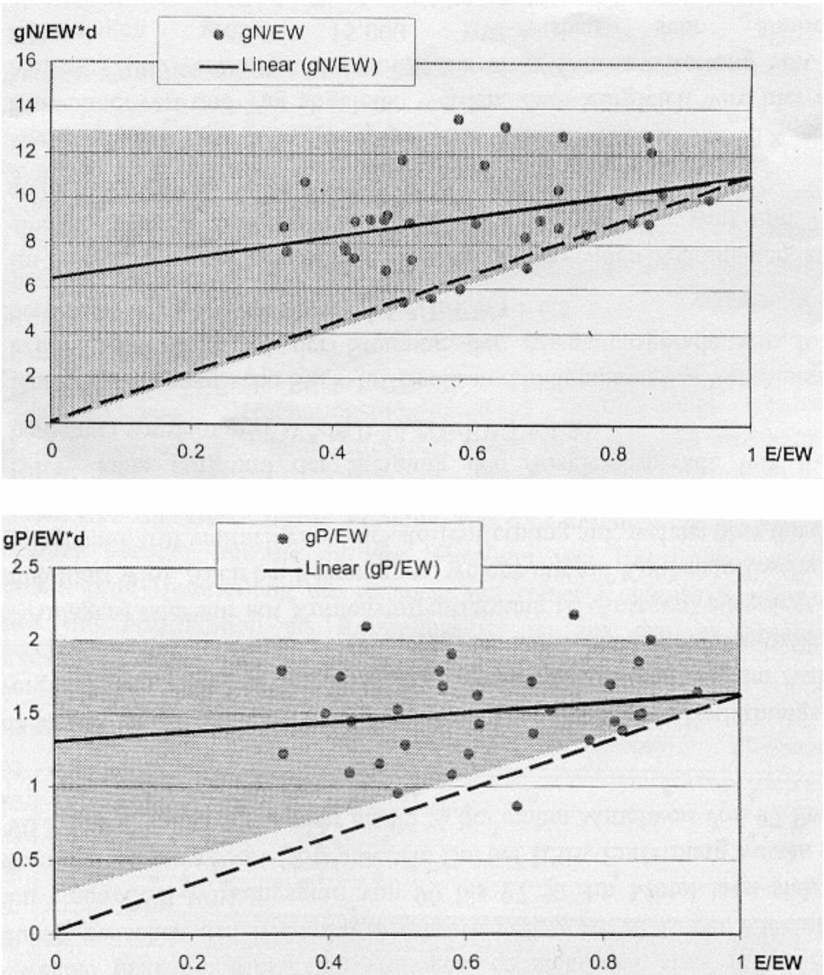

Fig. 3-3: Ntot. and Ptot. loads in relationship between true person inhabitants and PE design values (E/EW) (Lindtner and Zessner, 2003)

Fig. 3-4 shows that an N/P ratio in the inflow of the WWTP smaller than 5.5 can be distributed to the food industry. Here the reason might lay in P as ingredient in food or in detergents.

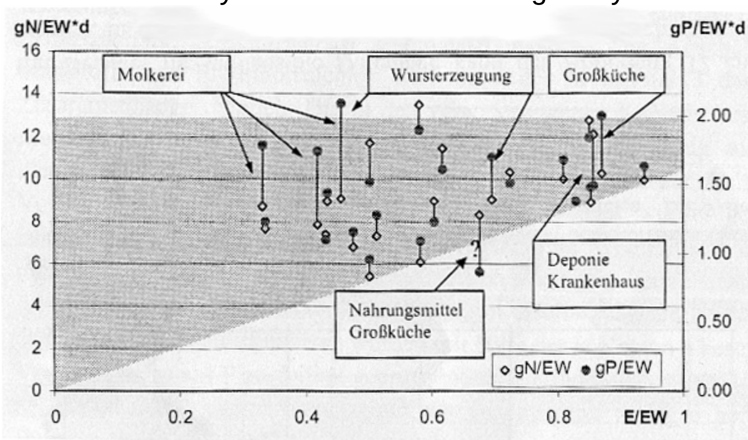

Fig. 3-4: (P,N) data pairs related to P/PE ratio (x-axis); increasing distances between data points N and P of each pair indicate industrial discharge (Lindtner and Zessner, 2003)

The report mentions also bone flour of slaughterer, which has very high phosphorus concentrations. Detergents are also used in a forced way in car washings.

In Tab. 3-5 I summarized the results of the study (Lindtner et al., 2002) showing the comparison between designed and investigated loads like discussed above.

Tab. 3-5: Design loads in comparison to determined loads in investigations of 76 WWTPs (Lindtner and Zessner, 2003)

Values for	Design PE for a WWTP	Investigations of average values (Lindtner et al., 2003) in existing WWTP	Investigation in average inhabitant specific loads in existing WWTP	Investigation in average ratio PE real/ PE design in existing WWTP	Removal efficiency for over 80% of C,N,D-WWTP	Typical ratios between the values
Inflow (l/d)	150					
BOD5 (g/d)	60	55		0,4 - 0,9 (80%); av.=0,64	97%	BOD/COD:
COD (g/d)	120	110			93%	0,5
TOC (g/d)		37				
Nges (g/d)	11	11	8		80%	N/P:
NH4-N (g/d)		6,27	(NH4-N/Nges = 0,57)			5,5 - 7,5
Pges (g/d)	1,8	1,6	1,5		85%	NH4-N/PO4-P:
PO4-P (g/d)	(1,15)	1,024	(PO4-P/Pges = 0,64)			4,9 - 6,7

Another investigation in this topic is the dissertation of Goetz (2007). Among others Goetz evaluates the loads and inflow of 6 small treatment plants (<1000 PE) in Lower Austria. In Tab. 3-6 I took the average of his statistical analysis for all 6 plants and 5 investigation years which includes also rainy days. Goetz used the 85% percentile to make a proposition over the "normal" consumption in domestic waste water. E.g. concerning the inflow to the plants all data showed a consumption which is to 85% smaller than 90l/PE*d. The 6 conventional WWTP were built as single stage aeration systems like the WWTP Lassee. The smallest serves 150 PE, the biggest 900 PE. No remarkable industry exists in these small WWTP. I listed also the absolute Min and Max values of the six plants to compare them with the untypical values and outliers of the WWTP Lassee.

The statistical analysis of Goetz (2007) show lower phosphorus and nitrogen loads than the ones of the investigations shown in Tab. 3-5.

Tab. 3-6: Average loads and inflow are below by 85% of available data, maxima and minima of 6 small WWTPs in Lower Austria, 2000 to 2005 (Goetz, 2007)

	85 % of data	Minimum	Maximum
Inflow (l/PE*d)	< 90	8	526
COD (g/ PE*d)	< 84	7	703
Nges(g/ PE*d)	< 5.97	0.8	40.3
Pges (g/ PE*d)	< 1	0.2	5.4

3.5.2 Literature research for carbamazepine and caffeine as screening parameters

To see if high loads in the WWTP Lassee are of domestic or other origin, parameters which are exclusively discharged by humans should be analyzed. If an average "normal" discharge concentration of this parameter would be known from studies before, one could make conclusions out of the existing concentration in Lassee waste water. Additionally a groundwater analysis of these parameters could detect the infiltration of waste water through cracks in the sewer system. A literature research was made on the parameters caffeine and carbamacepine. In this caffeine turned out to be to varying in its concentration in the waste water. Only a small part of caffeine (around 3%) is leaving the body after consumption. An average estimation with this value is not really possible. One cup of coffee thrown away would remarkable rise the concentration. Carbamazepine seemed to be more successfully, especially in the detection of waste water infiltration to the groundwater. Carbamazepine is a frequently used antieleptic. The active substance is also used as antidepressant and to treat trigeminal neuralgia. The dose of carbamazepine is between 200 and 1.600 mg/d. Approximately 2 – 3% of the active substance leave the body unchanged with the urine and may therefore end up in municipal waste water. Concentrations in waste water are generally 1000 times higher than the limit of quantification of 1ng/l (Fenz et al., 2005). The ATV-DVWK Klärwärter Taschenbuch (2004)" specifies an average measured concentration of carbamazepine in waste water of 912 (ng/l) in the inflow and 960 (ng/l) in the outflow. Why it is higher in the outflow than in the inflow is not explained. Carbamazepine does not undergo any noteworthy degradation, neither in waste water treatment plants nor in the subsoil or bank filtrate and it is not retained by adsorption (Fenz et al., 2005). Its mobility is relatively high in the (un)saturated zone. A reduction in the groundwater occurs mainly due to dilution.

In the next paragraph I refer to the article of Schramm et al. (2007). In this investigation 56 groundwater monitoring stations in Austria were sampled and analysed for carbamazepine and caffeine in order to test whether the active substances are detectable in groundwater and whether they are suitable for use as screening parameters for groundwater contamination from waste water as well for purposes of the EU Framewater Directive (2000/60/EC).

The study gave the result, that carbamazepine and caffeine are not ubiquitous in groundwater. In 29 of the monitoring stations that were investigated carbamazepine was measured in concentrations below the quantification limit. At 18 monitoring stations, carbamazepine concentrations ranging up to 10ng/l were measured, and at 8 monitoring stations concentrations were between 10ng/l and 30ng/l. At one monitoring station concentrations ranging up to 2660ng/l were measured. Overall, caffeine was more often found in concentrations above the quantification and detection limits than carbamazepine. The results of the investigation point to sources of caffeine inputs other than waste water (e.g. compost heaps, agricultural application of the contents of septic tanks). It was noted that the caffeine concentrations at the same measuring sites varied, sometimes considerably, during the sampling quarter (between the quantification limit and 260ng/l)."

Their conclusion was, that carbamazepine seems to be suitable for use as an indicator of groundwater contamination from leakages in municipal sewage networks and infiltration of municipal waste water (after biological as well as mechanical purification). Caffeine was found to be suitable with limitations.

Two groundwater sample in 1l glass bottles were taken in Lassee´ wells but not analysed by now.

4. Material and methods

4.1 Description of the WWTP Lassee

4.1.1 Site Description

Constructed in the year 1998 to 1999 the Waste Water Treatment Plant (WWTP) Lassee is a biological treatment plant category II according to AEV, 1996. It is a single stage conventional aeration system situated in a flat area of high agricultural production in Lower Austria – the

“Marchfeld” and serves the two villages Lassee and Schönfeld 4km north of Lassee. The “Marchfeld” is the most important agricultural area in Austria. It is an almost flat terrain. Schönfeld has an elevation of 156m above sea level and Lassee 149m. To transport the waste water from the furthermost part in Schönfeld and Lassee to the WWTP in the south eight pumping stations are necessary. The WWTP is designed for a maximal discharge of 800m³/day with an underlying Personal Equivalent of 3700PE. The location of Lassee 50 km east of Vienna to the Slovak border is shown in Fig. 4-1.

Fig. 4-1: Location of Lassee

The new WWTP should substitute the two old ones, of which one was situated in Schönfeld and the other one in Lassee. The old plants could not fulfill any more the advanced emission regulations published 1990 in the WRG (Water Act; BGBl. I Nr. 252/1990). An advanced system had to be found. The sewer system is a separation system and in most parts over 20 years old. For the transport of the waste water some new connection between the old sewer systems were built. The receiver of the effluents is the “Rußbach”, a small river 3 km to the south of the WWTP. Besides of a small area no sewer inspection or rehabilitation was done in these years. During a first meeting in the municipality the location of the sewer system and flow direction were drawn into a map.

I transferred the information about the sewer and the locations of the pump stations and the WWTP into a map with “Photoshop” shown in Fig. 4-2. Fig. 7-1 in the Appendix shows a detailed street map of Lassee.

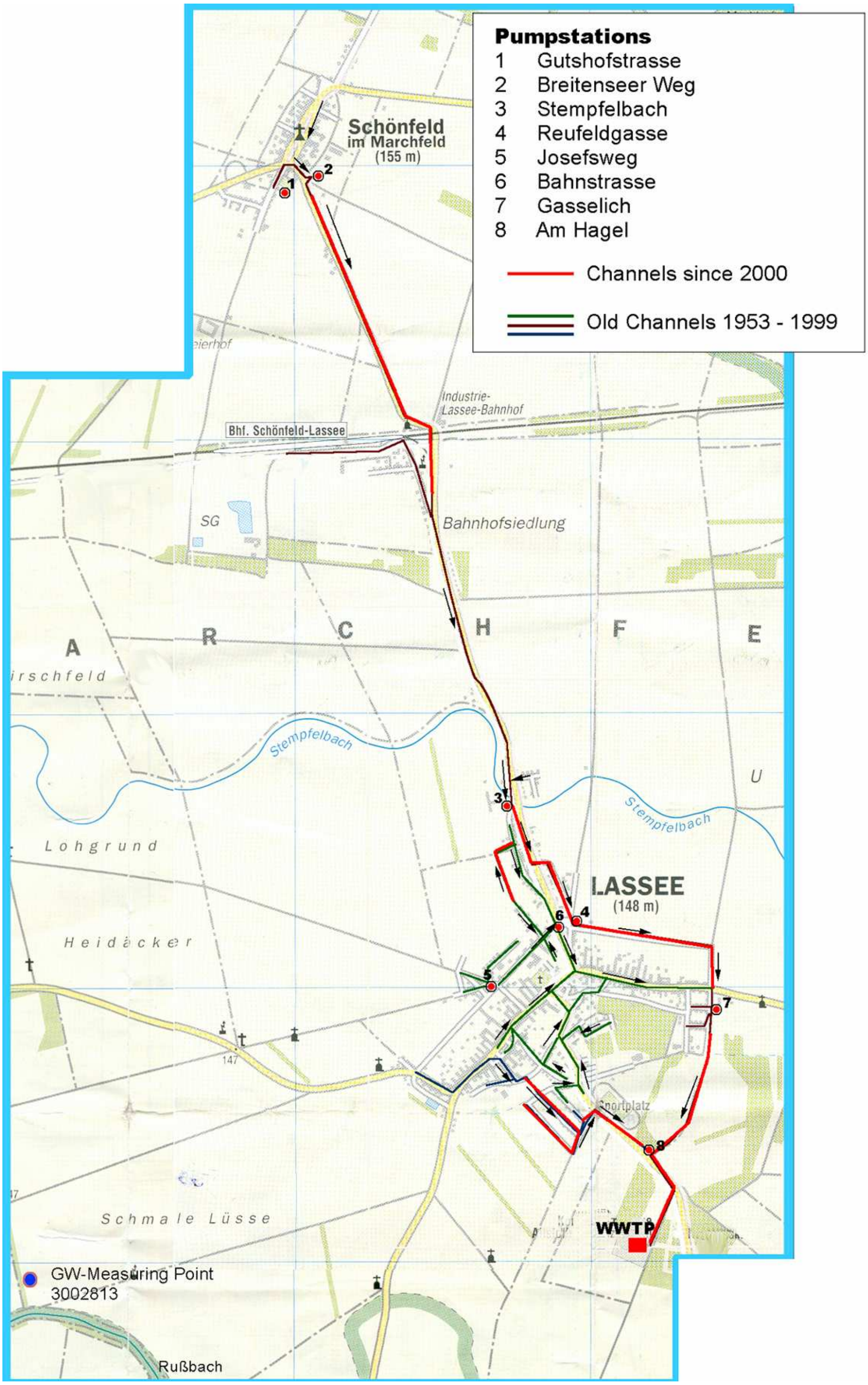

Fig. 4-2: Location of the WWTP, sewers, pumping stations and Groundwater Monitoring Point

4.1.2 Design of the WWTP Lassee

The calculation basis of personal equivalents is shown in Tab. 4-1 like assessed by the engineer office V. Trugina in 1998 and friendly provided for this thesis. The inhabitants were assessed to be 2280, most of them living in single – family homes with gardens. Additional trades, restaurants, one hotel, foreign employees, pupils of schools and Kindergarten were listed. Waste water related trade is one cannery, two car washings and one lorry washing. One new settlement area was included as well. A reserve of 26 % was calculated, a total of 3700 PE and ~800 m³/d was found.

Tab. 4-1: Calculation basis personal equivalents (PE) for the construction of the WWTP Lassee (Ing. V.Trugina, 1998) (translated by myself)

Type	PE	PE / spec.	Capacity	PE 60	spec.	Wastewater		Infiltrationwater		
			%		l/PExd	l/sxPE	h	l/sxPE	l/s	m³/d
Residentials	2280	1,0	100	2.280	200	0,005		0,003	18,24	456,0
Secondary Residentials	188	1,0	100	188	200	0,005		0,003	1,50	37,6
*W.A.Getreidegasse	140	1,0	100	140	200	0,005		0,003	1,12	28,0
Tourist Beds	80	0,5	100	40	100		8		0,28	4,0
Seats in Pubs	-----	-----	-----	-----						
- KG. Lassee	100	0,3	50	15	15		8		0,05	0,2
- KG. Schönfeld	400	0,3	50	60	15		8		0,21	0,9
External Pupils	70	0,3	100	21	65		8		0,16	1,4
External Employees	100	0,4	100	40	75		8		0,26	3,0
W.A. Cannery	250	1,0	100	250	100		10		0,69	25,0
Inc. Reinbold	-----	-----	-----	-----						
- Lorry Washings open air	-----	5,0	100	5			8		0,50	14
- 1 Washing Plant	-----	20,0	100	20			8		1,00	29
Fa. Gasselich	-----	-----	-----	-----						
- 1 Car Wash	-----	20,0	100	20			8		1,00	29
Sludge Dewatering	-----	-----	-----	100						
Commuter	-50	0,3	100	- 15	-60		8		0,10	0,9
Subtotal				**3.164**					**25,1**	**629**
Reserve and Rounding				**536**					**4,3**	**165**
Total				**3.700**					**29,4**	**794**

*W.A.Getreidegasse = **W**ater legalised **A**llocation for the new settlement area Getreidegasse

In the next paragraph I give a short summary of how the WWTP was conceived (Marktgemeinde Lassee – Kläranlage, 1999).

Fig. 4-3 shows a floor plan of the WWTP. The waste water treatment consists of a mechanical pretreatment with 5 mm screens. After passing the screens and the grid chamber (3) the waste water is channelled with simultaneous phosphorus precipitation (with iron) to the 2 aeration tanks with intermittent nitrification and denitrification (12). The 2 tanks have a total volume of 525 m³. They are surrounding the two secondary clarifier (13) each with 5 m in diameter and an average depth of 4.3 m. From here the surplus sludge is either flowing back to the aeration tanks or channelled to the sludge thickener (16) which has a volume of 350m³. The aeration tanks are equipped with fine bubbled depth aerators. The dewatering of the sludge amount is done around 4 times a year with a mobile press. The press water is recycled back to the plant the sludge is given to the compost plant just beside the WWTP. The outflow pumps as well as the inflow pumps have a maximum capacity of 30 l/sec. The treated waste water is channelled through an approx. 2 km long pipe to the receiver “Russbach”. The environmental constraints for emission values of the plant are already shown in Tab. 3-1 and are a bit more restricted like the usual ones for a plant of size II (500 – 5000 PE). The quantity measurements (9) of in- and outflow are done automatic by implemented IDM-meter. The room (7) is the control room. The automatic records on a PC comprise the daily in- and outflow and the amount of the returned activated sludge in m³ as well as the daily pH, T, O2 and electricity consumption. All technical equipment is controlled here on a display. The instantaneous capacity of the pumps is displayed in l/sec as well as pH and T. In room (6) is a small laboratory in which the monitoring of chemical-biologically parameters can be done like prescribed by the water law and already shown in Tab. 3-2. The BOD5 is tested with “Oxi-Top” and PO4-P, NH4-N as well as COD with a “Lange-Photometer”.

Laboratory work was done since the time of construction always by the same man, Mr. Ghysen. All other maintenance work was done by the municipality workers and their head Mr. Christ. The laboratory has all equipment necessary for measurements like e.g. a homogenisator (stirrer). BOD5 is analyzed with “Oxi-Top”, the other parameters with a Lange-Photometer (see chapter 3.1). A probe for measurement of electrical conductivity is not installed.

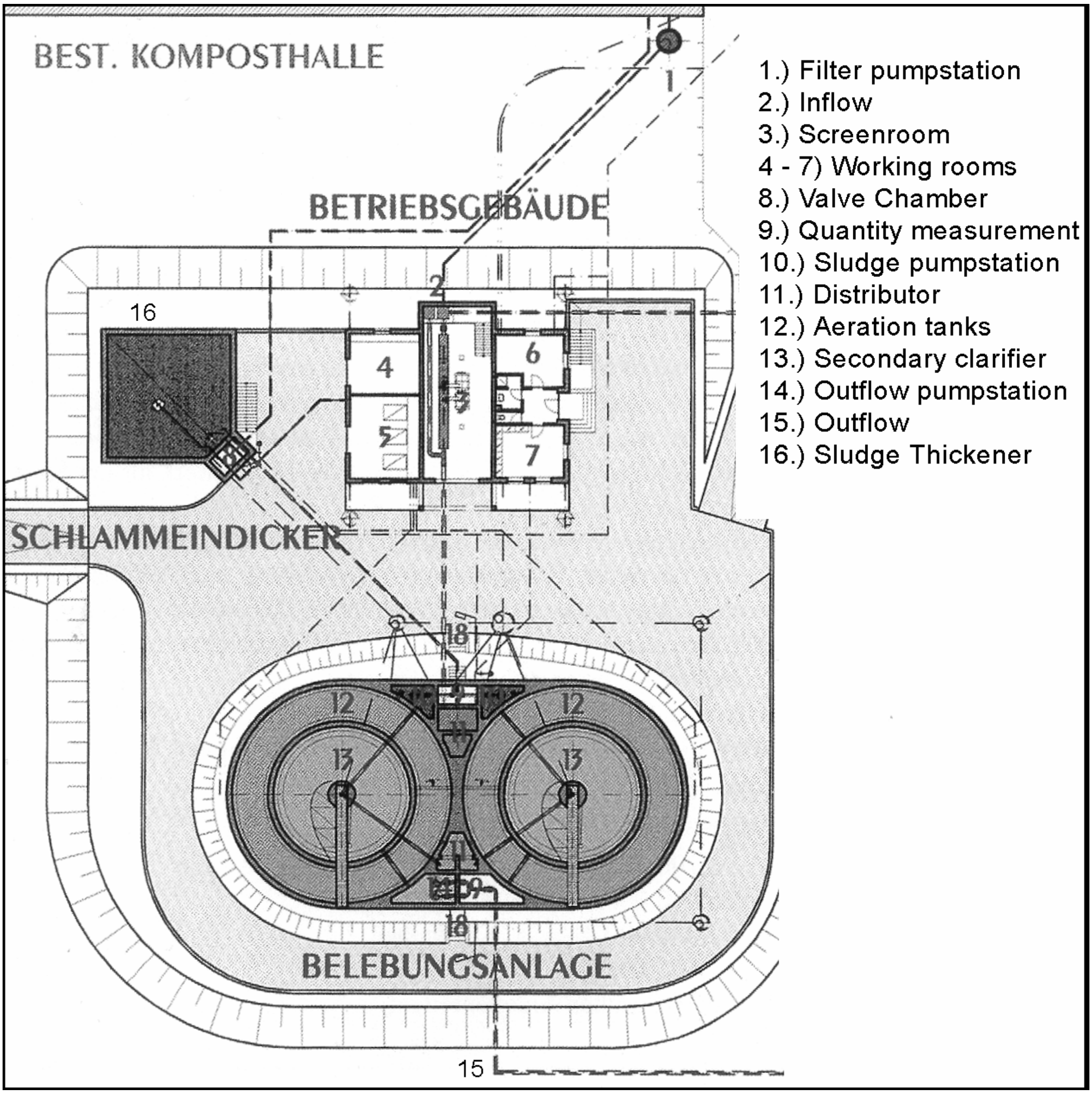

Fig. 4-3: Floor plan of the WWTP Lassee (Marktgemeinde Lassee – Kläranlage, 1999)

4.2 Data acquisition and specification

This chapter shows a brief overview of the acquired data, its specification and its use. The necessary data was acquired from different sources and provided at different times and forms.

For this thesis the following raw data were acquired:

- Digitized monthly reports 01.2004 – 04.2007 and 08.2007 including in- and outflow in Q(m³/d) and BOD5, COD, NH4-N and PO4-P in (mg/l) wherein:

  1. Q measurement was done with an IDM flow meter, gauged on daily measurement at 24:00

  2. Samples to analyze the chemical parameters were taken since 2004 mostly on Sundays at 7:00 after a 24h time proportional sampling

- 3 external quality control reports of the WWTP provided by the company Terrachem (2004, 2005 and 2006)

- For the assessment of precipitation events different sources were available:

  1. of Mr. Blaha, private owner of a rain gauge in the Bahnstrasse for the years 2005 and 2006 which were already digitized into the monthly reports

  2. of the Hydrographic Institute, Lower Austria government: (HD Oesterreich) gauge point HZB 109 694, located at Lassee Hauptplatz (Jan. 2004 to August 2007) and measured by Mr. Weiss on his premise. Daily readings in mm/d at 7:00

- For further assessment of possible infiltration due to the snow melt and groundwater the HD Oesterreich friendly provided the digitized data of:

  1. Daily temperatures T(℃) with readings at 0:00 of Franzensdorf LT108969 (~20km SW of Lassee)

  2. Daily snow heights (cm/d) with readings at 7:00 of Franzensdorf SH108969 as well as snow fall (cm/d)

  3. Groundwater level data (m.ü.A. = meter above Adria (sea or zero)) of measuring stations GS331223Lassee (see Fig. 5-5) and GS319327Schönfeld with frequently readings of 10 to 20 times a month.

- For the assessment of GW remediation:

  1. the company GEO-data friendly provided: pump amounts (l/sec) of three pumps in two remediation wells and GW level in (m.u.GOK = meter below ground level) of those wells from Jan. 2004 to Jan. 2007 measured once a month (bucket test in l/sec)

  2. the BH Gänserndorf as the administrate body was visited and the "intermediate reports 7.10.2005 to 15.1.2007" of GEOdata including data curves of pump amounts, GW levels and PER concentrations (the pollutant) since 1993 (measuring frequency=1/month) and the report from 14.6.1993 were copied including further information like GW flow assessment in Lassee

- For the assessment of consumption of domestic waste water the tab water consumption was analyzed. The data were provided from the company EVN for 2004 - 2006. The unit was m³/month. The calculation of the consumption of Lassee and Schönfeld was originally divided by the EVN in four different areas. For this thesis it was summed up for the whole area together.

- To locate and evaluate the reasons for the high loads the municipality Lassee provided:

  1. the dates of the use of the mobile sludge press

  2. counting of inhabitants according to the pump stations

  3. one permission for the indirect discharger Reinbold in paper form with detailed information about permission for emissions, tanks and pumps from 1995 (permission for 8 years)

  4. list of notified IE; additionally a list of notified water user (according to the WRG) was provided by the BH Gänserndorf

  5. access to the office files in which constructional drawings of the manholes and the sewer system were supposed to be

- To assess the accuracy of the IDM gauge of the WWTP and further the accuracy of meter and restrictions of pump volume assessment in the pump stations (see chapter 5.3: Problems due to WWTP control facilities and pump meter in PW 8) the electricity consumption of the WWTP pumps and Lassee` PW were required. The municipality Lassee provided meter readings in kWh/month of the WWTP outflow pumps and of 5 PW in kWh/year recorded in bills of the electricity company EVN.

Footnote to the precipitation data: A telephone call to Mr. Blaha revealed his gauge is not operating in the winter time, although it was placed under a tree for a while. A telephoncall to Mr. Weiss showed he had a certified gauge, also for the winter, standing on a free place. It is the official measuring gauge for hydrological purposes of the country. So the latter precipitation data of the hydrological institute was used for this investigation.

The data from HD Oesterreich sent for the year 2007 were not yet corrected. The record for August 2007 are raw data.

4.3 Overview of own measurements and analyze accomplishments

To evaluate the waste water flow through each pump station in its amount and load, measurements like listed below were accomplished from May to August 2007.

The PWs itself have only electricity meters, which count the consumed kWh of the pumps. To estimate the pump volume the power (kWh) had to be compared with the recording of a pressure gauge measuring the pressure height (m). The pressure sensor "EASYBUS" was submerged into the manholes over a certain time and its curves show the pump progression. For most of the PW two P-sensor measurements on two different days were made. The pump volume for the rest of all days were then based on these comparison values kWh – m³/h.

To evaluate the waste water flow the following measurements were done:

- A pressure sensor “EASYBUS” was used with 1-2 measurements in phases of 4 – 24 h (depending on pump amount) for each pump station with sampling rates of 0.5 to 1 min.
- 37 days of meter readings [kWh] each morning in the six Lassee PW, on 21 days additionally in the afternoon over a period of 2.5 months including rain storms and very dry periods. At 4 of these days also the two Schönfeld PW were read.
    - From 23.5.07 to 12.7.07: own readings (am and pm)
    - From 7.8.07 to 20.8.07: additional readings by the municipality worker (only am).
- Electrical conductivity eC(µS/cm) and temperature T(℃) measurements in each pump station as well as in tab water and in GW wells. This was made with an analogue and transportable gauge for more than 14 days.
- Additionally GW level measurements in 4 different wells at 7 days have been made.

To evaluate the chemical composition the following samples were taken:

- samples of the WWTP influent (taken by Mr.Ghysen) during 14 days in 1l plastic bottle (24h mix sample)
- samples of PW 4, 5 , 6 and 8, together 26 in 1l plastic bottle at nine different days (grab sample out of the pump reservoir)
- samples of PW 4, 5, 6 for heavy metal detection, together 12, stabilized at pH<2, in 200ml acid treated glass bottles at five different days (grab sample)

The samples were analyzed for the “typical” waste water parameters NH4-N, TKN, P_{tot}, PO4-P, BOD5, COD, TOC, settleable solids and suspended solids and in some cases additionally for the sum of hydrocarbon (emission parameter of IE petrol stations and car washings)

The heavy metal analysis included Cr, Cd, Zn, Pb, Cu and Ni.

Samples were collected between May and July 2007 the analysis was made in the laboratory of the “Department for Water, Atmosphere and Environment” at the BOKU.

4.4 Moving Minimum Approach

A good tool to assess the precipitation amount reaching a WWTP is the “Moving Minimum Approach” (for plants with IDM monitoring). The goal of the “Moving Minimum Approach” assessment is originally to find out the real “Dry weather inflow” to get an impression of the precipitation part.

Once the precipitation has been eliminated in this way from the inflow data, a better determination of other causes of infiltration can be made visible. In this thesis this approach was useful in the question of real waste water volumes of domestic and industrial discharge and to assess the amounts of groundwater infiltration caused by the remediation and ruptured pipes.

The dry weather inflow to the WWTP is calculated as follows:

1.) $Q_d - Q_{theor} = Q_F$ (if $Q_d > Q_{theor,}$ else “0”)

2.) $\partial Q = Min(Q_F(\partial t))$ (to eliminate the rain peaks)

3.) $\partial Q + Q_{theor} = Q_{D,d}$

Calculation of infiltration in percent:

4.) $Q_F(\%) = Q_F / Q_d * 100$

5.) $Q_{F,Dry}(\%) = \partial Q / Q_{D,d} * 100$

6.) $Q_{Prec,d} (\%) = Q_d - Q_{D,d} / Q_{D,d} * 100$

Q_d…………………………………………….. measured inflow (m³/d)

$Q_{D,d}$…………………………………………………………………… dry weather inflow (m³/d)

Q_F……………………………………………………………………resulting infiltration (m³/d)

$Q_{F,Dry}$…………………………………………………………………… resulting infiltration on dry weather days (m³/d)

Q_{theor}…………………………………………..theoretical value according to PE (m³/d)

∂Q……………………………………………moving minimum difference

Q_{Prec}…………………………………………...precipitation part of infiltration

∂t…………………………………………… time span (t_1 …. t_n)(d), e.g. 21days

4.5 The eight pump stations (PW) of Lassee and Schönfeld

4.5.1 Description of the PW

In each PW are 2 self priming centrifugal pumps whereof only one was in use most of the times - besides of PW 8, the last pump station in front of the WWTP and PW3, the first one in Lassee. No technical paper could be provided of the pumps, but for most of the manholes and sewers technical drawings existed in Lassee. Additional requests at the BH Gänserndorf for technical drawings did not bring more information. In Fig. 7-32 the information about the PW concerning elevation and dimensions are listed. All PW for which no corresponding drawings could be found we measured in diameter and depth ourselves with a measuring tape (PW 6, 7, 3). Besides PW 6 at Bahnstr., which is smaller in diameter and PW 1 in Schönfeld (the biggest one) all PW do have the same cylindrical form and width (see Appendix Fig. 7-31). There are 3 additional pump stations currently not in use. Two of them were used for pumping during inundations caused by rising GW level; one is in the “Blumenweg” and one in the “Josefsgasse”. The third one was build in case the small industrial center north east of Lassee would be connected to the sewer system, located close to Bahnstrasse north of the track.

Besides of PW 8 all pumps are synchronized with the waste water level. If the water reaches a certain level, the pumps are starting to work. While PW 2, 3, 4 and 8 do have a level control gauge, PW1, 5, 6 and 7 have none. PW 2, 4, 5 and 8 were constructed for the new WWTP. Through the last pump station (PW 8) the whole amount of waste water is flowing (or should flow) From PW 8 it is transported through a pressure line (DL DN200PVC) to the WWTP. Because of the big amount of waste water both pumps were working continuously with 12l/sec/pump (according to Mr. Christ) when reading the meter the first time 23.5.07.

4.5.2 Transferring meter readings to pump volume

Meter reading means to notice exact time and kWh of the meter counting the electricity consumption of each pump separately. Like mentioned each of the eight pump station has two pumps. Because no extraordinary loadings were expected in Schönfeld the two PW there were read only on 4 days.

To compare the waste water flows with each other and to consider the difference of the reading times kWh were calculated in kWh/min, once over the midday span and once from one morning to the next morning with the simple formula:

$$\frac{kWh(t_2) - kWh(t_1)}{t_2 - t_1}$$

The result is the average consumption over the time span t_2 - t_1. To evaluate the discharge during the day time or more precisely during official working hours the morning (~10:30) and afternoon (~17:00) readings in kWh/min were used. To evaluate the discharge from day to day the morning readings were used. The readings have not been done meticulous and can vary in time one hour more or less. The time was nregistered exactly on the minute.

To transfer the energy consumption into the pumped volume a pressure gauge was used, or more precisely a “hydrostatic fluid level sensor” named EASYLOG NS. This gauge is measuring the changes of water column in time and is registering the data on site over several hours or days in selectable sampling rates, limited by disk space. The resulting unit is a current [mA] at time t_i. The equipment is easy to carry, but needs electricity and its disk equipment must be kept dry, which is quite a disadvantage for outdoor purposes. The digitized data are made visible with a software called GSOFT40K V7.20. Resulting curves f(I,t) are showing the change of water column above the sensor. Knowing that the display ranges between 4 to 20mA wherein minimum and maximum are defined to be 0m respectively 10m of hydrostatic head, the curves in [mA] can be easily transformed to [m] of water column over the curve amplitudes:

$$\frac{(I_{max} - I_{min})\ [mA]}{(20 - 4)\ [mA]} = \frac{x\ [m]}{10\ [m]}$$

In Fig. 5-20 and Fig. 5-21 typical curves of the measurement are shown.

4.6 Sample Analysis

To evaluate the WWTP loads of the monthly reports 14 samples in series were taken at 8:00 from the 24h collector of the WWTP. To evaluate the chemical composition of the pump stations of interest waste water sample were taken on nine different days and bottle filled like described in chapter 4.2. Most of them were taken with a plastic bucket - beside of one exception in PW 5 at June 13th when an automatic sampler (CISCO) was used filling the 1l-bottle in 5 min intervals. This was done in the afternoon additional to counter reading, usually between 15:00 and 16:00. The samples were either conserved by cooling or for heavy metal detection with acid.

Chemical analyses were made at the laboratory of the BOKU SIG institute. Additionally own measurements with online probes for pH, electrical conductivity and temperature have been made.

Pump stations and inflow samples of June were analyzed for organic and inorganic parameter concentrations [mg/l] and loadings [g/d]. Samples of the PW were analyzed additionally for heavy metals and aromatic hydrocarbons. The latter analyzes were done to evaluate the effluents of the car and lorry washings discharged to Ringstr. (PW 6). The July samples were firstly analyzed only for TOC, suspended solids and heavy metals. The settleable solids were assessed. High values should lead to further investigations. This was the case for the sample of PW 6 (12.7.07). Phosphorus and ammonia were analyzed additionally. At first glance extreme values are marked grey (Appendix Tab. 7-4).

5. Results and discussion

5.1 Overview of loads and inflow from Jan. 2004 to Apr. 2007

The diagrams of the inflow, the COD, BOD, NH4-N and PO4-P (Fig. 5-1, Fig. 5-2 and Fig. 5-3), according to the monthly reports, give a good overview of the problems in Lassee. In a period of 3 years (2004 – 2006) the inflowing waste water amounts were exceeding the design value of 800m³/d during several weeks, reaching peak values of nearly 2.100m³/d with an untypical periodicity which is not easily interpretable. COD and BOD_5 loads were occasionally very high above expected ones (up to 400%). Expressed in terms of person equivalents (PE) maximum values of 14100 PE for COD and 9400 PE for BOD were measured. In contrary of this high values for organic matter, the ammonium and phosphate load stayed quite stable over the years and are tending rather to very low PE values with sparse remarkable outliers. Some peaks of COD are mirrored as well in NH4-N. Values in that range for COD and BOD facilitate the suspect of illegal dumps of sewage of unknown waste water origin or the remobilization of sediments of the sewers.

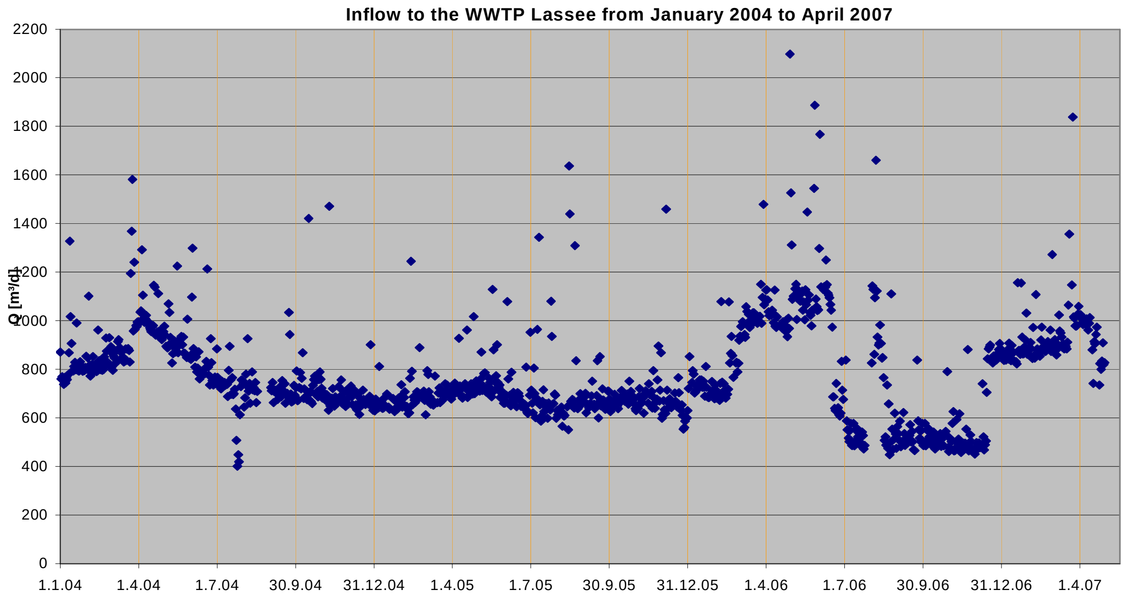

Fig. 5-1: Inflow from 400 to 2.100m³/d with periods of over 3 month oscillating around 1.000m³/d

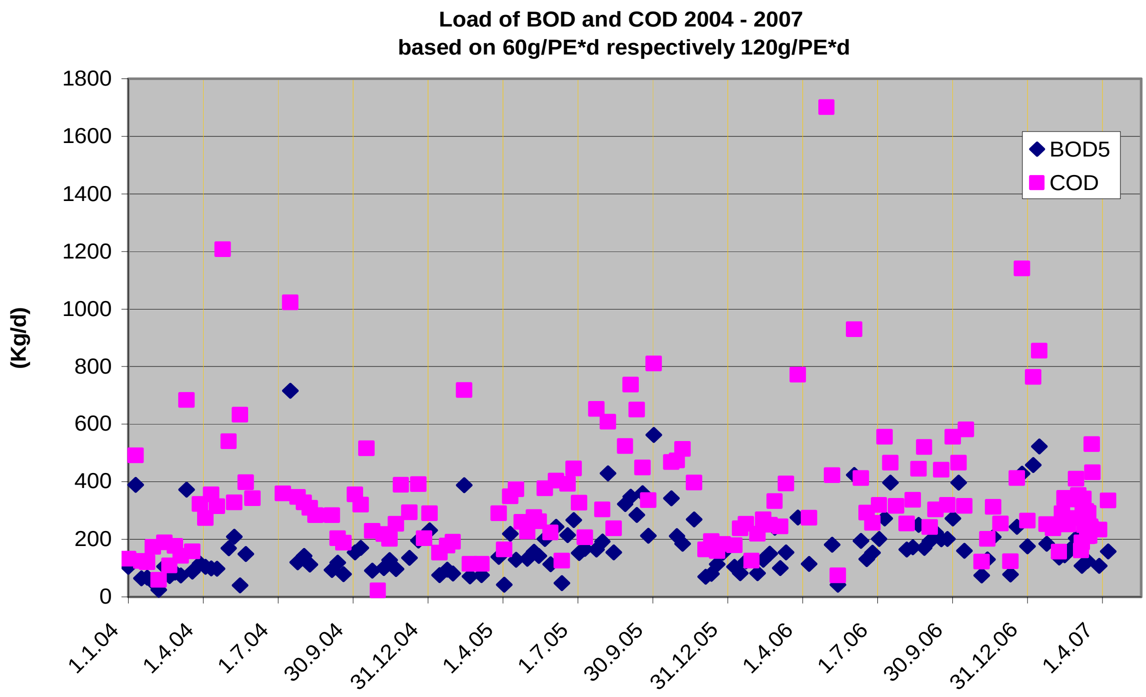

Fig. 5-2: BOD_5 ranging between 25 and 716 kg/d, COD between 22 and 1.700 kg/d

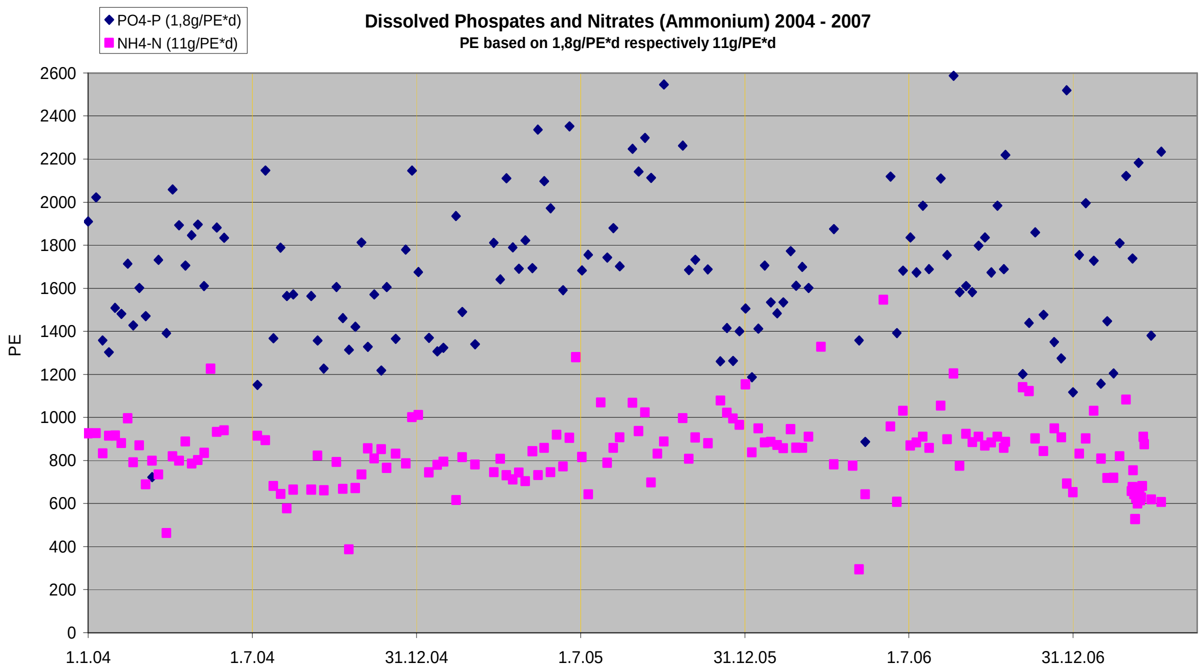

Fig. 5-3: NH4-N and PO4-P values in a first view in the influent between 1.1.2004 and 1.4.2007

The effluent concentrations of the WWTP of COD, BOD_5, PO4-P and NO3-N-N in (mg/l) do not exceed the guideline values in 99% of all events. Only NH_4-N lies in 9% of all cases over the permitted 5 mg/l.

5.2 Groundwater (PER) remediation

A meeting in Lassee in May 2007 revealed the surprising aspect that a big amount of groundwater (GW) was pumped into the sewer system what was reported by the WWTP technician Mr. Christ as well as from the company Co. Terrachem, the independent yearly compulsory investigation company controlling the WWTP effluent. Obviously a groundwater remediation located at “Neustift” in Lassee was the reason. The amount of infiltration to the sewer system was assessed by Mr. Christ and Mrs. Rappold (Co. Terrachem) to be 1.5l/sec to 2l/sec. It seemed that this was the case since many years. Own check ups confirmed the high amount of discharge. So a very important infiltration source was already found.

The remediation was initialized after the pollution of the soil with chlorinated hydrocarbons by a laundry on the premise Neustift 1 (mainly tetrachlorethen (PER)) (see chapter 3.4). Originally the pumped GW was supposed to be discharged into the rain water system and later on into the “Stempfelbach” (see Fig. 4-2).

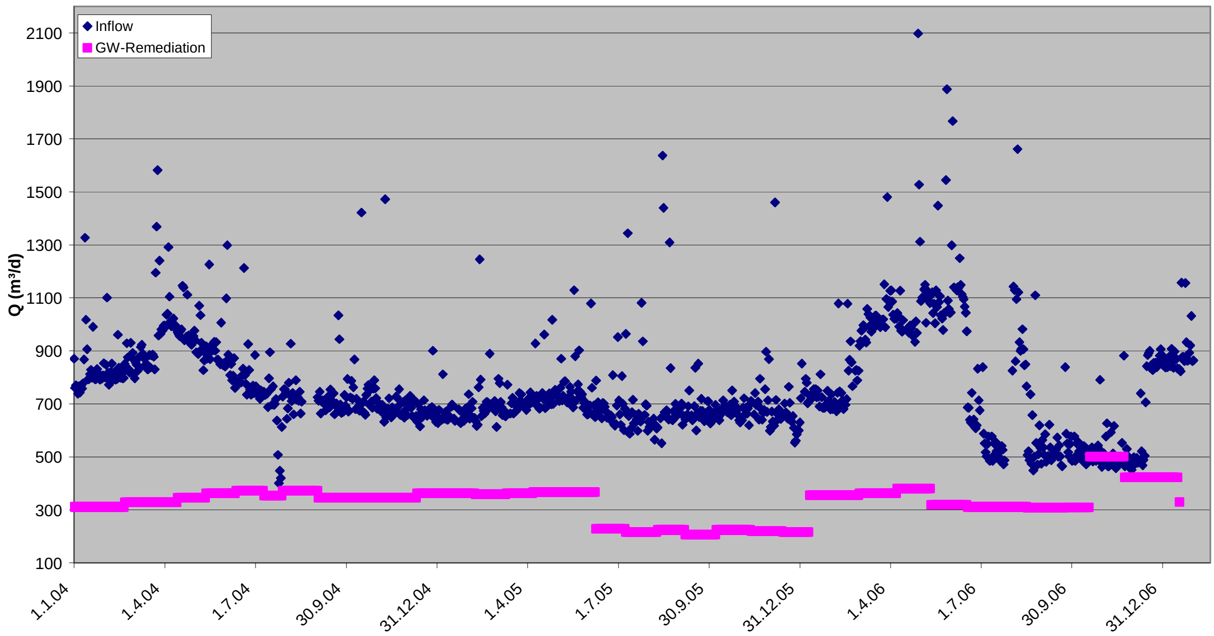

Fig. 5-4: Inflow to the WWTP Lassee and values according to the data of GEOdata from Jan. 2004 to Jan. 2007

The remediation company GEOdata was contacted telephonically and they provided their records of pumping amounts (l/sec) of the three pumps (Neustift 1 and Neustift 5). They estimated them by stopping the time for filling in a bucket. This measurement was done once a month. The pumps were running continuously since more than 10 years, but with different amounts. For the relevant period between 2004 and Jan. 2007 no interruption of pumping was reported (caused e.g. by freezing). The GW of all wells was discharged to the same channel or sewer in Neustift. Fig. 5-4 presents the provided data of pump amounts together with the inflow Q_d to the WWTP. For the days between the monthly bucket tests I simply assumed the pumped volume to be constant before. The average pumping rate in this period was 320 (m³/d) ranging from 207m³/d to 500m³/d. For a WWTP of 800 (m³/d) permissions this is quite a high range.

Fig. 5-4 shows at a first glance that this data could not be used in the simple way to say that the pumped GW is in the same amount reaching the WWTP. E.g. in Nov. 2006 no waste water would be left. So either the part of the pump volume flowing to the WWTP was lower than the discharged one or the available data were not reliable. For this thesis there was always the great problem to assess this influx to achieve a “net” inflow data without the supposed big and constant inflow of the GW remediation. The only reasonable solution to assess the GW flow to the WWTP was either to stop the pumps in the measurement period (at least for 4 weeks) or to channel the GW definitively and completely via rain channels to the “Stempfelbach”. Unfortunately that did not happen in spite of many requests since April 2007 to all responsible stakeholders (the mayor, the lawyer (BH Gänserndorf), the comp. Geodata) and an agreement with the mayor of Lassee to stop the pumps for 4 weeks. At least the pumps were not stopped in a required time span during own investigations in Lassee.

Only one day before my official last day of measurement July, 12th the pumps were stopped in the afternoon. According to statements of the company GEOdata the pumps were turned off on July, 10th and turned on again on August, the 10th. One day of own measurement to assess the inflow by meter readings is of course much to less. One data point based on meter readings is quite erroneous for an assessment of the pumped GW volume. The readings should be continued by the municipality workers, but they were not. They started not until August, the 7th. Before the meter in PW 8 did not measure the electricity consumption. After fixing the problem the values were not comparable with the own readings in PW 8. An intersection with the GW pump stop remained anyway only from August, 7th to August 10th wherein the read values for PW7 are as well not easy comparable with the own data acquisition (see chapter 5.8.5.4 and 5.8.5.5).

In the middle of May was a meeting in the BH Gänserndorf concerning the GW-remediation with deputies of GEOdata, the municipality and office surveyors. The result was to carry on until the next meeting in 2009. After all induced by the Vice Mayor of Lassee mentioning this investigation it was considered that the GW is possibly channelled into the sewer. The authorities gave the advise to review this again (´Niederschrift, KZ: GFW2-WA-004275; 16.5.2007`) together with the company Geodata, who negated this. Officially the groundwater is still discharged via rain channels to the “Stempfelbach”.

Further concentration monitoring is useful in the direction of the flow where the groundwater is used as drinking water (towards the east).

5.3 Problems due to WWTP control facilities and pump meter in PW 8

After starting the thesis it turned out, that the automatic continuous IDM meter recordings of inflow and outflow (m³/d) dropped out completely end of April 2007. After statements of the WWTP workers the computer for the recordings made problems since longer times. This made us handle the data with care, specially the drop of inflow in the second half of the year 2006 and the following data. No further inflow data were available. The digitizing PC which recorded the IDM meter was not fixed until the beginning of August 2007. Control facilities like the pH measurement failed as well, obviously at least since February 2007.

The interpretation of the measured data was made difficult through the failure of the IDM monitoring, especially the assessment of the GW remediation. Furthermore the electricity meter of the last pump station just in front of the WWTP (PW 8) failed over 50% of measurement days.

In this paragraph I give a short description of the meter reading problems at PW 8:

Soon after starting the meter readings at May 23rd of the PW the meter of PW 8 did not count any more (from 1.6.07 on). After fixing the problem only one meter was counting, obviously the volume was pumped by only one pump from June 28th to July 12th. (In most of the other pump stations usually only one pump is running). But now the meter reading showed only around half of the daily consumption of what they had registered before they failed while at the same time more or less the same water amount should be pumped. Between June 15th and June 27th no reading were done a.o. because the manholes have been cleaned in that time. In this cleaning a reason was suspected for this remarkable drop down of consumption. Another explanation was the change in pump switching, which was now intermittent and not continuous any more, thus enhancing the power consumption of the pumps. Failures in electricity connections could be the reason as well. A probable reason could be as well that the 2nd pump was also working, but the meter was still broken and did not count.

After July 12th the meter failed again and had to be fixed once more. When starting the next readings from August 7th to 20th by the municipality workers the two meters showed both pumps working, now in its electricity consumption quite high. The consumption was very varying now in a way the IDM inflow gauge of the WWTP, repaired in the meantime, did not reflect (see Fig. 7-54).

Comparison measurements with the pressure gauge (see chapter 4.5.2) were done between June 27th and July 12th 2007. If the 2nd pump was working in this period, it is unknown how. So the PW 8 meter readings are usable as a direct assessment for the inflow volume only for this period but the assigned pump volume is eventually varying in addition. This is a pity, because like mentioned before, the IDM of the WWTP inflow failed too until beginning of August 2007. The August readings and the ones before June 15th are showing comparable data concerning the energy consumption [kWh] but the values cannot be transferred to Q (m^3/d) (see chapter 5.8.5).

5.4 Determination of PE and their distribution to the PW

In June 2007 the inhabitants of Lassee and Schönfeld were newly estimated for this thesis. This was done by the municipality. The old estimation of PE for the construction of the WWTP was presented in Tab. 4-1: Calculation basis personal equivalents (PE) for the construction of the WWTP Lassee (Ing. V.Trugina, 1998) (translated by myself)

Type	PE	PE / spec.	Capacity	PE 60	spec.	Wastewater		Infiltrationwater		
			%		l/PExd	l/sxPE	h	l/sxPE	l/s	m^3/d
Residentials	2280	1,0	100	2.280	200	0,005		0,003	18,24	456,0
Secondary Residentials	188	1,0	100	188	200	0,005		0,003	1,50	37,6
*W.A.Getreidegasse	140	1,0	100	140	200	0,005		0,003	1,12	28,0
Tourist Beds	80	0,5	100	40	100		8		0,28	4,0
Seats in Pubs	-----	-----	-----	-----						
- KG. Lassee	100	0,3	50	15	15		8		0,05	0,2
- KG. Schönfeld	400	0,3	50	60	15		8		0,21	0,9
External Pupils	70	0,3	100	21	65		8		0,16	1,4
External Employees	100	0,4	100	40	75		8		0,26	3,0
W.A. Cannery	250	1,0	100	250	100		10		0,69	25,0
Inc. Reinbold	-----	-----	-----	-----						
- Lorry Washings open air	-----	5,0	100	5			8		0,50	14
- 1 Washing Plant	-----	20,0	100	20			8		1,00	29
Fa. Gasselich	-----	-----	-----	-----						
- 1 Car Wash	-----	20,0	100	20			8		1,00	29
Sludge Dewatering	-----	-----	-----	100						
Commuter	-50	0,3	100	- 15	-60		8		0,10	0,9
Subtotal				**3.164**					**25,1**	**629**
Reserve and Rounding				**536**					**4,3**	**165**
Total				**3.700**					**29,4**	**794**

*W.A.Getreidegasse = **W**ater legalised **A**llocation for the new settlement area Getreidegasse

.

The list of indirect discharger handed over by the municipality Lassee and a list of permissions for IE according to the WRG handed over by the BH Gänserndorf is to see in Tab. 5-1. The list of permissions according to the WRG contains as well companies as private owner of heat pumps. Those owners are listed because the possibility of discharge of the circulated water to the sewer exists in case the water cycle for the heating is interrupted through the occlusion of a well. The inhabitants were counted for each house and street. All inhabitants, schools and IE were then distributed to the single pump stations in order of the flow direction (according to Mr. Christ). In the Appendix Tab. 7-1 the list is shown.

Companies in Lassee who could cause bigger amounts of discharge or/and loads are:

- The cannery Pfluger situated in the Ringstrasse: it is a mixed production cannery (fruits and vegetables) and registered as IE with allowance for discharge to the rain channel: Qmax = 10m^3/d and max 30l/sec. A mixed production cannery has after Henze et al. (1996) a water consumption (tf = ton finished product) and a concentration in the effluent of:

  2 – 30 m^3/tf and 800 – 5.000 g BOD7/m^3 (1kg BOD7 corresponds to ~0.85 kgBOD5)

- The transport company Reinbold in the Ringstrasse realises sewer cleaning and hazardous waste transports. It has a number of tank lorries and trucks, own washing places and a sludge storage tank with a volume of V = 33.7m^3. According to the WRG the company has a permission for discharge to the sewer of Qmax = ~40m^3/month and 6.5 l/sec. Because of the nature of the business any effluent concentration could be very high.

- Possible are also wrong connected drainages of agriculture

The sewer of Ringstrasse ends in PW 6 (Bahnstrasse). Tab. 5-1 shows that permission for discharge for both companies are in parts out of date.

Waste water from fruit and vegetable canneries are among the strongest of organic trade effluents and moreover occur in large volumes.

Additional water consumer not classified as significant are 2 schools, 1 Kindergarten, 1 Supermarket with own meat preparation, 1 petrol station registered as IE (car washing) with max 0.3m³/d, three restaurants and pubs.

Tab. 5-1: 1) IE list from the municipality Lassee and 2) admission holder after the WRG (BH Gänserndorf) a) trade and industry b) heat pump owner

Indirect discharger (IE or ID)	business	announced ww amount (m³/d)	Allowance in l/sec	AEV		Discharge amount used for WWTP design (m³/d)	equivalent PE (0,15m³/d)
Gerhard Zettel	car washing	0,70		9000 V Kfz	Gasselich?	29	193
Fa. Kolm Pfluger	fruit and vegetable cannery	18,75		5010 V		25	167
Dr. Günther Frohner	dentist	0,88		1400 V med B			
Raiffeisen- Lagerhaus	petrol station	0,30	1,26	9000 V Kfz			
	washboxes	0,20		9001 V Kfz			
Busam GmbH	washing place for busses	1,00		9002 V Kfz			
Reinbold*	lorry washing	4,90	1,5 (throttled)	9003 V Kfz		43	287
Billa	flesh processing (superma	0,63		5001 AEV		**Total PE**	**647**

Water right reply like provided in August 2007 of the BH Gänserndorf **Industrial discharger**									
name and trade and premise number	discharge street	discharge in: rain channel	waste water	type	allowance m³/d	l/sec	controls after IEV 1998	first and last replies and last controllings	discharge allowance limited until:
Reinbold Transport	Ringstrasse	x		car washings	15			1966	
Hauptplatz 6		x			1,5	5	0	reply 1997	
problem stuff disposal			x	car washings	20m³/month	1,5	0	reply 1997	2005
and channel cleanings			x	lorry washings	5m³/week	5	0		
Fa. Kolm Pfluger	Ringstrasse	x	own 3 ch.	washings	10		0	1967	Jul.-Sept.
Fruit and vegetable cannery			WWTP	Abwasser				control 1995	
122/2		x		precipitation		30		2000:	
33				pulp water				IE-partly annihilated	
Schalud car washings 313		x		car washings			0	1962	
Lagerhaus, petrol station and garage 961/7				washing place		1,26	0	control 1995	2016
EVN electricity provider 784/2		GW		rain filtering	k.A.			control 1999	

heat pumps owner in Lassee

Street or premise	adm. [m³/d]	year of constr.	next PW	**PW4**	**PW 7**	**PW 8**
1431/95	50	1995				
Loimersdorfer Str. 29	54	1999	PW 7		54,4	239,8
Neubaugasse 6	30	1999	PW 8		185,4	153
Obere Hauptstrasse 34	31	2003	PW 7			
Bahnstr. 37	14,4	2003	PW4			
Am Holzgarten 18	36	2003	PW 7			
Hauptstr. 7	18	2003	PW 2			
Loimersdorfer Str. 26	14,4	2003	PW 7			
855/86	20	2004	PW 7			
Getreidegasse 10	30	2005	PW 8			
Loimersdorfer 9	30	2006	PW 7			
Getreidegasse33	93	2006	PW 8			
Hauptstr. 8	22	2007	PW 2			
Max. possible discharge to pump stations (m³/d):			**Total**	**54,4**	**239,8**	**392,8**
equivalent PE (150l/PE*d):			**Total**	**363**	**1599**	**2619**

The Tab. 5-2 and Tab. 5-3 show the number of PE designated to pump stations PW 1 to PW 8 in the order of flow direction. Tab. 5 2 shows the discharge for the IE according to the design of the WWTP by the engineering company Trugina (1999) and Tab. 5-3 the admitted values for IE after Tab. 5-1. Owners of heat pumps and their possible discharge are not listed in the tables.

Tab. 5-2: Distribution of inhabitants and indirect dischargers to pump stations, wherein the inhabitants are newly estimated in June 2007 and the IE discharge is taken over from the design values of the WWTP

PE for each pump station (resident counting 2007)

Discharge in brackets is overtaken from Fa. Trugina (Design of WWTP), cannery has not been considered
Values of transport, car and lorry washings are equivalent to 480PE and are laying much above admittance of PE=46

pump station	**Inhabitants**	School	Seasonal farm worker	Restaurant, Hotel	Cannery (rain ch.)	Transport, car + lorry washings	Externals	**PE**
	PE	**m³/d**	**PE**	**m³/d**	**m³/d**	**m³/d**	**m³/d**	
PW1	162							162
PW2	375			x (0,9)				375
PW 3	690							690
PW4	739	2,925				x		818
PW5	105							105
PW6	384				[25]	x (43)		814
PW7	2054	3,9	50	x (4,2)		x (29)	(3,0)	2534
		(1,4)						
PW8	2432							2912

Tab. 5-3: The same inhabitants distribution like in Tab. 5-2 above, but IE according to permitted discharge

PE for each pump station (resident counting 2007)

Industrial indirect discharger amount according to admittance after water right and IEV legislation
public places like restaurants and schools are re-evaluated

pump station	**Inhabitants**	School	Seasonal farm worker	Restaurant, Hotel	petrol station Lagerhaus	car washing Zettel	transport Reinbold	Billa	Externals	**PE**
	PE	**m³/d**	**PE**	**m³/d**	**m³/d**	**m³/d**	**m³/d**		**m³/d**	
PW1	162									162
flows to										
PW2	375									375
flows to										
PW 3	690									690
flows to										
PW4	739	2,925			0,5					762
flows to PW7										
PW5	105									105
flows to										
PW6	384						1,3			393
flows to PW7										
	931									
PW7	2054	3,9	50	5		0,7			3	2200
flows to										
PW8	2432							0,63		**2582**
to WWTP										

5.5 Infiltration assessment 2004 – 2007

5.5.1 Results of the first "Moving Minimum Approach"

In Fig. 7-3 to Fig. 7-5 the result of the „Moving Minimum Approach" is shown for the WWTP Lassee added by tab water consumption in the years 2004 to 2006. The diagrams were in parts already calculated and provided by Dipl. Ing. T. Ertl (BOKU). Raw data of automatic flow measurement showed some gaps between 5 and 14 days per year most probably caused by the IDM monitoring technique. The following data of the first measurement days after the gaps were not plausible and therefore eliminated.

The consumption of tab water for the whole municipality was provided by the EVN in consumption per month. The personal equivalents have been evaluated new to be PE = 2912 according to Tab. 5-2 (chapter 5.4). The PE correlate with a waste water discharge Q_{theor} = 5.06 l/sec (0.15m³/PE*d). When comparing the dry weather inflow $Q_{D,d}$ with the tab water consumption one has to know, that not all water used in Lassee comes from the tabs. Some people have there own wells. So this water might be used as grey water, e.g. for flushing toilets as well. The transport company Reinbold is using its own well water for e.g. lorry and car washings and other purposes and discharge it to the sewer. Vice versa is not all consumed water is discharged to the sewer but is as well used for irrigation or swimming pools like reflected in the rising consumption in summer times. Comparison of Q_{tab} and Q_d in the year 2006 with the other years show from June 18th to Dec. 12th an untypical progression in its curves with Q_{tab} close to Q_d values, in July even higher.

For the comparison of tab water consumption with waste water discharge only data of those periods of the year can be used, in which tab water is not used in a remarkable way for irrigation or swimming pools. In general this will be the case in autumn, winter and early spring time. The expression for that time of year was choosing to be "tab water without summer". Warm and/or longer dry periods can still occur in spring and autumn. This possibility was reviewed with the data of air T (℃) combined with precipitation data. Tab. 5-4 presents the yearly resulting infiltration:

- The upper part of the table compares Q_{theor} =5,06l/sec with the average "tab water without summer" consumption to assess the minimum of Q_{theor} representing the domestic part of the waste water discharge in Lassee. To achieve a better assessment of Q_{theor} the year 2006 was not considered because of its unusual curves and the high Q_{tab}. The average over the other years Q=~ 3,49l/sec can assess the minimum of Q_{theo} best.

- In the lower part of Tab. 5-4 the infiltration water amount is presented calculated with: a.) the min. Q_{theo}=3,49l/sec and b.) the norm value Q_{theo}=5.06l/sec. The resulting infiltration is between 293m³/d and 415m³/d assuming case a.) respectively 135m³/d less in case b.), wherein a big part is probably caused by the GW remediation.

The Fig. 7-59 to Fig. 7-61 (Appendix) show the resulting infiltration water based on Q_{theo}=3,49l/sec according to chapter 5.9.

Tab. 5-4: Analysis of „Moving Minimum Approach" and tab water consumption of Fig. 7-3 to Fig. 7-5

Daily average discharge and consumption of water over the years 2004 - 2006				
	Theoretical discharge	Dry weather	Tab water (without summer)	
	(Qm³/PE*d = 0,15 m³/d)	discharge	consumption	Difference
	Qtheor.[l/sec]	QD[l/sec]	Qtab [l/sec]	Qtheor. - Q tab[l/sec]
2004	5,06	8,3	3,39	1,67
2005	5,06	6,88	3,56	1,5
2006	5,06	7,11	4,25	0,81
2007			3,52	
	m³/d	m³/d	m³/d	m³/d
2004	437,18	717,12	292,9	144,28
2005	437,18	594,43	307,58	129,6
2006	437,18	614,3	367,2	69,98
2007			304,13	
Calculation of Qtheor. after Qtab in the years 2004-2005 and Jan-March 2007:				
Qtheor (l/sec)	3,49			
Qtheor (m³/d)	301,54			
Qm³/PE*d	**0,104**			
			without summer values:	
Average difference of QD,d with the two Qtheor. values			aver. Diff. between	Difference between
	a.) domestic part	b) norm value	dry weather discharge	the minimum of QD,d
	(Qm³/PE*d = 0,104 m³/d)	(Qm³/PE*d = 0,15 m³/d)	and tab water cons.	and analogous Qtab
	QD,d - Qtheor. (l/sec)	**QD,d - Qtheor. (l/sec)**	**QD,d - Qtab(l/sec)**	**QD,d - Qtab(l/sec)**
2004	4,81	3,24	1,72	3,77
2005	3,39	1,82	2,06	1,28
2006	3,62	2,05	3,44	1,6
	m³/d	**m³/d**	**m³/d**	**m³/d**
2004	415,58	279,94	148,62	325,7
2005	292,89	157,25	177,98	110,6
2006	312,76	177,12	297,22	138,2

It was shown that 100l/PE*d and 2912PE (Tab. 5-2) is most valid according to Q_{tab}. Infiltration water caused by IE might be represented then in the difference between 2912PE (Tab. 5-2) and 2582PE (Tab. 5-3) (100l/PE*d) resulting in 33m³/d (further used in chapter 5.9).

Approaches to assess the GW remediation

With an underlying domestic discharge of (min.) Q_{theor}=301m³/d like estimated in Tab. 5-4 the amount of water of unknown origin on dry days lays between 50% (2005) and 58% (2004). A big part of it will be the GW-remediation. An assessment with (max) Q_{theor} = 437m³/d (2004) yields to an amount of infiltration water between 26% and 39%. Assuming that the pumped amount stayed more or less constant over the whole year like specified the minimum (157m³/d) could reflect the GW-remediation. Another approach is to subtract the daily tab water consumption Q_{tab} from $Q_{D,d}$ and to look for the minimum, of course only with data of "tab water without summer". The minimum is 110m³/d in November 2005. Nov. 2005 recorded T > 0℃, so the GW pumps should have worked. This is all very speculative, but 157m³/d reflects best the measurement of 1 day without GW pumps in the manhole PW 8 (chapter 5.8.5.4).

In chapter 5.9 the tool of the moving minimum (10days instead of 21days) was used to assess the infiltration by the GW remediation more detailed in percent.

5.5.2 Quarterly comparison between inflow, rain and snow height

In the Appendix 14 diagrams (Fig. 7-6 to Fig. 7-19) show a more detailed view of inflow, rain and snow height from Jan. 2004 to April 2007 for each quarter of the year. Snow height measurements were only available from a station in "Franzensdorf", which is ~25km away from Lassee. Additionally one diagram of all years is shown for a better overview.

The direct influx of the rain to the WWTP can be clearly seen in the diagrams. Strong single peaks in the inflow curve are representing precipitation days. Retention times cannot be referred to the curves. IDM measurement reads the data at 0:00 while precipitation is read every day at 7:00 am in the morning. So a two days span in representing a rain event in the inflow according to this time displacement has to be considered. Tab. 5-6 compares the highest peaks with the precipitation.

Snow melt cannot be referred in a substantial way to high inflow amounts over longer periods like shown below:

- **2005/2006**: the strong winter in 2005/2006 should reflect an influx best. Snow melts at February, 8th 2006 first time in this year completely from 7 cm height (see Fig. 7-14 according to data of the HD Österreich). The precipitation event shown in the diagram is snow (7.5 mm). The inflow peak is directly corresponding with a rise of 400m³/d to 1100m³/d above the neighboring values of ~ 700m³/d. The high value can be attributed to the snow melt as well. On the other hand no recognizable rise was measured during the drop of snow from 23 cm to 7 cm. From Feb. 16th on the inflow curves increase around 130m³/d after a continuous increase in temperature. This rise might reflect the defrosting period. Values of inflow get steady higher from 700m³/d in February to more than 1.100m³/d in June, where dropping again to 600m³/d. Other reasons must superpose the defrosting period. The snow rise and fall is not reflected in the inflow curve over longer periods.

- **2004/2005**: By times of the first melt in 2005 the inflow rise ~70m³/d. The snow level rise and fall is not reflected in the inflow curve substantially.

- **2003/2004**: 12.1.: Snow melt (9 cm) together with a former snow and rain fall event (10.7mm) causes a peak of 550m³/d above the neighboring values of 800m³/d. Similar conditions with rising temperatures two months later do not show such a dramatically rise. The snow level rise and fall is not reflected in the inflow curve substantially over longer periods.

In Tab. 5-6 is a detailed review of the quarterly presentation of inflow and precipitation of the 13 quarterly diagrams shown in the Appendix (Fig. 7-6 to Fig. 7-19). One can see that the WWTP is infiltrated in a high amount by rain. At the time of precipitation events the inflow rises in average 60%. Rain events of more than 40mm (14.8.2005 and 29.4.2006) show an effect of inflow rise >1.000m³/d. The neighboring values in these cases vary between 500m³/d and 1100m³/d. Maximum inflow pump capacity was reached one day in April 2006 with 2.100m³/d.

A rough estimation of runoff calculated for 14km sewer pipelines and 5m broad streets (70.000m²) shows an average rain infiltration of 40% to the WWTP.

There exist 3 long periods of extraordinary high inflow values and one smaller which cannot be led back to precipitation:

- **2004, 23.3. – 12.6**.: Inflow rises from ~840m³/d to ~1000m³/d at 12th April after a period of heavy rain which lasted 3 days. It drops slightly down again with ~3,6m³/d during the next 2 months until ~740m³/d in June.

- **2006, 16.2. - 18.6**.: Inflow rises first from ~700 to 800m³/d in 10 days, then to ~ 1.000m³/d in 6 days until May, when reaching ~1.100m³/d. Drops in 1day back from ~1000m³/d to ~700m³/d (18.6.)

- **2006: 2.8. – 15.8**.: Inflow rises of 300m³/d from ~500m³/d to ~800m³/d (heavy rain period)

- **2006/7: 13.12.06 – 30.4.2007** (breakdown of computer): inflow rises from 500 to ~900m³/d in 3d, oscillates around ~850m³/d until 17.3.2007, then rises again up to ~1.000m³/d

Because of the increasing inflow in late winter/early spring times a coherence with snow melt and GW rise can be supposed.

The sum of rain (mm) for each half year (2004 and 2007) is listed in Tab. 5-5. To answer the question if a dry period might be the reason for the low inflow values in the 2nd half 2006 one can compare the data e.g. with the data of the 2nd half 2004 or Jan. to April 2007, both similar dry periods (see Fig. 7-18). Here the inflow values are still high (2004 = ~700m³/d and 2007=~ 850m³/d). According to these comparisons a dry period as a reason for the unusual low inflow values in the 2nd half 2006 (~500m³/d) can be excluded.

Tab. 5-5: Comparison of the sum of precipitation for each half year 2004 to 2007

Sum of rain [mm]		
	1st half year	2nd half year
2004	343	191
2005	220	367
2006	344	225
2007	256	
Jan. to Apr. 2007	157	

Tab. 5-6: Detailed analysis of the 13 diagrams (Fig. 7-8 to Fig. 7-18) of comparison between quarterly precipitation and inflow and analog representation of period of high inflow values (yellow) and comparable low inflow values (blue)

Inflow peaks and precipitation events with more then 10mm, Pump limit of inflow and outflow is 25l/sec = 2160 m³/d, admission 800m³/d					
Date	Inflow m³/d	Neighbouring trend (m³/d)	Difference m³/d	Precipitation mm/d	other causes and remarks
12.1.04	1327	790	537	10,7	snow melt (Jan.11th 9cm and Jan. 12th 0cm snow height)
3.2.	1100	800	300	12,4 + 4	
25.3.	1580	870	710	17,2 + 29,5	**Period of high inflow values starts for 50 days. From 23.3. - 26.3. rain over 10mm every day, inflow stays high afterwards on ~ 1000m³/d for 30d.**
5.4.	1290	**1000**	290	4,4	
15.5.	1230	880	350	12,8	
3.6.	1300	840	460	11,1 + 20,6	
20.6.	1210	780	430	13,4	
23.9.	1030	670	360	9,2 + 11,8	
16.10.	1420	680	740	23,2	
9.11.	1470	650	820	18,5 + 10	
26.12.	900	650	250	8,8	
12.2.05	1240	650	590	10,4	
26.4.	1020	700	320	12	
18.5.	1130	690	440	19,4	
4.6.	1080	680	400	13,7	
1.7.	950	650	300	13,2	This quarter has a lot of peaks, but not high and much rain
5.7.	800	610	190	16,8	
9.7.	960	600	360	15,8	
11.7.	1340	600	740	27,3	
25.7.	1080	630	450	28,6	
14.8.	1630	620	1010	32,3 + 18,7	
22.8.	1300	640	660	11,7 + 13,5	
20.9.	850	630	220	9,2	
27.11.	900	640	260	5 + 10,2	
6.12.	1460	630	830	24,8	
8.2.06	1080	680	400	7,5	snow melt (Feb. 7th 7cm and Feb. 8th 0cm snow height)
17.2.	1080	700	380	4,1 + 3,7	(snow melt) **Period of high inflow values starts for over 4 months (16.2. - 18.6.) Arising first to 800m³/d in 10d, then to ~ 1.000m³/d in 6d until May, when reaching ~1.100m³/d. Drops in 1d back from 1000m³/d to ~700m³/d (18.6.) Drops from 18.6. until 6.7. to ~500m³/d until 25.7. Then Data-Gap.**
28.3.	1480	1000	480	12,9	
29.4.	2100	940	1160	16,4 + 32,7	This quarter has a lot of high peaks and much rain
18.5.	1450	**1060**	390	12,4	
27.5.	1890	1000	890	9,4 + 29	
3.6.	1770	1030	740	31,5	
27.6.	830	600	230	18,4	**Period of low inflow in July and late August 2006 ~500m³/d**
3.8.	*1140*	*820*	320	*22,4*	**Period 2.8. - 15.8. much rain and ~800m³/d** (300m³/d more)
8.8.	*1660*	*900*	760	*41,6*	
20.8.	740	500	240	11,2	**Period of low inflow ~500m³/d (20.8. - 12.12.2006)**
24.8.	1110	**500**	610	17,2	
22.11.	880	470	410	13,3	
9.12.	740	490	250	8,7	
					Period of high inflow values starts: 13.12.06 inflow arise to~900m³/d in 3d, falls slightly back to ~850m³/d in 1d, oscillate around that value until 17.3.2007, then arises again until ~1.000m³/d, stays like this until the system breaks down end of April 2007
19.3.07	1350	900	450	14,7	
23.3.	1840	**1000**	840	27	

5.5.3 Coherence of inflow and groundwater level

5.5.3.1 Probability of sewer damage

This chapter investigates if groundwater infiltrates the sewer and can be the reason for longer lasting periods of high inflow.

Lassee has a sewer system which is in its oldest parts, the center of Lassee, 44years old. According to information of the municipality it has never been monitored. In the Appendix in Tab. 7-1 the age of the sewers is listed according to different information sources: the view to permissions for sewer constructions (according to the WRG) administrated by the BH Gänserndorf as far as they were named there, construction plans administrated in Lassee and information of Mr.Christ. The 3 information sources were in parts contradictory and the list should not be taken as the final truth. The municipality Lassee itself should know the question of sewer age the best. The list contains as well the estimation of inhabitants.

Fissures and breaks in the concrete pipes are quite probable considering the age of 44 years and additionally the big amount of trucks frequenting the village every day. Two big transport companies are settled in Lassee since many years with around 40 (heavy) trucks. Gravel sites are besides agriculture a very important income source for the area and are transported through Lassee. The probability of damage due to the pressures of daily vibrations to the underground pipe systems is quite high.

Additionally other pressures on parts of the systems like in Neustift exist, where 3-5l/sec gushes on the channel bottom due to the GW remediation every day since 1993.

5.5.3.2 GW level measuring station GS331223/3002813 (GS Lassee) and inflow

The nearest GW monitoring station (GS331223) of the "Hydrografischer Dienst NÖ Landesregierung" is in the SW of Lassee (see Fig. 4-2), in the following called GS Lassee. Another measuring point is in Schönfeld (GS319327 or GS Schönfeld). The groundwater level is recorded since 1984 once a week. In 1996 the GW level was rising 1.4m in both stations. According to information of the EVN (water supply company) the municipality Lassee made a contract for the water supply from Obersiebenbrunn in1994.

The trend of the Lassee GW curve was oscillating in a similar manner over all years. Since then every year the GW level had its maximum between March and May (once in 2006 also in June) and its minimum between August and September. Most plausible reason for the rise is the snow melt also considering the fact, that the GW point lays close to the river. The drop may be caused by irrigation. The Schönfeld well does not follow this yearly trend, but it has in a similar manner every 2 to 3 years maximum GW levels around July. This aquifer reacts more slowly which indicates a lower hydraulic conductivity of geological layers in Schönfeld than in Lassee.

In Fig. 5-5 the GW-level of GS Lassee is shown together with the inflow of the WWTP since 2004. The GW curves 2004 to 2005 are typical in their progression, but the following curve until 2007 is untypical. The inflow to the WWTP shows the same progression like the GW-level. Its maximum is 143.6m above sea level, its min. 142.87m (2.49m and 3.22m below groundlevel). The average level since 1996 is 143.22m.ü.A. (2.87m). To locate infiltration possibilities it has to be compared with the elevation of the sewers. Sewers are reaching their deepest points in the pump stations. This is shown in Tab. 5-7 in comparison with the GW level values since 1996. All entrances to the PW in Lassee show elevation levels which lay within the GW level of the measuring point, even if it reaches its min-value. The comparison between the measuring points GS Schönfeld and GS Lassee shows a higher GW level in Schönfeld (+1.13m in average).

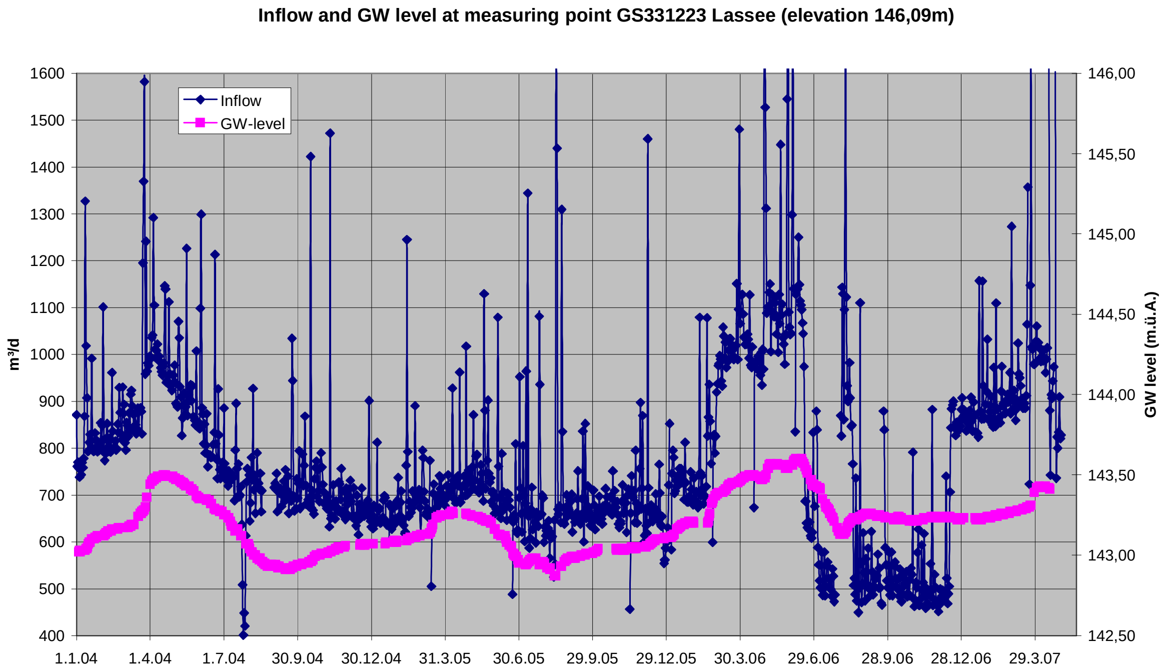

Fig. 5-5: Comparison of GW level (m.ü.A.) of GS Lassee (146,09m.ü.A.) and inflow

The elevation of the well in Schönfeld is 154,47m. PW 1 and PW 2 in Schönfeld are not touched by the aquifer.

Tab. 5-7: Infiltration possibilities for ground water (elevation data were taken out of funnel plans)

Pumpstation PW (S=Schönfeld)	elevation (m)	deepest sewer inlet (m)	funnel depth (m)	GW Level in m since 1996
PW 1 S	154,87	149,3	146,97	GS Lassee (146,09m):
PW 2 S	155,45	152,87	148,35	MIN 142,86
PW 3	145,95	141,95	140,75	MAX 144,06
PW 4	145,17	142,39	141,02	Average 143,22
PW 5	144,86	142,11	141,26	GS Schönfeld (154,47m):
PW 6	no info available	no info available	4,3m.u.GOK	Min 144,04
PW 7	144,91	142,04	140,27	Max 145,08
PW 8	144,78	140,75	139,42	Average 144,5
WWTP	145,67	143,2		

5.5.3.3 GW level within Lassee

There exist several wells in and around Lassee, which were in use for private water supply until the connection to Obersiebenbrunn. Many of them are still in use for irrigation and industrial purposes.

Easy accessible wells without being pumped (with unknown elevation) in the village itself were found like this: One at "Jugendzentrum" (public well) and the other one at the crossing "Untere Hauptstrasse", "Hagelweg" (home of Mr. Christ). The closest point with known elevation is at PW7 (144.91m.ü.A.). It lies 1.18m lower than the GW monitoring station GS Lassee. In the first well south of PW 7 the GW level measured with a tape measure was 1.1m.u.GOK, the other one north of PW7 of 2m.u.GOK. Both points were measured May 23rd and May 31th 2007 showing the same results. A simple comparison with GW level at the same days gives GS Lassee = 2.88m.u.GOK. This shows an even higher probability of infiltration due to the elevation.

One further and more exact measurement with a light solder together with Dr. Cordt could be made in a well 10m away from PW 5. It is the only point with exact height comparison (elevation of PW5). A comparison of hydraulic heads H gives the following result:

Date 31.7.07: H=142.83m in GS Lassee and H=142.24m at the pump station PW5.

Thereafter the GW level in Lassee at point PW5 is about 60cm lower than at the hydrographical measuring point.

Also the well of GW remediation was measured for a comparison (with a tape measure). In the well Neustift 5 the level was approx. 3.3m u.GOK (12.6. and 31.5.). It has to be considered, that the permanent pumping affects a drawdown. The catchment area was determined 1993 of GEOdata. But the radius touches only a smaller part of the village around Neustift.

In the south of Lassee H(m) might differ in a (+-)10cm order and tend to coincide with the hydrographical point again.

Generally can be said that the GW level is quite high in Lassee. Inhabitants also report about flooding caused by rising GW in the area of "Josefsgasse" (PW5) and "Blumenweg" (south) (see street map Fig. 7-1). Just because of this problem 2 pump stations were built, but were not in use in the last years according to information of the municipality.

5.5.3.4 Assessment of influence of GW rise to the inflow

In Fig. 5-6 to Fig. 5-9 the curves for the years 2004 to 8.2007 show the strong coherence between inflow and GW-Level in many periods more detailed. In the curves for 2004 and 2005 it can be seen that a GW level rising over ~143.04m results in a remarkable increase of the inflow. Or vice versa, if the level drops this level, GW does not infiltrate any more as the inflow then stays comparable constant.

The overview of all years (Fig. 5-5) indicates at a first view superposing reasons for the rise of the inflow up to 1100m³/d until the June 18th 2006. Fig. 5-7 13 shows more detailed that H (m) reaches as well the highest level at this time. GW can infiltrate now in parts of the sewer system where it could not before. A critical level seems to be at 143.36m. If the GW rises over this value it infiltrates to an even higher amount.

Dropping GW level could vice versa result in waste water infiltrating the aquifer.

5.5.3.5 Exception: inflow from June 18th 2006 to the end of the year 2006

This period shows untypical low values when comparing the GW-level and inflow of the other years. In 2006 a GW level of ~143.22m results in only 500m³/d instead of ~700m³/d in 2004 and 2005. These low values seem to be questionable. The decrease at June 18th and increase at Dec. 13th as well as at Sept. 23rd are too drastic and cannot be explained with registered rain falls (see Fig. 5-7). The high values in August can be attributed to rain (see 5.5.2). In the time Δt = 19.6.06 to 13.12.06 the outflow is 8551m³/Δt higher than the inflow (see Fig. 7-2 Appendix).

The following reasons for the low values of the 2nd half 2006 could be e.g. possible:

1. The GW remediation was stopped in contrast to our information.

2. In this time a sewer part collapsed and the waste water trickled in the underground in an amount more than 200m³/d.

3. The IDM meter worked imölausible in this period so that the data is not explainable.

   The last point gets even more probable when comparing the electricity bills for the outflow pumps provided by the municipality Lassee with the pumped volume. The consumption in the 2nd half 2006 was with 2.800kWh similar to the 1st half 2006 with 2.825kWh. According to the IDM measurements a total volume of 167.258m³ in the 1st half 2006 had to be pumped and only 107.135m³ in the 2nd half 2006. This is not reflected by the electricity bills.

Summary: Besides of the 2nd half 2006 the high inflow periods 2004 to April 2007 are reflected very well in every small fluctuation of the rising GW level. Large parts of the sewer system are lying periodically within the first aquifer.

In Tab. 5-8 the periods of increased GW levels and the number of days within the years with plausible IDM data for further estimations in chapter 5.9.

Tab. 5-8: Estimation of days with a GW level in GS Lassee > 143.03 m.ü.A.

Year	Number of days with GW > 143.03 m.ü.A. and IDM-monitoring	Periods in general with GW > 143.03 m.ü.A
2004	242	14.1.2004 – 31.7.2004 18.11.2004 – 21.6.2005 6.10.2005 – 30.4.2007
2005	251	
2006 until June 17th	159	

Thrickling of waste water out of its part is very probably polluting the aquifer.

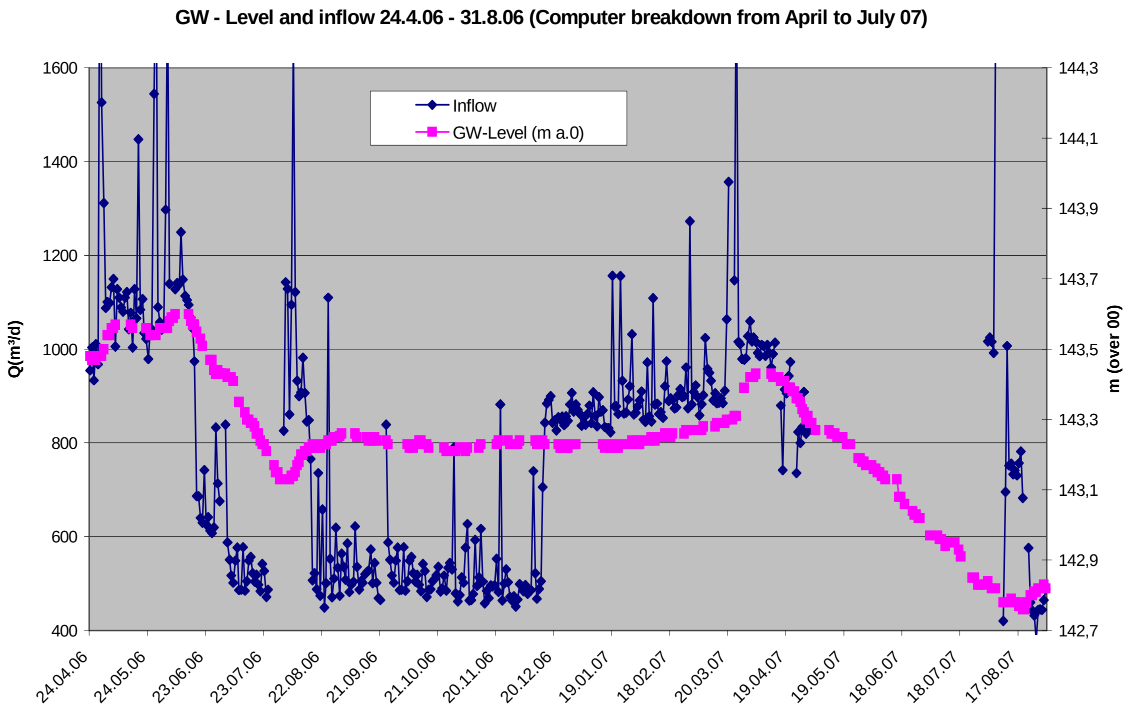

Fig. 5-6: GW level in comparison with the inflow from 24.4.2006 to 31.8.2007

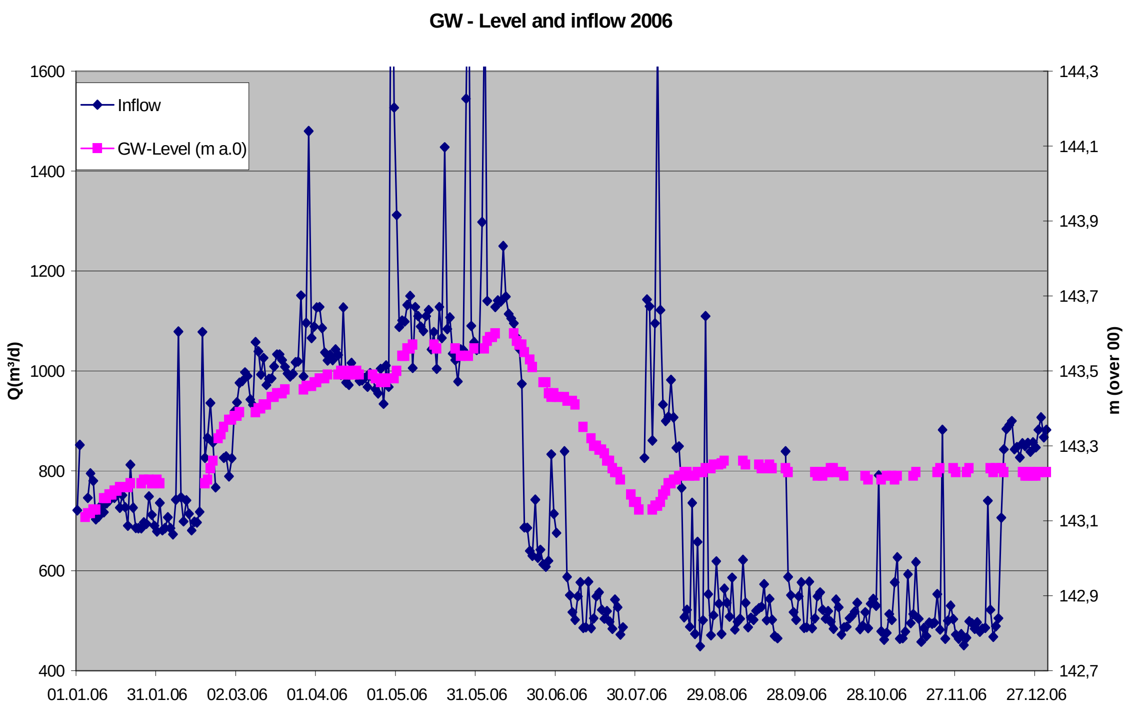

Fig. 5-7: GW level in comparison with the inflow of the whole year 2006

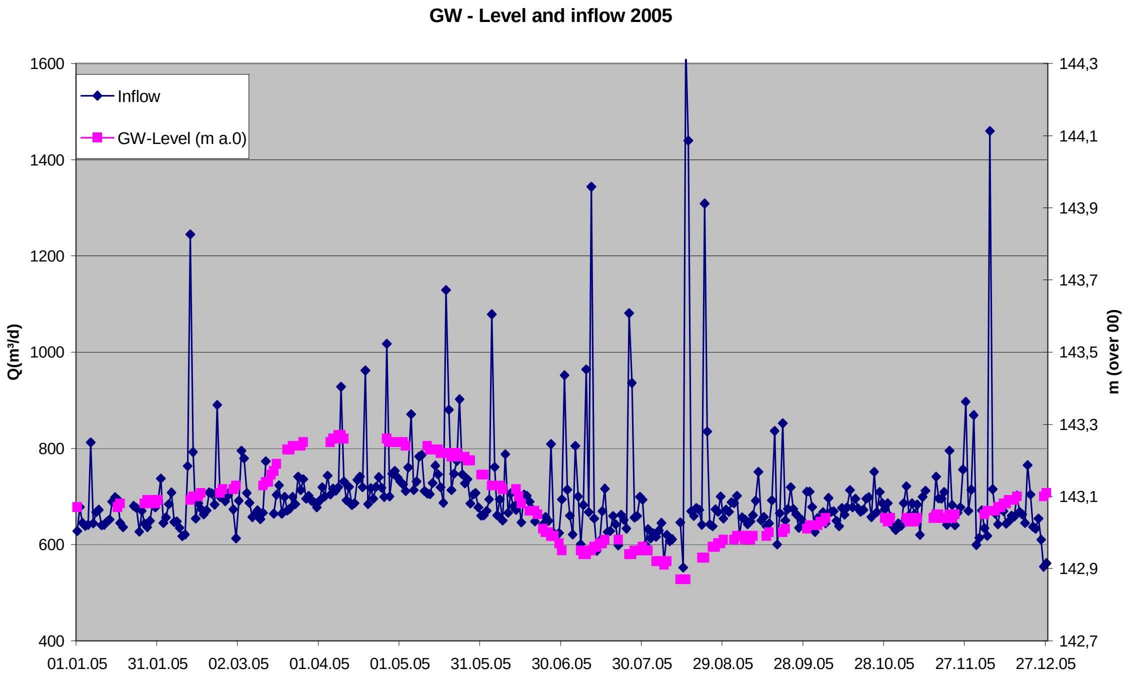

Fig. 5-8: GW level in comparison with the inflow of the year 2005

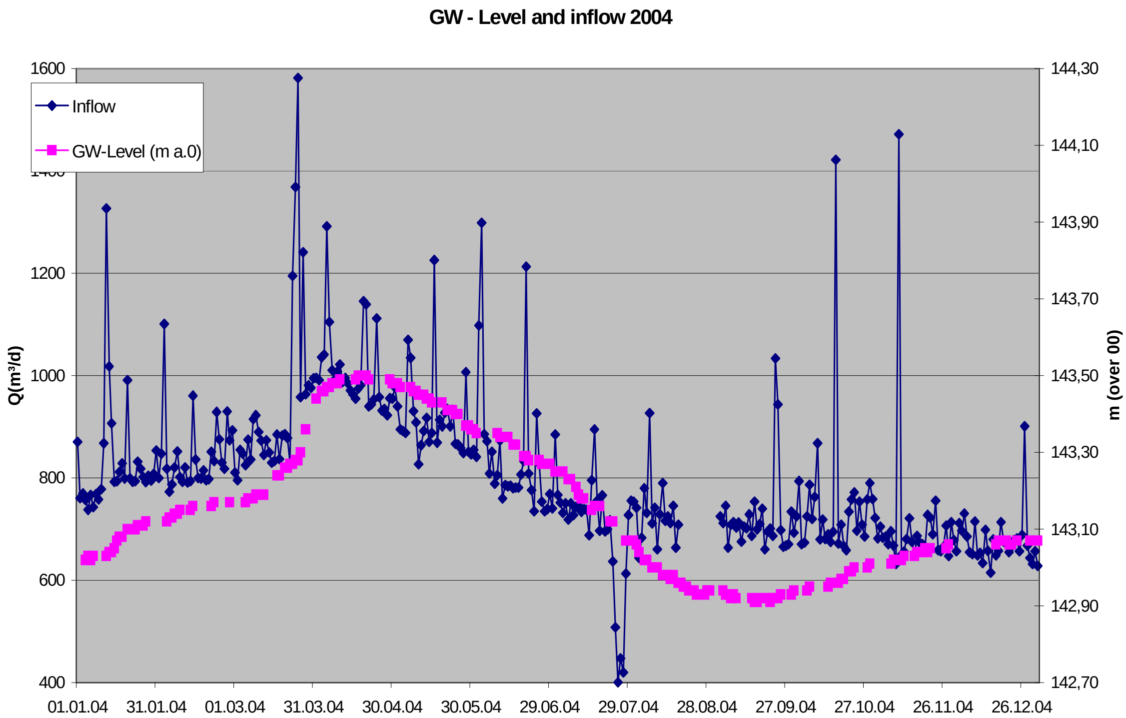

Fig. 5-9: GW level in comparison with the inflow of the year 2004

5.5.3.6 Inflow Temperatures T (in) and GW level

How temperatures T are corresponding with GW level is shown in Fig. 7-21, Fig. 7-23 and Fig. 7-25 (Appendix). Untypical low T (in) could be a further indicator for more GW. Fig. 7-21, Fig. 7-23 and Fig. 7-25 show each year GW level, T(in) and air temp. T (outs). The Figures allow no easy interpretation. T(outs) and T(GW) are superposing with waste water temperatures. T(GW) will also slightly rise with T(out). In own measurements May 2007 some well T(GW) were determined ranging between 11.9℃ and 14.6℃ (wells: WWTP, Jugendzentrum and Neustift 5).

The Figures show, that the T(in) behaviour is approximately the same every year. The curves are following T(out) until ~June, where they progress more slowly, reaching max value at 18.9℃ in August and min. values of 8.5℃ to 9℃ in February, March. In that time T(out) is already increasing, which can be a hint for GW infiltration.

The GW remediation will have a constant influence to T(in) as well.

5.6 Evaluation of the high loads from the monthly reports

5.6.1 Comparison between inflow and high loads

A data list for comparison of inflow, BOD5 and COD 2005 and 2006 friendly provided by the company Terrachem is shown in Tab. 7-2 and Tab. 7-3. Terrachem does the yearly control of parameters like described in the chapter 3.2. Inflow and loads are transformed to PE with an assumed water consumption of 200l/PE. PE values according to loads lower than to the one of inflow are indicated in the table with green colour, higher values with red and similar values with pink. A diagram in Fig. 5-10 shows an overview of COD and BOD5.

- **2005**: from the beginning of the year until the middle of June the load tends to be (much) lower than the according inflow. From 19 data points 2 points are higher and 3 similar. BOD5, COD reflect the real PE better than inflow does in the case of the WWTP Lassee. In the second half of the year with 21 data points the PE for the loads tend to be higher than the inflow. Here 11 are higher and 4 similar. From the 6 lower ones are 4 in December. This marks a trend for lower organic loads compared to the inflow in the winter and spring time which could be a further argument for GW infiltration due to level increase. (In all this it was assumed that GW infiltration by the remediation is constant over the whole year).

  At August 7th and October 2nd the loads are significant higher. Outliers could be explained e.g. with illegal discharge, sewer wash outs by rain or errors in sample analysis. In average the PE values according to the loads are corresponding with the PE values according to the inflow. Fig. 7-28 (Appendix) shows the trend of rising PE of loads until August, staying high then until October.

- **2006**: A similar picture was observed for 2006 except of one extreme value with ~17.000PE in April.

- **2004** 3 data points are higher than the inflow, no trend to see.

In the Appendix Fig. 7-27 to Fig. 7-29 show the organic loads together with the inflow for the years 2004 to 2006 corresponding in this case to 150l/PE*d. In 2004 organic loads are reflecting best the discharge per day of theoretical PE. They are laying much below the corresponding inflow. In average in 2004 the inflow is ~2800PE higher per day (see Tab. 5-9). In 2005 the inflow is in average ~1430PE higher per day and in the first half of the year 2006 ~3200PE. The inflow data of the 2nd half 2006 is probably erroneous from June 18th on (chapter 5.5.3.4.). The strong fluctuations of the loads in 2005 – in contrary the inflow is not differing much - are good to see in Tab. 7-2. Between the end of June to the end of October the loads are corresponding with the inflow volume the best.

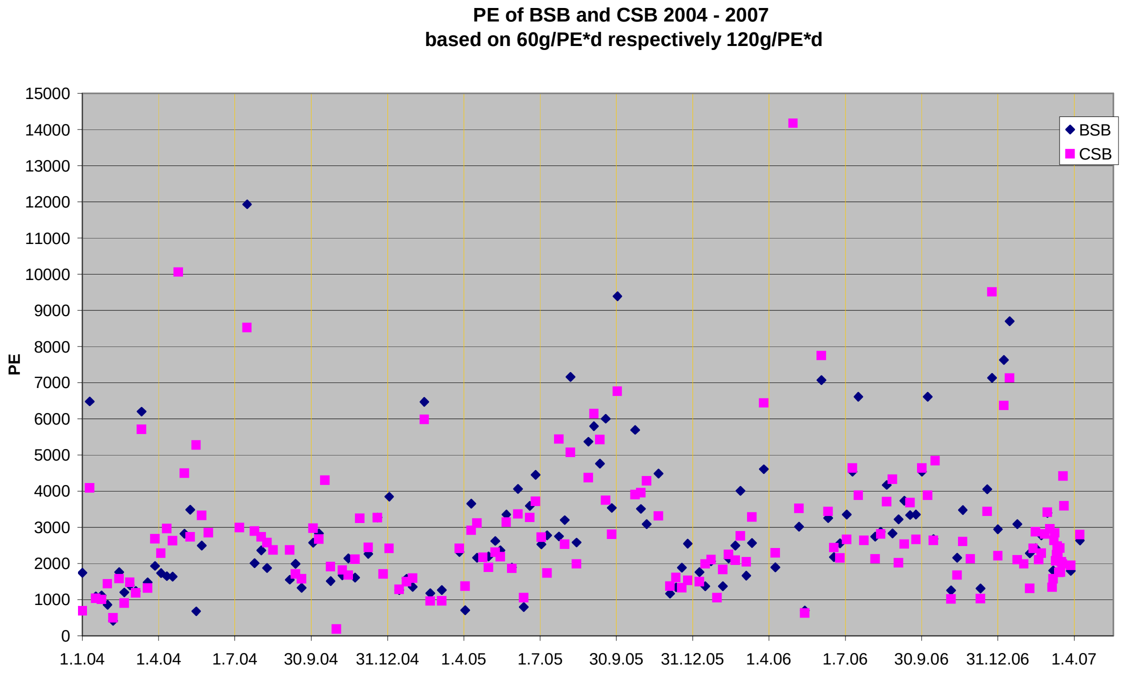

Fig. 5-10: PE of BOD5 and COD 2004 – 2007 based on 60g/PE*d respectively 120g/PE*d

In the 3 years the COD loads slightly rise in median from 2440PE (2004) over 2530PE (2005) to 2630PE (2006) per day. Some errors in sample analysis or data input yielded probably in some cases to higher BOD5 than COD values (see Fig. 5-10).

Different sources of (additional) discharge can be expected. Wrong pipe connections between sewer and rain channels are possible as well. It is worthwhile to look to the fabrication period of the cannery in the years 2004 to 2006. If the most intensive period is after harvest times, it might fall into the listed period of comparable high load values. The cannery has allowance to discharge into the rain channel – 10m³/d and max 30l/sec.

Tab. 5-9: Comparison of inflow (according to 0.15m³/PE*d) and organic loads for the years 2004 to 2006 by subtracting the loads from the inflow equivalent to PE

	PE inflow - PE BOD 5			PE inflow - PE COD		
	Average	Max	Min	Average	Max	Min
2004	3092	7499	-5966	2634	5122	-3672
2005	1276	3967	-5217	1634	3748	-2583
2006, 1.half	3571	6258	1520	2981	6330	-3996
2006, 2.half	710	4562	-3132	1003	5174	-1586

Henze et al. (1996) give values for organic pollution in vegetable canneries waste water of 680 to 4250g BOD5/m³, depending on the type of vegetables. When discharging 10m³/d BOD5 loads of the cannery could be in the range of 6.8 to 42.5 kg/d. This corresponds with 113 to 708 PE (60g BOD5/PE*d). When discharging the max permitted 30l/sec over an arbitrarily assumed time of 1h the load would be between 72,5kg and 459kg. According to the WRG the cannery is listed with an own 3 chamber WWTP.

5.6.2 Investigation if high loads can be allocated to special days

One first investigation of the high COD and BOD5 loads 2004 – 2007 was to look, if they can be connected to special week days, e.g. Sunday. If high loads could be connected with additional discharge, maybe a special day would be preferential. After an information of the mayor there were complaints about bad odours in the area of Bahnstr., Ringstr., especially at the weekends.

Measurements of the chemical parameter COD were done in the laboratory of the WWTP Lassee according to Austrian standards at least 2 times per month. One can see in Fig. 5-11 that samples were taken mostly on Sundays. For reasons of better presentation Thursday was left out in the diagram. Anyway only 5 data points exist, which are furthermore below 3.000PE. Loads were calculated in PE and are ranging between 200PE and 10.700PE (150l/PE*d).

High loads cannot be allocated to special days. The analyze frequency is too low besides Sundays when 80% of the sample were taken for analysis. On Friday e.g. are 2 from only 6 data points (2004) higher than 5.500PE. From 10 data points for Saturday are 2 points very high, one with 8000. Exceedances of the theoretical 2.900PE (according to Tab. 5 2) appear on all week days.

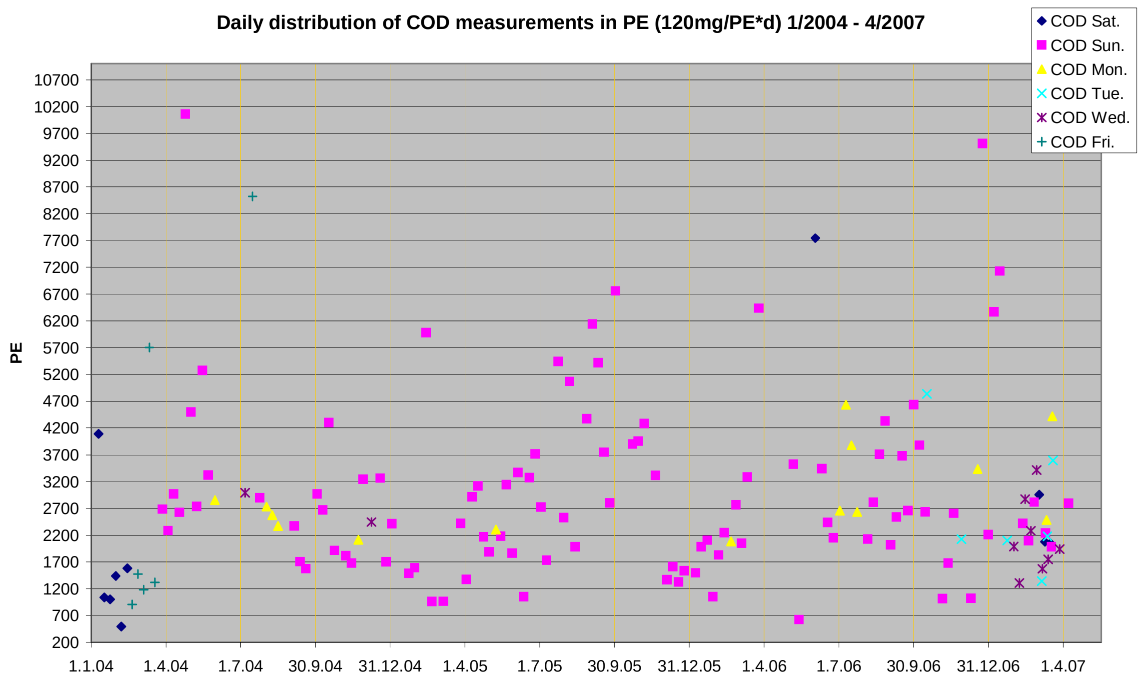

Fig. 5-11: The daily distribution of the measurements. They were mostly done on Sundays

5.6.3 Organic loads of the WWTP Lassee in comparison with other studies

In chapter 3.5.1 the deviation of measured loads in (g/PE*d) with design loads (see Tab. 3-4 and Tab. 3-5) were discussed. In the study of Goetz (2007) loads in (g/PE*d) could be estimated through the accurate knowledge of personal equivalents (PE) of the municipalities. Investigations in COD discharge of this 5 villages in Lower Austria (<1000PE) resulted in average in values smaller than 84g/PE*d (Tab. 3-6) for 85% of all data. In its WWTP also extreme values were measured, once with a max of 700g/PE*d.

Each particular WWTP had the following averaged COD loads for the years 2000 to 2004: 86.6 g/PE*d, 74.8 g/PE*d, 70.1g/PE*d, 118.3 g/PE*d and 69.1 g/PE*d

Tab. 5-10 and Fig. 5-12show the values for the WWTP Lassee. The limit for 85 % of data is 200g/PE*d. Compared with the other WWTP the values are unusual high. A maximum value is reached with 660g/PE*d and average BOD/COD=0.5.

Tab. 5-10: COD loads 2004 – 2006 WWTP Lassee (according to PE=2580 of Tab. 5-3)

Number of data points		157
data points	<= 120 g/PE*d	83
data points	121 - 300 g/PE*d	67
data points	301 - 660 g/PE*d	7
discharge of 85% <=		200 g/PE*d
average discharge of 100%		139 g/PE*d
median discharge of 100%		120 g/PE*d

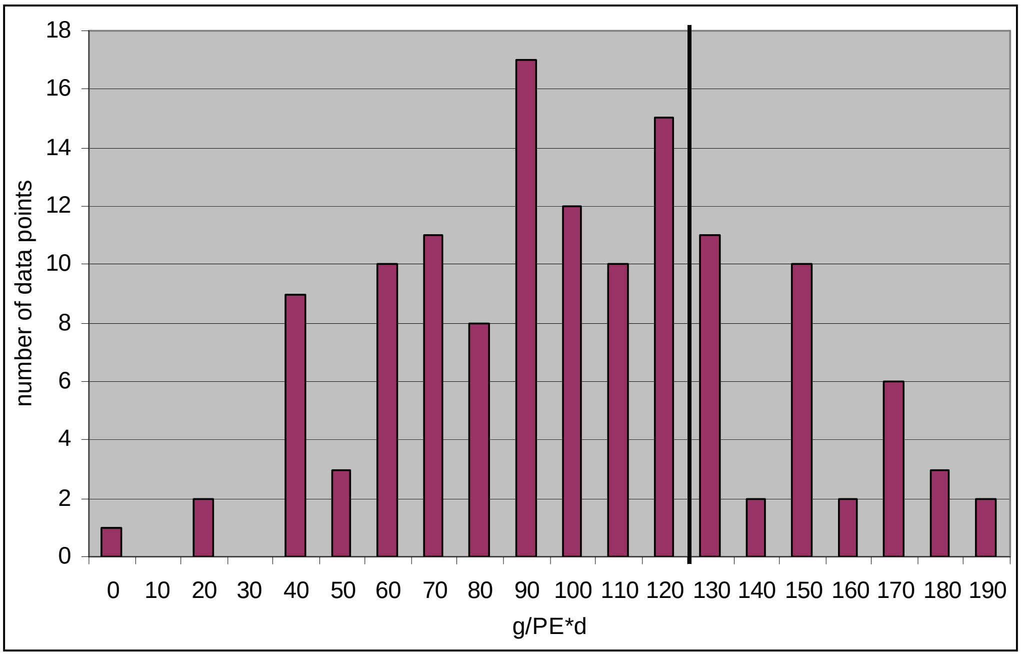

Fig. 5-12: 85 % frequency distribution of COD loads of data points 2004 –2006 WWTP Lassee; the bold black line indicates the design value of 120g/PE*d

5.6.4 Ammonium and phosphate loads 2004 – 2006

To evaluate the ammonium and phosphate loads of the WWTP Lassee the conversion factor for P/PO4-P and N/NH4-N had to be found according to the design loads of P=1.8g/PE*d and N=11g/PE*d (see chapter 3.3). Lindtner and Zessner (2003) (see chapter 3.5.1) assessed these factors with:

P/PO4-P= 1.56 and N/NH4-N= 1.7

Comparison the concentrations of TKN and NH4-N, P and PO4-P in (mg/l) of the WWTP Lassee inflow sample taken from 24.5. – 15.6.07 and analyzed at the laboratory of the BOKU institute resulted in average in:

P/PO4-P= 1.29 and TKN/NH4-N=1.78 (see Tab. 7-4)

For N the factors are quite similar, but the P factor is differing remarkable. Because the IDM monitoring was not working the results of the sample analysis could not be transformed to g/PE*d. This is a pity because no conclusion could be made if the P-discharge is really according to the design value of P=1.8g/PE*d. The investigation of Lindtner and Zessner (2003) show that the average value of P-discharge in 76 investigated WWTP in Lower Austria is lower with P=1.6g/PE*d. The investigated N discharge was congruent to the design value (see chapter 3.5.1). For the calculation of the phosphate loads according to the monthly reports in (PE) it had to be decided which of the values for the P discharge and conversion factor should be taken. Tab. 5-11 shows the differences.

Tab. 5-11: Differences in estimation of PO4-P (PE) due to the uncertainties of the basis values (g/PE*d)

	Factor	If P=1.8g/PE*d (design value)	If P=1.6g/PE*d (Lindtner 2003)
	P/PO4-P	PO4-P (g/PE*d)	PO4-P (g/PE*d)
Lindtner and Zessner (2003)	1.56	1.15	1.026
WWTP Lassee samples	1.29	1.395	**1.24**

The basic value of 1.24g (PO4-P)/PE*d was chosen presented in Fig. 5-13 considering the frequency distribution of the PO4-P discharge in g/PE*d shown in Fig. 5-15. This diagram was calculated similar to Fig. 5-12 (COD) with a PE of 2580 and the average discharge is 1.24g/PE*d.

For the calculation of the ammonium loads according to the monthly reports in (PE) the factor TKN/NH4-N=1.78 was chosen wherein TKN=11g/PE*d leading to 6.2g (NH4-N)/PE*d.

The PE values for PO4-P and NH4-N are drifting apart from each other. In Fig. 5-14 PE values for PO4-P and COD values are compared showing a better congruence. The two “outliers” of PO4-P >4900PE are both reflected in extremely high COD values which are again e.g. at Apr. 30th 2006 much higher: COD=14170PE and PO4-P=7130PE. At this day the NH4-N discharge is not exceeding (1380PE).

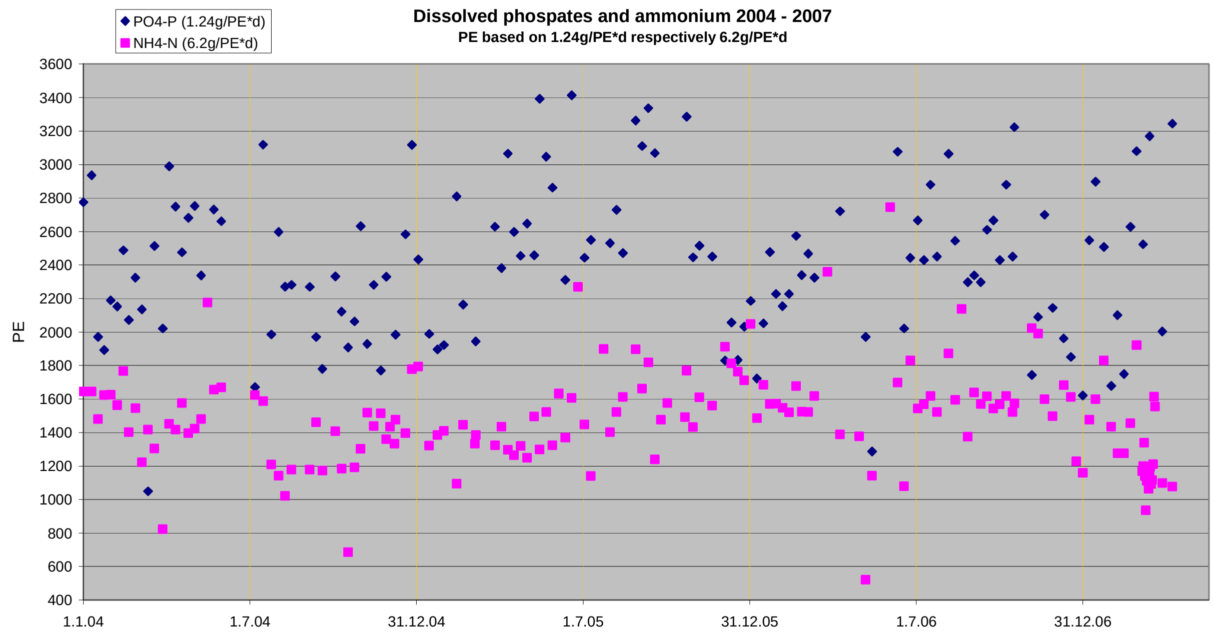

Fig. 5-13: Personal equivalents for ammonium and phosphates in comparison; for reason of better visibility the upper limit is 3600 PE; for values of PO4-P more than 3600PE see Fig. 5-14.

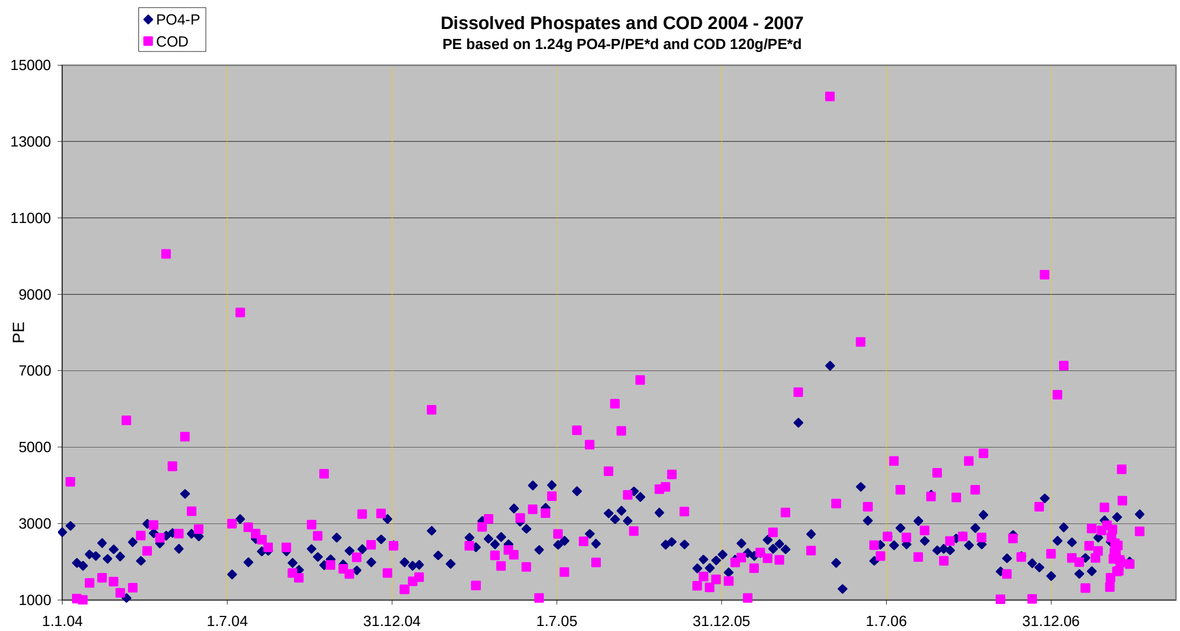

Fig. 5-14: Personal equivalents for phosphates and COD in comparison

Fig. 5-14 shows a frequency distribution of all available PO4-P values (in g/PE*d). One outlier (3.6g/PE*d) has been cut because of better presentation. If compared with the other investigation in NÖ WWTPs (Goetz, 2007) the phosphate loads lay slightly higher in Lassee. Goetz` statistical evaluation for 3 WWTPs in the years 2000 to 2004 shows average P_{tot} concentrations for the inflow of 1g/PE*d, 1g/PE*d and 1.16g/PE*d. Total phosphorus is in average is 1.29 times higher than dissolved phosphates like discussed before. Regarding to Fig. 5-15 PO4-P = 1.23 g /PE*d in average in Lassee, so probably P_{tot} =1.6 g/PE*d. In Fig. 5-16 the frequency distribution of ammonium is presented. Here NH4-N is rather too low than too high compared with other studies. When looking to these values it can be assumed that the theoretical values of 6.2 g NH4-N/PE*d like discussed before is still too high.

The study of Goetz (2007) shows N_{tot} loads in average of 5.2 g/PE*d, 7.3g/PE*d and 5.4 g/PE*d for three different WWTP. With the factor N/NH4-N=1.78 ammonium can be calculated to 2.92 g NH4-N/PE*d, 4.1 g NH4-N/PE*d and 3.03 g NH4-N/PE*d. The average discharge of NH4-N= 3.64 g/PE*d in Lassee are reflected in these values.

Comparison of N and P loads with the study of Lindtner and Zessner (2003) (chapter 3.5.1, Fig. 3-3 and Fig. 3-4) show the following results:

The ratio of P/PE for Lassee is approx. E/EW=0.6. Average N_{tot} lays between 5.5 and 6.2g N/EW (depending on the multiplier of NH4-N) and average P_{tot} ~ 1.6g P/EW. In Fig. 3-3 Lassee N_{tot} is to find under or at the lower, dashed line which represents values without any industrial share. P_{tot} of Lassee on the other hand is to find slightly above the regression line of Fig. 3-3 representing values with industrial discharge.

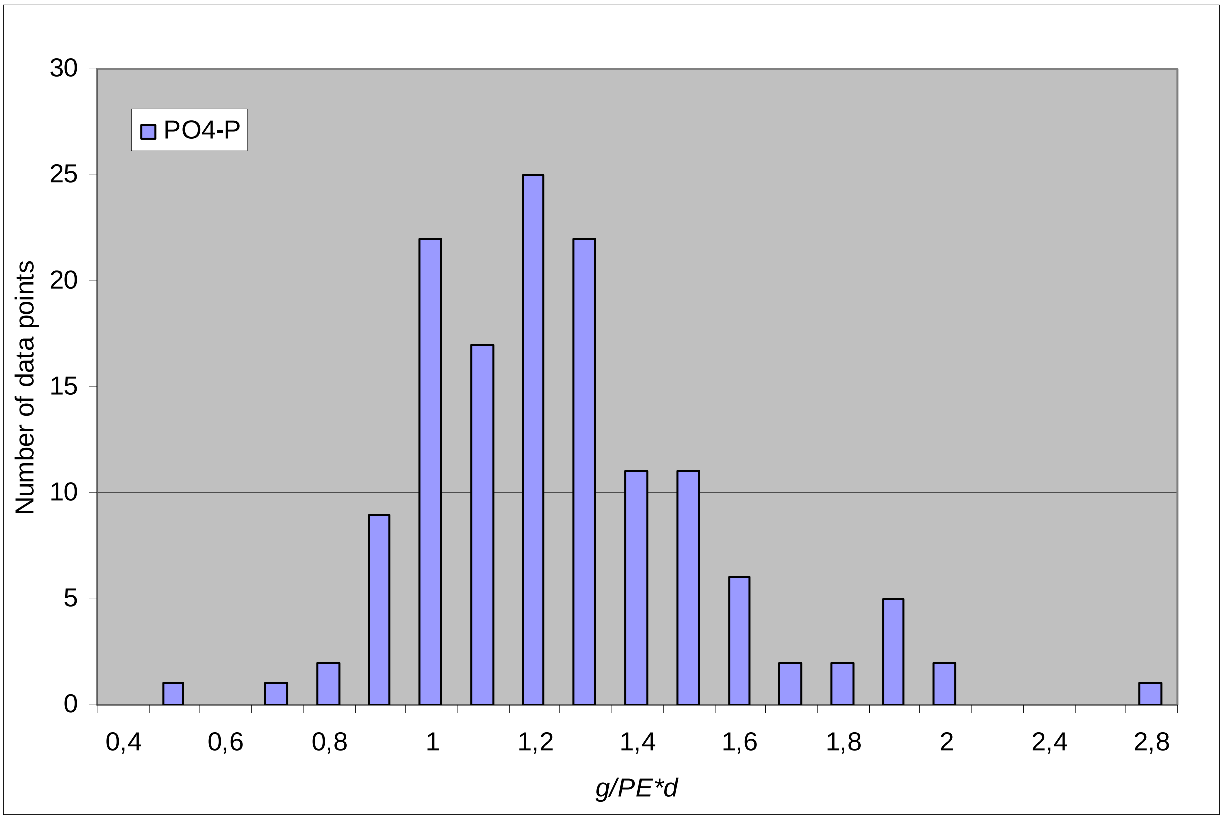

Fig. 5-15: Frequency distribution of PO4-P loads 2004 –2006; the average is reflecting the theoretical value like discussed above of 1.24g/PE*d

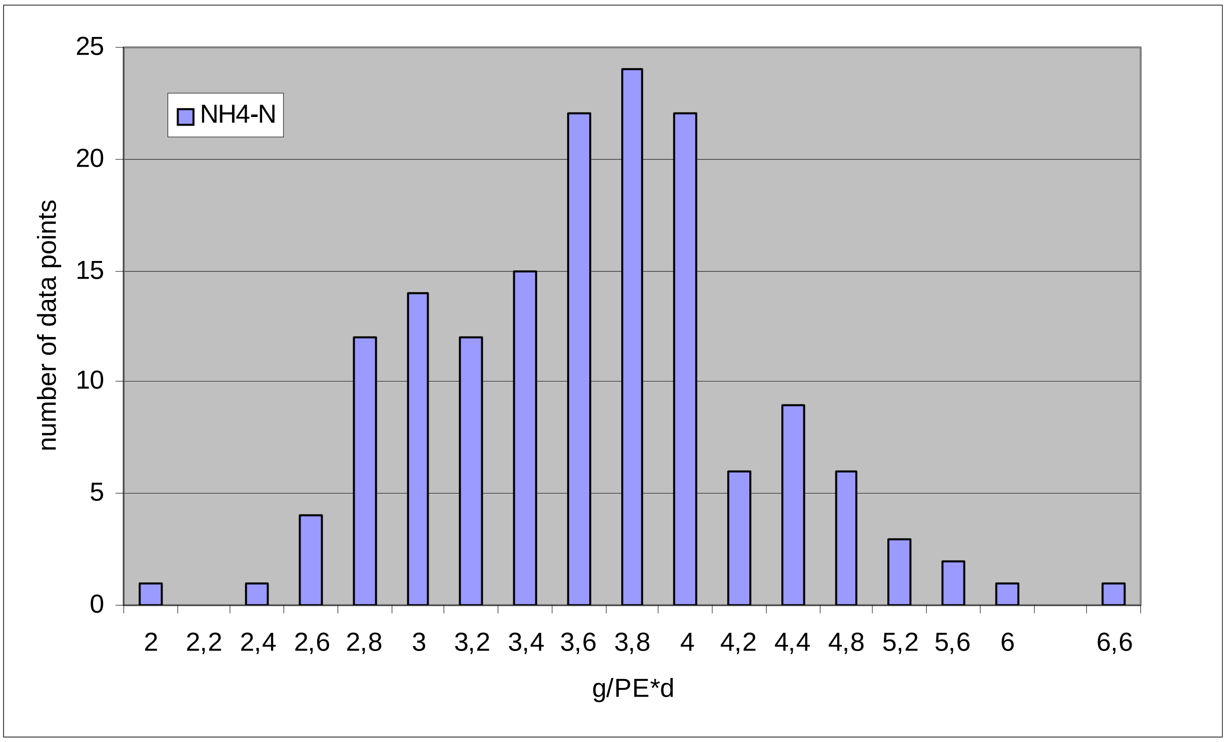

Fig. 5-16: Frequency distribution of NH4-N loads 2004 –2006; all values are below the theoretical value like discussed of 6.2g/PE*d

5.6.5 NH4-N/PO4-P ratio

Like discussed in chapter 3.5.1 the NH4-N/PO4-P ratio can be an indication of the origin of the waste water. For domestic waste water the ratio should lay between 4.9 – 6.7 (Lindtner and Zessner, 2003). As producer of ratios below < 4.9 they identify mainly the food industry in their studies. Fig. 5-17 shows the frequency distribution of the ratios in Lassee. One can see that the ratio is very low. 50% of all values are < 3. Another interesting point is the coherence of the ratio with the COD values. Tab. 5-12 shows that very high COD values can be referred to very low ratios.

Tab. 5-12: Organic loads in comparison with the NH4-N/PO4-P ratio from Jan.2004 to Apr.2007

NH4-N/ PO4-P ratio	Number of data points of COD according to the ratio				
	50-100 (g/PE*d)	100-200 (g/PE*d)	200-250 (g/PE*d)	250-300 (g/PE*d)	> 300 (g/PE*d)
< 3	13	38	6	6	6
3 - 4	27	23	3	1	0
4 - 5	12	2	0	0	0
> 5	2	1	0	0	0

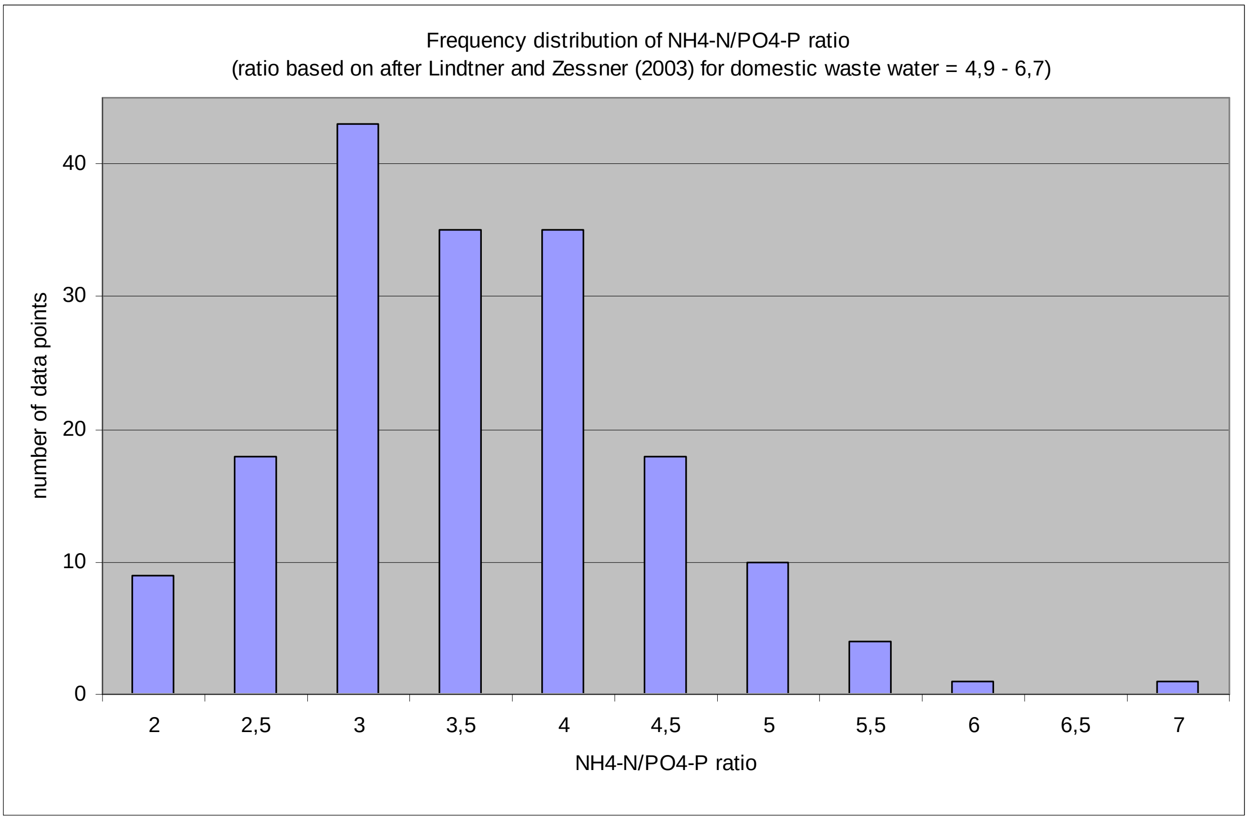

Fig. 5-17: Frequency distribution of the NH4-N/PO4-P ratio in the WWTP Lassee from Jan. 2004 to Apr. 2007

Fig. 5-18: View into the manhole PW 8

5.7 High loads in comparison with precipitation

Extreme loads of monthly reports 2004 to 2006 where picked out and compared with inflow and precipitation at these days. This was done to see if rain increases the loads for example by out washing of the sewer. To involve eventually retention times of the rain amount three more days were taken for comparison for each data point of loads. Bold fonts indicate the maximum values. For the PE calculation the conversion factors (g/PE*d) like discussed were taken.

Tab. 5-13: High loads in comparison with rain events 2004 – 2006 (numerical data given in German)

Date		**BOD**	**COD**	**PO4-P**	**NH4-N**		**Inflow Qd**			**Precipitation**
		(60g/PE*d)	(120g/PE*d)	(1.24g/PE*d)	(6.2g/PE*d)		(0.15m³/PE*d)			
		(PE)	**(PE)**	**(PE)**	**(PE)**		**(PE)**	**(m³)**		**(mm)**
23.4.04	Fri.						6.360	954		4,5
24.4.04	Sat.						**7.413**	1.112		1,9
25.4.04	Sun.	no value	10.059	2681	1395		6.387	958		0
26.4.04	Mon.						6.213	932		0
14.5.04	Fri.							871		0
15.5.04	Sat.							888		12,8
16.5.04	Sun.	674	5.272	3.777	2.175			1.226		0
17.5.04	Mon.							869		0
15.7.04	Sat.						5.307	796		11,1
16.7.04	Sun.	**11.933**	8.525	3.118	1588		**5.967**	895		0,5
17.7.04	Mon.						5.307	796		0
5.8.05	Fri.						4.193	629		0
6.8.05	Sat.						4.300	645		0
7.8.05	Sun.	7.159	5.066	2729	1522		3.767	565		0
8.8.05	Mon.						4.133	620		2
30.9.05	Fri.						4.733	710		0
1.10.05	Sat.						4.520	678		0
2.10.05	Sun.	9.390	6.756	3.695	1575		4.173	626		0
3.10.05	Mon.						4.367	655		4
28.4.06	Fri.						6.453	968		0
29.4.06	Sat.						**13.987**	2.098		**36**
30.4.06	Sun.	no value	**14.176**	**7130(max)**	1377		10.180	1.527		20
1.5.06	Mon.						8.840	1.326		8
1.6.06	Thu.						6.967	1.045		
2.6.06	Fri.						8.653	1.298		7
3.6.06	Sat.	7.068	7.745	3.962	**2745(max)**		**11.780**	**1.767**		**28**
4.6.06	Sun.						7.600	1.140		
23.12.06	Sat.						5.667	850		0
24.12.06	Sun.	7.133	9.509	3.659	1229		5.707	856		0
25.12.06	Mon.						5.587	838		0

Remarkable that BOD5 is higher than COD in 3 of 6 cases. No explanation besides of mistakes in measurement or notice can be found. At May 16th COD is 8 times higher than BOD. In 5 of 8 cases of high loads there were precipitation events. When looking to the values it can be concluded that heavy rain events seem in any case to reinforce the high inflow of loads.

The experiment has been done vice versa (Fig. 5-19). Precipitation events and dry days were compared with loads over 2500 PE (underlying 150l/PE*d and 120g COD/PE*d). No further distinctive features besides of the one already discussed can be identified with rainy days.

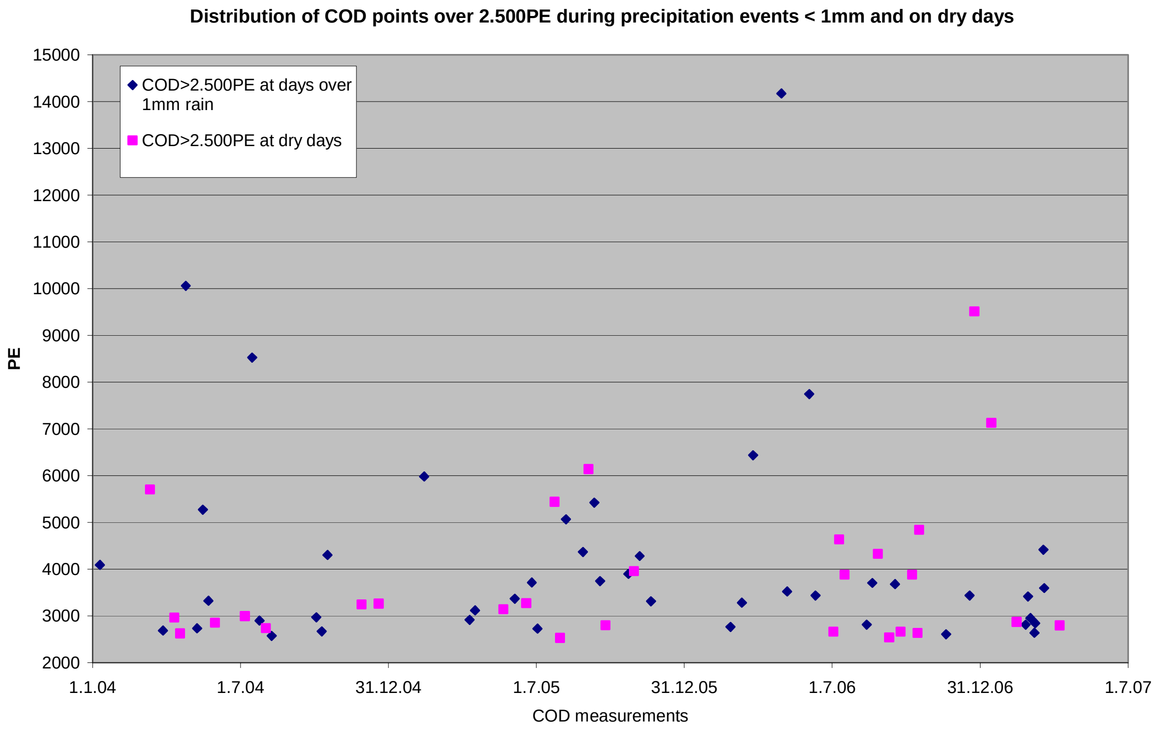

Fig. 5-19: Dry days and rainy days in comparison

5.7.1 Results of this data analysis

COD concentrations of the years 2004 – 2007 are much higher than “normal”. Compared with the Goetz study (2007) the average value of 139g/PE*d is 1.66 times higher. The median value of COD reflects the design value.

PO4-P with the average value of 1.23 g/PE*d is ~1.52 times higher. NH4-N with the average value of 3.64 g/PE*d reflects the comparison values. The NH4-N/PO4-P ratio is compared with the “normal” ratios of domestic waste water of 4.9 to 6.9 (Lindtner and Zessner, 2003) very low (see Fig. 5-17). Nearly 50% of all values are < 3 and 88% < 4. Lindtner and Zessner (2003) refer low ratios in their studies to the food industry (chapter 3.5.1). Compared with the evaluation of Lindtner and Zessner (2003) of typical domestic loads in Fig. 3-4 the Lassee loads of N_{tot} are on or respectively under the dashed line representing values to be expected when there is no trade and industry. On the other hand P_{tot} is laying in the array of industrial mixed waste water.

All extreme outliers of COD are corresponding with the low NH4-N/PO4-P ratio <3 (see Tab. 5-12).

The most extreme cases of high COD concentrations can be correlated with heavy rain events. Vice versa the comparison of dry with rainy day loads from 2500PE to 9.500PE show an equally distribution (Fig. 5-19).

Because nearly all sampling was done on Sunday no further statement can be made over the accumulation of high loads on the other week days.

Comparing the dates of sampling with the sludge dewatering days excludes the sludge press as a cause for high loads. Samples were never taken during this time.

Most simple reason might be the reflow of parts of the surplus sludge via an overflow in the sludge tank to the filtrate storage, causing high loads when reloaded into the system again, of course only in case this is in front of the sampling point.

High loads during heavy rain periods indicate washing outs of the sewer. Sewer deposits could as well be the cause of high loads due to illegal discharges. Anyway, chemical composition of sewer deposits is said to be indeterminable in its chemical composition. It undergoes unknown temporal changes in its physical and chemical properties.

At least one can assume that the additional loads in the waste water of Lassee are not dominated by domestic waste water.

5.8 Measurements from May to August 2007

5.8.1 Meter readings of the pump stations

In the Appendix the results of the meter readings are listed for all days and pump stations wherein the midday consumption was multiplied to kWh/4h and the daily consumption to kWh/24h Fig. 7-34 and Fig. 7-35.

In Tab. 5-14 the average values of electricity consumption of the 6 pump stations are shown according to Fig. 7-34 and Fig. 7-35 are shown. The average values are divided in 3 reading periods:

- From 23.5. – 15.6.: before funnel cleaning and before PW 8 meter failure, dry and hot period
- From 28.6. – 11.7. and 12.7.:
    - only reliable period for the readings of PW 8 due to the meter problems described in chapter 5.3.
    - including the two days with the “special measurements”: the heavy rain events (2.7. and 12.7.) and the one day definitely known (by own observations) without GW pumping (12.7. as well)
- From 7.8. to 10.8. and 11.8. – 20.8.: readings done by the municipality workers (at 8am) after fixing 2nd PW 8 meter failure; according to GEOdata GW pumps were stopped until 10.8.; rainy period

Tab. 5-14 shows at a first glance the differences between the average electrical consumption over the three periods and the consumption at the “special measurements days” (heavy rain and with/without GW pumping).

The rain “storms” at July 2nd lasted 20min and at July 12th around 30min (own observations). The time span of readings are shown detailed in Fig. 7-34 and Fig. 7-35. At July 12th two different readings were made: one before and one after the heavy rain. According to these different readings Tab. 5-14 shows for July 12th the differences in electricity consumption once caused by GW pumping and once by heavy rain. Pump stations not affected by the GW pumping are listed in cursive font. According to own observations the pumps were stopped between July 10th and July 11th, according to the information of GEOdata until August 10th. Stopping of the GW pumps according to this information is not reflected in the August readings in contrary to the clearly drop down of inflow at July 12th. For the assessment of the GW remediation infiltration to the sewer only the readings of July 12th of PW 7 and PW 8 are reliable.

Tab. 5-14 further shows that the influence of the funnel cleaning on the pump power is rather low.

All rain events in the measurement period are listed in Tab. 5-18. For comparison reasons the flow Q in this span was multiplied to 24 hours. Most extreme values after rain are in PW 6 with around 6 to 7 times the average flow volume and in PW 5 with around 3 times more. Because both have the same transport line the rain water discharge is superposing in PW 6. The impact of rain from day to day can be better seen in the Fig. 7-6 to Fig. 7-19 (Appendix).

Tab. 5-14: Average values of counter readings calculated to 24h for comparison

Metering in average in [kWh/d] (of day to day readings)					
	own readings			**read. of comm. workers**	
		after funnel cleaning	no GW pumping, (own check)	Info of Geodata:GW pump stopped till 10.8. (no own check)	
Periods	23.5. - 15.6.	1.7.-11.7.	11.-12.7. 15:00 - 15:00	6.8.- 10.8.	10.8. - 20.8.
PW 3	1,71	1,98	*1,51*	1,57	1,71
PW 4	0,99	1,29	*0,98*	1,19	1,14
PW 5	0,24	0,25	*0,22*	0,37	0,29
PW 6	0,71	1,2	*1,65*	1,57	1,46
PW 7	4,47	4,97	2,28	5,48	5,36
PW 8	24,73	11,68	7,3	25,09	25,31

Metering in average in kWh/d of readings by day own readings all calculated to 24 h					
variying daytimes (~10:30 to 17:00)		after funnel cleaning	no GW pumping, (own check)	extra readings after heavy rain events	
Periods	23.5. - 15.6.	1.7. and 3.7. to 11.7	12.07.2007 11:30-15:00	02.07.2007 16:00 - 18:00	12.07.2007 15:00 - 16:40
PW 3	1,87	1,95	*2,22*	3,54	1,82
PW 4	1,06	1,07	*1,07*	2,97	1,52
PW 5	0,25	0,3	*0,3*		0,86
PW 6	0,74	1,64	*1,89*	7,56	7,12
PW 7	4,28	5,64	2,71	7,47	4,32
PW 8	24,17	9,55	6,78	12,71	10,73

5.8.2 Transferring meter readings [kWh] to pump volume [m³/d and m³/4h]

To transfer the energy used into the pumped volume a pressure gauge was used like described in chapter 4.5.2. In the beginning and at the end of the measurement the meters were read. Out of the curve one now has to find the water column which is pumped.

In Fig. 5-20 and Fig. 5-21 typical curves of the measurement are shown. The time interval is once 4h in PW 4 and in the next Figure 20h in PW4. In this example the sampling rate was 1min. In other measurements it was 30sec.

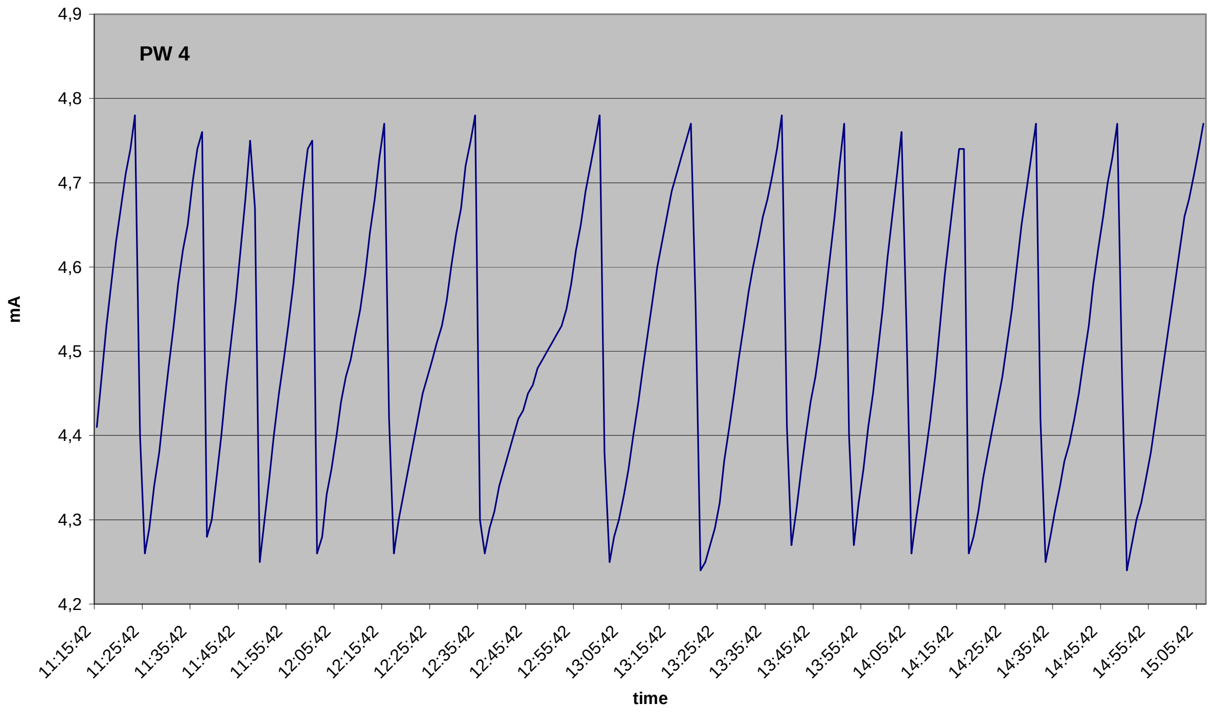

Fig. 5-20: Typical pumping cycles measured with the pressure gauge in PW 4

In the curve interpretation are several problems. The power used is normally for every pumping cycle the same, but there are exceptions. Longer pump times (which occurred rather seldom) indicate, that more water is pumped. Or the pumps suffer under clogging. The amplitudes of the curve are not always exactly the same. One simple reason is that the sampling rate does not exactly meet the whole pump column. Another that the sensor is not fixed and moved by turbulences in the water changing in depth. It also can be influenced by other things than water causing additional pressure. Anyway, the curves can be interpreted in the following way: Assuming that the sampling rate does not really reflect in every wavelength (cycle) the true min and max [mA] one can make the assessment that the maximum of representing amplitudes series with the mostly straight line downward is taken as the true water column being pumped per cycle looking for the true max and min optically.

Example of Fig. 5-20: Representing amplitude is 4.78[mA] – 4.26[mA] = 0.52[mA]. Convert to pressure height [m] with the formula above result in a water column of 0.325m. The dimension of PW4 is a 1m radius cylinder, so the pumped volume is 1.02m³/cycle. Now one has just to count the cycles in the time interval, in this case 15. So the pumped volume is 15*1.02 = 15307m³ in 231min. In this time the electricity consumption was 0.25 kWh. V [m³] / 1 [kWh] = 15.307m³ / 0.25kWh = 61.23 m³/kWh in PW4.

In Tab. 5-15 the results of the calculation for each pump station are presented in [m³/kWh]. Additional measurements with the pressure gauge have been made for 5 of the 8 PW. The results differ in parts which indicates, that the same amount of electricity does not exactly move the same amount of waste water. Especially in PW7 the differences are big caused probably by clogging. Its pumps are very old as well. In PW 5 the sampling rate was to low in the measurement from July 2nd to July 3rd and the result can only be used in comparison of transported water column per pump cycle ($\Delta H[m]$), which is quite identical for both measurements. The discharge to PW 5 is quite low in water but high in waste as known from own observations, so the probability of pump clogging is high. For the transfer of the meter readings the results indicated in bold were used. These values are thought to be the most valid.

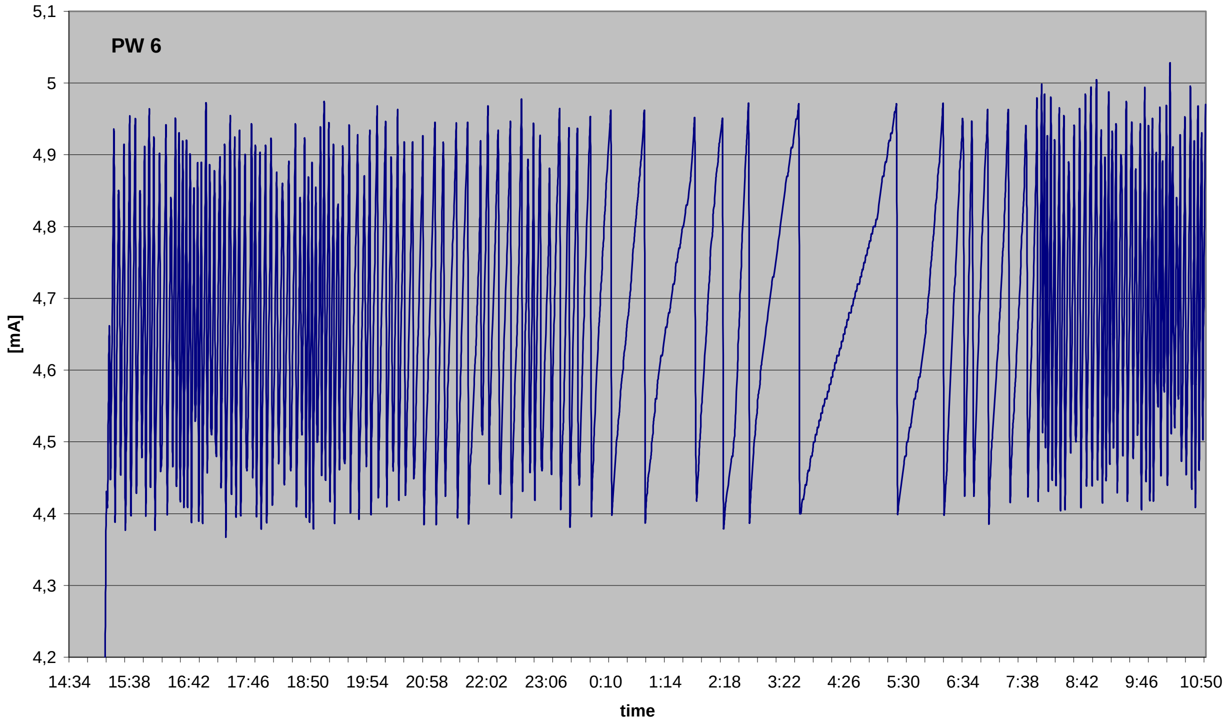

Fig. 5-21: Another example of pumping cycles measured with the pressure gauge in PW 6

Fig. 5-22: View of the manhole no. PW 5

Tab. 5-15: Analysis of pressure sensor measurements in the 8 pump stations

	Calculation of the Pump Volume									
Pumpstation ID	Date 2007	Start	End	timespan Δ t(min)	Pump cycles	Sample rate [sec]	Amplitudes in [mA] min	max	Difference/cycle Δ I [mA]	Δ H[m]
PW 1	9.7.-10.7.	15:52	10:18	1106	17	30	4,55	4,84	0,29	0,181
PW 2	10.7.-11.7.	10:31	10:59	1468	31	30	4,67	5,37	0,7	0,438
PW 3	23.5 -24.5.	17:26	12:42	1156	74	60	4,91	5,3	0,39	0,244
	24.5.	13:18	17:22	254	15	60	4,91	5,3	0,39	0,244
	31.7.	11:47	15:58	251	21	20	4,55	4,94	0,39	0,244
PW 4	4.7. - 4.7.	11:15	15:06	231	15	60	4,26	4,78	0,52	0,325
	31.7.-1.8.	16:28	10:45	1097	45	30	4,66	5,21	0,55	0,344
PW 5	2.7. -3.7.	13:08	10:58	1310	21	300	4,49	4,95	0,46	0,288
	5.7. - 6.7.	15:24	10:48	1164	16	30	4,26	4,71	0,45	0,281
PW 6	24.5.	18:20	23:50	325	34	60	4,49	5,07	0,58	0,363
	3.7.-4.7.	15:15	10:55	1180	131	60	4,4	4,97	0,57	0,356
	1.8.	11:18	15:26	248	16	15	4,3	4,9	0,6	0,375
PW 7	5.7.	12:51	14:44	1:53	21	60	4,41	5,04	0,63	0,394
	11.7.	11:36	15:37	241	31	30	4,48	5,12	0,64	0,400
PW 8	9.7.	11:30	15:23	223	109	30	4,01	4,38	0,37	0,231

continuation					counter correlation			Vol. on measurement days		
Date 2007	funnel dimensions r [m]	form	Δ V/ cycle [m³]	Δ V(Δ t) [m³*cycle]	Δ *E*(Δ t) [kWh]	**Δ V/ Δ *E* [m³/kWh]**	ID	m³/t(min)	m³/4h	m³/d
9.7. - 10.7.	1,5	Cylinder	1,2805	21,769	1	**21,769**	**PW 1**	0,0197	4,72	28,34
10.7. - 11.7.	1	Cylinder	1,3738	42,586	0,83	**51,309**	**PW 2**	0,0290	6,96	41,77
23.5. - 24.5.	1	Cylinder	0,7654	56,638		no value		0,0490	11,76	70,55
24.5.	1	Cylinder	0,7654	11,481	0,38	30,212	**PW 3**	0,0452	10,85	65,09
31.7.	1	Cylinder	0,7654	16,073	0,45	**35,718**		0,0640	15,37	92,21
4.7. - 4.7.	1	Cylinder	1,0205	15,308	0,25	**61,230**	**PW 4**	0,0663	15,90	95,42
31.7. - 1.8.	1	Cylinder	1,0794	48,572	0,73	66,537		0,0443	10,63	63,76
2.7. -3.7.	1	Cylinder	0,9028	18,958	0,28	67,706	**PW 5**	0,0145	3,47	20,84
5.7. - 6.7.	1	Cylinder	0,8831	14,130	0,14	**100,929**		0,0121	2,91	17,48
24.5.	0,75	Cylinder	0,6403	21,769		no value		0,0670	16,08	96,45
3.7. - 4.7.	0,75	Cylinder	0,6292	82,429	0,88	**93,669**	**PW 6**	0,0699	16,77	100,59
1.8.	0,75	Cylinder	0,6623	10,598	0,1	105,975		0,0427	10,26	61,53
5.7.	1	Cylinder	1,2364	25,964	0,42	61,819	**PW 7**	0,2298	55,14	330,87
11.7.	1	Cylinder	1,2560	38,936	0,54	**72,104**		0,1616	38,77	232,65
9.7.	1	Cylinder	0,7261	79,148	1,97	**40,176**	**PW 8**	0,3549	85,18	511,09

5.8.2.1 Sources of error

Problems appeared by transforming the electrical consumption of the pumps (kWh) in real fluxes Q (m³/d). One unavoidable source of error was the amount of electricity consumption introduced by temporary plugging. At the last pump station just before the WWTP (PW 8) the meter readings of this PW 8 had specially to be handled with care.

As sources of error can be named:

- clogging of pumps
- possible inaccuracy of the meter (specially in PW 8)
- possible inaccuracy in the P-measurements by e.g. shifting of the sensor or weights other than water on it
- proper counting of the meter and time

- inaccuracy caused by different reading times (specially for the 4h estimation)
- limits of curve interpretation
- other pump and electricity problems
- possible change of pump mode (e.g. from continuous to intermittent)

Tab. 5-16: Error estimation in transferring kWh/d to m³/d due to Tab. 5-15.

PW 3	PW 4	PW 5	PW 6	PW 7
18%	9 %	25%	13 %	16 %

A more general error assessment transferring meter reading results from kWh/d to m³/d is difficult. The most reliable values in Lassee are the meter readings in PW 4 and PW 6. In PW3 the first P-measurement was done before manhole cleaning. Clogging will have been reduced from June on and the error counter reading transfers will be smaller from that time on. Most probable reason for the differences in m³/kWh in PW 7 is as well clogging. The error in PW 8 is difficult to assess due to the counter problems discussed in 5.3 From June 28th to July 12th it might be 20%, readings of other dates are not usable anyway. Uncertainties of meter readings are as well reflected in the electricity bills, which are posted every summer from the EVN and were provided by the municipality (see Fig. 7-52).

The results of transferring meter readings to Q [m³/ 4h] and [m³/d] is shown in the Fig. 7-36 and Fig. 7-37.

For all measurements the manhole covers had to be moved with the help of the municipality workers.

5.8.3 Theoretical amount of Q [m³/d] of each pump station

From the number of inhabitants and the PE connected to each pump station in Tab. 5-3 one can easily determine the amount of waste water which should be approx. daily discharged through the pump stations.

Tab. 5-17: Theoretical waste water flow Q through the single pump stations estimated once with 0.1m³/d*PE and once with 0.15 m³/d*PE in the order of flow direction

	PW 1(to 2)	PW 2 (to 3)	PW 3 (to 4)	PW 4 (to 7)	PW 5 (to 6)	PW 6 (to 7)	PW 7 (to 8)	PW 8
	162 PE	375 PE	690 PE	762 PE	105 PE	393 PE	2200 PE	2582 PE
x 0.1m³/PE*d	16 m³/d	37 m³/d	69 m³/d	76 m³/d	10 m³/d	39 m³/d	220 m³/d	258 m³/d
x 0.15m³/PE*d	24 m³/d	56 m³/d	103 m³/d	118 m³/d	16 m³/d	101 m³/d	358 m³/d	415 m³/d

5.8.4 The weather during the measurement period

This spring and early summer 2007 was very dry and sunny, though it was interspersed with a very stormy period including heavy rains end of June, beginning July. It was following an unusual warm winter (see Fig. 7-25) with nearly no snow. During two of the heavy rain events (2.7. between 17:30 and 17:50 and 12.7. between 16:00 and 16:30) I was in Lassee and did an extra reading to catch the impact on the flux through the PW. The precipitation data of the NÖ hydrological institute does not reflect the heavy rain event from July 2nd with only 0.5mm (3.7.) and the one from July 12th with only 2mm, although it was raining cats and dogs. Tab. 5-18 shows own notices of the weather in Lassee (during meter reading time span) supplemented with the precipitation data of the relevant days of the Hydrological Institute, measured at 7:00.

Tab. 5-18: Precipitation data of the NÖ Hydrological Institute (raw data) and own notices of the weather

	precipitation [mm]	**weather notices Lassee**
23.5.07		hot and dry
24.5.07		hot and dry
25.5.07		hot and dry
27.5.07	0	
28.5.07	10	little rain
29.5.07	1.7	cold,
30.5.07	0.2	cold, little rain
31.5.07		nice, dry, windy
1.6.07		sunny
2.6.07	8	
10.6.07	0	
11.6.07		sunny, dry
12.6.07	4.5	sunny, dry
13.6.07		sunny, dry, sticky
14.6.07	3	sunny, dry
15.6.07		sunny, dry
16.6.07	1	
27.6.07	0	*days with heavy storms and rains (in Vienna)*
28.6.07	0	
29.6.07	0	
30.6.07	0	
1.7.07	0	
2.7.07	0	rain17:30 - 17:50
3.7.07	0.5	sunny, had rained
4.7.07	3	cold, drizzle
5.7.07	1	afternoon rain
6.7.07	0	sunny, windy
7.7.07	0	
8.7.07	0	
9.7.07	24	nice, later rain
10.7.07	3	cold, drizzle
11.7.07	0.5	sunny, little rain
12.7.07	2	rain 16:00 - 16:30
13.7.07	0	

5.8.5 Results of the flow measurements of the single pump stations

In the Appendix the diagrams Fig. 7-38 to Fig. 7-44 show the daily waste water discharges for each PW based on the Fig. 7-36 and Fig. 7-37 of the calculations for Q [m³/ 24h] and Q [m³/ 4h] including precipitation data (provided in September 2007 by the NÖ Hydrological Institute). The 12.7.07 is shown twice, once with the influence of the already mentioned rain event, once without. Because one day before the GW pumping was stopped in the afternoon, Q on this day was calculated from July 11th pm to July 12th pm to see the influence in PW 7 and PW 8. The rain event was included by adding the time to the previous value (11.7. pm – 12.7. pm as well, plus ~100min). All other data were calculated from am to a.m. An estimation from pm to pm was also made, but did not bring different results.

The rain events from July 2nd and July 12th are more clearly to see in the 4h diagrams in the Fig. 7-37 to Fig. 7-44 (Appendix).

When comparing the flow with each other one has to keep in mind not only the unknown retention time in the pipeline but also the time shifts in reading. Under every diagram this time shifts are shown for every day. Normally the shift was in “flow direction”, if not it is indicated with a minus. Time shift is besides clogging probably the main reason that Q (4h) in PW 3 is higher than in PW 4 sometimes. It has to be kept in mind, that the presented pump volumes are only assessments. The minimum level to pump the water was adjusted e.g. in PW 6 quite deep to the pump sump. Possibly not a completely cylindrical column was pumped because the pump sump is ending more conically like shown in Fig. 7-31. PW 6 results would be too high then. In the following the measurement from May 23rd to July 12th are presented.

5.8.5.1 From Schönfeld PW 1 to PW 2 to Lassee PW 3

The four measurements in PW 1 show result from 15m³/d to 25m³/d are correlating very well with the associated PE. Rain does barely infiltrate. Somewhere in the rest of the village the infiltration of rain is significant as can be seen at July 3rd in PW 2, causing over 100% more water. The 55 m³/d are reflected in the further flow direction in PW3 barely added with more rain water over the distance between the two PW (see Fig. 5-23). The discharge of PW 2 should be added with around 30m³/d to 45m³/d in PW 3. In Fig. 7-48 the 4h diagram is presented.

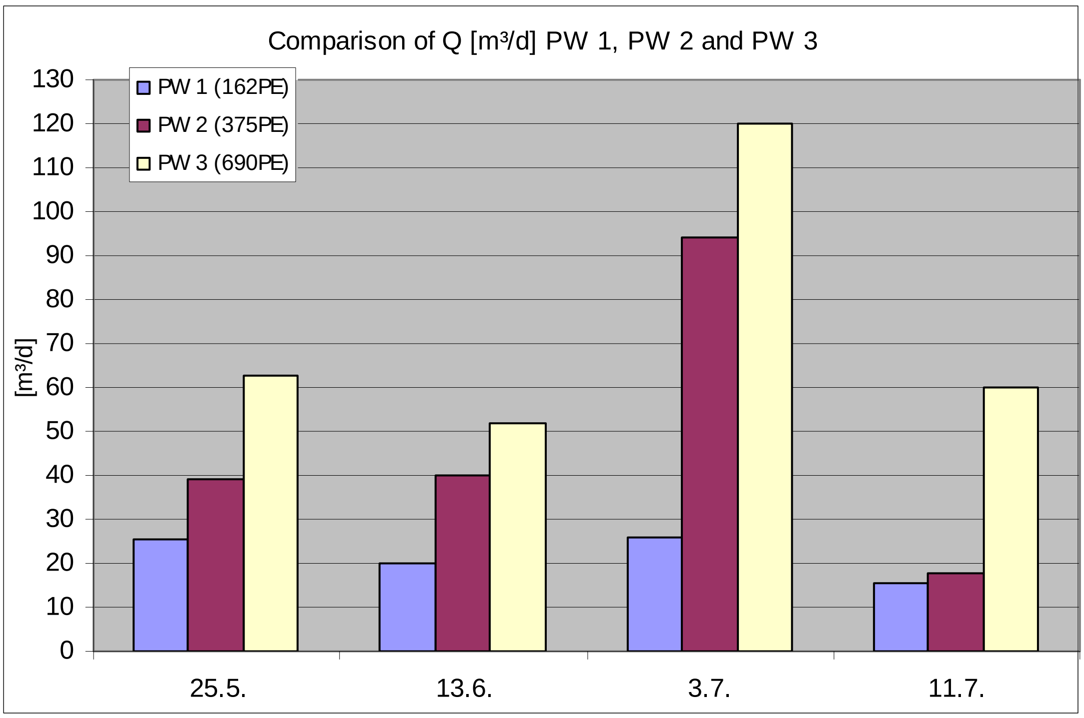

Fig. 5-23: Comparison of Q[m³/d] of Schönfeld pump stations PW 1 which flows to PW 2 and then to Lassee PW 3

Fig. 5-24: View into the manhole PW 3

5.8.5.2 From PW 3 to PW 4

All waste water flowing through PW 3 should end up in PW 4. The measurements show quite a good match with each other as well with the PE at least until 12.7.07. Inflow to PW 3 should be between 65m³/d and 100m³/d and in PW 4 around 10m³/d more. Maybe in both PW the pump volume is assessed a little too low. At 10.7 the rain probably coming from Schönfeld bears on Q with ~70m³ in PW 3 and ~90m3 in PW4.

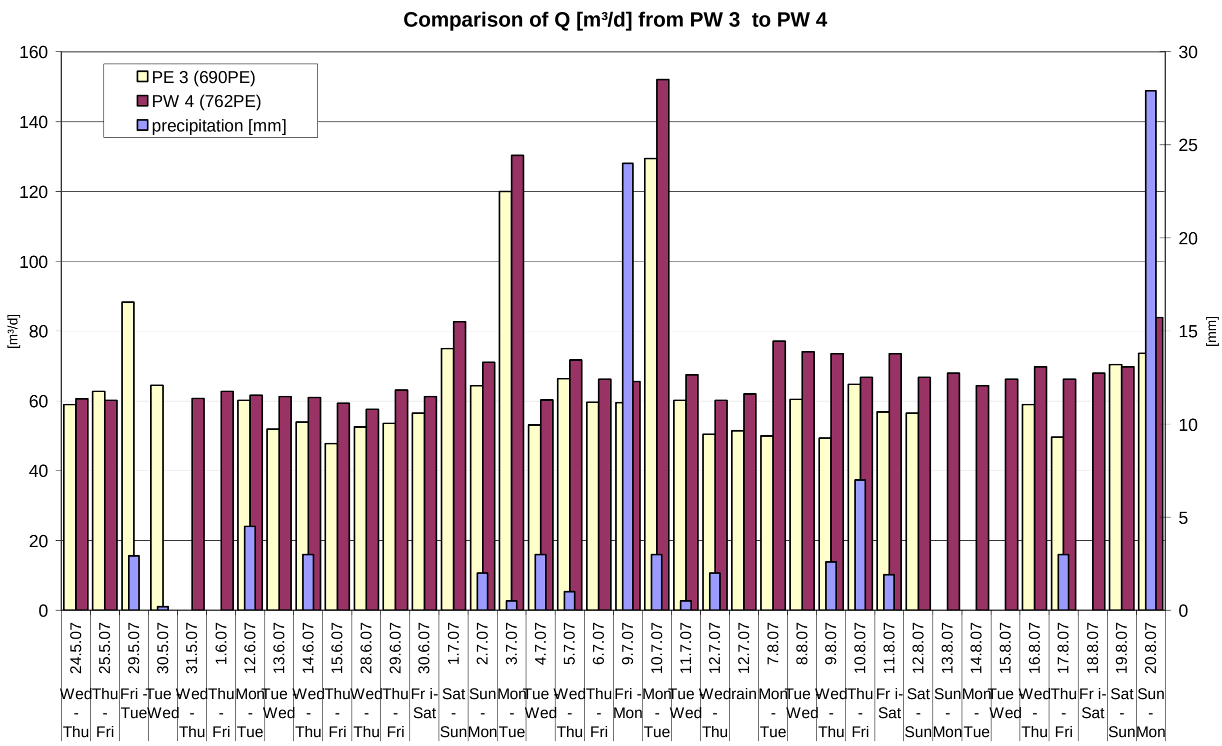

Fig. 5-25: Comparison of Q(m³/d) from PW 3 to PW 4 and precipitation

The 4h diagram Fig. 7-49 show that the 20min heavy rainfall at July 2nd is the cause for an increase of 12m³ in PW 3, probably coming from Schönfeld and 20m³ in PW 4 (Δt was 2 hours). The rainfall of July 2nd is reflected as well in a remarkable amount on July 3rd in Fig. 5-25.

5.8.5.3 From PW 5 to PW 6

The waste water discharge of PW 5 should be around 10 m³/d to 15 m³/d and be added to PW 6 with around 30 m³/d to 50 m³/d to result in 40 m³/d to 65 m³/d. Fig. 5-27 shows very differing results. Maybe the assessment of the volume of 10m³/d in PW 5 is already too high. The values in PW 6 show a great variance from one day to the other, also on days without rain, indicating additional discharges caused possibly by industry. An infiltration of groundwater would result in a more even progression. In the case GW infiltrates other causes of additional discharge cover it. While measuring in PW5 clear water was seen to flow in. The pump volume of PW 6 is maybe estimated generally too high. An assessment of a possible error looking to the lowest value of 48m³/d lays as well as the average of values on dry days around 10m³/d to 20m³/d Tab. 5-19. The sewer lines leading to PW 6 are infiltrated in a high amount by precipitation. At July 10th it contributes with 83m³ to Q in PW 6 compared with the day before and additional 10m³ in PW 5, which is a quite remarkable increase of volume. The influence of rain events is in PW 6 often seen one day longer than in the other pump station; if no other reasons come with it.

When looking at the 4h diagrams in Fig. 7-50 the 20min heavy rain on 2.7.07 causes an increase of 100m³ in PW6 (Δt was 100min).

Tab. 5-19: Investigation in how the inflow of PW 6 meets the correlating PE (maxQ=70m³/d) from June May 23rd to July 12th (from 24h data); maxQ is assessed to consider the possible errors in volume calculation

PW 6		%	Average	Max
meeting the PE- value (<70m³/d)		39	58	67
on mainly dry days:				
	> 70m³/d to 110m³/d	22	85	98
	> 110m³/d	17	117	125
on rainy days:				
	> 120m³/d	22	157	185

From May 23rd to July 12th the flow through PW 6 is laying over the theoretically values to 61% in its volume. Under consideration of possible errors the maximal theoretical value according to PE is assessed with 70m³/d. All August values are in average 100% higher (~140m³/d). If comparing the shape of the curve in PW 6 with the other pump stations it is obvious that the high Q must as well have other reasons than precipitation. Two industrial dischargers could infiltrate: the transport company with its washing plant and the cannery.

Fig. 5-26: View into the manhole PW 6

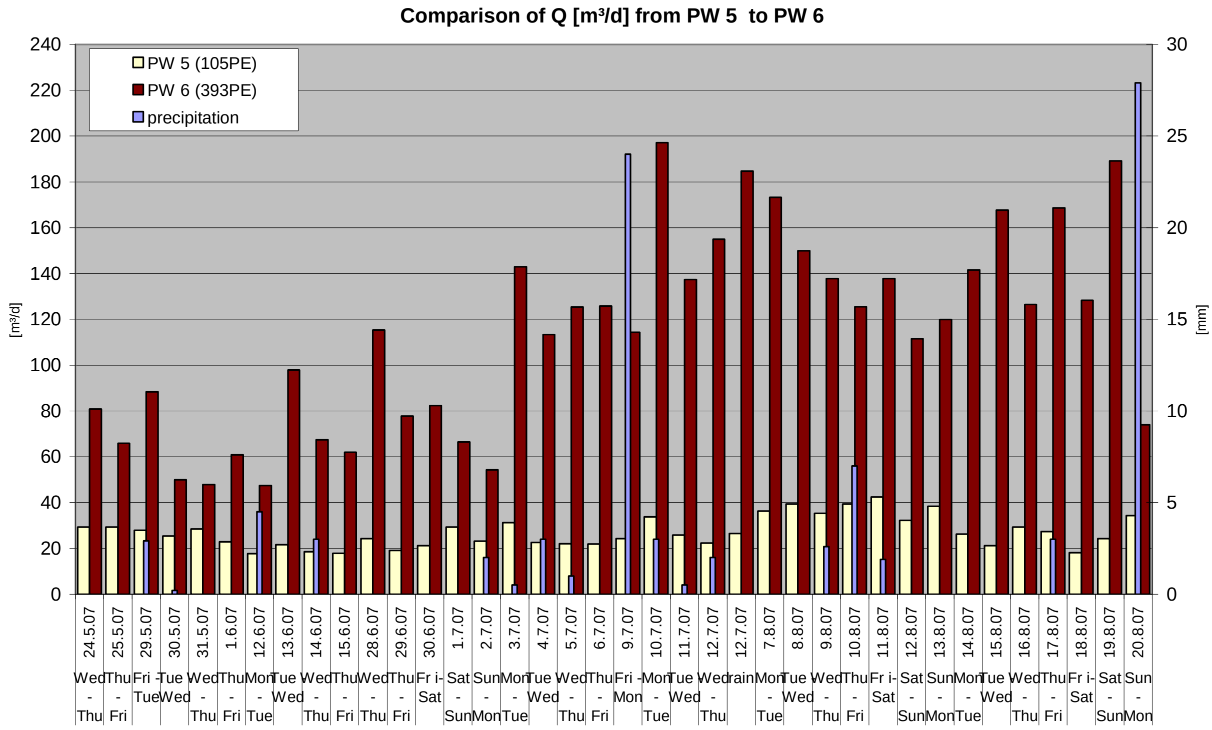

Fig. 5-27: Comparison of Q(m³/d) from PW 5 to PW 6 and precipitation

5.8.5.4 From PW 4 and PW 6 to PW 7 showing the GW remediation

The waste water from PW 4 and PW 6 is flowing to PW 7 where it is supplemented by the discharge of 1100 PE and the GW remediation. The GW remediation is assessed with 186m³/d (see Fig. 7-42 at July 12th of PW 7) in comparison with the average values of the time before. So the discharge of PW4 and PW6 should be added with around 250m³/d in PW 7. In Fig. 5-28 the flow through PW 7 is shown after subtracting Q of PW 4 and PW 6.

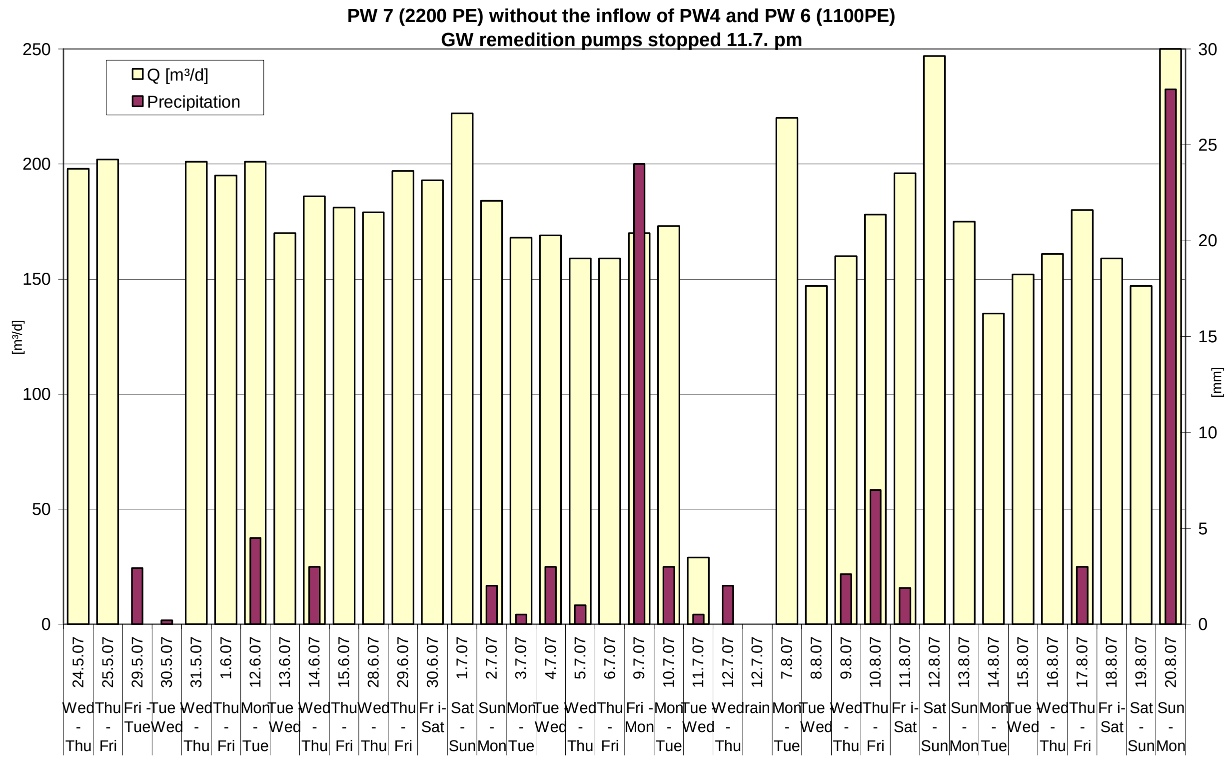

Fig. 5-28: Inflow Q (m³/d) to PW 7 without the inflow coming from PW 4 and PW 6 and precipitation (mm)

The assessed volume of 250m³/d is not reached. At July 12th after stopping the GW remediation pumps Q is even ~65m³/d lower than the sum of the two pump stations ahead. Even if considering an error of 30 m³/d discharge of PW 6 it stays in the minus range. The strange values after stopping the pumps between July 10th and July 11th can be seen more clearly in Fig. 5-33. It is not an error in meter reading. The average until July 10th of 180m³/d in Fig. 5-28 indicate either a wrong assessment of GW remediation, which is in the same height or an error in Q assessment of PW 7, because the discharge of 110PE is missing. But it is difficult to find an explanation for an error in this size. The manhole is not different from the others in its form and diameter, so its volume has probably not been underestimated. So maybe a big part of waste water is trickling away in the sewer network between PW 4, PW 6 and PW 7 or/and transported with long retention times due to clogging. Maybe also not all sewers are connected according to the map. A comparison with the flow through PW 8 in Fig. 5-31 shows clearly the same remarkable drop. Tab. 5-20 shows the comparison of the values for July 12th 2007.

Tab. 5-20: Q [m³/d] pump amounts on July 12th

Q [m³/d] pump amounts on 12.7		
	without	with rain
PW 4	60	62
PW 6	137	155
SUM	**197**	**217**
PW 7	165	172
PW 8	293	296

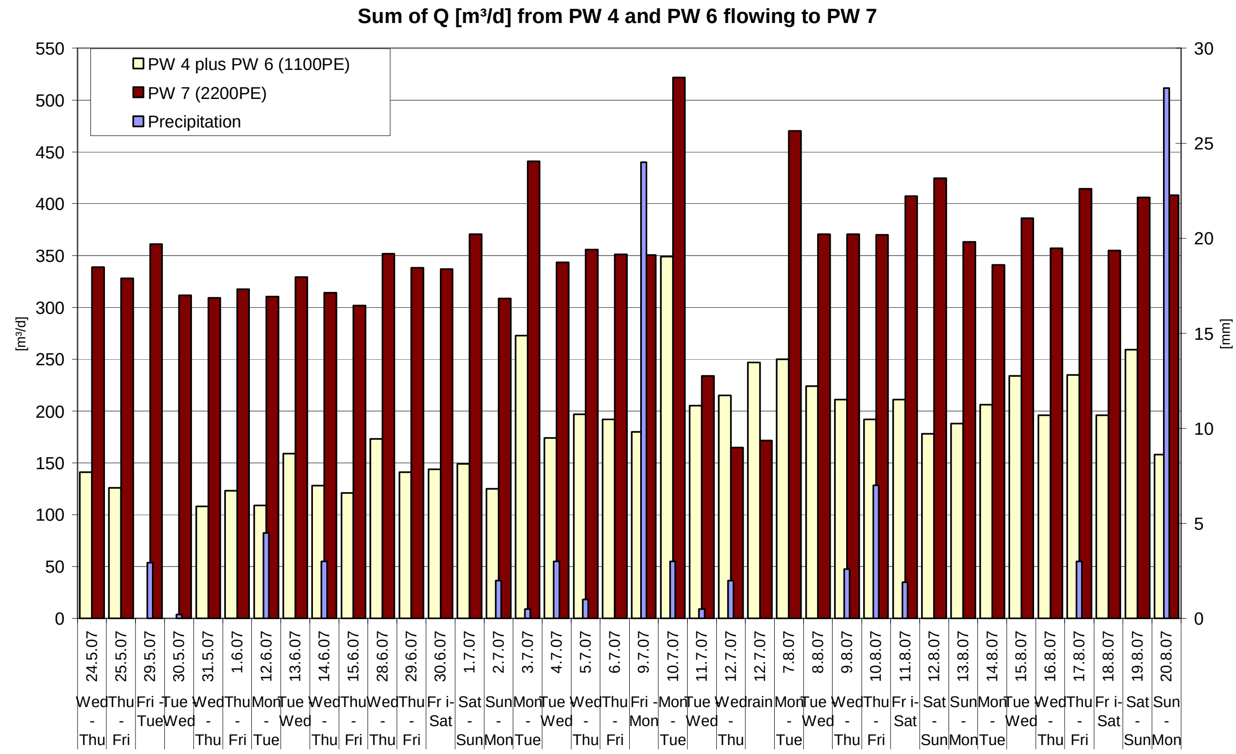

Fig. 5-29: Sum of Q(m³/d) from PW 4 and PW 6 flowing to PW 7 and precipitation(mm)

The rain at July 10th contributes on Q (PW7) with an increase of 170m³ as well as in Q (PW4+6). On July 3rd the additional rain discharge of Q(PW4+6) of 150m³ does not reach PW 7 fully, where only an increase of 130m³ was measured.

Concerning the rain one can see the influence best on the 4h diagram in Fig. 7-51 where the 20min heavy rain on 2.7.07 causes an increase of 44m³ in PW 7 (Δt was 79min).

Fig. 5-30: View into the manhole PW 7

5.8.5.5 From PW 7 to PW 8 showing the GW remediation

PW 8 is supplemented with 360PE according to 40 to 60m³/d. Q in PW 8 is in average 113m³ higher with a minimum at July 10th of 85m³, indicating that the sewer lines to PW 8 are barely infiltrated by rain. No remarkable additional rise of inflow to PW 8 can be seen when comparing rainy days with dry days. On July 11th a max in difference of 131m³ can be seen, maybe because of the longer retention time of the GW in the sewer between PW7 and PW 8. The results of this comparison confirm the assumption of a too low pump volume of around 80m³/d in PW 7 or PW 8 is estimated too low as well. On the other hand are the additional values of PW 8 quite conforming to the PE.

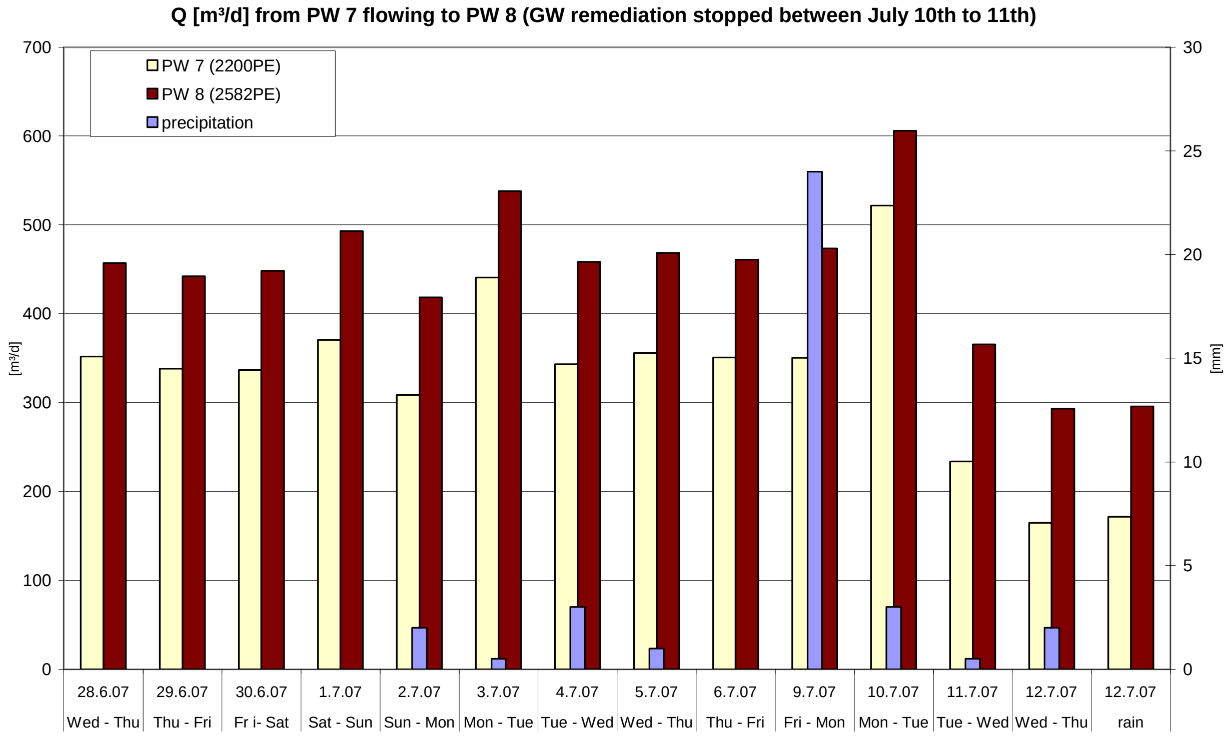

Fig. 5-31: Comparison of Q (m³/d) from PW 7 to PW 8 and precipitation (mm)

5.8.5.6 August readings of PW 7 and inflow measurements

A further (max) error estimation of PW 7 shall be considered. The inflow shall be compared with the pump volume of PW 7 between August 8th and August 19th 2007. In Fig. 5-32 the data are presented. Tab. 5-21 shows the difference between Q_{inflow} and Q_{PW7}. The result should lay in the same range like the differences between PW 8 – PW7 shown in Fig. 5-31. If not either PW 7 and PW 8 were underestimated in the calculations before or the sewer to PW 8 and to the WWTP were additionally infiltrated due to rain or other reasons in August. Another reason could still be failures in IDM monitoring. Here I calculate the possible underestimation in PW7.

Tab. 5-21: $Q_{inflow} – Q_{PW7}$ in August 2007

Day	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Date	8.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8	17.8	18.8	19.8
m³/d	351	49	326	600	327	393	392	355	374	342	427	277
average	351,1											

The average difference of Q_{inflow} – Q_{PW7} =351m³/d in August compared with the average difference of Q_{PW8} – Q_{PW7} =113m³/d until July 12th is 238m³/d higher. So Q=238m³/d is now attributed to be the possible max error of underestimation in PW7. But it could be as well the amount of resulting infiltration beyond PW 7. Only at August 9th the difference is according to the difference in PE between the inflow and PW 7. August 11th (and 18th) on the other hand shows that the supplementing sewers after PW 7, which enter PW 8, are obviously infiltrated by rain in a remarkable amount.

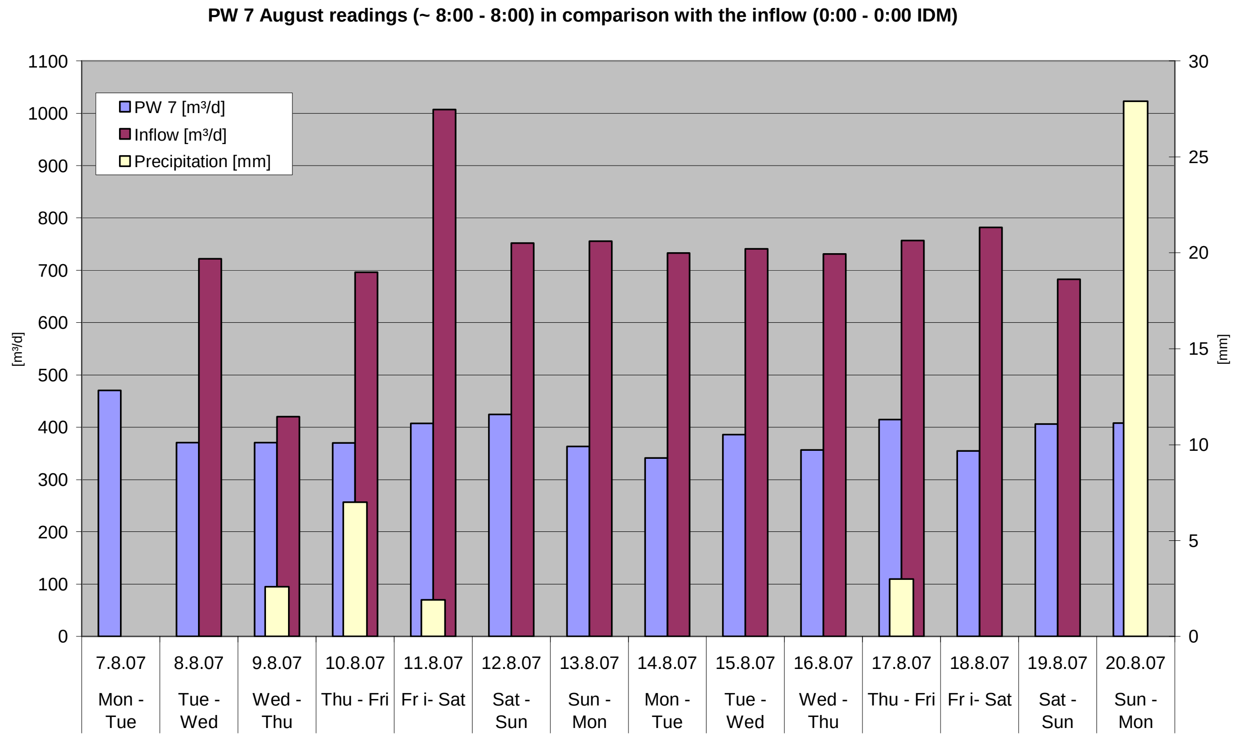

Fig. 5-32: Comparison of Q (m³/d) of PW 7 and the inflow of the WWTP

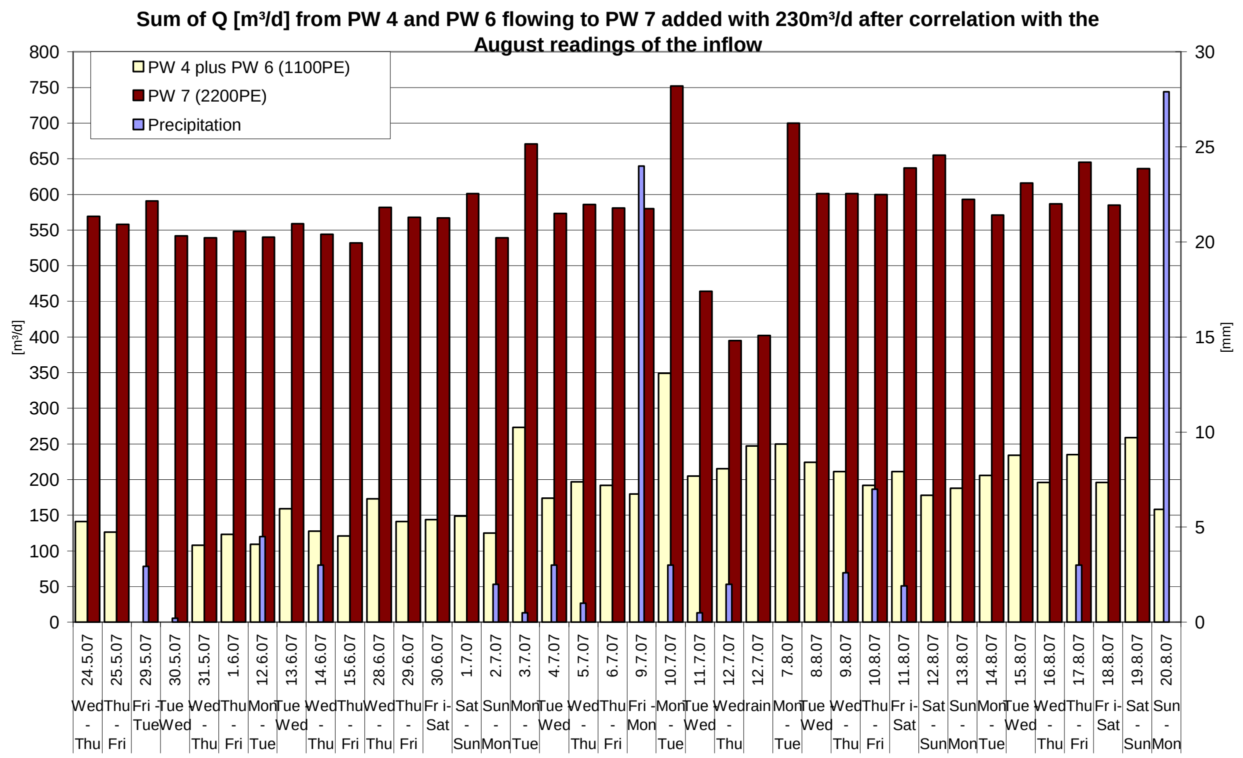

Fig. 5-33: Sum of Q(m³/d)= Q(PW4)+Q(PW6) flowing to PW 7 added with 230m³/d (error estimation)

In Fig. 5-33 the sum of Q_{PW4} + Q_{PW6} which is flowing to Q_{PW7} is shown once more. Now Q_{PW7} is added with the calculated error of underestimation = 230m³/d. This Figure shows better results for July 12th after stopping the GW remediation. The resulting Q_{PW7} - Q_{PW4} + Q_{PW6} =~190m³/d reflects better the difference in PE=1100 than in Fig. 5-29. On the other hand is average Q_{PW7} =~550m³/d for the first 20 measurement days very high compared to the average sum of Q_{PW4} + Q_{PW6}=~140m³/d. If this approach here reflects the truth than the GW pumping due to the remediation reaches indeed PW 7 in its whole volume according to the Co. GEOdata with ~300m³/d (550m³/d - 140m³/d – 110m³/d).

5.8.5.7 Inflow to the WWTP and PW 8 meter readings in August

The different variability in counter reading and metering are very good to see in a comparison of the PW 8 August readings with the in- and outflow Q of the WWTP IDM after repair of the computer failure (see Fig. 7-47 (Appendix)). The data are not consistent. The progress in the curves should be the same – or an additional discharge between PW 8 to the WWTP or in the WWTP itself exists. In- and outflow volumes in the WWTP itself differ in a remarkable amount as well (see Fig. 7-46) indicating further problems in IDM-Metering not solved by the computer repair. Outflow in August is 30% higher than the inflow. To evaluate PW 8 either with the inflow or the outflow the discharge Q through PW 8 has been determined like this: The discharges of the 12 reading days were summed up as well for the PW 8 as for the WWTP. ΣQ [m³/d] for PW 8 was determined by transferring the kWh with the value from the P-measurement of the July 9th (Tab. 5-15) even if it cannot be valid after July 12th. After calculating the difference in the averages like:

$(\Sigma Q\ (PW\ 8) - \Sigma Q\ (WWTP))\ /\ 12\ days = \Delta Q\ /day = 96\ m^3/d$

This value was then subtracted from every Qi of PW 8 [i=1..12days]. The diagrams are showing much differing amplitudes between the discharges of PW 8 as well with the inflow as with the outflow. So neither the question of infiltration in PW 8 nor the validity of the inflow gauge can be assessed in a comparison. The question of GW infiltration due to the remediation can also not further be cleared. It seems there was some wrong or missing information about it. According to information of the company Geodata the pumps were only stopped between July 10th and August 10th 2007. In the August diagrams of PW 7, PW 8 and the inflow an additional inflow related to the GW remediation from August 11th on cannot clearly be identified. In Fig. 7-35 the results of meter readings in (m³/d) for PW 3 to PW 7 in August are shown (Appendix)

5.8.5.8 Infiltration of groundwater reflected in the pump stations

The discussion of groundwater infiltration in chapter 5.5.3 shall now be investigated in the PW. Tab. 5-22 shows the GW level during the measurement period. It is compared to the according inflow data of the years 2004 to 2006 at times, when the same GW level was reached. Some dates are added as well in brackets. In the comparison years it can be seen, that, if the GW level drops ~143,04m, the inflow stays more or less the same (2004, 2005). An influence of groundwater to the PW data can be expected only until ~23.6.07. For the measurements this mean, only until June, the 15th a drop can be expected. In 2006 the GW level was generally higher. Compared with the years before the level was never so low in early summer like in July/August 2007.

The following trend for the years 2004-2006 of decrease of the inflow Q is visible, when the GW level drops each year from 143.23m to ~143.04m or rise vice versa (according to the drop of GW level during the measurement period in 2007 (see diagrams Fig. 7-20 to Fig. 7-26).

(2004, 2005, 2006): (40m³/d, 60 – 80³/d, >80m³/d)

Tab. 5-22: GW level (elevation in [m.a 00]) during the measurement period

Date in 2007	GW level [m]	2004 (min:142,91m)	2005 (min:142,8m)	In 2006 (min:143,1m)
22. Mai	143,23	750 (7.7.)	700 (22.3)	800 (25.2)
26. Mai	143,19	746(10.7)	736 (26.5)	730 (21.1)
01. Jun	143,17			740 (13.1) *487(25.7)*
08. Jun	143,14	710 (18.7.)	700 (3.6)	717 (11.1)
11. Jun	143,13		700(7.6.)	708 (9.1.)
16. Jun	143,08	~700	655 (15.6)	No values
23. Jun	143,04	670 (3.8.)		
27. Jun	143,02	640	650	
02. Jul	142,97	712 (august)	601	
10. Jul	142,94	700	620	
17. Jul	142,93	714	611	
22. Jul	142,87	No values	620	
31. Jul	142,83		No values	
09. Aug	142,78			
16. Aug	142,78			
20. Aug	142,76			

A comparison with the pump stations for the time May 23rd to June 15th 2007 shows a decrease in PW 7 of 569m³/d to 532m³/d. In PW 8 a drop can be observed as well, but no values can be allocated. The data amount of the measurements is to less to do further conclusions, especially concerning the other pump stations.

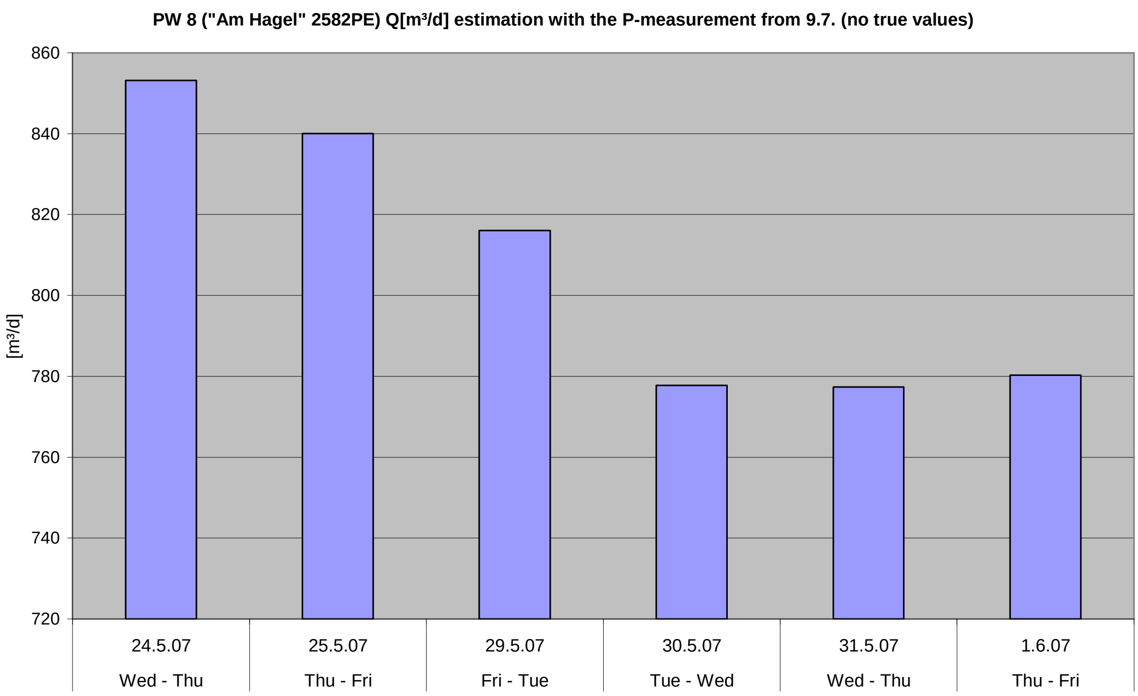

Fig. 5-34: Drop of Q[m³/d] from May 24th to June 1st 2007. 06 in PW 8 probably caused by sinking GW level

5.8.6 Analysis of the rain events

In Tab. 5-23 the data comparison of Q during the rain events had been made. Longer periods of rain seem to lead to stowage in the sewer system or to infiltrations either to the underground or back to the rain channel.

Schönfeld PW2 was once compared at a rainy day on July 3rd with PW3 and PW 4. At that day 96% of the discharge in PW 4 is coming from PW 2. In PW 7 is a loss of the water coming from PW 4 and PW 6 of 16%. These losses get higher on stronger and longer rain (98% on 10.7.) while in PW 3, 4 and PW 6 the maximum of Q is reached on that day. The maximum in PW 6 is probably superposed with other emissions, because this high value is not reached in a comparable value on the other rain days. At July 12th the losses in PW 7 show a value of 258%, but probably part of it is caused by the retention time of the remaining GW after stopping the remediation pumps between July 10th and July 11th. After the heavy rain event on July 12th stowage (level of ~20cm) in the channel where the GW was usual pumped in was observed. At July 12th a 117% loss in PW3 and PW 4 is observed as well when comparing with the 2mm rain on July 2nd. The water which can be expected from Schönfeld (54m³/d) is not reaching PW3. The same picture we have in August in PW3. The missing water from Schönfeld does not reach it in the following dry days.

In August only 12 – 14% of the increase in the inflow of the WWTP flows through PW 7. Also in the next dry days no additional water reaches the WWTP due to retention time.

The factor or percentage of Q laying above the volume according to the PE in PW 6 is the highest. PW 7 and 8 were only considered at July 12th in order to the assumption that the remediation groundwater is channelled to these pump stations on all other days before.

Tab. 5-23: Before and after rain events: factors exceeding theoretical PE and differences in Q[m³/d]

Differences in Q [m³/d] after rain events										
	PW 1	**PW 2**	**PW 3**	**PW 4**	**PW 5**	**PW 6**	**PW 7**	**PW(7-6+4)**	***PW 8***	**WWTP**
factor exceeding PE (calculated with 0,1m³/d*PE):										
		2,3	1	1	3	3,4				
3.7.07	26	94	120	130	31	143	441		*538*	
2.7.07	~20	~40	64	71	23	54	309		*418*	
Difference	**6**	**54**	**56**	**59**	**8**	**89**	**132**	**-16**	*120*	
rain: 2mm		**96% from PW 2**			**10% from PW 5**		**11% loss in PW 7**			
rain [mm] from 9. - 12.7.: (24; 3; 0,5; 2)										
factor exceeding PE(0,1):			1,9	1,1	3,1	4,7				
10.7.07			130	152	33	197	173		*606*	
9.7.07			60	66	24	114	170		*474*	
Difference			**70**	**86**	**9**	**83**	**3**	**-166**	***132***	
					10% from PW 5		**98% loss in PW 7**			
factor exceeding PE(0,1):			0,7	0,9	2,5	4,6	1,4		1,2	
12.7.07			51	62	26	185	297		*296*	
11.7.07			60	67	26	137	365		*365*	
Difference			**-9**	**-5**	**0**	**48**	**-68**	**-111**	***-69***	
					0% from PW 5		**258% loss in PW 7**			
rain [mm] from 9.8. to 11.8.: (2,6; 7; 1,9)										
factor exceeding PE(0,1):			0,8	1,1	4	3,4				4
11.8.07			57	73	42	137	407		*970*	1007
10.8.07			65	67	39	126	370		*714*	696
Difference			-8	**6**	3	**11**	**37**	20	***256***	**311**
					28% from PW 5		**46% from PW 4and 6**		**12 - 14%from PW7**	

August readings

August readings in PW 3, 4 and 5 led in average to nearly identical discharges Q [m³/d].

PW 6 rises in average with Q=41m³/d, PW 7 with Q=61m³/d and PW 8 with 378m³/d when comparing rainy days with dry days. PW 8 average value in rising during rainy days is identical with the WWTP inflow average value.

5.8.7 Results of the sample analysis

The results of the analysis are shown in Appendix Tab. 7-4 to Tab. 7-6 in (mg/l) and (kg/d).

Because of the IDM failure in the time from May to August 2007 only the PW results could be transferred to loads in [kg/d or PE] using the pump volume estimation according to the counter readings (pm). The results of Tab. 7-6 were calculated with the pump volume estimation shown in Tab. 7-7. Loads in PE/d transferred from kg/d are presented in Tab. 5-25. It has to be kept in mind that the presented values were calculated with all the possible inaccuracies in transferring [kWh] to Q [m³/d] described in chapter 5.8.2.

5.8.7.1 The WWTP sample analysis

The analysis of the WWTP samples at the BOKU laboratory for which no transfer to kg/d were possible could still be used to evaluate the analysis of the self-monitoring at the WWTP Lassee laboratory. Tab. 5-24 show that the analysis made in the WWTP laboratory in the last years are lying in the same range as own results. No clear weekly variation could be verified.

Tab. 5-24: Comparison of WWTP inflow samples analysed in the laboratory of the BOKU institute with WWTP inflow samples analysed in the WWTP laboratory

(IDM gauge out of range		**BOD**	**COD**	**NH4-N**	**PO4-P**
Q[m³/d]=unknown)		mg/l	mg/l	mg/l	mg/l
Average WWTP 2004-2007		**247**	**432**	**12**	**4**
BOKU inst.		(result*3)			
24.5.07	Thu	99	199	11,4	3,70
25.5.07	Fri	126	287	11,3	4,30
2.6.07	Sat	108	240	11,9	4,00
3.6.07	Sun	141	235	14,3	4,70
4.6.07	Mon	120	242	14,9	3,70
5.6.07	Tue	108	191	14,1	3,70
6.6.07	Wed	132	245	12,6	3,70
15.6.07	Fri	78	229	12,9	2,50
Average labor BOKU		**114**	**234**	**12,93**	**3,79**
usual monthly control					
30.5.07	Wed.	180	284	11,2	2,78
13.6.07	Wed.	180	188	12,6	3,22
20.6.07	Wed.	230	481	14,7	4,55
4.7.07	Wed.	280	329	11,4	3,32
11.7.07	Wed.	160	281	10,2	2,62
Average labor WWTP		**147**	**223**	**12,02**	**3,3**

The Tab. 7-4 was completed with the calculation of the ratios between the inorganic loads of the WWTP samples resulting in average in:

[TKN/NH4-N] = 1.78; [P_{tot}/PO4-P] = 1.29; [NH4-N/PO4-P] = 3.52 and [%N_{org} in COD] = 4.28

The ratios were already used in 5.6.4. The low ratio in average between ammonium and phosphates reflects the results of the monthly reports presented in Tab. 5-12 and Fig. 5-17. Beside of one exception at Friday, June 15th with NH4-N/PO4-P = 5.16 no value is lying within the "normal" span 4.9 – 6.7 (according to Lindtner and Zessner, 2003) in the inflow of the WWTP. In Tab. 7-4 also the ratios of the PW sample are shown. When looking to the ratios in PW 5 and PW 6 at June 15th with NH4-N/PO4-P=11.82 and 12.53 the reason for this exception is found. In the monthly reports have only 3 of 135 data points a ratio NH4-N/PO4-P > 5, all in winter time and one on Friday, a day at which was sampled only five times. On this day the nitrogen amount in PW 6 (Q=67m³/d) was relatively high combined with a low P influent from PW 5(Q=19m³/d). Nitrates and nitrites are below 0.1 mg/l and 0.003 mg/l with the exception at June 15th with 1.6 mg/l NO3-N. In PW 6 is as well one higher value with 2.6 mg/l NO3-N, but at June 13th and not June 15th.

5.8.7.2 Results of PW sample analysis

Heavy metals, NOX and Hydrocarbons

The results of the analyses of the heavy metals and hydrocarbons are shown in Tab. 7-5. Besides of one copper value in PW 4 at June 15th all others are below the threshold values for industrial effluents. Nitrates and nitrites could be observed below 0.1 mg/l and 0.003 mg/l as well beside two exceptions in PW 6 with 2.6 mg/l NO3-N and in PW 5 with 1.6 mg/l.

Organic and inorganic loadings, pH, T, conductivity

The organic and inorganic loads were calculated to kg/d and PE after estimating Q [m³/d] with the afternoon meter readings like shown in Tab. 7-7. Tab. 5-25 shows the results in PE. At the side the precipitation is listed for comparison issues. The graphic below shows Q [m³/d] for PW 4, PW 5 and PW 6 at the sampling days in June and July.

Fig. 5-35: View into the manhole in PW 4

Tab. 5-25: Analysis of the PW 4, 5, 6 and 8 samples in PE/d and suspended solids in mg/l

Analysis of PW samples: higher PE values are marked green, lower grey, extreme values orange

Loads in the manholes (PE/d)						*Suspended Solids "normal" value: 600mg/l (Henze et al.; 1996)*				
*(g/PE*d)*	*7,2*	*11*	*1,4*	*1,8*	*120*	*37*				
PW / Date	**NH4-N**	**TKN**	**PO4-P**	**Pges.**	**COD**	**TOC**	**SS**	**pH**	**µS/cm**	**°C**
PW 4 (762)	**PE /d**	**PE /d**	**PE /d**	**PE /d**	**PE /d**	**PE /d**	**mg/l**			
13.6.07	608	563	416	428	393	450		7,48	2500	16,6
14.6.07	578	504	329	343	425	439		7,7	1700	18
15.6.07	554	510	360	389	297	305		7,93	1650	15
2.7.						573	400		1870	18
3.7.						774	330		1854	18
4.7.						406	382	7,34	1634	18,1
10.7.						793	225	7,67		
11.7.						502	352	7,46	1865	18,1
12.7.						826	685	7,65		
PW 5 (105)								8,2	1748	19,7
15.6.07	157	150	68	81	176	194			1605	20,3
3.7.						295	350	8,06		
10.7.						216	170	7,36	1848	20,2
12.7.						289	650	7,84		
PW 6 (393)										
13.6.07	554	687	588	611	2197	2606		5,4	3910	19,1
14.6.07	769	780	680	713	913	978		7,2	2860	19,5
15.6.07	927	797	381	389	367	406		8,36	1930	19,5
2.7.07						572	400		1966	30,7
3.7.						830	120		2100	29,3
4.7.						500	180	7,47	1750	29,2
10.7.						767	160	8,09		
11.7.						369	240	7,65	1950	26,7
12.7.	710			2710		716	280	4,44		
PW 8 (2582)										
3.7.						1459	80		1421	17,1
4.7.						843	120			
11.7.						2164	350		1765	19,5
12.7.07						2638	500			

precipitation	
Date	[mm]
13.6.07	
14.6.07	3
15.6.07	
2.7.	
3.7.	0,5
4.7.	3
10.7.	3
11.7.	0,5
12.7.	2

(9.7.07: 24mm)

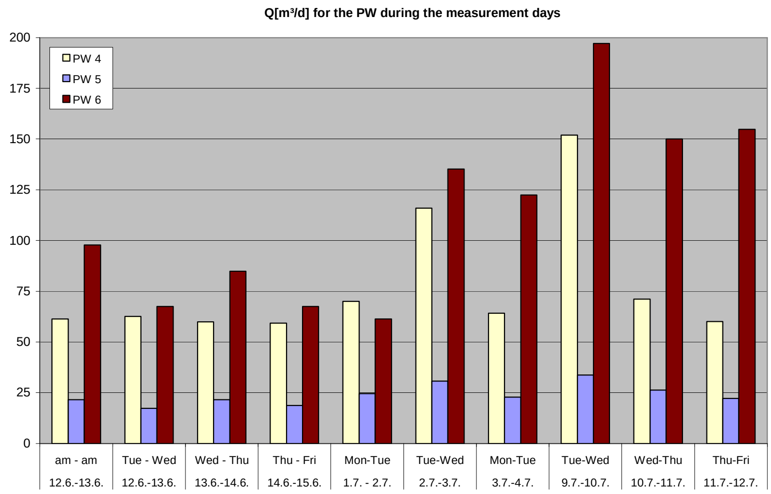

Fig. 5-36: Q[m³/d] for PW 4, PW 5 and PW 6 at the sampling days from June 12th to July 12th

In PW 4 the loads are rather too low then too high, probably by partly sedimentation from Schönfeld to Lassee. Only at July 12th are higher values like in the other PW.

The analysis in PW 6 shows waste water very differing in composition, indicating discharges to the sewer which are of different matter and not of domestic origin. They also cannot be explained by the effluent of the permitted Q=5m³/week of car and lorry washings, even if Q would be higher.

Organic loads at June 13th are exceeding PE_{theor} with 560% together with a pH of 5.4. Q [m³/d] is ~35m³/d higher then the surrounding days [am – measurements]. At June 14th with COD loads

(250%) are still high together with an increase of N and slightly as well P. At June 15th the ammonium increase is significant resulting in a N/P ratio >12, whereas organic loads and P are “normal” now. Possibly NH4-N increased due to biological degradation of the settled parts of the organic load (2.180PE at June 13th) reaching PW6.

Phosphorus loads at July 12th exceed ~700% indicating an industrial discharge with a high amount of probably P-acid H_3PO4-P (pH=4.4 at July 12th) which is used e.g. as a preservative agent in food production as well in detergents, fertilizers, or other acidic compounds. Sauerkraut production could also contribute significant to the high acidity and organic loads.

Two of four days of the PW 6 analysis (more parameters than TOC) show loads in the range of 600% increase while pH <5.5. At these days the discharge to this manhole alone are in the range of the total PE load of Lassee. Tab. 5-26 shows the exceedances in average.

PW 5 shows too high loads as well without significant increase in inorganic loadings.

Tab. 5-26: PE of sample analysis in average (all chemical parameters) and % for true PE value

	PW 4 (762 PE)	PW 5 (105 PE)	PW 6 (393 PE)	PW 8 (2582 PE)
PE of loads in average	490	180	866	1170
% of PE $_{(theor.)}$	64%	170%	220%	69 %

The ratio in average with NH4-N/PO4-P=7.62 (all analysis, every PW) do not represent the very low WWTP value of ~3.5 (see chapter 5.6.5). In PW 6 it would, if the high NH4-N amount of June 15th would be absent. Analyses in PW 8 were not made because of all the problems in Q determination, but would be certainly useful to solve this question.

Error assessment in PW 6:

When supposing a max error of Q = 30m³/d in PW 6 like assessed in chapter 5.8.5.3 and 5.8.5.4 the PE values results in:

Tab. 5-27: Differing results in PW 6 after supposing a max. error in Q-estimation of 30m³/d (numerical data given in German)

Q[m³/d]-30m³	NH4-N	TKN	PO4	Pges.	COD	TOC	SS		
	PE /d	PE /d	PE /d	PE /d	PE /d	PE /d	mg/l	pH	µS/cm
PW 6 (393)									
13.6.07	308	381	326	339	1220	1447		5,4	3910
14.6.07	498	505	440	461	591	431		7,2	2860
15.6.07	515	442	211	216	204	226		8,36	1930
2.7.07						292	400		1966
3.7.						646	120		2100
4.7.						377	180	7,47	1750
10.7.						651	160	8,09	
11.7.						295	240	7,65	1950
12.7.	572			2185		577	280	4,44	

A subtraction of 30m³/d from Q is of course reducing the loads due to the different calculation conditions. The P load in July is now 560% higher then the equivalent PE value which is still very high.

5.8.8 Salinity and electrical conductivity

The electrical conductivity (eC) in the pump stations was measured during the pm-readings with an online gauge on 14 different days (accuracy=[µS/cm] scale). Fig. 5-37 shows the results for Lassee. In Fig. 7-55 to Fig. 7-58 the data can be seen more detailed including the pump stations of Schönfeld. They are almost similar to PW 3, besides of the May 23rd, where in PW1 the eC is as low as in PW 4. Fig. 5-38 shows some measurement points for comparison in the wells of Lassee (the tab water of the WWTP which origins from its own well) and the drinking water of Lassee. Electrical conductivity of the shallow wells lay between 1156µS/cm and 1378µS/cm, in the pumped well it lays slightly lower. The conductivity of drinkable tab water was always around 734µS/cm, which is expressed in terms of salinity 330mg/l. Conductivity was transformed to salinity with the formula 1µS/cm = 2.2232 * 1[mg/l] according to Geigy (1977).

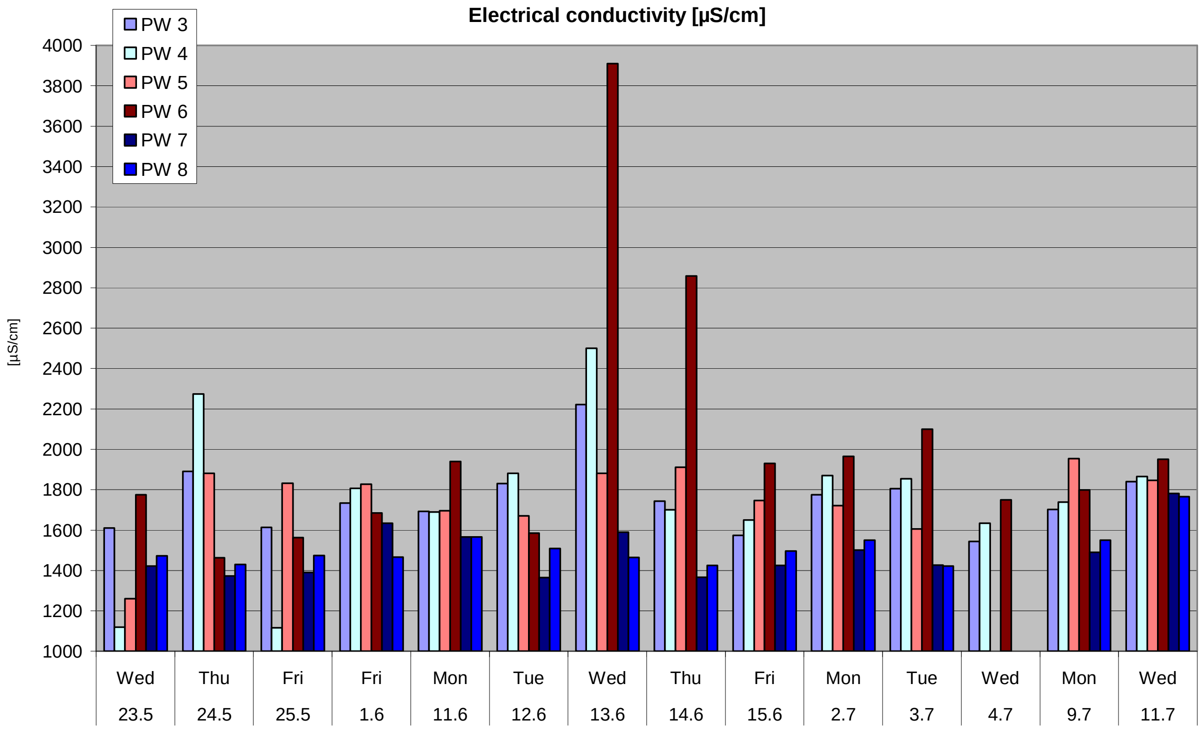

Fig. 5-37: Conductivity from PW 3 to PW 8

Tab. 5-28: Average electrical conductivity in µS/cm

PW 1	PW 2	PW 3	PW 5	PW 6	PW 4	PW 7	PW 8
1525	1663	1756	1756	2019	1765	1487	1507

PW 6 again is - according to the chemical analysis - the pump station with the most varying conductivity as well as with the highest average and an extreme value of 3891µS/cm. One can easily trace back the high organic loadings at June 13th and this extreme salt amounts. At this day conductivity is also higher in PW 3 and PW 4. The day before a 4mm rain event was recorded, but besides in PW 6 (51m³ more) no additional discharge (Fig. 5-23 to Fig. 5-29). Superposing reasons must be assumed.

Easy recognizable is the ground water discharge leading to the low conductivity values in PW 7 and PW 8, which already rises a bit after stopping the GW pumps between July 10th and July 11th. In Tab. 5-28 the average conductivity of all PW are shown. PW 6 lies around 400µS/cm higher.

Next it was tried to utilize the statistical evaluated human excretion of salts (Geigy, 1977) for the determination of the domestic parts of waste water. In Tab. 7-9 the 28 different ionic components in urine and faeces are presented in its concentrations.

The calculation of excreted salts in "normal" discharge volume of Q=0.1m³/PE*d results in a salinity of 355mg/l. This value is added to the salinity of the tab water resulting in 685mg/l.

The average conductivity over all PW and all days - but without PW 6 - is 1636µS/cm or expressed in terms of salinity with the above formula 736mg/l and is compared with the domestic part only slightly higher. The average conductivity in PW6 (4488µS/cm) corresponds to a salinity of 2019mg/l, three times as high as the assessed domestic part, a further indicator for illegal discharges.

Groundwater in Lassee and its conductivity

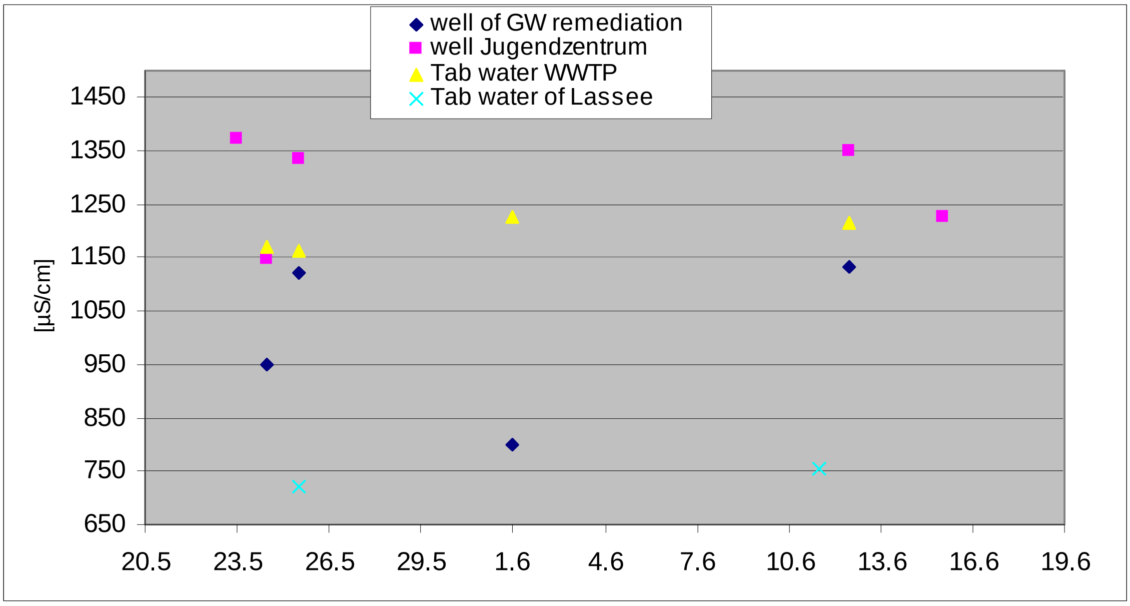

Fig. 5-38: Ground water electrical conductivity (µS/cm) in Lassee

The electrical conductivity of groundwater is generally depending on the geological composition of the soil. The hydrogeological situation in Lassee was not the topic of this thesis, but possibly the high conductivity in the wells (e.g. on May 23rd and 25th in "Jugendzentrum" higher than in PW 4 and PW 5 (see Fig. 5-38 and Fig. 5-37) could be caused additionally by fertilizer as well as by intrusion of waste water through sewer cracks to the ground water. When comparing the wells of the WWTP (tab water WWTP) and "Jugendzentrum" with the tab water of Lassee and the well of the GW remediation – or in other words comparing shallower GW layers with deeper ones – this seems to be probable. The well "Jugendzentrum" lays ~200m SE of PW 7.

5.9 Resulting infiltration with the "moving minimum"; second approach

Under consideration of the former results a new assessment of infiltration with the "moving minimum approach" – compare chapter 4.4 – was done. The pump amounts of the GW remediation like provided by the company GEOdata were included to answer the question which part of the resulting infiltration is caused by the GW remediation and which one by the GW infiltration.

The values of the diagrams were changed like this:

- The moving minimum is now 10 instead of 20 days, which fits better the inflow curve.
- Extraordinary singular low inflow values were assumed to be an IDM measurement failure and displaced with the average of the surrounding plausible values.
- The 2nd half of 2006 was not considered at all.
- Instead of 150l/PE only 100l/PE were assumed according to chapter 5.5.1
- Due to the uncertainties of the real discharge of the IE the personal equivalent of PE = 2912 according to Tab. 5-2 chosen instead of PE=2582 (Tab. 5-3).

The diagrams are shown in Fig. 7-59 to Fig. 7-61. With the results for IE discharge of chapter 5.5.1 together with the measurements of Q in PW 6 one can assess an additional discharge by the residential industries to the Ringstrasse of around 30m³/d to 50m³/d, but not at all days. The size of the storage tank of the transport company is 33m³. Additional discharge by the resident industry in the Ringstrasse (PW 6) was assessed with:

(2912-2582) PE * 0.1m³/d*PE *365d = 12000 m³/year.

Tab. 5-29 shows the results for the infiltration assessment with the moving minimum (10d) approach. Q_F, $Q_{F,dry}$ and Q_{Prec} were calculated like described in chapter 4.4. In Tab. 5-30 I try to assess the GW remediation in its minimum and maximum. Possible IE discharge in % according to 12000m³/year is shown as well. The max $Q_{GW,rem}$ and IE are calculated like:

1. Q_{IE} (%) = Q_{IE} / $Q_{D,d}$ * 100 wherein Q_{IE} = 12000m³/year
2. max $Q_{GW,rem}$ (%) = $Q_{GW,rem}$ / $Q_{D,d}$ * 100 wherein $Q_{GW,rem}$ = Q according to GEOdata

The right column show max $Q_{GW,rem}$ and the left column show min $Q_{GW,rem,\ PW}$ = ~186m³/d according to chapter 5.8.5.4 and Fig. 5-28 calculated simply like

$$Q_{GW,rem,\ PW}\ (\%) = Q_{GW,rem,\ PW} / Q_{F,Dry} * 100$$

The perceptual GW infiltration through ruptured pipes (cracks) shown in Tab. 5-30 was calculated only for those days with a GW level high enough to infiltrate the sewer system according to chapter 5.5.3, wherein Min Q_{GW} (%) = (∂Q – Min $Q_{GW,rem,\ PW}$) / $Q_{F,Dry}$ * 100 and Max Q_{GW} (%) = (∂Q – Max $Q_{GW,rem}$) / $Q_{F,Dry}$ * 100. The assessed IE discharge was due to its additional uncertainty not considered in this estimation.

Tab. 5-29: Infiltration assessment Q_F, $Q_{F,dry}$ and Q_{Prec} to the WWTP of Q (m³/year) like presented in Fig. 7-59 to Fig. 7-61

	2004	2005	1st half 2006
Total infiltration Q_F	64%	59%	70%
Resulting infiltration $Q_{F,Dry}$	60.8%	54%	65%
Infiltration by rain Q_{Prec}	7.6%	10%	14%

Tab. 5-30: GW remediation, GW infiltration through ruptured pipes and IE in % of $Q_{F,Dry}$(m^3/year) =100%

Infiltration attribution	**2004** ($Q_{F,Dry}$ =60.8% = 165407m^3/a)		**2005** ($Q_{F,Dry}$ = 54% = 124385 m^3/a)		**1st half 2006** (**$Q_{F,Dry}$ = 65% = 87967m^3/a)**	
	Min	Max	Min	Max	Min	Max
GW remediation	25%	76%	29%	83%	22%	64%
IE according to 12000m^3/year	7.3%		9.6%		6.8%	
Max and Min of GW infiltration through cracks according to Tab. 5-8 (GW level > 134.04m.ü.A)						
GW infiltration through fissures	23.5%	58.6%	9.1%	33.9%	35.6%	65.6%

5.10 List of facts like discussed in the single chapters

Infiltration in general

1. Q in PW 6 is at least more than 220 % too high from 3.7.07 until 19.8.07. Readings show high fluctuations during all weeks with ~50m^3/d also on dry days.

Rain infiltration

2. Rain infiltration increases the inflow up to 1100m^3/d.

3. The highest rise caused by rain events (PW 1 to PW 7) shows PW 6 with a factor of 6.5 (4h-diagram July 2nd ; Fig. 7-50)

4. The rain infiltration discharged from PW 4 and PW 6 does not reach PW 7 in the same amount at the same day. Its loss is 11% to 100% (June and July 2007) during longer precipitation.

5. On 12.7.2007 the GW pumps are stopped. The channel gets dry. After a heavy rain event of 30min the channel is full 2/3 of accumulated not flowing water.

6. August readings indicate an increase of $Q_{av.}$ flowing through PW 8 (inflow)=378m^3/d, PW6=41m^3/d and PW7=61m^3/d. $Q_{av.}$ in PW 3, PW4 and PW5 do not increase. The GW level in August is low, but there are many rain events.

GW infiltration through ruptured pipes

7. Monthly reports Jan. 2004 to June 2006 show a periodic increase of the inflow Q[m^3/d] to the WWTP at the same time the GW level rises and decrease if the GW level drops down.

8. In 2004, 2005 and 1st half 2006 the values according to the same GW level are very similar, with the exception that in the 1st quarter 2004 they are ~100m^3/d higher (GW level of ~143.04m to ~143.27m)

9. At a high GW level of ~143.3m the inflow Q to the WWTP rises erratic. If the GW level fall below 143.04m the inflow stops to fall simultaneous to the GW level.

10. All sewer inlets to the PW in Lassee lay usually below the groundwater table in spring. Elevation is lower towards the WWTP.

GW-pumping in Neustift due to the GW remediation

11. A stop of the pumps of the GW remediation led to a drop of around 186m³/d in PW 7 at the same day (July 11th to 12th); no more clear water discharge was observed.

12. The remediation company GEOdata measured the amount of GW pumping in average with Q=~320m³/d.

Indirect discharger IE

13. A cannery which has permission for 19m³/d and 30l/sec discharge to the rain channel and a transport company which has permission for 5m³/week and 1.5l/sec discharge to the sewer are connected to Ringstr. (PW6).

14. The transport company has a storage tank in the size of 33m³ and several tank lorries.

15. The cannery was considered in the WWTP design with 29m³/d and the transport company with 43m³/d.

16. No other industrial indirect discharger with the potential for high discharges is considered.

Loads

17. Chemical analyses in PW 6 (393PE) show a very differing composition of the waste water. Organic loads exceeded once 650% of the connected PE without a similar significant increase of inorganic matter and phosphorus loads; on another day there was an increase of 700% of phosphorus without a similar significant increase of TOC.

18. In PW 6 is in 2 of 7 measurements once the pH=5.4 and once pH=4.4

19. Electrical conductivity is mostly varying and highest in PW 6 with 2019µS/cm in average and peak value >3780µS/cm

20. PW 5 (105PE) has in average 160% increase of loads.

21. PW 4 (762PE) shows rather too low loads.

22. (Av.) Electrical conductivity is lowest with ~1490µS/cm in PW 7 and PW 8

23. Av. Electrical conductivity in the PWs (without PW 6) is ~1623µS/cm and in the shallow GW wells ~1223µS/cm.

Fig. 5-39: One of the aeration and settlement tanks of the WWTP

6. Conclusion

The infiltration water Q_F flowing to the WWTP Lassee in the years 2004-2006 had a total volume between 59% and 70% of the whole inflow. Between 8% and 14% was caused by rain. The resulting infiltration $Q_{F,Dry}$ (m³/d) during dry days calculated with the 10d "Moving Minimum Approach" was ranging between 54% and 65%. By far the biggest part of the resulting infiltration can be allocated to GW infiltration. The IDM metering of the 2^{nd} half 2006 from 18.6.06 until 18.12.06 was considered as not reliable. From April 1^{st} 2007 the IDM monitoring failed completely until August 1^{st} 2007.

Based on the counter readings (of 11. and 12.7.07) it could be proved that the GW infiltration due to the remediation reaches the sewer system at least in a big amount. Stopping the pumps on June 11^{th} (or 10^{th}) led to a drop of Q in PW 7 of ~180m³/d. Retention of the GW still remaining in the sewer could have led possibly to further drops in the following days, which were not measured any more. Additional indicator for GW infiltration is the low electrical conductivity in PW7 and PW 8 during all measurements apart of July 11^{th} and 12^{th}. The uncertainties of the assessments of the amounts caused by the GW remediation make concrete statements expressed in volumes attributed to single causes impossible. Only broad ranges can be presented here: The volume reaching the WWTP in this years by the GW remediation can range between 22% and 83% of $Q_{F,Dry}$.

GW infiltration through ruptured pipes occurs obviously when the GW level is rising to 143,04m.ü.A. (reference point GS331223), which is mainly in spring time. This GW level corresponds with a GW level ~0.61m lower in Lassee (~142.43m.ü.A.; at PW 5) (see chapter 5.5.3.3). In 2006 the GW level stays the whole year above this mark and rises up to 143.6m.ü.A. leading probably to extraordinary high inflow amounts up to 1.120m³/d in June 2006. In this year $Q_{F,Dry}$ is generally extraordinary high (until June 18^{th}). Expressed in (%) the GW infiltration through ruptured pipes in 2006 is ranging between 36% and 67% of $Q_{F,Dry}$. In 2005 it is due to the low GW level only between 9% and 34% (see Tab. 5-30). The depths of the sewer inlets to the Lassee PW are all below 142.4m.ü.A. All sewers in Lassee could be affected by the infiltration.

Emissions of industrial discharges were assessed to be 12.000m³/year, which is 7% to 10% of $Q_{F,Dry.}$ Assessment of PE = 2912 for these calculations were taken of Tab. 5-2. Most probable discharge was considered to be 100l/PE*d.

An infiltration of wrong recycled heat pump water could not be verified by the data of 2004 to 1^{st} half 2006. If it would have been the case the increase of inflow should have started in earlier winter time. Only in winter 2006/2007 from 18.12.06 it could be possible because the inflow of 850m³/d is unusual high. The contributing GW level of 143.22 led in the former months and years to ~750m³/d. But comparison of the graphs between GW in winter 2006/2007 and inflow makes an additional GW infiltration more plausible. Anyway IDM metering of the whole winter period 2006/2007 is to be handled with care.

The unusual high organic loads according to the monthly reports corresponds with an unusual low NH4-N/PO4-P ratio <3. The periodically highest values occur ~June to October with 3000 to 8000 PE and the 3 most extreme outliers of COD, BOD and PO4-P are corresponding with heavy rain indicating washing outs of former congestions.

Own measurements form May 23^{rd} to July 12^{th} 2007 of the pump volumes in the pump stations showed that PW 6 is most affected by rain and high loads. Probably rain channels are wrongly connected. Under this assumption not only the transport company but as well the cannery could discharge to the sewer connected to PW 6. If the highest production time of the cannery is summer to autumn after harvesting this would explain the periodicity of load increase from June to October.

The contribution of rain water in PW 6 cannot be the only reason leading to the increase in Q during and after rain fall in the WWTP inflow. It must be assumed that the sewer connections to PW 8 are highly effected by rain as well. But due to the meter problems and further the failure of the IDM monitoring until August no statements for PW 8 can be made, only a rough assessment: Matching August readings (rainy period) with the inflow indicate indeed a coherence (increase of 378m³/d).

The situation of the old sewers (some of 1954) connected to PW 7 seems to be complex. They suffer from GW infiltration the most and are probably at the same time leaching out water to the underground, also congestions might occur. This is indicated by the too low waste water volumes in PW 7. The volumes leaving PW 4 and PW 6 do not reach PW 7 in the same amounts under the assumption the information for sewer connections and manhole diameters were correct. In PW 7 rain (and other) water seems rather to "disappear". To explain the low waste water volume in PW7 different error estimations were approached. Due to the complexicity of the situation and the failure in automatic monitoring in the WWTP and PW 8 a final statement concerning infiltration in PW 7 is difficult.

Congestions occur as well between Schönfeld and Lassee. The precipitation effecting PW2 (Schönfeld) did not reach PW3 and PW 4 in the same amount.

It was not possible to allocate the GW infiltration through ruptured pipes to the single pump stations. The GW level was already quite low on May 23rd and at June 15th it dropped < 143.04m.ü.A. A slightly decreasing trend only in PW 7 of 37m³/d can be seen. In PW 8 a drop can be observed as well, but no values can be contributed. In 2007 spring irrigation started very early because of the unusual dry and hot weather. Corresponding inflows at such low GW level reflect best the year 2005 with ~670m³/d. The measurements of PW7 would give a contribution to this value with only ~350m³/d to 460m³/d wherein 460m³/d is assessed with the maximal error in Q-estimation in PW 7 of +230m³/d (see chapter 5.8.5).

Chemical analysis at the BOKU laboratory of the WWTP samples could verify the high loads of the WWTP. The highest loads of the pump station waste water can be attributed to PW 6 (395 PE). Corresponding values for organic loads up to 2.700PE were found. The composition of loads points to other than domestic origin. High P and COD loads fits with cannery waste water whereas different composition of pollutants indicate an emptying of tanks from any kind of industrial polluter transported to and stored in Lassee. In the case the cannery produce Sauerkraut this could contribute significant to the high acidity in PW6 at July 12th and June 13th together with the high amount of organic loads. Oil residues could not be proved nor a significant concentration of heavy metals.

PW 4 (and so PW 3) is not affected by high loads or high inflow. PW 5 has a singular position, because it suffers due to its small waste water volume (100PE) under coarse matter sedimentation. Samples of PW5 had a higher contribution of matter than the other PW. Clear water flow was observed to this PW as well over several days, indicating a.o. either GW infiltration or wrong drainage connections, which could also be an additional reason for an increased inflow. Especially in August av. Q is with ~35m³/d quite high in PW 5.

Restrictions for the interpretation are a.o. caused by the failure of the inflow IDM gauge, the electricity counter in PW 8 during the whole own measurement period and the fact that in contrary to the former agreement with the mayor the GW pumps were not stopped in time.

Summary of the results

The unusual high inflow to the WWTP Lassee in the investigation period between January 2004 and August 2007 could be explained mainly by ground water infiltration. Two different types of infiltration could be distinguished: once the GW infiltration through ruptured pipes and once by the ground water pumping due to the remediation in Neustift.

The infiltration through ruptured pipes seems to start at a certain level of the groundwater table = 143.04m.ü.A usually in spring (GW monitoring station GS 331223). In the investigated years GW level was rising up to 143.6m.ü.A., reaching more ruptured pipes due to the increase, which explains the high inflow rates lasting over longer periods up to 1140m³/d in 2006. All sewer inlets to the pump stations in Lassee lay below the critical mark of GW level. The GW level in GS 331223 is corresponding to a GW level ~0.61m lower in Lassee Josefsgasse (at PW5). The highest elevation has the inlet in pump station “Reufeldgasse” PW4 (142.39m.ü.A.) and the lowest in pump station “Am Hagel” PW 8 (140.75m.ü.A.). To answer the question which sewer of Lassee are affected by ground water infiltration a TV monitoring is recommended. Those sewer lying below ~143m.ü.A. (143.6m.ü.A. (GS Lassee) – 0.61m (at PW5)) and those built 1954 should be most regarded.

Rain fall could be attributed to inflow peaks up to 2100m³/d. The high increase caused by rain events indicates a.o. that sewers are wrong connected with rain channels. This seems to be for example the case for the channel system leading to the pump station “Bahnstrasse” (PW 6). Here the resident industry is located. Probably additionally to the other IE the waste water of the cannery is reaching PW 6. The unusual high organic loads according to the monthly reports corresponds with an unusual low NH4-N/PO4-P ratio <3. The highest loads of the pump station waste water could be attributed to PW 6. Its composition point to other than domestic origin. High phosphate and organic loads, together with sometimes high acidity could fit with cannery waste water. Emptying of tanks from any kind of industrial polluter transported to and stored in Lassee could be the reason for the different composition of pollutants as well. The amount of additional waste water discharge by industrial discharger was assessed to be around 12000m³/year.

Further steps should be taken. A TV monitoring and repair of the sewer system as well as an enhanced control of industrial discharger are strongly recommended. It should be stopped to pump the ground water of the remediation in Neustift to the WWTP.

Abbreviations

	German origin of abbreviations	English origin of abbreviations or translations
a.o.		among others
am		before 12.00 o`clock
BH	Bezirkshauptmannschaft	Administrate body of the region
E/EW	Einwohner/ EW	P/PE
eC (eL)	elektrische Leitfähigkeit	electrical conductivity
EW	Einwohnerwerte gemäß KA-Design	PE according to the WWTP design
GOK	Geländeoberkante	ground level
GW		groundwater
HD	Hydrologischer Dienst	Hydrological institute
IE	Indirekteinleiter	indirect discharger
IEV	Indirekteinleiterverordnung	Emission regulations for IE
KA	Kläranlage	Waste Water Treatment Plant
m.ü.A.	Meter über Adria	meter above Adria (sea level)
P/PE	Person/PE	inhabitants/PE according to the WWTP design
PE		personal equivalents
pm		after 12.00 o`clock
Pmeasurements		phosphate measurements
PW	Pumpwerk	pump station
Q_d		measured inflow (m³/d)
$Q_{D,d}$		dry weather inflow (m³/d)
Q_F		resulting infiltration (m³/d)
$Q_{F,Dry}$		resulting infiltration on dry weather days (m³/d)
∂Q		moving minimum difference
Q_{Prec}		precipitation part of infiltration
Q_{theor}		theoretical value of inflow according to PE (m³/d)
∂t		time span (t_1 …. t_n) in days
t(GW)		temperature of groundwater
t(in)		temperature of inflow
t(out)		temperature of air
tf		ton finished product
WRG	Wasserrahmengesetz	water act
WWTP		Waste Water Treatment Plant

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Identification of Figures and Tables

Figures:

Tables:

7. APPENDIX

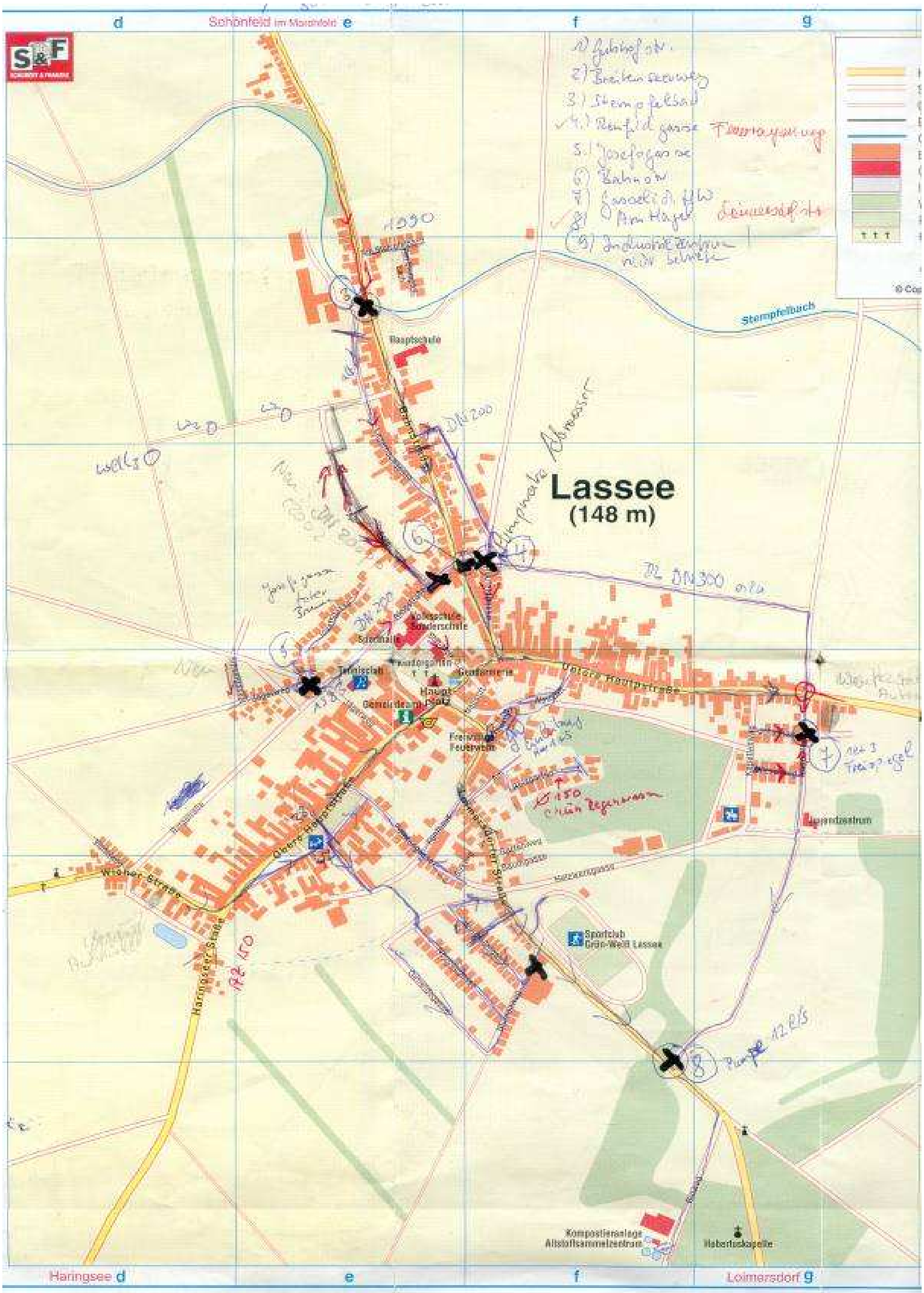

Fig. 7-1: Street map of Lassee: blue drawn lines indicate the sewer incl. flow direction and the numbers indicate pump stations in flow direction, whereas PW1 and PW2 are located in Schönfeld in the north. The WWTP is the red square in the south.

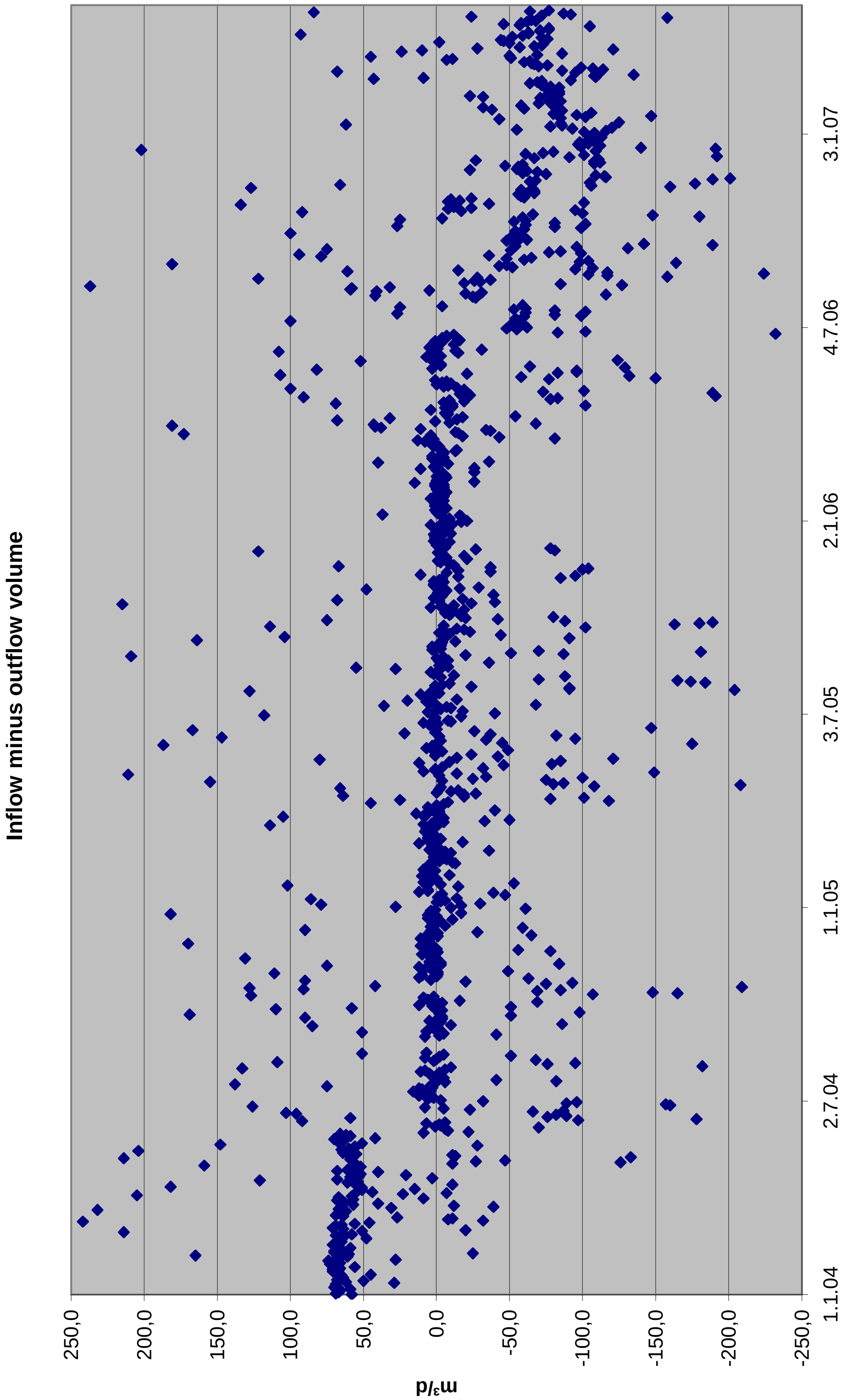

Fig. 7-2: Difference between influent and effluent (Qin – Qout (m^3/d))

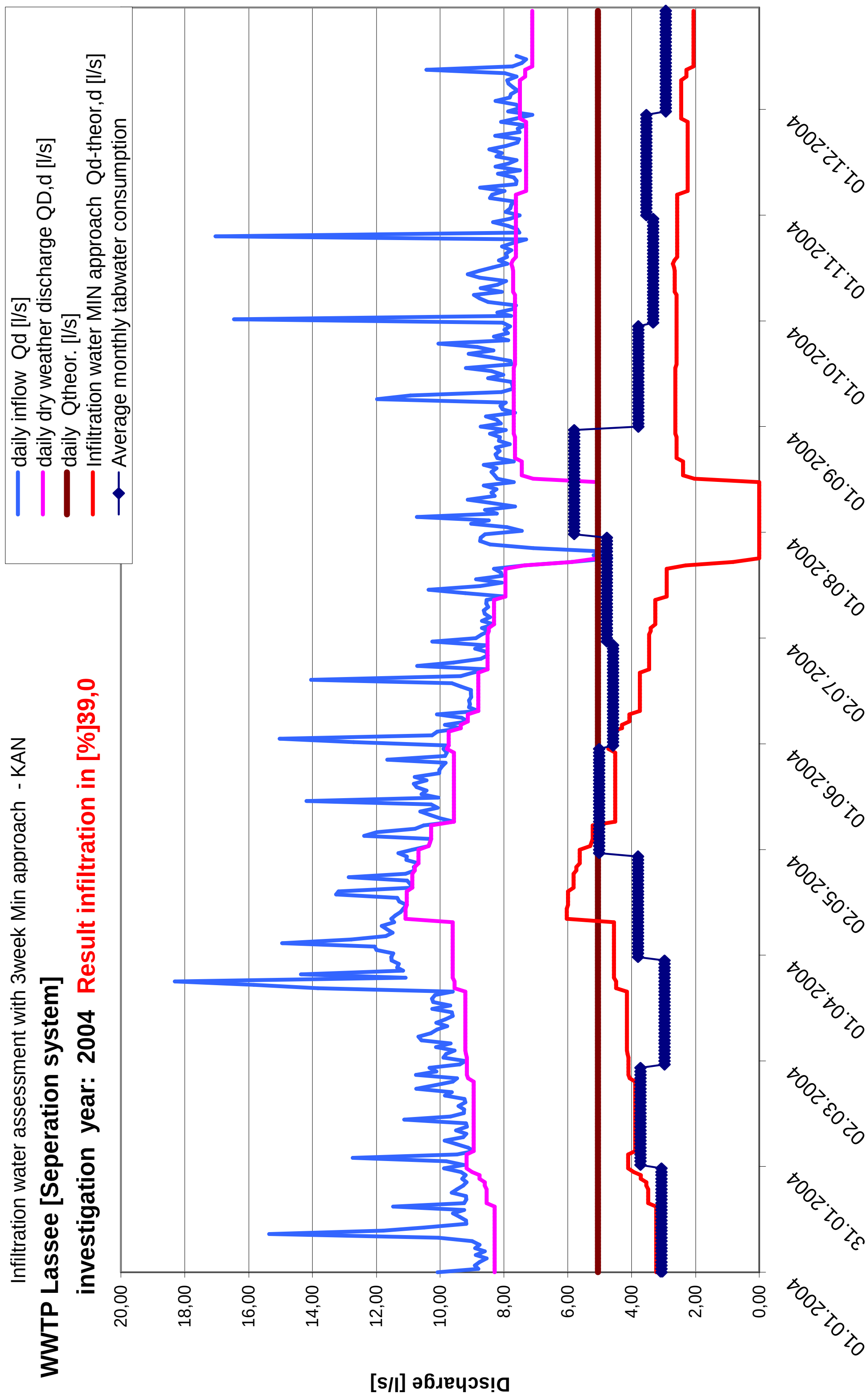

Fig. 7-3: Infiltration water assessment with the „Moving Minimum Approach“ 2004 incl. tab water consumption

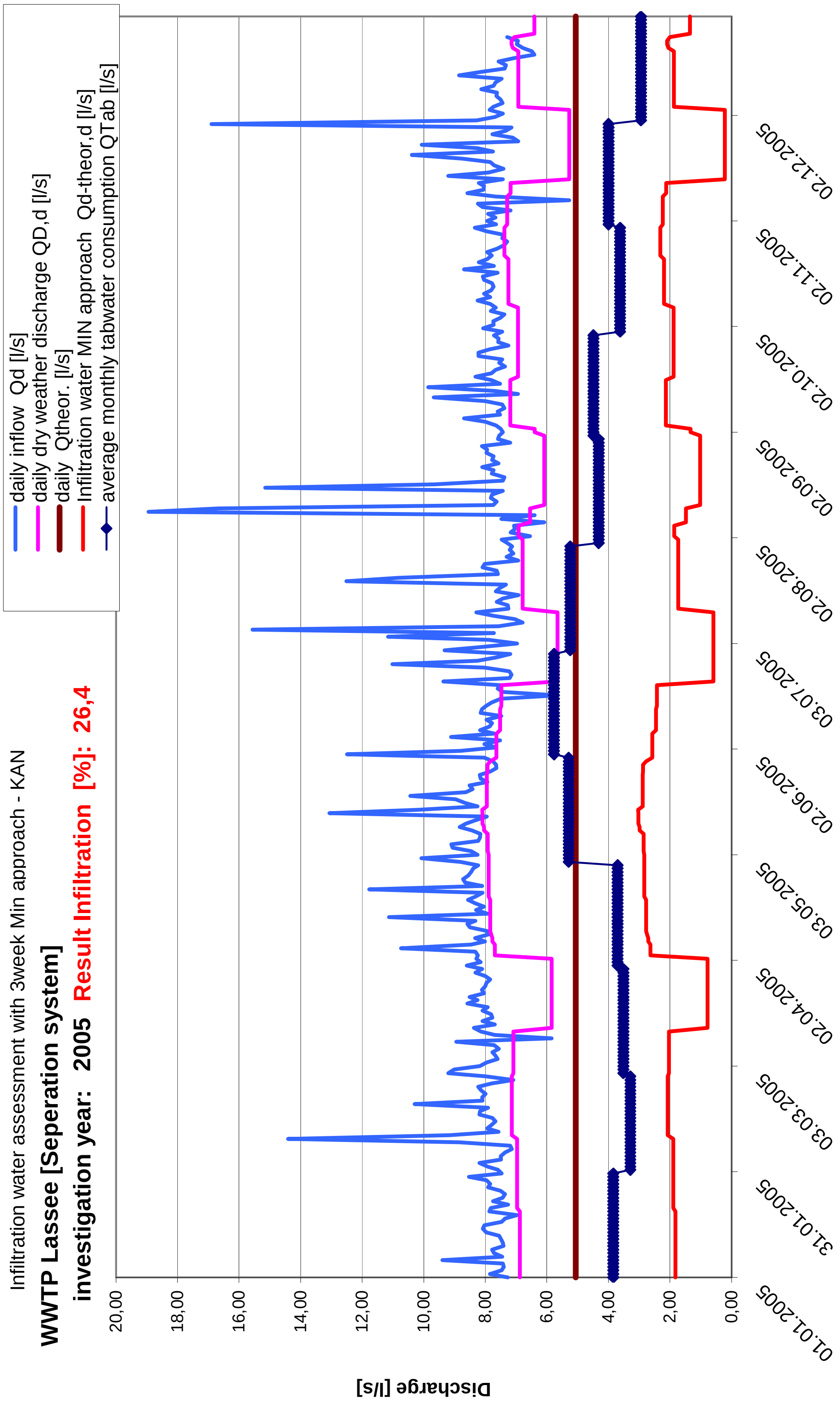

Fig. 7-4: Infiltration water assessment with the „Moving Minimum Approach“ 2005 incl. tab water consumption

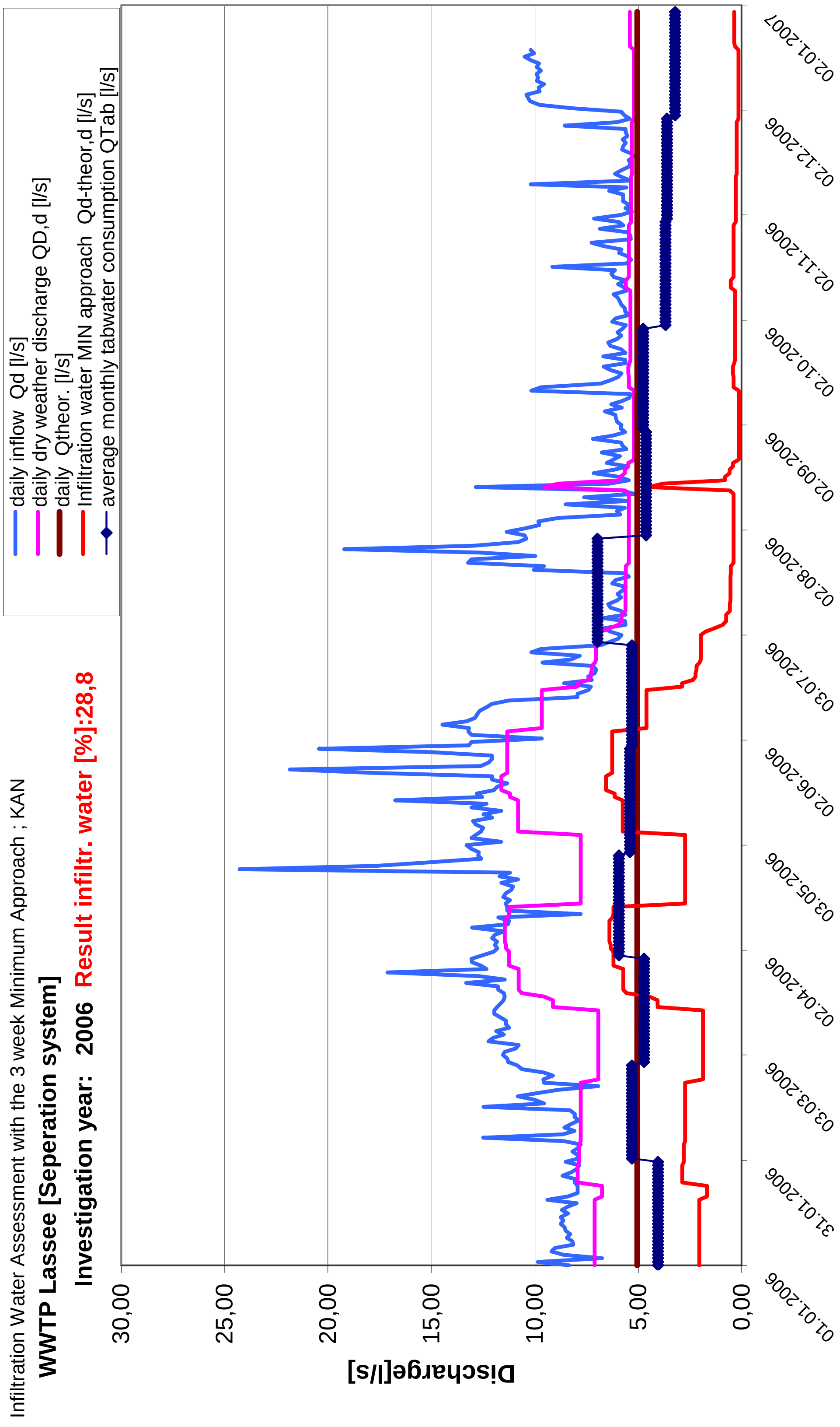

Fig. 7-5: Infiltration water assessment with the „Moving Minimum Approach“ 2006 incl. tab water consumption

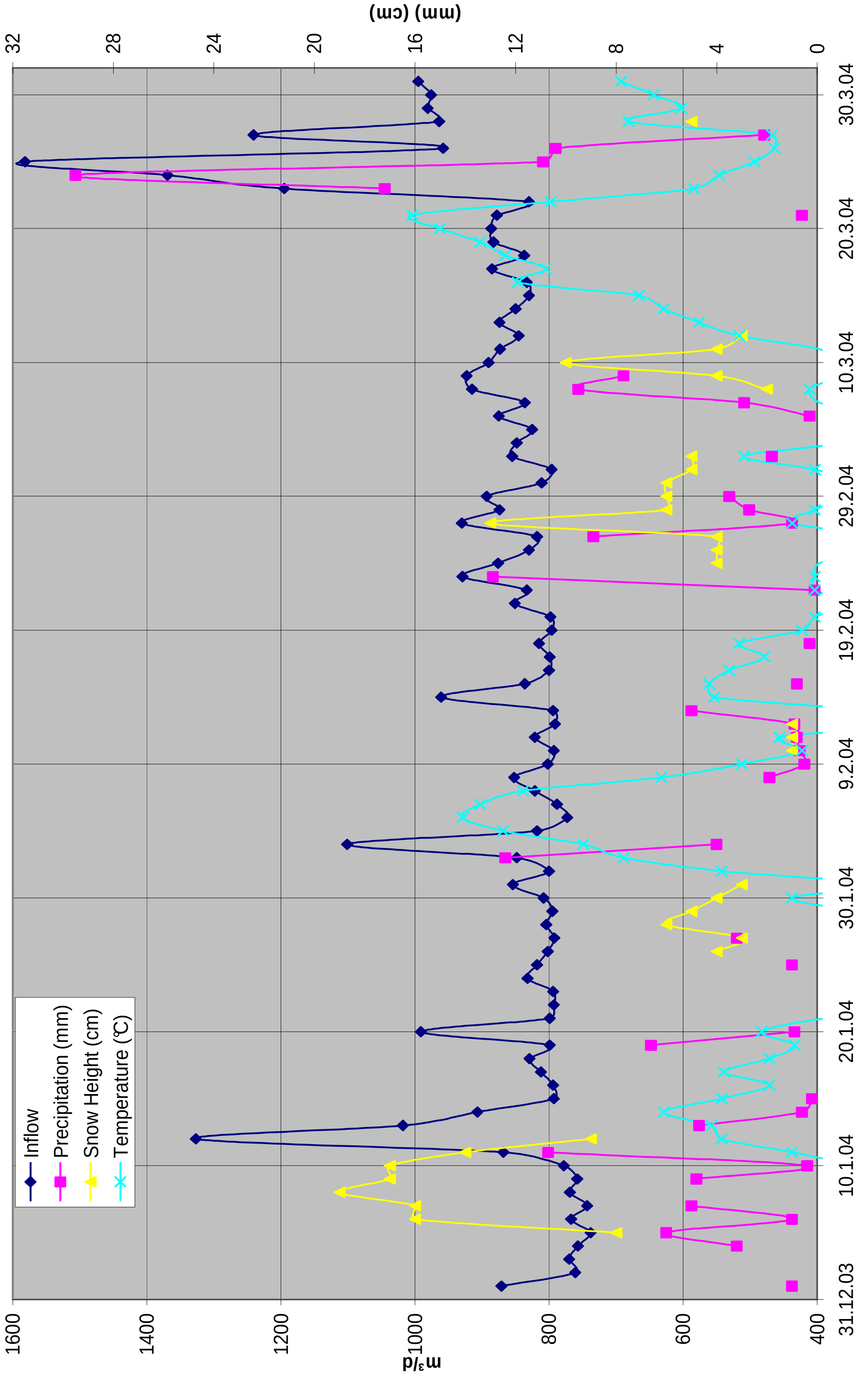

Fig. 7-6: Comparison of WWTP inflow with hydrographical data 1st quarter 2004

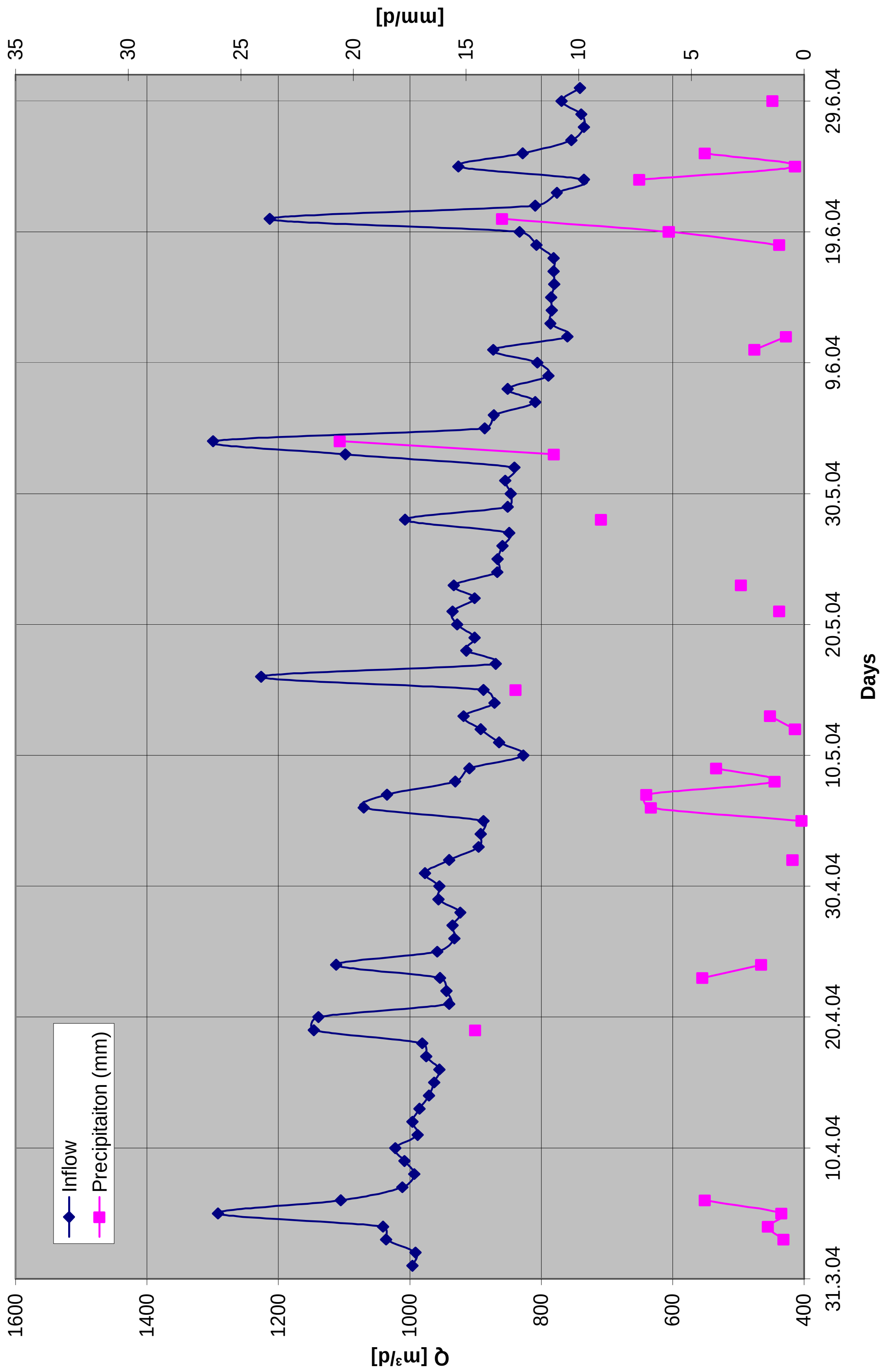

Fig. 7-7: Comparison of WWTP inflow with hydrographical data 2nd quarter 2004

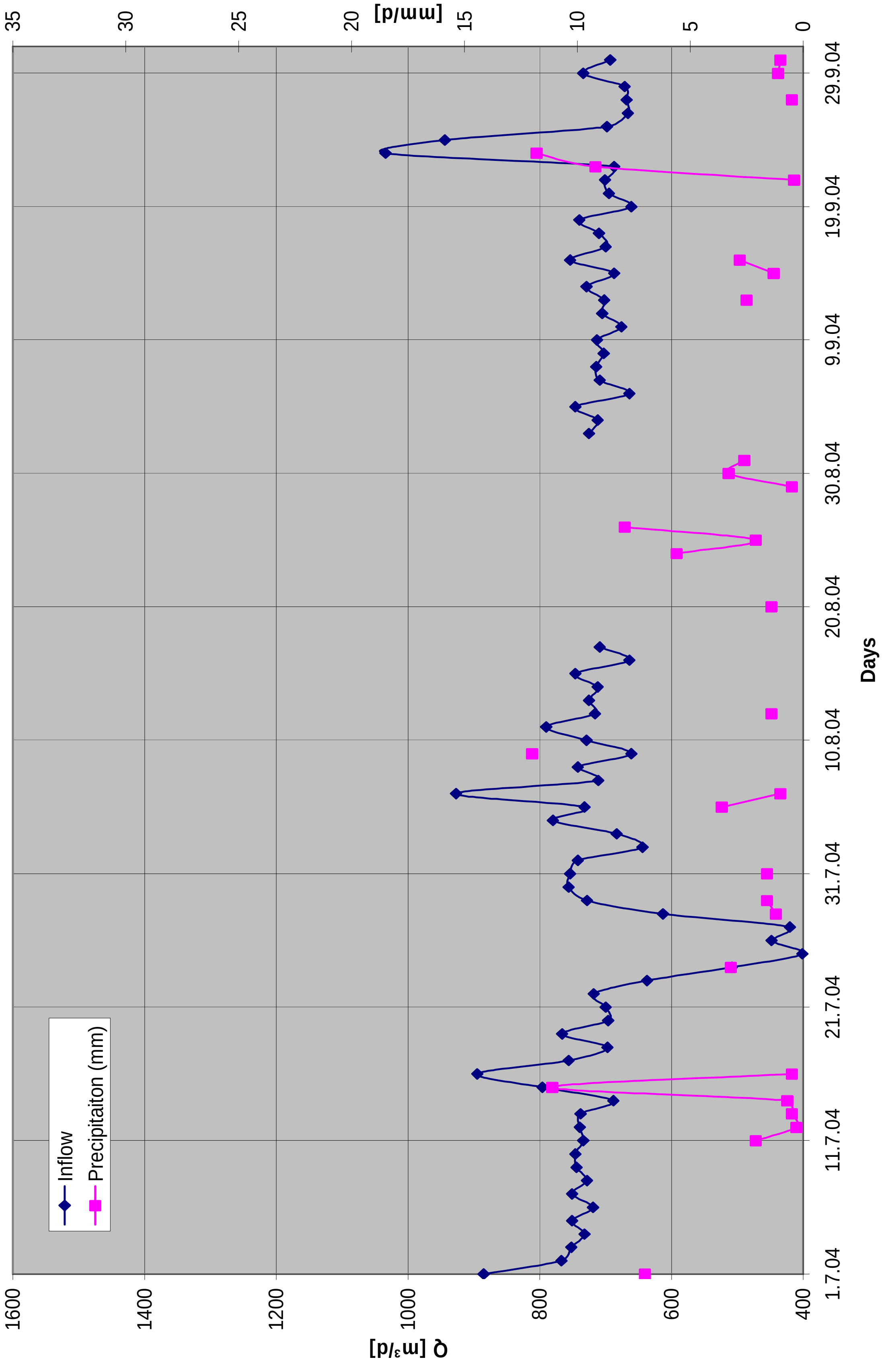

Fig. 7-8: Comparison of WWTP inflow with hydrographical data 3rd quarter 2004

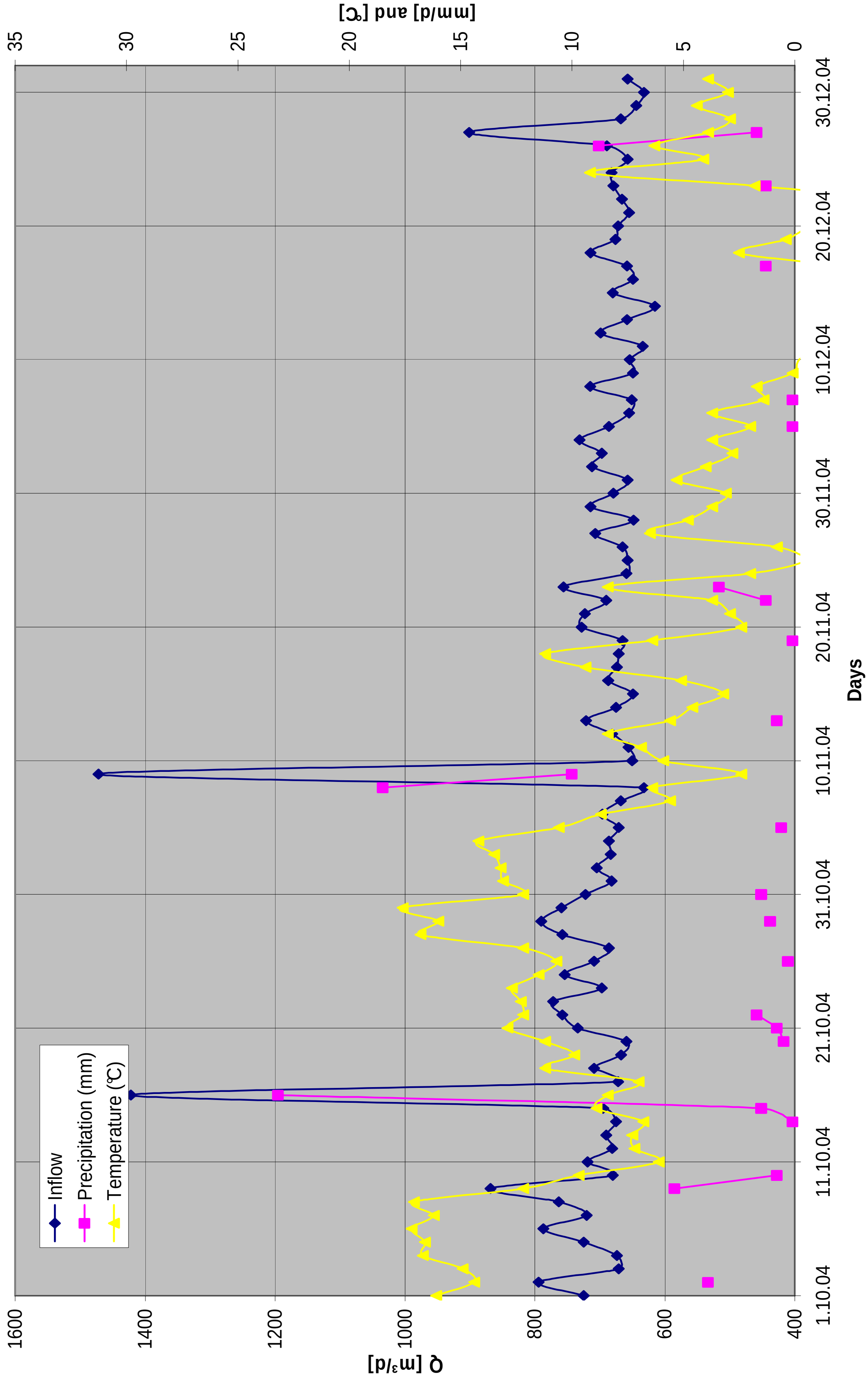

Fig. 7-9: Comparison of WWTP inflow with hydrographical data 4th quarter 2004

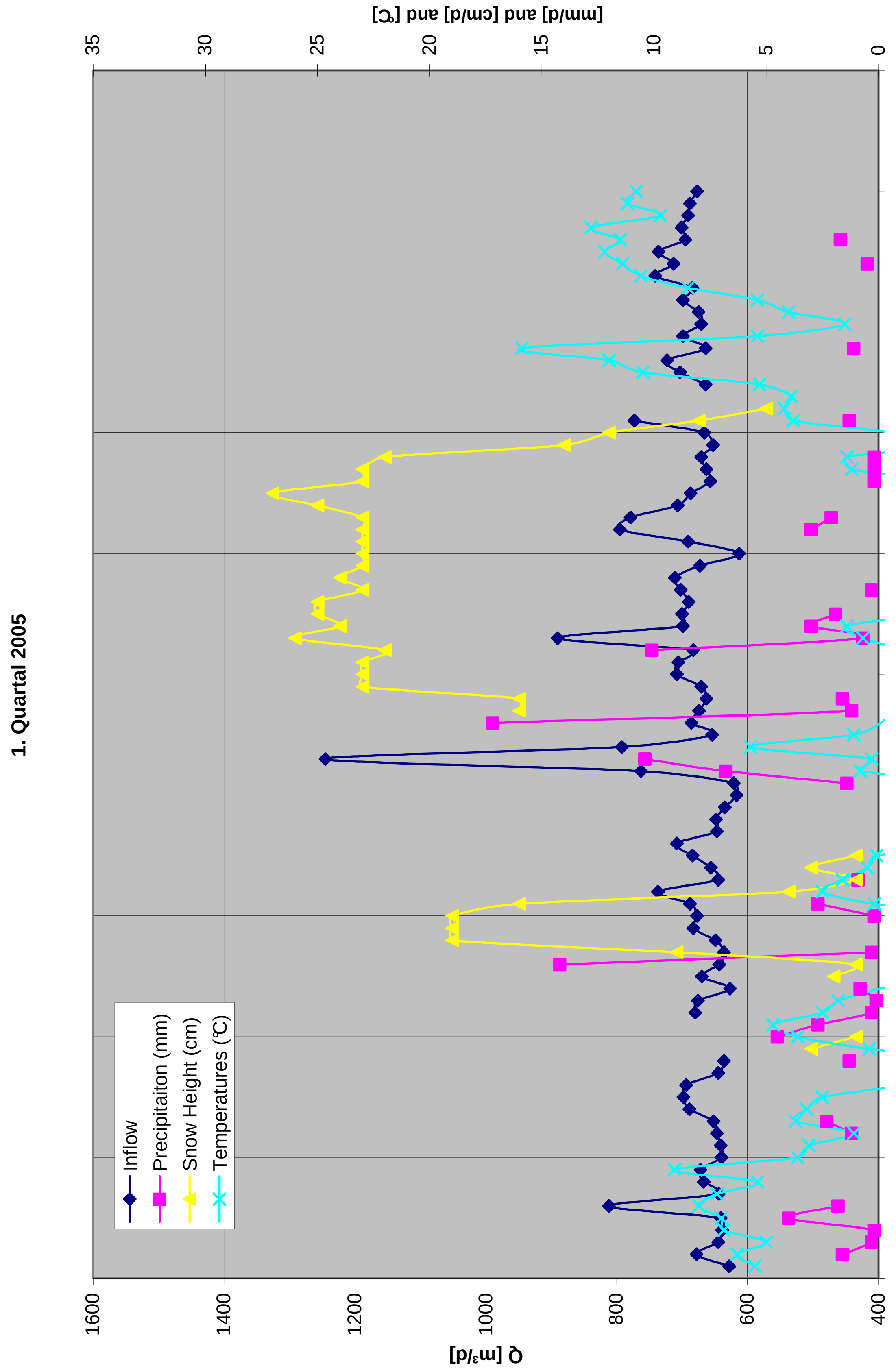

Fig. 7-10: Comparison of WWTP inflow with hydrographical data 1st quarter 2005

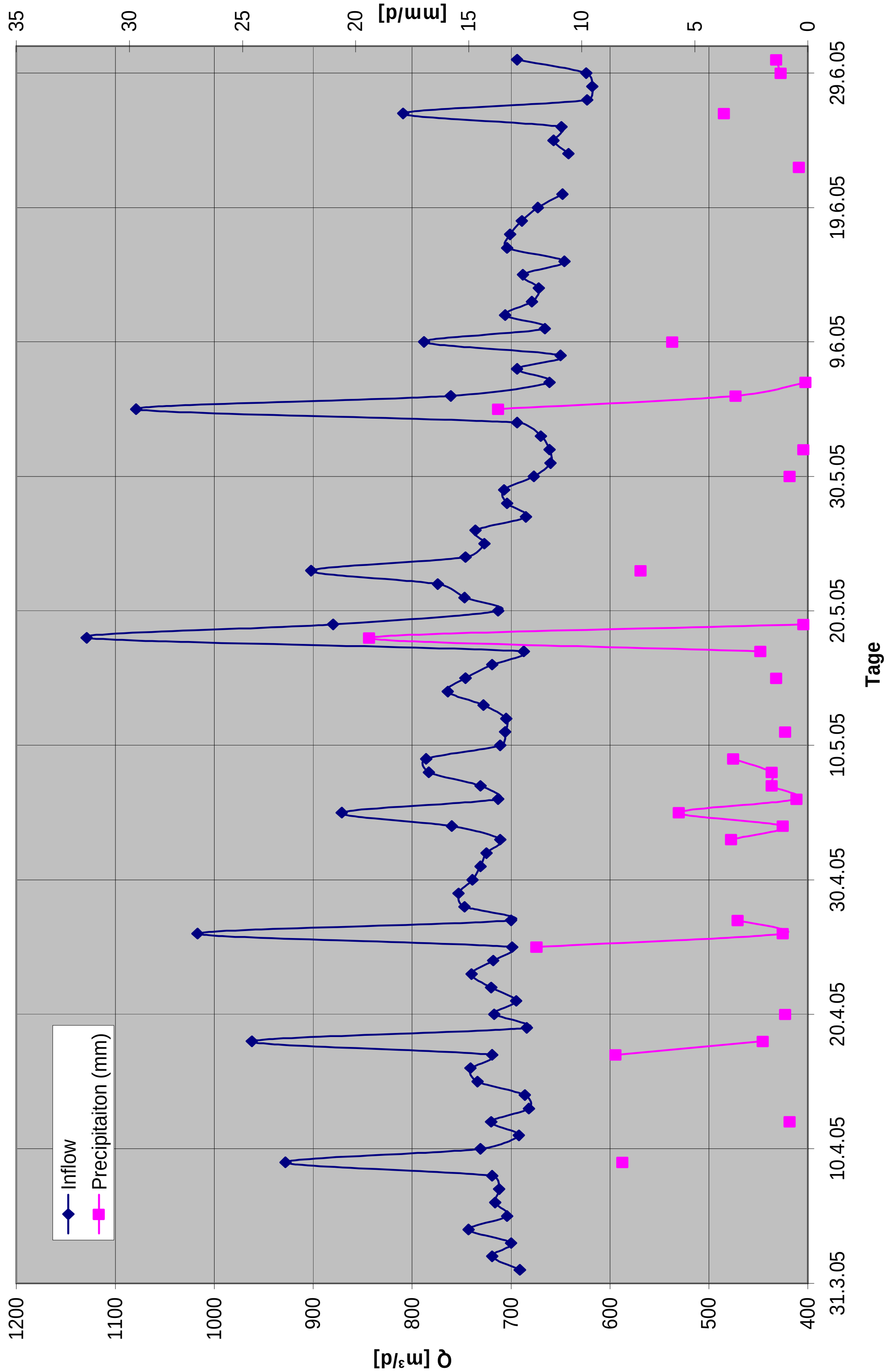

Fig. 7-11: Comparison of WWTP inflow with hydrographical data 2nd quarter 2005

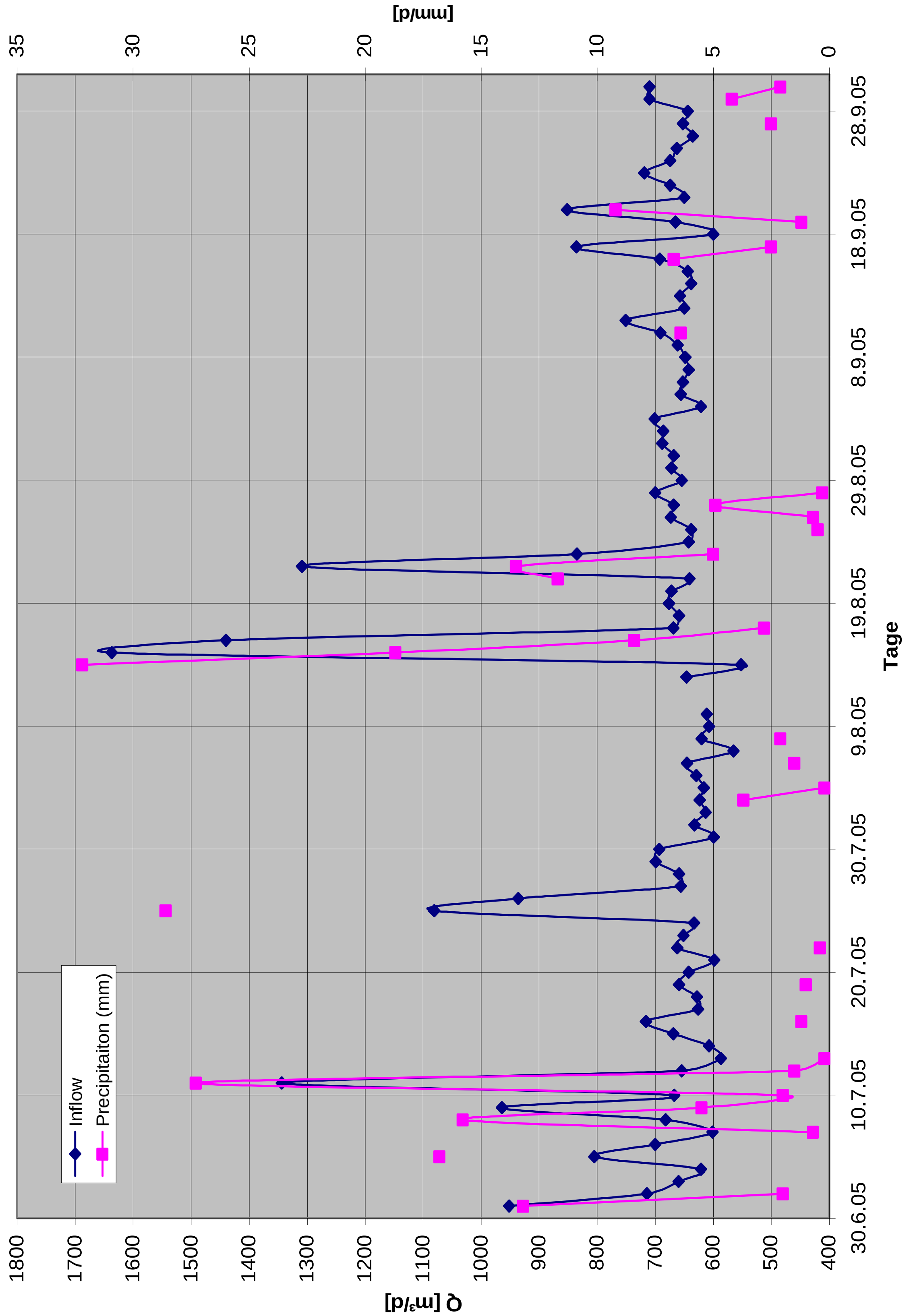

Fig. 7-12: Comparison of WWTP inflow with hydrographical data 3rd quarter 2005

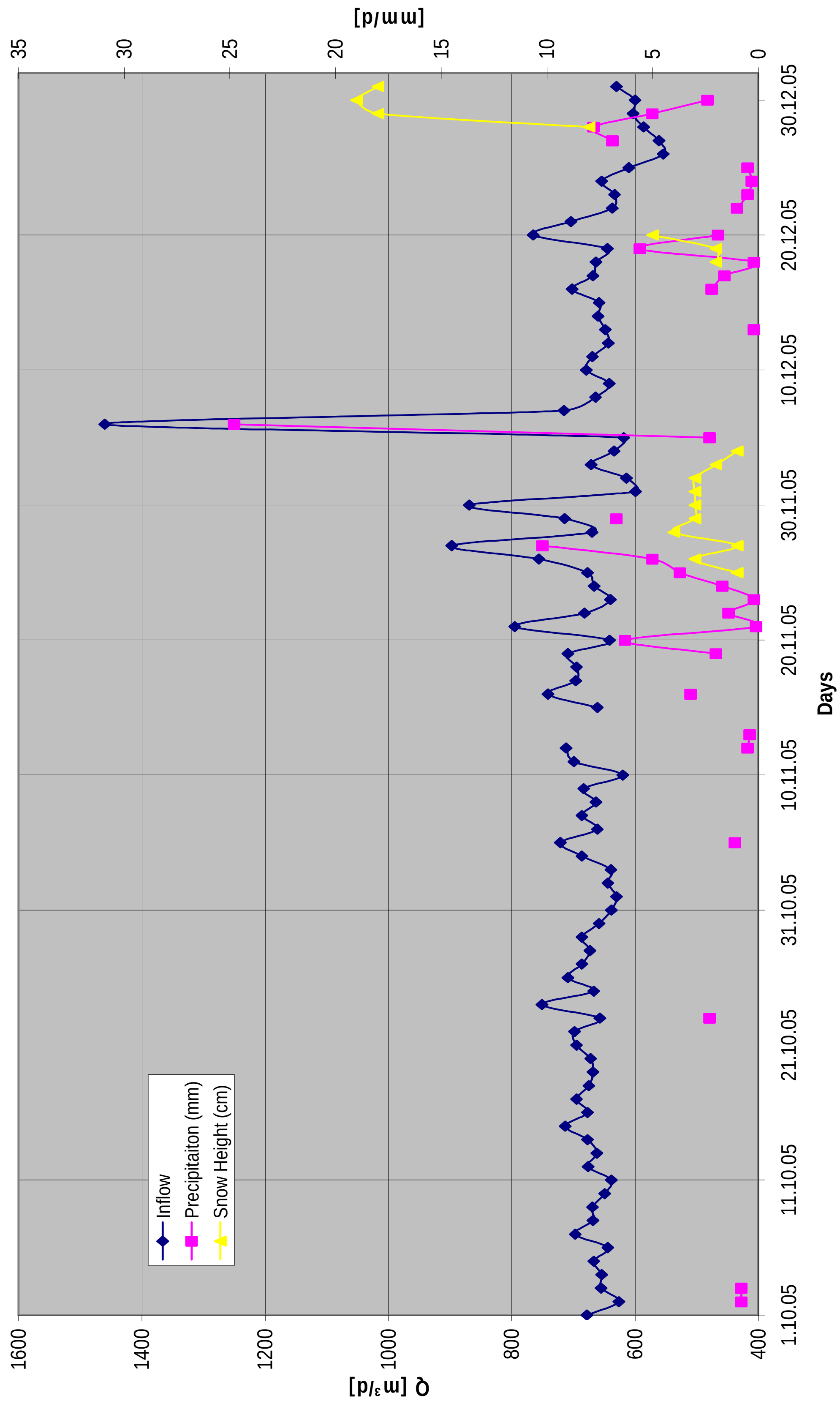

Fig. 7-13: Comparison of WWTP inflow with hydrographical data 4th quarter 2005

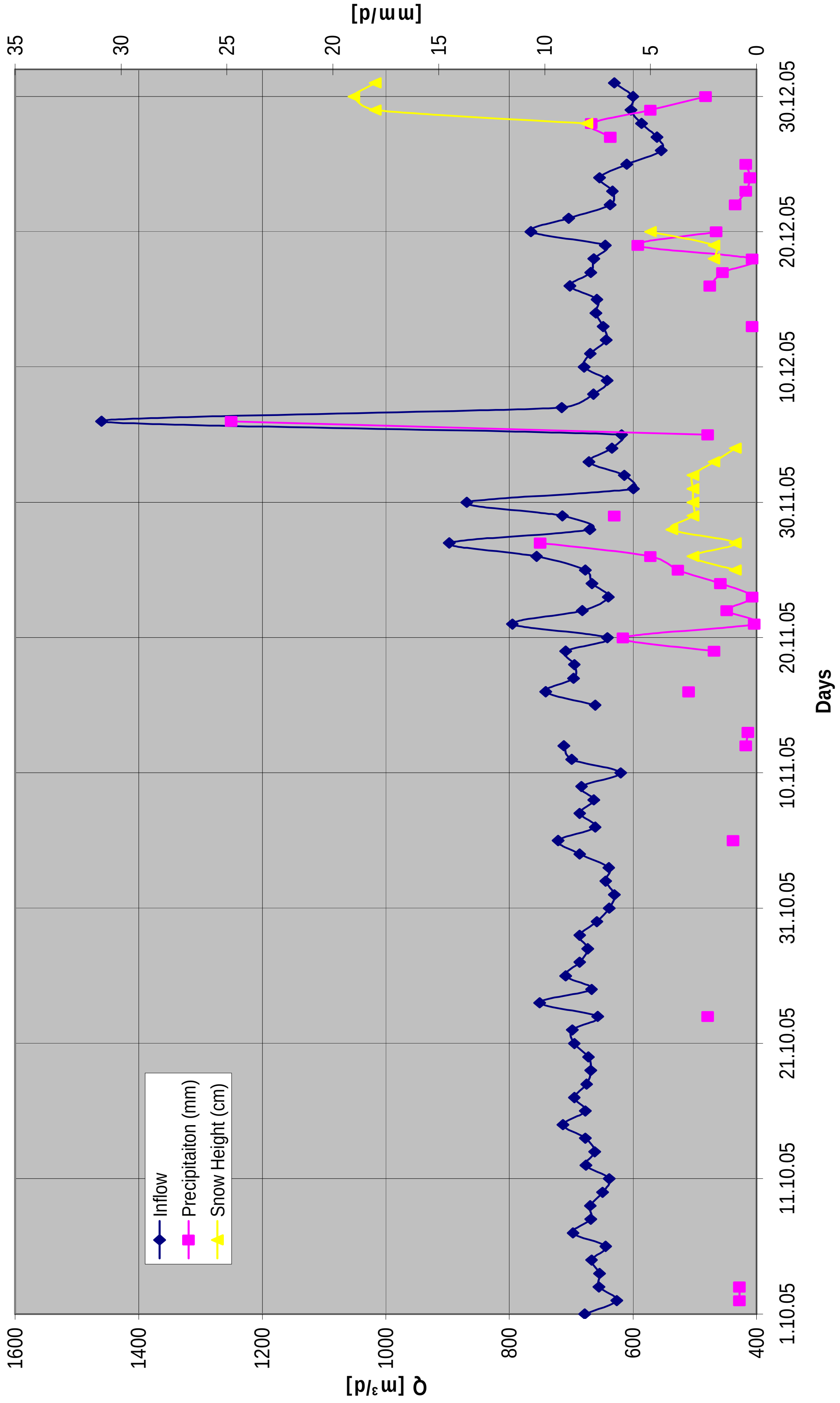

Fig. 7-14: Comparison of WWTP inflow with hydrographical data 1st quarter 2006

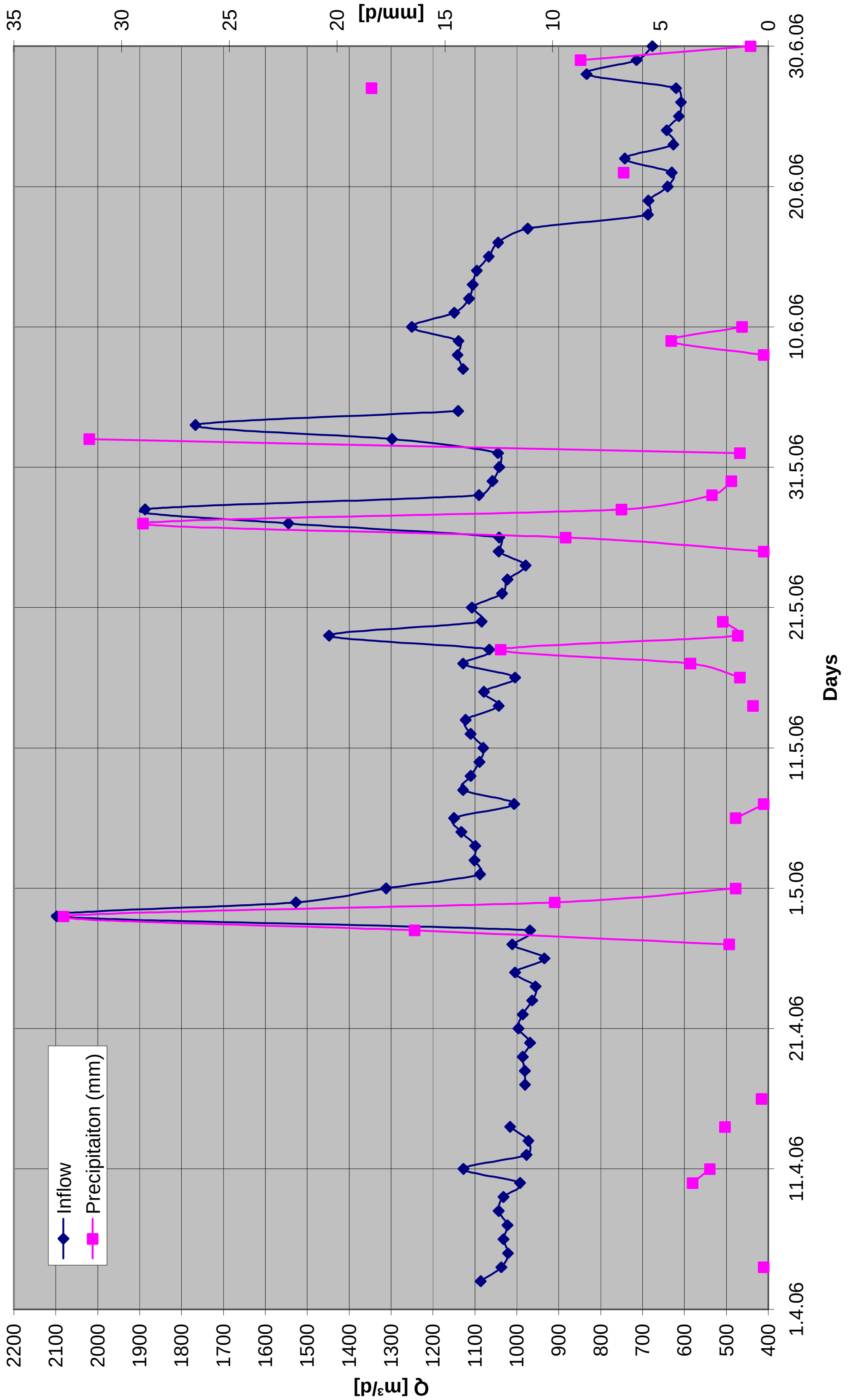

Fig. 7-15: Comparison of WWTP inflow with hydrographical data 2nd quarter 2006

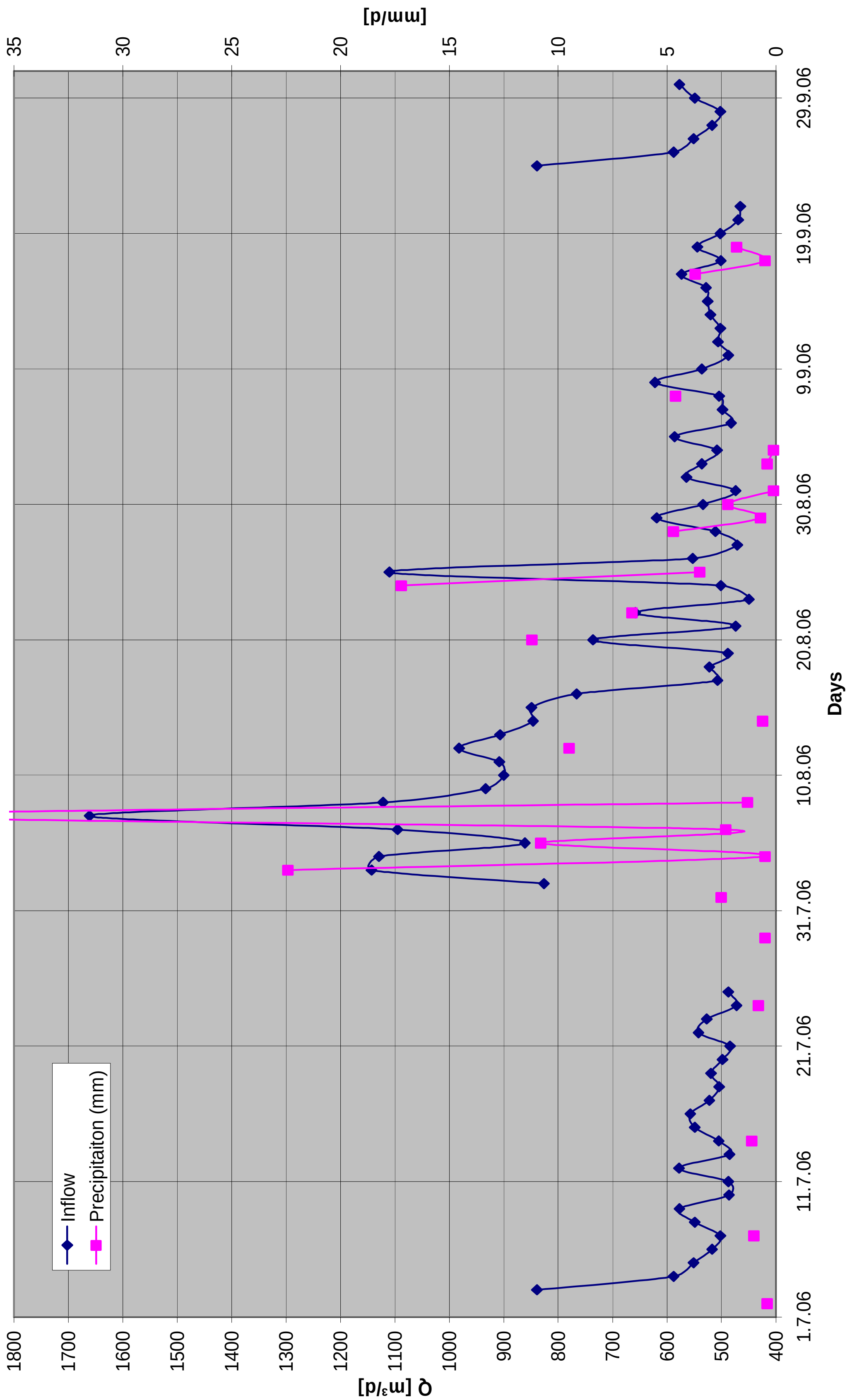

Fig. 7-16: Comparison of WWTP inflow with hydrographical data 3rd quarter 2006

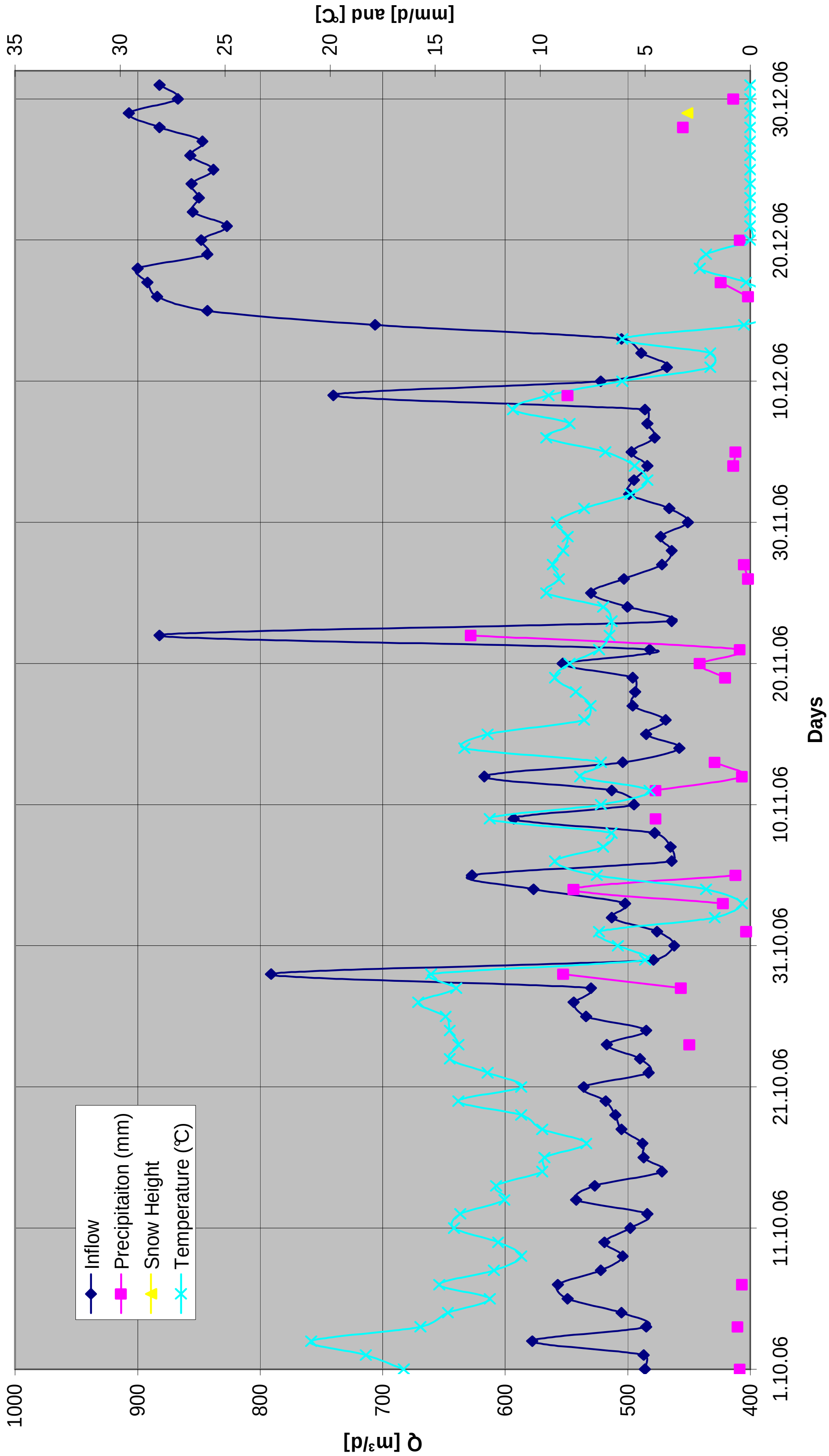

Fig. 7-17: Comparison of WWTP inflow with hydrographical data 4th quarter 2006

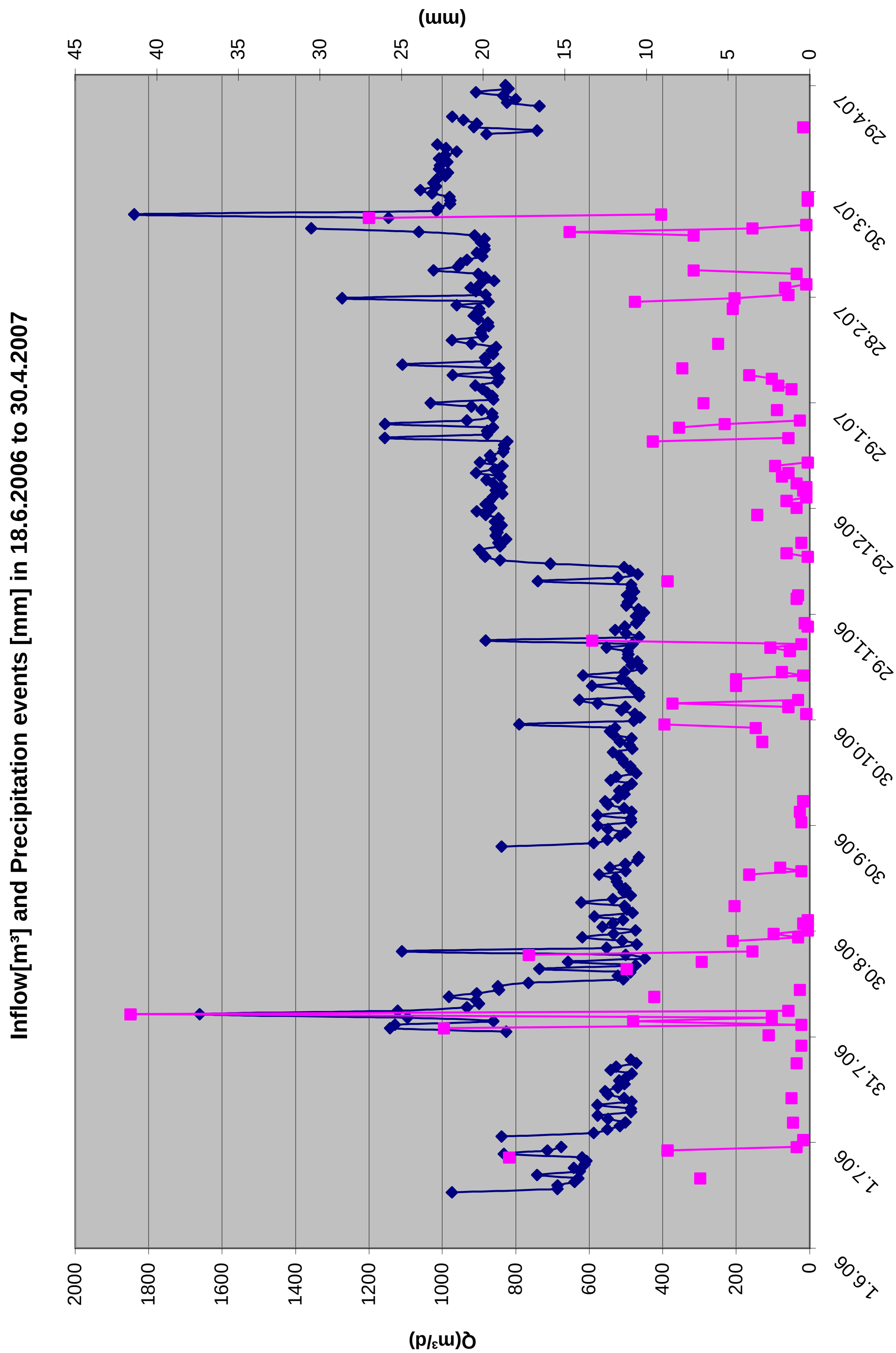

Fig. 7-18: Comparison of WWTP inflow with hydrographical data 01.06.2006 to 30.04.2007

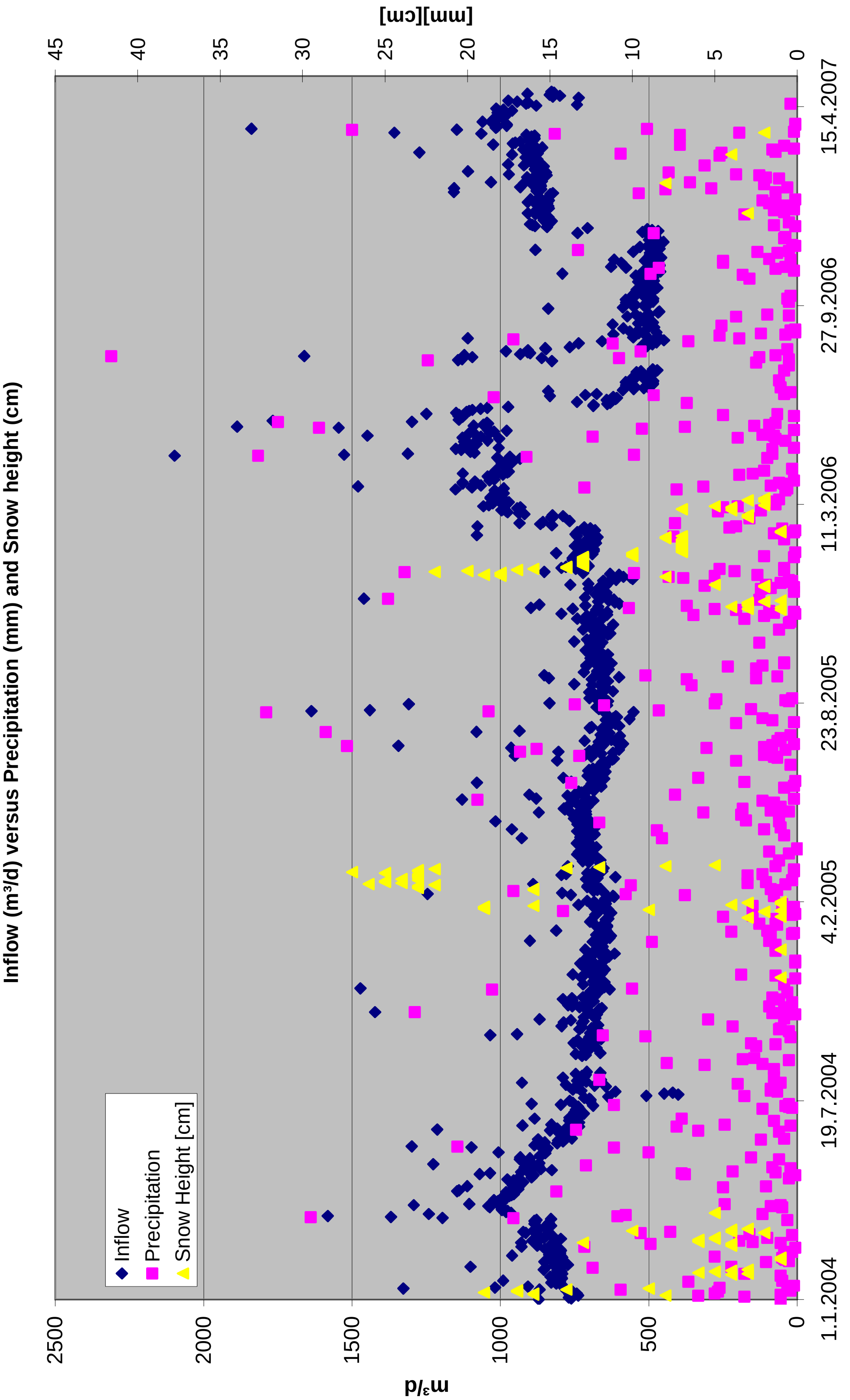

Fig. 7-19: Overview of WWTP inflow in comparison with hydrographical data 2004 – 2007

Tab. 7-1: Attribution of inhabitants, restaurants, schools and small industries to the pump stations

Streets and inherent pump stations	Inhabitants	Foreign workers, trades and public institutions	channel age like discussed with WWTP worker Christ	WRG replies for the sewer system like handed over by the BH Gänserndorf August 2007		new residents
1. Line: PW 1- PW 4				**sewer**	Jahr	
Brennereigasse	46		1983	Bürgerpark	1954	
Föhrenweg	19		1983	**Sewer enhancement:**		
Fasangasse	20		1983	Bahnstr	1958	
Gutshofstraße	72		1983	Loimersdorfer	1963	
Silogasse	5		2002	Hauptstrasse	1964	
Pump station 1 SILOGASSE (PW1)	**162**			Wienerstr	1965	
Hauptstraße	120		1999	**Sewer enhancement:**		
Marchegger Straße	13		1999	Bahnstr	1977	
Breitenseer Weg	3		1999	Groißenbrunner Str.	1985	
Oberweidner Straße	39		1999			
Wiener Straße	15		1999	Feldgasse/Lagerhaussi	2002	70
Neuhofgasse	14		1999	Amselgasse		8
Bahnstraße	9		1999	Schönfeld-Silogasse		5
Pump station 2 Breitenseerweg (PW2)	**375**					
Am Bahnhof	3		1999	Transport line old WWT	1996	
Am Bahnhof	6		1999	**New premises valued:**		
Am Stempfelbach	26		1990	Getreidegasse	2000 - 2002	41
Bahngasse	29		1999	Neubaugasse	2001 - 2002	79
Bahnstraße	31		1999	Blumenweg	2002 - 2002	23
Bahnstraße (57 - 93 und 70 - 82)	77		1983			**226**
Bahnweg	17		1999			
Wagramstraße	126		1999			
Pump station 3 Stempfelbach (PW3)	**690**					
Bahnstraße (37 - 55 unf 56 - 68)	49	school (~150 pupils) and small petrol station (registered as ID Lagerhaus with 0,3 m³/d)	1983			
Pump station 4 Reufeldgasse (PW4)	**739**					
2.line: PW 5 to PW6						
Amselgasse	3		2002			
Josefsgasse	75		1993			
Jägerweg	27		1983			
Pump station 5 Josefsgasse (PW5)	**105**					
Bahnstraße (13 - 35 und 22 - 54)	91		1983			
Feldgasse	110		2002 und 1983			
Lagerhausgasse	26		1983			
Ringstraße	52	1.) **Cannery Pfluger,** registered with 10 to ~19m³/d to rain channel and 30l/sec and 2.) **Fa.Reinbold Transport** registered as IE with 40m³/month and 6,5 l/sec	1983			
Pump station 6 Bahnstraße (PW6)	**384**					
PW6 and PW4 flow to PW7						
Am Holzgarten	68		1983			
Bahnstraße (1-11 und 2 bis 20)	45		1983			
Baumgasse	6		1999			
Birkengasse	3		1999			
Fünfhaus	24		1983			
Gartenweg	5		2002			
Hauptplatz	61		1983			
Johannesweg	25	*(Fa. Gasselich (Trugina:29m³/d))*	1983			
Kapellenweg	11		1983			
Loimersdorfer Straße (1 - 56)	163		1983			
Neustift	50		1983			
Obere Hauptstraße (1 - 45 und 2 - 36)	137	50 persons 1/2 year saison worker vegetable production M. Weiss, Musichouse	1983			
Pointengasse	37		1983			
Reufeldgasse	30		1983			
Stift Melk Gasse		(70 + 200) kindergarden and school	1983			
Untere Hauptstraße	216	restaurants and pub, after design Trugina: 0,2m³/d . Should be more	1983			
Wiesenweg	20		1983			
Windmühlgasse	30		1983			
Pump station 7 (Gasselich) (PW7)	**2054**					
last PW and connector:						
Wiener Straße	64		1983			
Haringseer Straße	19	Billa, reg. With 0,63m³	1983			
Viertelweg	16		1983			
Getreidegasse	41		2002			
Neubaugasse	79		2000			
Blumenweg	23		2000			
Windmühlgasse (15 - 29 und 18 - 32)	34		1983			
Obere Hauptstraße (47 - 77 und 38 bis 70)	95		1983			
Loimersdorfer Straße 58 - 62)	7		1999			
Pump station 8 Am Hagel (PW8) (total)	**2432**					

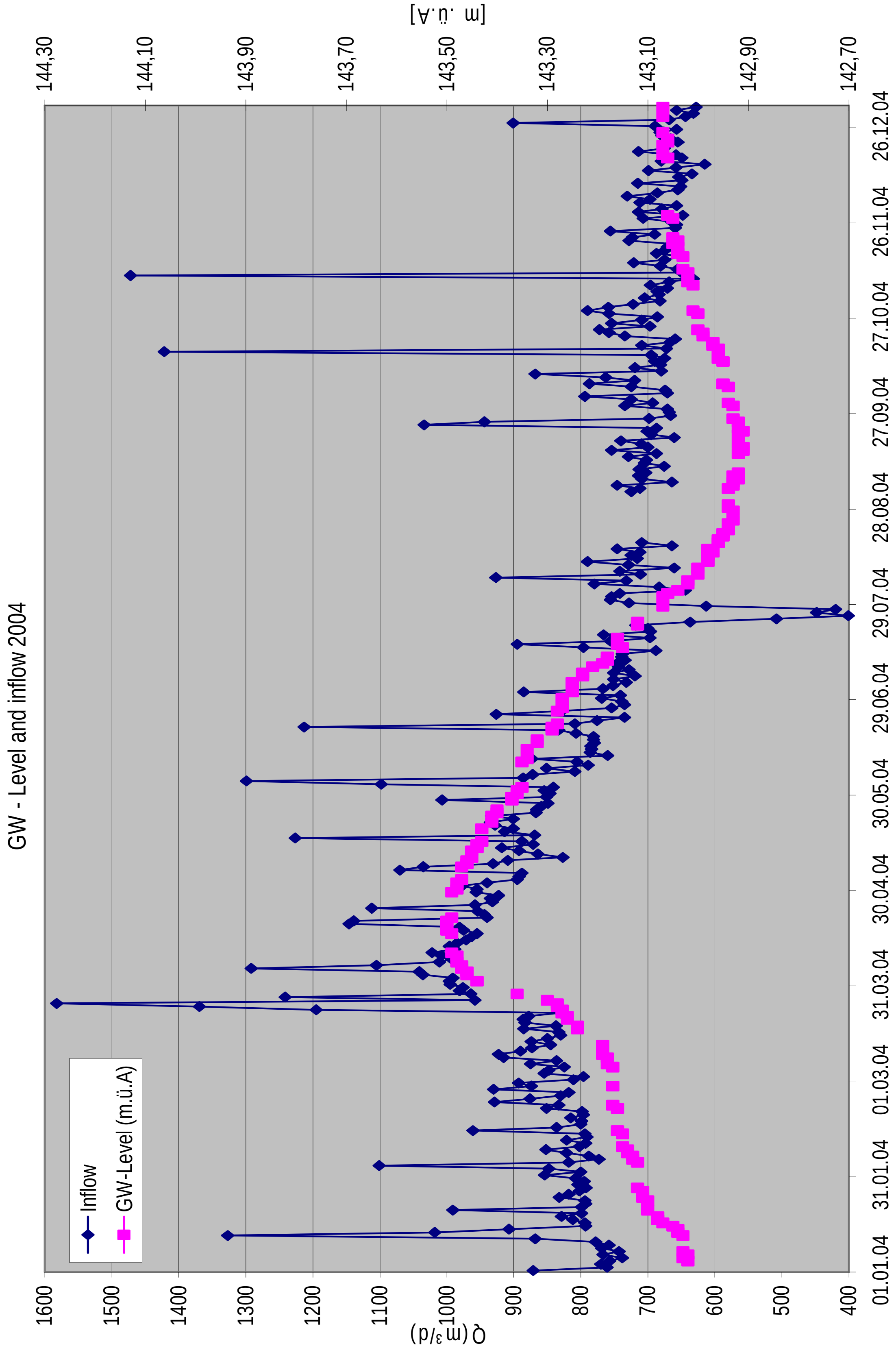

Fig. 7-20: GW level in comparison with the inflow to the WWTP 2004

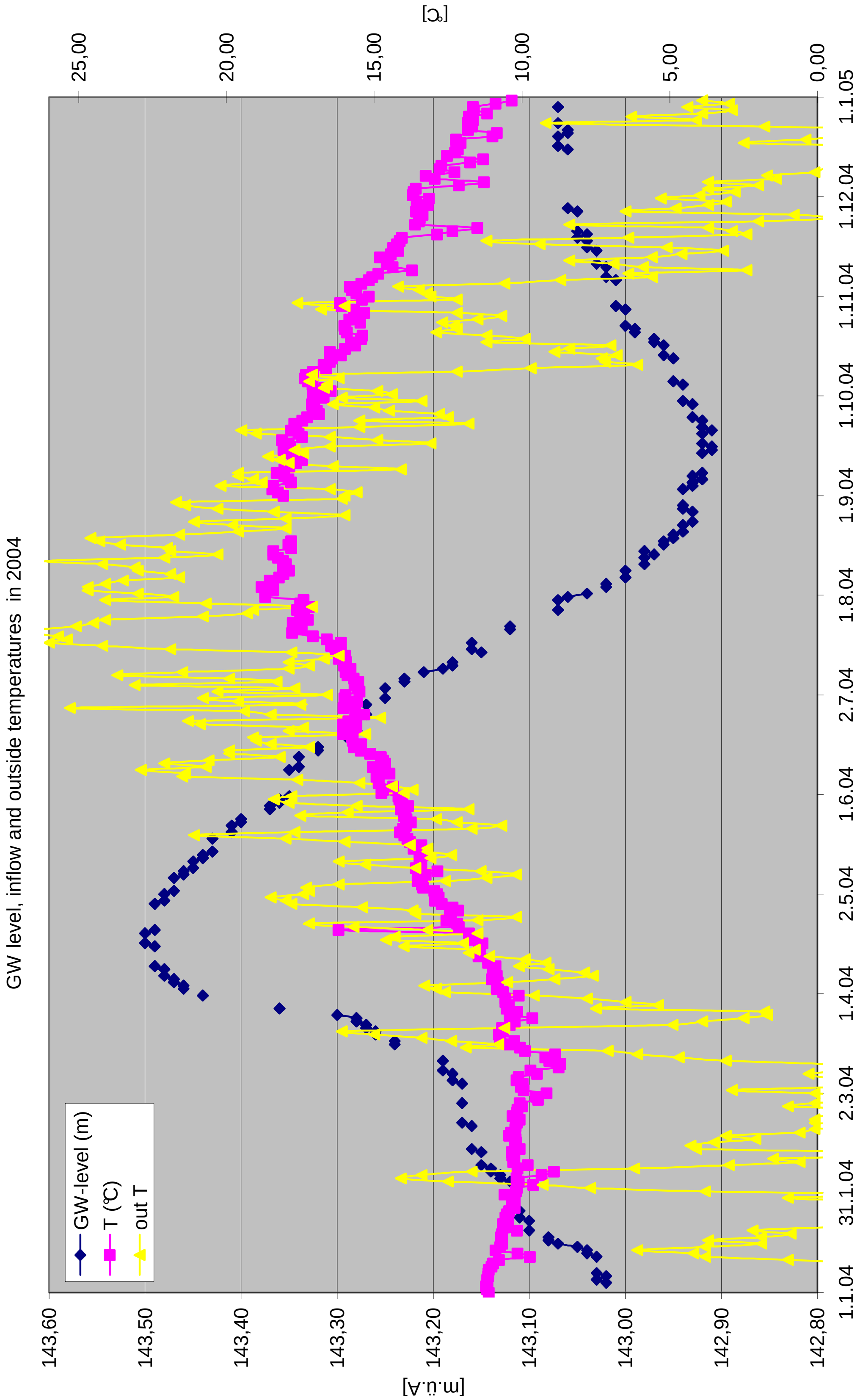

Fig. 7-21: GW level and air temperatures in comparison with inflow temperatures 2004

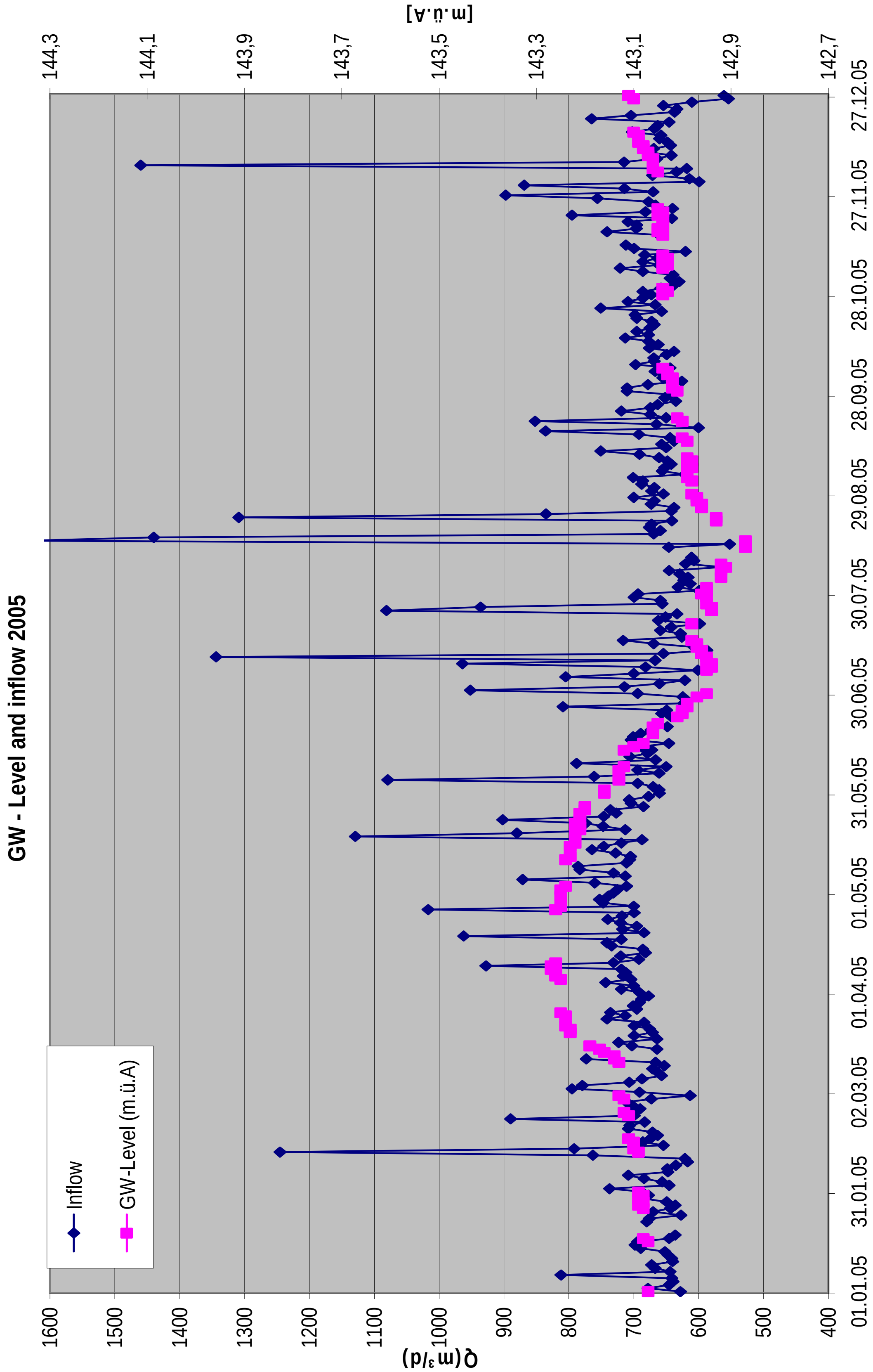

Fig. 7-22: GW level in comparison with the inflow to the WWTP 2005

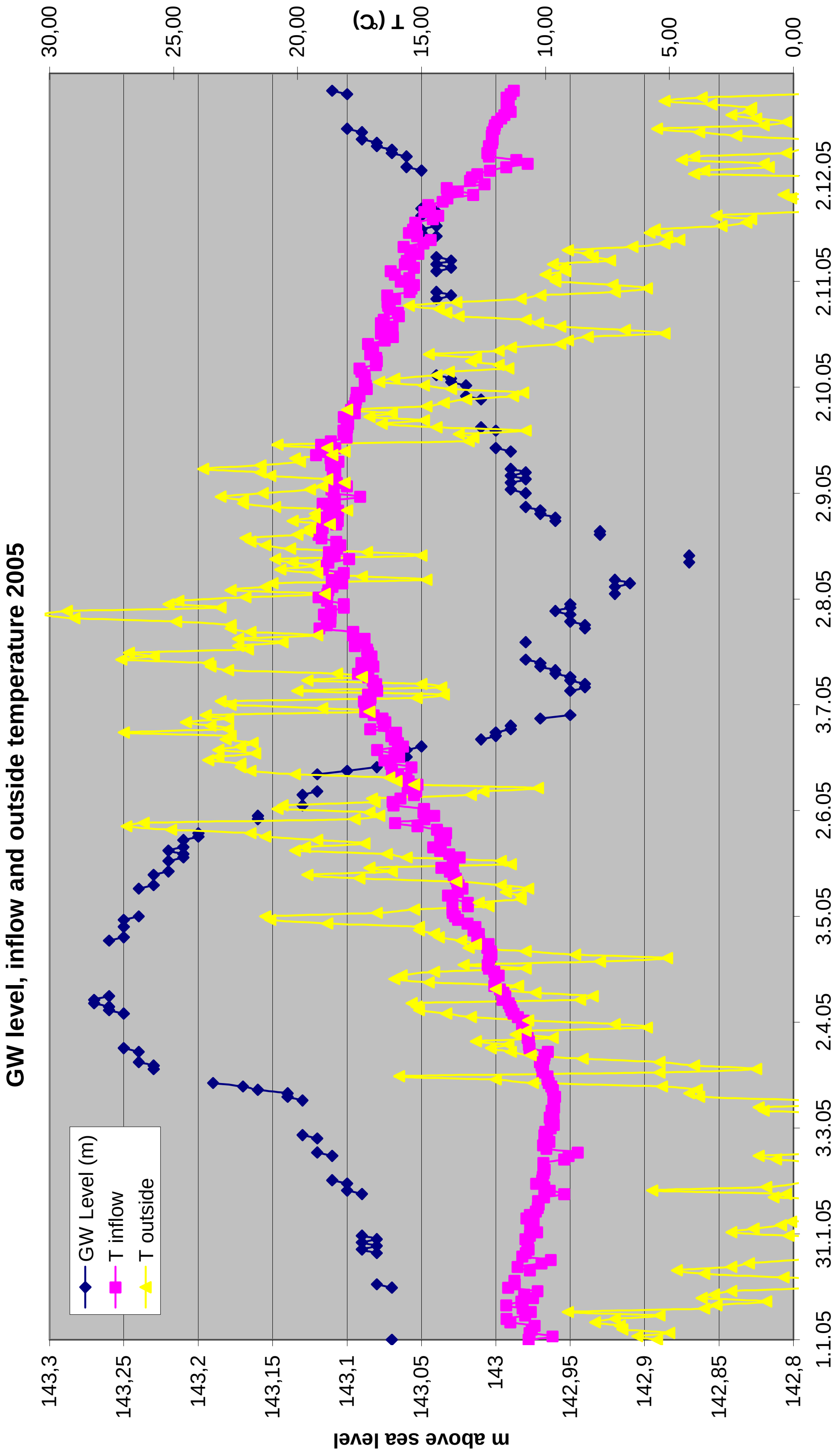

Fig. 7-23: GW level and air temperatures in comparison with inflow temperatures 2005

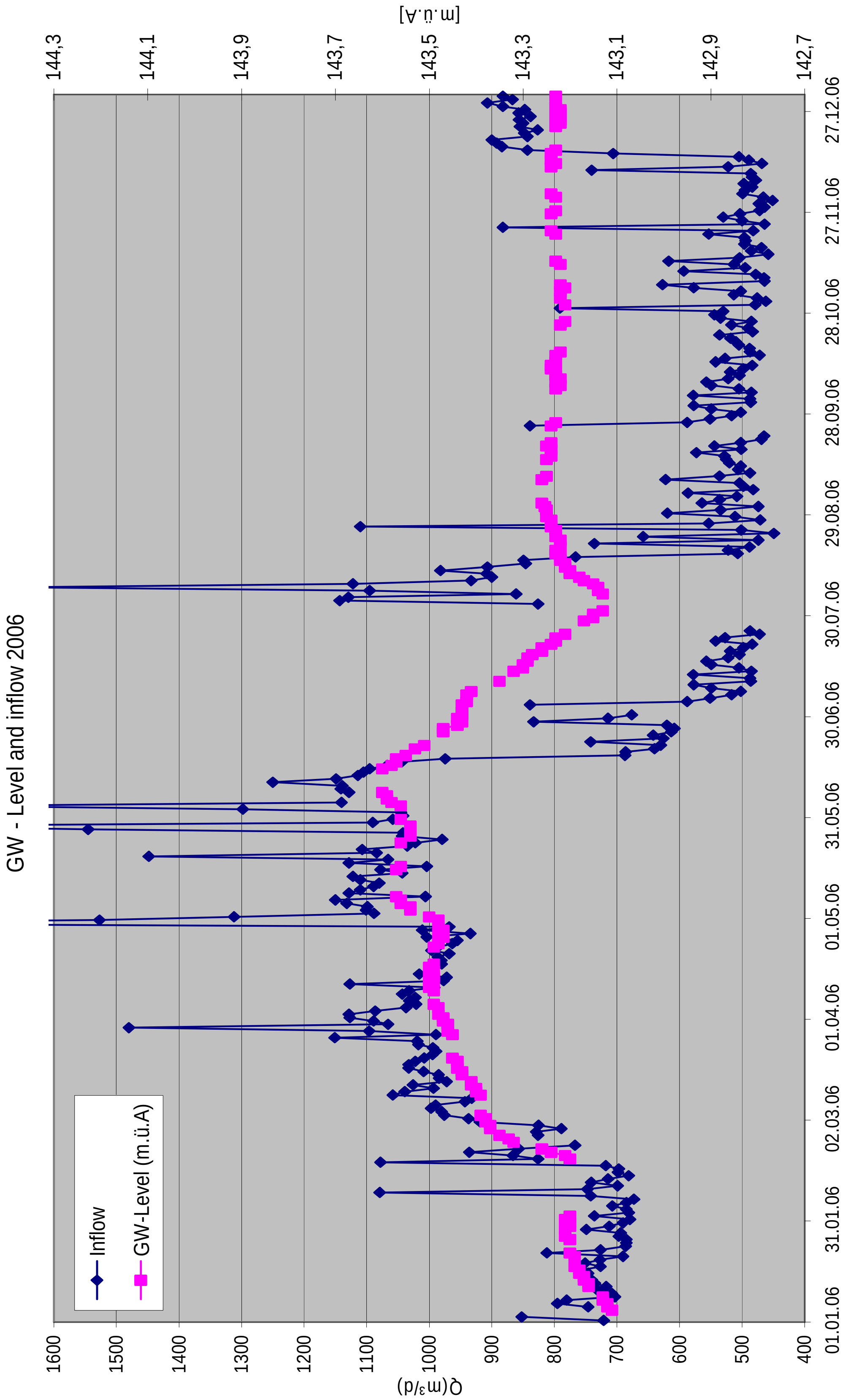

Fig. 7-24: GW level in comparison with the inflow to the WWTP 2006

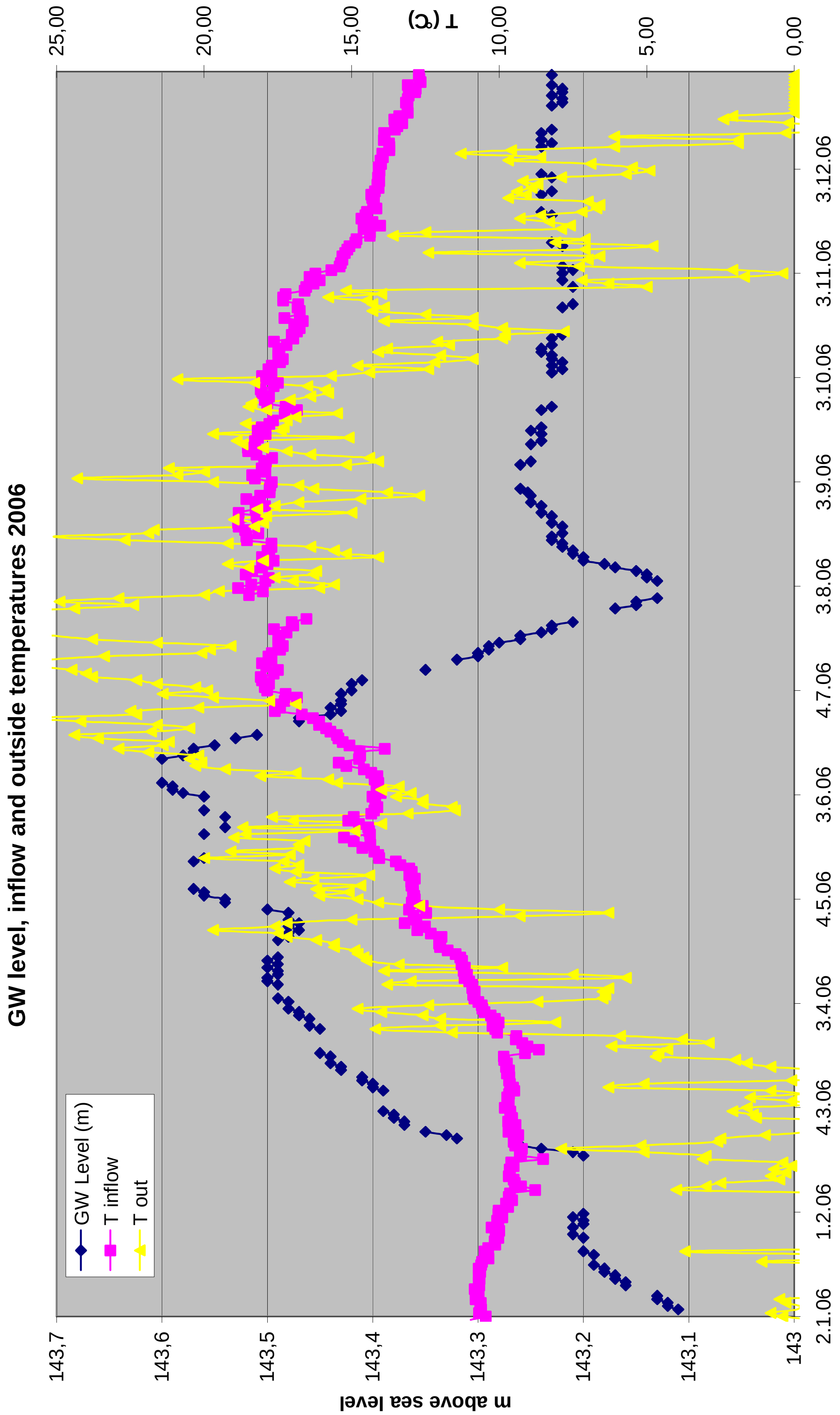

Fig. 7-25: GW level and air temperatures in comparison with inflow temperatures 2006

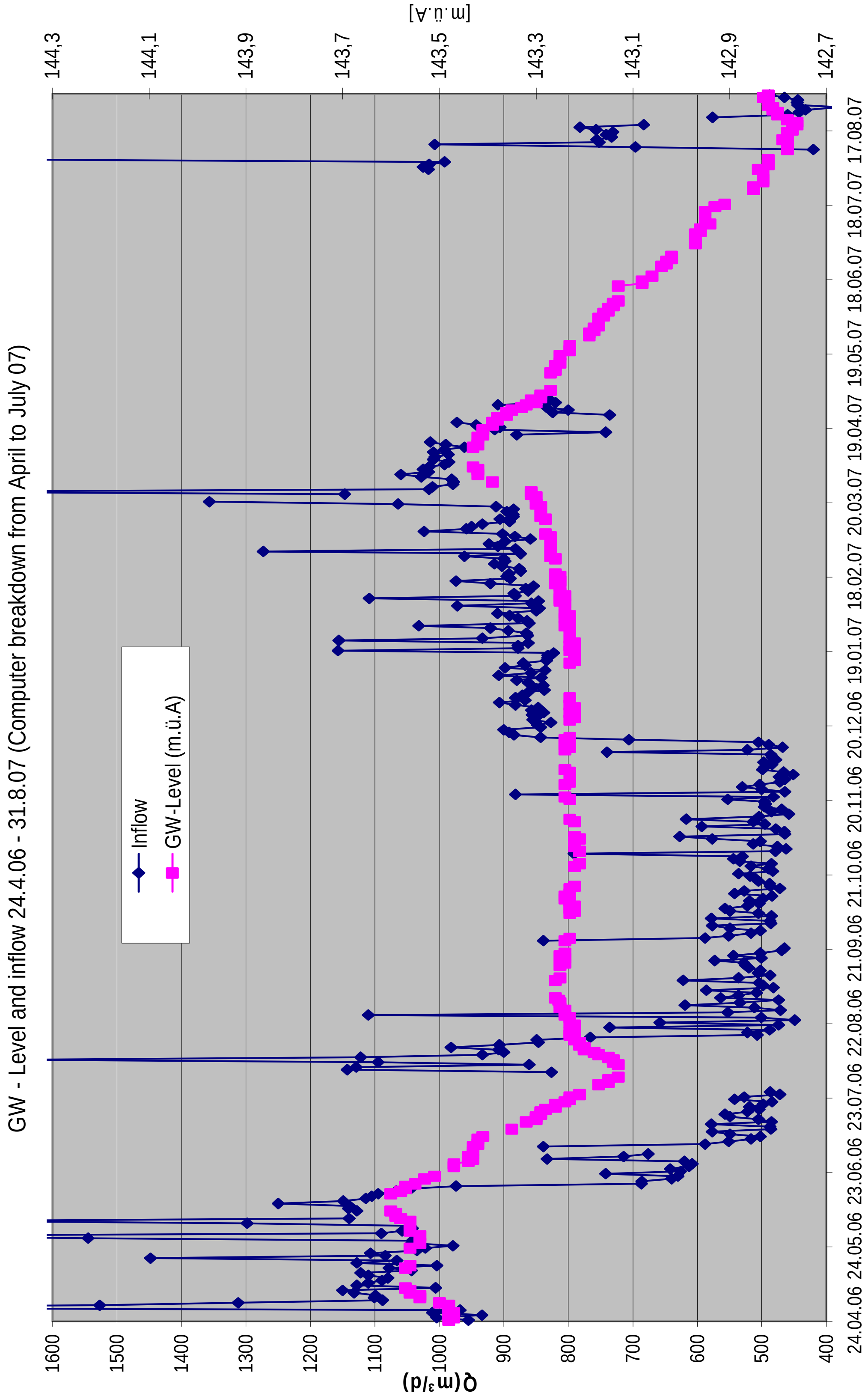

Fig. 7-26: GW level in comparison with the inflow to the WWTP from 24.6.2006 to 31.08.2007

Tab. 7-2: Loads 2005; copies out of the examination report (Terrachem, 2006)

Frachten 2005									
Datum	Zulauf m3	EGW hydr.	BSB5 mg/l	BSB5 kg/d	EGW BSB5	CSB mg/l	CSB kg/d	EGW CSB	W
02.01.2005	678	3.390	340,00	230,52	3.842	427,00	289,51	2.895	So
14.01.2005	689	3.445	110,00	75,79	1.263	222,00	152,96	1.530	Fr
23.01.2005	676	3.380	140,00	94,64	1.577	264,00	178,46	1.785	So
30.01.2005	677	3.385	120,00	81,24	1.354	282,00	190,91	1.909	So
13.02.2005	792	3.960	490,00	388,08	6.468	906,00	717,55	7.176	So
20.02.2005	706	3.530	100,00	70,60	1.177	163,00	115,08	1.151	So
06.03.2005	687	3.435	110,00	75,57	1.260	168,00	115,42	1.154	So
27.03.2005	695	3.475	200,00	139,00	2.317	417,00	289,82	2.898	So
03.04.2005	700	3.500	60,00	42,00	700	235,00	164,50	1.645	So
10.04.2005	731	3.655	300,00	219,30	3.655	478,00	349,42	3.494	So
17.04.2005	719	3.595	180,00	129,42	2.157	520,00	373,88	3.739	So
24.04.2005	718	3.590				362,00	259,92	2.599	So
01.05.2005	731	3.655	180,00	131,58	2.193	310,00	226,61	2.266	So
09.05.2005	786	3.930	200,00	157,20	2.620	352,00	276,67	2.767	Mo
15.05.2005	746	3.730	190,00	141,74	2.362	351,00	261,85	2.618	So
22.05.2005	774	3.870	260,00	201,24	3.354	487,00	376,94	3.769	So
29.05.2005	707	3.535	160,00	113,12	1.885	316,00	223,41	2.234	So
05.06.2005	761	3.805	320,00	243,52	4.059	531,00	404,09	4.041	So
12.06.2005	679	3.395	70,00	47,53	792	186,00	126,29	1.263	So
19.06.2005	673	3.365	320,00	215,36	3.589	583,00	392,36	3.924	So
26.06.2005	809	4.045	330,00	266,97	4.450	551,00	445,76	4.458	So
03.07.2005	660	3.300	230,00	151,80	2.530	495,00	326,70	3.267	So
10.07.2005	667	3.335	250,00	166,75	2.779	311,00	207,44	2.074	So
24.07.2005	633	3.165	260,00	164,58	2.743	1031,00	652,62	6.526	So
31.07.2005	599	2.995	320,00	191,68	3.195	506,00	303,09	3.031	So
07.08.2005	565	2.825	760,00	429,40	7.157	1076,00	607,94	6.079	So
14.08.2005	552	2.760	280,00	154,56	2.576	431,00	237,91	2.379	So
28.08.2005	700	3.500	460,00	322,00	5.367	749,00	524,30	5.243	So
04.09.2005	621	3.105	560,00	347,76	5.796	1186,00	736,51	7.365	So
11.09.2005	751	3.755	380,00	285,38	4.756	866,00	650,37	6.504	So
18.09.2005	600	3.000	600,00	360,00	6.000	749,00	449,40	4.494	So
25.09.2005	663	3.315	320,00	212,16	3.536	507,00	336,14	3.361	So
02.10.2005	626	3.130	900,00	563,40	9.390	1295,00	810,67	8.107	So
23.10.2005	657	3.285	520,00	341,64	5.694	712,00	467,78	4.678	So
30.10.2005	658	3.290	320,00	210,56	3.509	721,00	474,42	4.744	So
06.11.2005	661	3.305	280,00	185,08	3.085	777,00	513,60	5.136	So
20.11.2005	641	3.205	420,00	269,22	4.487	620,00	397,42	3.974	So
04.12.2005	634	3.170	110,00	69,74	1.162	259,00	164,21	1.642	So
11.12.2005	669	3.345	120,00	80,28	1.338	289,00	193,34	1.933	So
18.12.2005	663	3.315	170,00	112,71	1.879	240,00	159,12	1.591	So
25.12.2005	610	3.050	250,00	152,50	2.542	301,00	183,61	1.836	So
Mittelwert	682	3.410			3.265			3.495	
W = Wochentag									

Data are arranged and calculated as PE (200l/PE*d) according to the monthly reports of the WWTP Lassee, Zulauf = Inflow (m^3/d); EGW = PE; BSB5 = BOD; CSB = COD; W = Week day; So = Sunday

Tab. 7-3: Loads (Frachten) 2006; copies out of the examination report (Terrachem, 2006)

Frachten 2006									
Datum	Zulauf m3	EGW hydr.	BSB5 mg/l	BSB5 kg/d	EGW BSB5	CSB mg/l	CSB kg/d	EGW CSB	W
01.01.2006	721	3.605	80,00	57,68	961	335,00	241,54	2.415	So
08.01.2006	703	3.515	150,00	105,45	1.758	255,00	179,27	1.793	So
15.01.2006	746	3.730	110,00	82,06	1.368	319,00	237,97	2.380	So
22.01.2006	726	3.630	170,00	123,42	2.057	348,00	252,65	2.526	So
29.01.2006	712	3.560				177,00	126,02	1.260	So
05.02.2006	685	3.425	120,00	82,20	1.370	320,00	219,20	2.192	So
12.02.2006	714	3.570	180,00	128,52	2.142	377,00	269,18	2.692	So
19.02.2006	866	4.330	160,00	138,56	2.309	267,00	231,22	2.312	So
26.02.2006	829	4.145	290,00	240,41	4.007	400,00	331,60	3.316	So
05.03.2006	997	4.985	100,00	99,70	1.662	246,00	245,26	2.453	So
12.03.2006	1026	5.130	150,00	153,90	2.565	384,00	393,98	3.940	So
26.03.2006	1151	5.755	240,00	276,24	4.604	671,00	772,32	7.723	So
09.04.2006	1032	5.160	110,00	113,52	1.892	266,00	274,51	2.745	So
16.04.2006	673	3.365	130,00	87,49	1.458	181,00	121,81	1.218	So
30.04.2006	1527	7.635				1114,00	1701,08	17.011	So
07.05.2006	1006	5.030	180,00	181,08	3.018	420,00	422,52	4.225	So
14.05.2006	1043	5.215	40,00	41,72	695	72,00	75,10	751	So
03.06.2006	1767	8.835	240,00	424,08	7.068	526,00	929,44	9.294	Sa
11.06.2006	1149	5.745	170,00	195,33	3.256	359,00	412,49	4.125	So
18.06.2006	687	3.435	190,00	130,53	2.176	425,00	291,98	2.920	So
25.06.2006	613	3.065	250,00	153,25	2.554	420,00	257,46	2.575	So
03.07.2006	839	4.195	240,00	201,36	3.356	380,00	318,82	3.188	Mo
10.07.2006	486	2.430	560,00	272,16	4.536	1144,00	555,98	5.560	Mo
17.07.2006	522	2.610	760,00	396,72	6.612	892,00	465,62	4.656	Mo
24.07.2006	472	2.360				669,00	315,77	3.158	Mo
06.08.2006	1095	5.475	150,00	164,25	2.738	233,00	255,14	2.551	So
13.08.2006	907	4.535	190,00	172,33	2.872	372,00	337,40	3.374	So
20.08.2006	736	3.680	340,00	250,24	4.171	604,00	444,54	4.445	So
27.08.2006	471	2.355	360,00	169,56	2.826	1103,00	519,51	5.195	So
03.09.2006	508	2.540	380,00	193,04	3.217	476,00	241,81	2.418	So
10.09.2006	487	2.435	460,00	224,02	3.734	625,00	304,38	3.044	So
17.09.2006	501	2.505	400,00	200,40	3.340	881,00	441,38	4.414	So
24.09.2006	839	4.195	240,00	201,36	3.356	380,00	318,82	3.188	So
Mittelwert	**825**	**4.125**			**2.923**			**3.790**	

Data are arranged and calculated as PE (200l/PE*d) according to the monthly reports of the WWTP Lassee, Zulauf = Inflow (m³/d);
EGW = PE; BSB5 = BOD; CSB = COD; W = Week day; So = Sunday

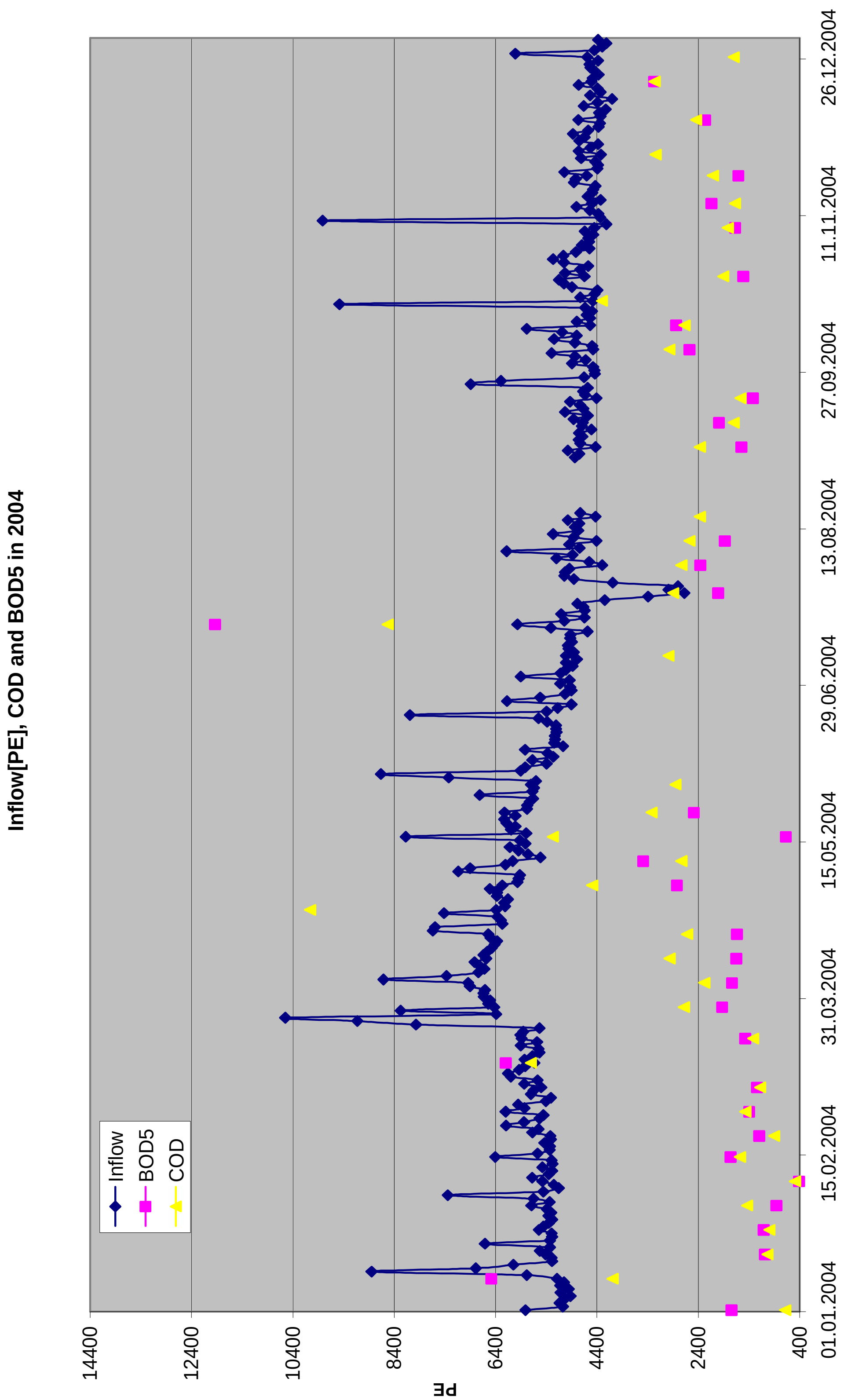

Fig. 7-27: Inflow, BOD5 and COD in comparison calculated as PE (150l/PE*d) in 2004

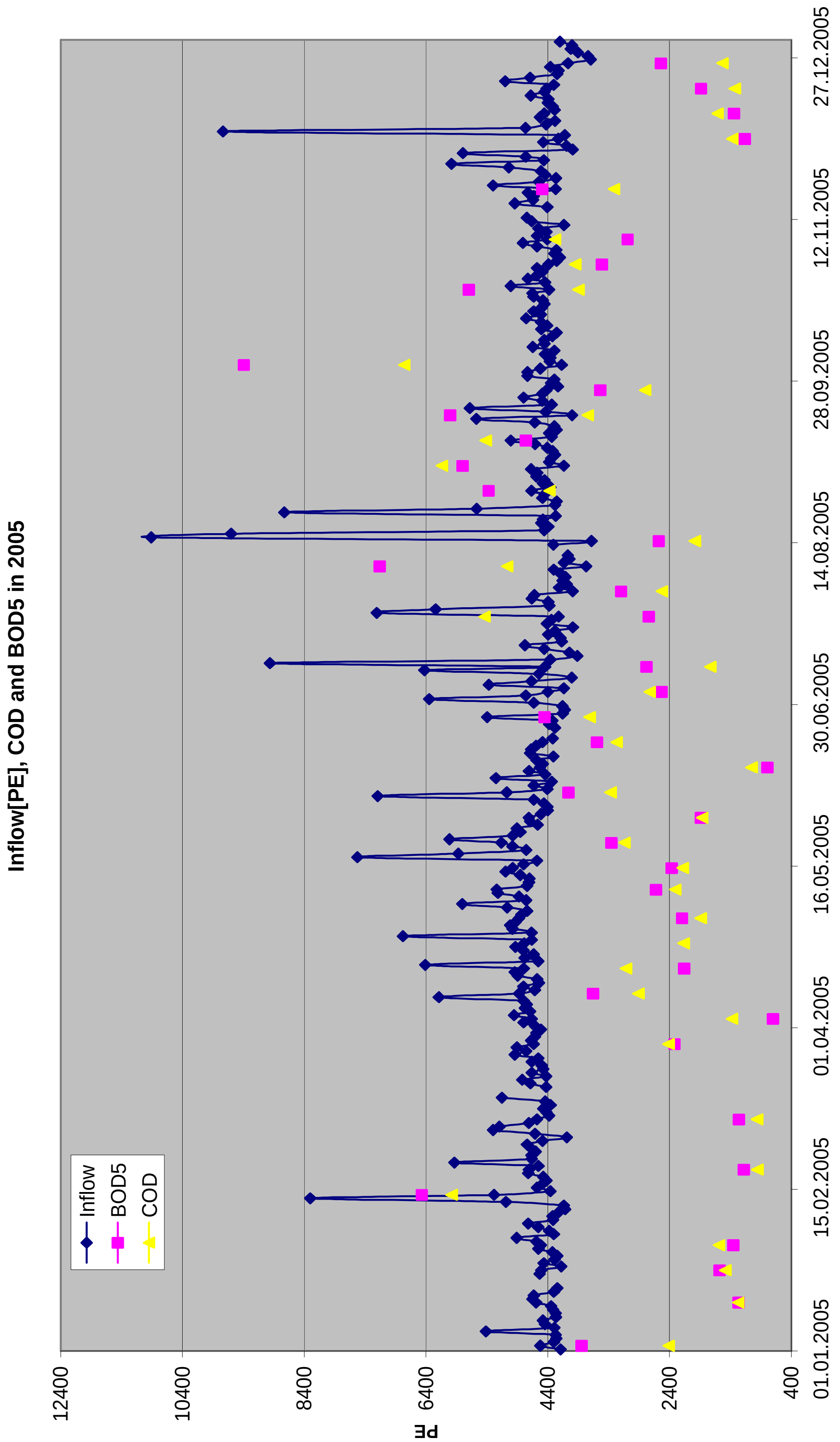

Fig. 7-28: Inflow, BOD5 and COD in comparison calculated as PE (150l/PE*d) in 2005

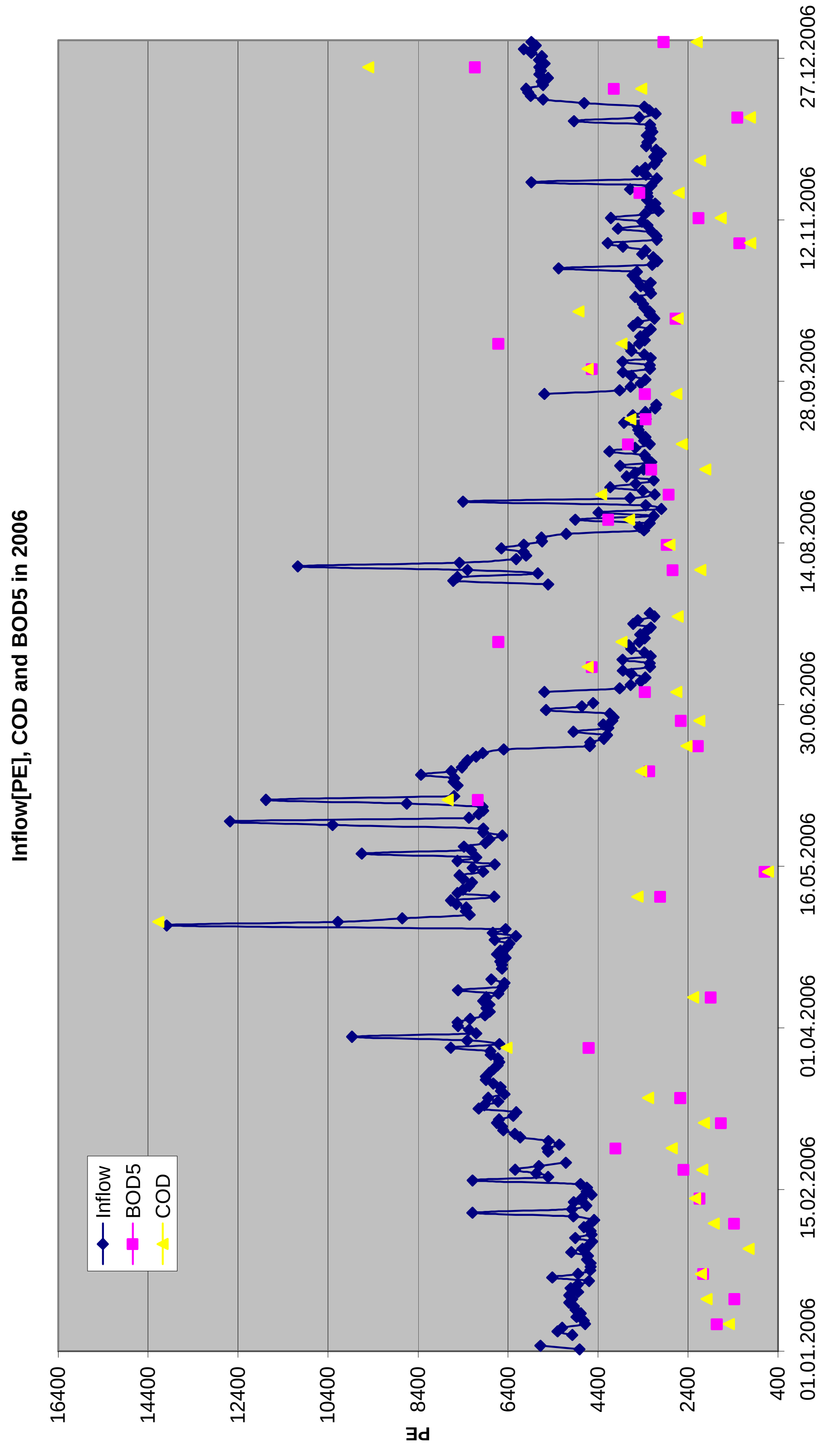

Fig. 7-29: Inflow, BOD5 and COD in comparison calculated as PE (150l/PE*d) in 2006

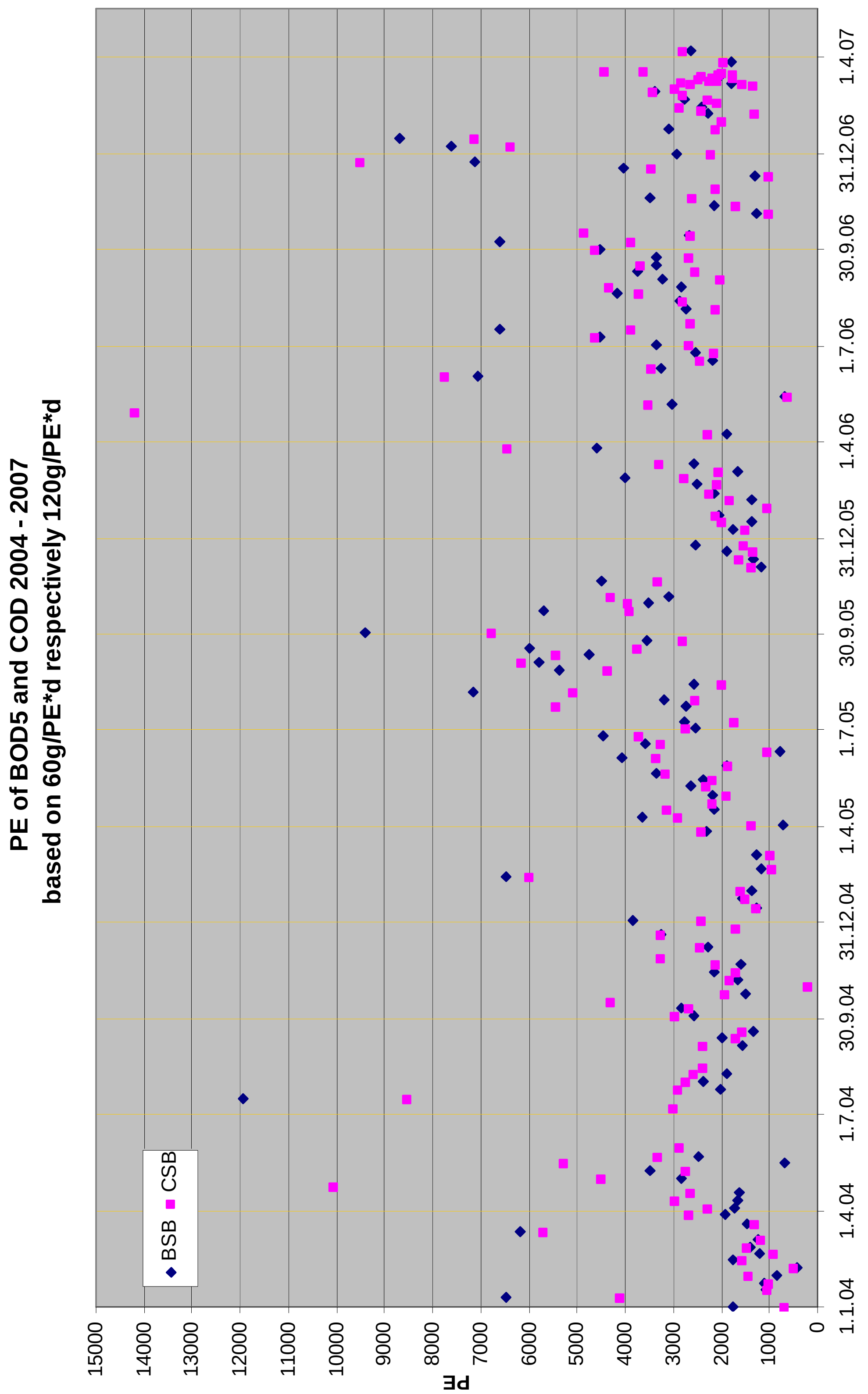

Fig. 7-30: Overview of organic loads calculated in PE in the years 2004 to Apr. 2007

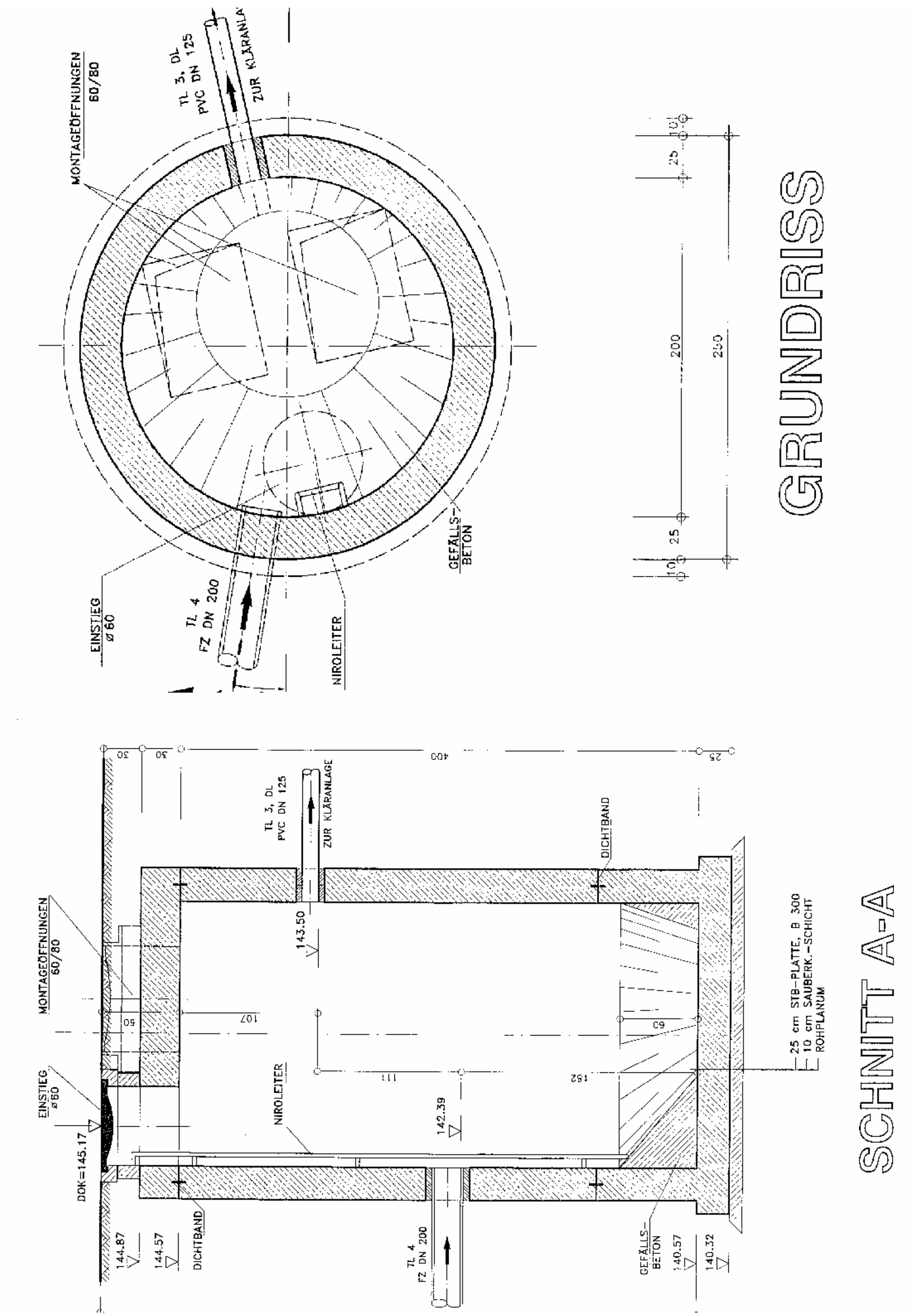

Fig. 7-31: Plan view of the pump station PW 4 representing the typical form of all pump stations besides PW 6

Information about the pump stations

location	No. PW used in this thesis	No. PW in canal sectio ns	technical drawings of PW available	technical drawings of longitudinal canal sections available	Diameter [m]	Elevation of PW (GOK) [m]	Elevation of inlet 1 [m]	Diff. [m]	Elevation of inlet 2 [m]	Diff. [m]	Elevation of outlet 1 [m]	Diff. [m]	Total depth of manhole [m]	age remarks
Gutshofstr.	**1**		yes		3	154,87	149,3 DN400	4			154,47 DN200	0,4	7,9	old
Breitenseer Weg	**2**		yes		2	155,45	152,87	4	152,02	3,43	153,48	1,97	7,1	new
Am Stempfelbach	**3**	**5**	no	yes	2	145,95	141,95	4			145,04 DL DN125	0,91	5,2	old
Reufeldgasse	**4**	**4**	yes	yes	2	145,17	142,39	2,78			143,5	1,67	4,3	new
Josefsgasse	**5**	**?**	no	yes	2	144,86	142,11	2,75			144,05	0,81	4,15	new
Bahnstr.	**6**		no	no	1,5		Ringstr.	2,6	Bahnstr.	2,4			3,6	old
Gasselich HW	**7**	**3**	no	yes	2	144,91	142,04 DN300 TL3	2,87			142,83 DN200 TL		4,7	old
Am Hagel	**8**	**2**	yes	yes	2	144,78	140,75 area DN 250	4,03	140,89 from PW 7 DN 300	3,89	142,79	1,99	5,36	new
WWTP		**1**	yes			145,67	143,2 DL200	2,47						

* DL= Pressure Line, TL=Transport Line

*new = built for the new WWTP ~2000

Fig. 7-32: Information about the pump stations like dimensions, elevation and inlets

Transport lines: dimensions and age from Schönfeld PW 2 to Lassee WWTP					
	PW 2 to PW 3	**PW3 to PW4**	**PW 4 to PW7**	**PW 7 to PW 8**	**PW 8 to WWTP**
Type and name	**DL DN 100 PVC**	**DL DN 125**	**TL 3 PVC DN125**	**TL2 AZ DN 200**	**TL1 DL DN 200 PVC**
consolidation	Apr 01	Apr 01	Apr 01		Apr 01
length	167m (incl. 0,5%)	36,05m	988,91m	144,52m	
discharge in	end of Schönfeld:	Bahnstr.:	"Untere Hauptstrasse":	"Wiesenweg"	
Type and name	**TL 5 FZ DN 200**	**TL 4 FZ DN 200**	AZ DN 300	AZ DN 300	
consolidation	Apr 01	Apr 01	(old)	?	
length	1391m	757m	~120m	~ 850m	~550m
discharge in	"Am Bahnhof"	PW 4	PW 7	PW 8	WWTP
	existing old sewer ~ 1.800 m PW 3				

* TL = Transport Line; DL=Pressure Line; DN200=diameter [mm]; AZ,FZ and PVC: material specifications
* informations for bold marked sewer lines are from technical drawings found in the community Lassee

Fig. 7-33: Information about transport and pressure lines (TL and DL) from PW2 to the WWTP

Countdifferences from readings ~10:30 to 10:30 calculated to 24 hours											
am to am	Wed - Thu 24.5.07	Thu - Fri 25.5.07	Fri - Tue 29.5.07	Tue - Wed 30.5.07	Wed - Thu 31.5.07	Thu - Fri 1.6.07	Mon - Tue 12.6.07	Tue - Wed 13.6.07	Wed - Thu 14.6.07	Thu - Fri 15.6.07	
PW1		1,16511384						0,92			
PW2		0,76294737						0,78			
PW3	0,96730038	0,93456954	1,23195739	0,9519833	0,91572327	0,92235294	0,88248017	0,88183042	0,85665722	0,83831982	funnel
	0,68441065	0,82013245	1,24034621	0,85177453			0,79942322	0,5717362	0,65269122	0,49874724	cleaning
Sum PW 3	1,65171103	1,75470199	2,4723036	1,80375783			1,68190339	1,45356662	1,50934844	1,33706706	
PW5	0,28981132	0,29071332	0,27673797	0,25192442	0,28215535	0,22588235	0,17560976	0,21405405	0,18356941	0,176	
PW6	0,86222222	0,70314381	0,94284283	0,53445378	0,51070932	0,64941176	0,50726096	1,04390244	0,7205074	0,66133333	
PW4	0,98903592	0,98247492			0,99068798	1,02315789	1,00634006	1,00080972	0,99450317	0,96851441	
PW7	4,698	4,5504	5,00973983	4,32402235	4,28725017	4,40504313	4,3054755	4,56820926	4,35918367	4,18461538	
PW8	13,6235737	12,3552	14,412006	23,9932961	23,9835165	24,0576					Info: PW8
	12,2474227	13,1885714	10,5362798					Repairs			is fixed
Sum PW 8	25,8709963	25,5437714	24,9482858	23,9932961	23,9835165	24,0576					

Countdifferences from readings ~10:30 to 10:30 calculated to 24 hours									incl. heavy rain event			Groundwater pumps stoppe	
	Wed - Thu 28.6.07	Thu - Fri 29.6.07	Fr i- Sat 30.6.07	Sat - Sun 1.7.07	Sun - Mon 2.7.07	Mon - Tue 3.7.07	Tue - Wed 4.7.07	Wed - Thu 5.7.07	Thu - Fri 6.7.07	Fri - Mon 9.7.07	Mon - Tue 10.7.07	Tue - Wed **11.7.07**	Wed - Thu 12.7.07
PW1						1,18751001						0,71468813	
PW2						1,83314652						0,81416894	
PW 3	0,87	0,87	0,9	1,16	1,02	2,19428571	0,81395673	1,10234483	0,96536313	1,01666667	2,391729841	0,99176232	0,85621622
	0,6	0,63	0,68	0,94	0,78	1,16571429	0,67327285	0,75475862	0,70391061	0,65	1,230599586	0,69034436	0,52540541
Sum PW 3	1,47	1,5	1,58	2,1	1,8	3,36	1,48722959	1,85710345	1,66927374	1,66666667	3,622329428	1,68210668	1,38162162
PW5	0,24	0,19	0,21	0,29	0,23	0,30967742	0,22469471	0,21771058	0,21743308	0,24	0,33442623	0,25538881	0,22348178
PW6	1,23	0,83	0,88	0,71	0,58	1,52677346	1,20939502	1,33859155	1,34211633	1,22	2,104918033	1,46657553	1,74663073
PW4	0,94	1,03	1	1,35	1,16	2,12823529	0,98443636	1,17006415	1,08126316	1,070282	2,482758621	1,10088737	1,05982444
PW7	4,88	4,69	4,67	5,14	4,28	6,11506849	4,76167665	4,93390558	4,86760563	4,86	7,234544208	3,24562118	2,37878994
PW8	11,37	11,01	11,16	12,27	10,41	13,3904915	11,4031915	11,6620443	11,4672304	11,7899303	15,08189415	9,0972973	7,66356164
Sum PW 8	11,37	11,01	11,16	12,27	10,41	13,3904915	11,4031915	11,6620443	11,4672304	11,7899303	15,08189415	9,0972973	7,66356164

Countdifferences from readings by the commnunity workers from ~8:00 to 8:00 calculated to 24 hours													
		Mon - Tue 7.8.07	Tue - Wed 8.8.07	Wed - Thu 9.8.07	Thu - Fri 10.8.07	Fr i- Sat 11.8.07	Sat - Sun 12.8.07	Sun - Mon 13.8.07	Mon - Tue 14.8.07	Tue - Wed 15.8.07	Wed - Thu 16.8.07	Thu - Fri 17.8.07	Fr i- Sat 18.8.07
		info of Geodata: GWpumps were stopped 10.7. to 10.8.											
PW 3		0,89	0,87	1,16	0,95	1,08	1,03	0,89	0,94	1,02	0,97	0,96	not read
		0,51	0,82	0,22	0,86	0,51	0,55	not read	not read	not read	0,68	0,43	not read
Sum PW 3		1,4	1,69	1,38	1,81	1,59	1,58				1,65	1,39	
PW5		0,36	0,39	0,35	0,39	0,42	0,32	0,38	0,26	0,21	0,29	0,27	0,18
PW6		1,85	1,6	1,47	1,34	1,47	1,19	1,28	1,51	1,79	1,35	1,8	1,37
PW4		1,26	1,21	1,2	1,09	1,2	1,09	1,11	1,05	1,08	1,14	1,08	1,11
PW7		6,52	5,14	5,14	5,13	5,65	5,89	5,04	4,73	5,35	4,95	5,75	4,92
PW8	Repair	11,2	10,99	14,71	11,26	14,23	12,1	13,22	11,26	12,45	12,45	12,46	12,46
	PW8	14,8	12,42	13,69	11,3	14,7	10,5	15,55	8,95	13,4	10,6	14,57	9,31
Sum PW 8		26	23,41	28,4	22,56	28,93	22,6	28,77	20,21	25,85	23,05	27,03	21,77

Fig. 7-34: Electrical consumption (kWh/d) according to the meter readings of the pump stations (PW) in the mornings from 23.5. to 12.7.2007

Countdifferences from readings ~10:30 to 17:00 calculated to 4 hours													
Day	Wed	Thu	Fri	Tue	Wed	Thu	Fri	Mon	Tue	Wed	Thu	Fri	
Date	23.5.07	24.5.07	25.5.07	29.5.07	30.5.07	31.5.07	1.6.07	11.6.07	12.6.07	13.6.07	14.6.07	15.6.07	
PW1	0,19636364		0,18133333					0,16377953		0,15168			funnel
PW2	0,14511628		0,14					0,15873016		0,12576			cleaning
PW3		0,18075314	0,19404255	0,17211155	0,1443609	0,168093385	0,19555556	0,1632	0,17211155	0,14676259	0,1427762	0,14634146	
		0,20083682		0,15298805	0,13533835		0,16888889	0,2112	0,03824701	0,11223022	0,10878187	0,10731707	
Sum P3		0,38158996	0	0,3250996	0,27969925		0,36444444	0,3744		0,25899281	0,25155807	0,25365854	
PW5	0,04682927	0,08101266	0,07093596	0,03692308	0,03678161	0,076494024	0,03529412	0,02891566	0,02868526	0,02608696	0,0305949	0,02521008	
PW6	0,18	0,14222222	0,13714286	0,08275862	0,07356322	0,102723735	0,11345455	0,08888889	0,28075472	0,15539568	0,12008457	0,09850746	
PW4	0,14769231	0,15189873	0,20571429		0,2	0,181132075	0,1826087	0,1707113	0,18876404	0,16826568	0,16575053	0,21312741	
PW7	0,87771429	0,78222222	0,83428571	0,71627907	0,73282443	0,759272727	0,7620438	0,75428571	0,86616541	0,7426009	0,72653061	0,7255814	Info: PW8
Sum PW8	3,90666667	4,20083682	4,08585366	4,0128	4,0030888	3,985559567	4,00291971	Repairs					is fixed

Countdifferences from readings ~10:30 to 17:00 calculated to 4 hours						additional measurements incl. rain event			
Day	Mon.	Mon.	Tue	Wed	Thu	Mon	Wed	Thu	Thu
Date	2.7.07	2.7.07	3.7.07	4.7.07	5.7.07	9.7.07	11.7.07	12.7.07	12.7.07
PW1	0,13584906								
PW2	0,16603774								
PW3	0,15260116	0,41311475	0,16462094	0,27526882		0,176470588	0,14117647	0,18461538	0,1631068
	0,11098266	0,17704918	0,18194946	0,17204301		0,132352941	0,07058824	0,18461538	0,13980583
SUM PW3	0,26358382	0,59016393	0,3465704	0,44731183		0,308823529	0,21176471	0,36923077	0,30291262
PW5			0,04528302	0,04819277	0,06597938	0,044117647	0,04979253	0,04923077	0,14257426
PW6	0,19672131	1,26060606	0,32	0,40829876		0,273529412	0,40163265	0,31515152	1,18651685
PW4	0,16684492	0,49484536	0,2031746	0,25974026		0,185294118	0,25469388	0,17910448	0,25411765
PW7	0,77938144	1,24556962	0,87412141	1,04516129	0,92459016	0,882352941	0,53775934	0,45217391	0,72
PW8	2,03930636	2,11764706	2,0278481	2,33170732		1,95	1,6661157	1,13057851	1,78909091

Fig. 7-35: Electrical consumption (kWh/4h) according to the meter readings of the PW once in the morning and once in the afternoon from 23.5. to 12.7.2007; green colour indicate: incl. heavy rain

Pump volume Q[m³/d]											
am to am	Wed - Thu	Thu - Fri	Fri - Tue	Tue - Wed	Wed - Thu	Thu - Fri	Mon - Tue	Tue - Wed	Wed - Thu	Thu - Fri	funnel
~ 10:30	24.5.07	25.5.07	29.5.07	30.5.07	31.5.07	1.6.07	12.6.07	13.6.07	14.6.07	15.6.07	cleaning
PW 1		25,363						20,028			
PW 2		39,146						40,021			PW 8
PW 3	58,995	62,674	88,305	64,426			60,073	51,918	53,91	47,757	get fixed
PW 5	29,25	29,341	27,931	25,426	28,478	22,798	17,724	21,604	18,527	17,763	
PW 6	80,763	65,863	88,315	50,062	47,838	60,83	47,515	97,781	67,489	61,946	
PW 4	60,559	60,157			60,66	62,648	61,618	61,28	60,893	59,302	
PW 7	338,743	328,101	361,221	311,778	309,127	317,62	310,441	329,385	314,313	301,726	

Pump volume Q[m³/d]								incl. heavy rain event			Groundwater pumps stopped 11.7. pm			
am to am	Wed - Thu	Thu - Fri	Fr i- Sat	Sat - Sun	Sun - Mon	Mon - Tue	Tue - Wed	Wed - Thu	Thu - Fri	Fri - Mon	Mon - Tue	Tue - Wed	Wed - Thu	Wed - Thu
~ 10:30	28.6.07	29.6.07	30.6.07	1.7.07	2.7.07	3.7.07	4.7.07	5.7.07	6.7.07	9.7.07	10.7.07	**11.7.07**	12.7.07	12.7.07
PW 1						47,767						21,59		
PW 2						59,811						35,421		
PW 3	52,505	53,576	56,434	75,007	64,291	120,011	53,12	66,331	59,622	59,529	129,381	60,081	49,348	54,773
PW 5	24,223	19,176	21,195	29,269	23,214	31,255	22,678	21,973	21,945	24,223	33,753	25,776	22,556	26,477
PW 6	115,213	77,745	82,429	66,505	54,328	143,011	113,283	125,384	125,715	114,276	197,165	137,373	163,605	184,735
PW 4	57,556	63,067	61,23	82,661	71,027	130,312	60,277	71,643	66,206	65,533	152,019	67,407	64,893	61,986
PW 7	351,866	338,166	336,724	370,613	308,604	440,919	343,335	355,753	350,972	350,424	521,637	234,021	171,52	171,556
PW 8	456,806	442,343	448,369	492,965	418,237	537,983	458,14	468,54	460,713	473,678	605,937	365,497	307,895	295,656

Pump volume Q[m³/d]		info of Geodata: GWpumps were stopped 10.7. to 10.8.							readings by community workers					
	am to am	Mon - Tue	Tue - Wed	Wed - Thu	Thu - Fri	Fr i- Sat	Sat - Sun	Sun - Mon	Mon - Tue	Tue - Wed	Wed - Thu	Thu - Fri	Fr i- Sat	Sat - Sun	Sun - Mon
	~ 8:00	7.8.07	8.8.07	9.8.07	10.8.07	11.8.07	12.8.07	13.8.07	14.8.07	15.8.07	16.8.07	17.8.07	18.8.07	19.8.07	20.8.07
2.Repair	PW 3	50,005	60,363	49,29	64,649	56,791	56,434			0	58,934	49,647		70,363	73,578
PW8	PW 5	36,334	39,362	35,325	39,362	42,39	32,297	38,353	26,241	21,195	29,269	27,251	18,167	24,223	34,316
	PW 6	173,288	149,87	137,693	125,516	137,693	111,466	119,896	141,44	167,667	126,453	168,604	128,326	189,211	73,998
	PW 4	77,15	74,088	73,476	66,741	73,476	66,741	67,965	64,292	66,128	69,802	66,128	67,965	69,802	83,885
	PW 7	470,116	370,613	370,613	369,892	407,386	424,691	363,403	341,051	385,755	356,913	414,596	354,75	405,944	408,107

Fig. 7-36: Pump volume Q (m³/d) of the PW calculation according to the day to day meter readings

Pump volume Q[m³/ 4h] calculations from readings ~10:30 to 17:00												
am - pm	Wed	Thu	Fri	Tue	Wed	Thu	Fri	Mon	Tue	Wed	Thu	Fri
	23.5.07	24.5.07	25.5.07	29.5.07	30.5.07	31.5.07	1.6.07	11.6.07	12.6.07	13.6.07	14.6.07	15.6.07
PW 1	4,275		3,947					3,565		3,302		
PW 2	7,446		7,183					8,144		6,453		
PW 3		13,629		11,612	9,99		13,017	13,373		9,251	8,985	9,06
PW 5	4,726	8,176	7,159	3,727	3,712	7,72	3,562	2,918	2,895	2,633	3,088	2,544
PW 6	16,86	13,322	12,846	7,752	6,891	9,622	10,627	8,326	26,298	14,556	11,248	9,227
PW 4	9,043	9,301	12,596		12,246	11,091	11,181	10,453	11,558	10,303	10,149	13,05
PW 7	63,286	56,401	60,155	51,646	52,839	54,746	54,946	54,387	62,454	53,544	52,386	52,317

Pump volume Q[m³/ 4h]			GW remediation stopped 11.7. pm				additional measurements incl. rain event		
am - pm	Mon.	Mon.	Tue	Wed	Thu	Mon	Wed	Thu	Thu
	2.7.07	2.7.07	3.7.07	4.7.07	5.7.07	9.7.07	11.7.07	12.7.07	12.7.07
PW 1	2,957								
PW 2	8,519								
PW 3	9,415	21,079	12,379	15,977		11,03	7,564	13,188	10,819
PW 5			4,57	4,864	6,659	4,453	5,025	4,969	14,39
PW 6	18,427	118,08	29,974	38,245		25,621	37,621	29,52	111,14
PW 4	10,216	30,299	12,44	15,904		11,346	15,595	10,967	15,56
PW 7	56,196	89,81	63,027	75,36	66,666	63,621	38,774	32,603	51,915
PW 8	81,932	85,08	81,472	93,68		78,344	66,939	45,423	71,879

Fig. 7-37: Pump volume Q(m³/4h) calculation of the PW according to the ~ 4h meter readings

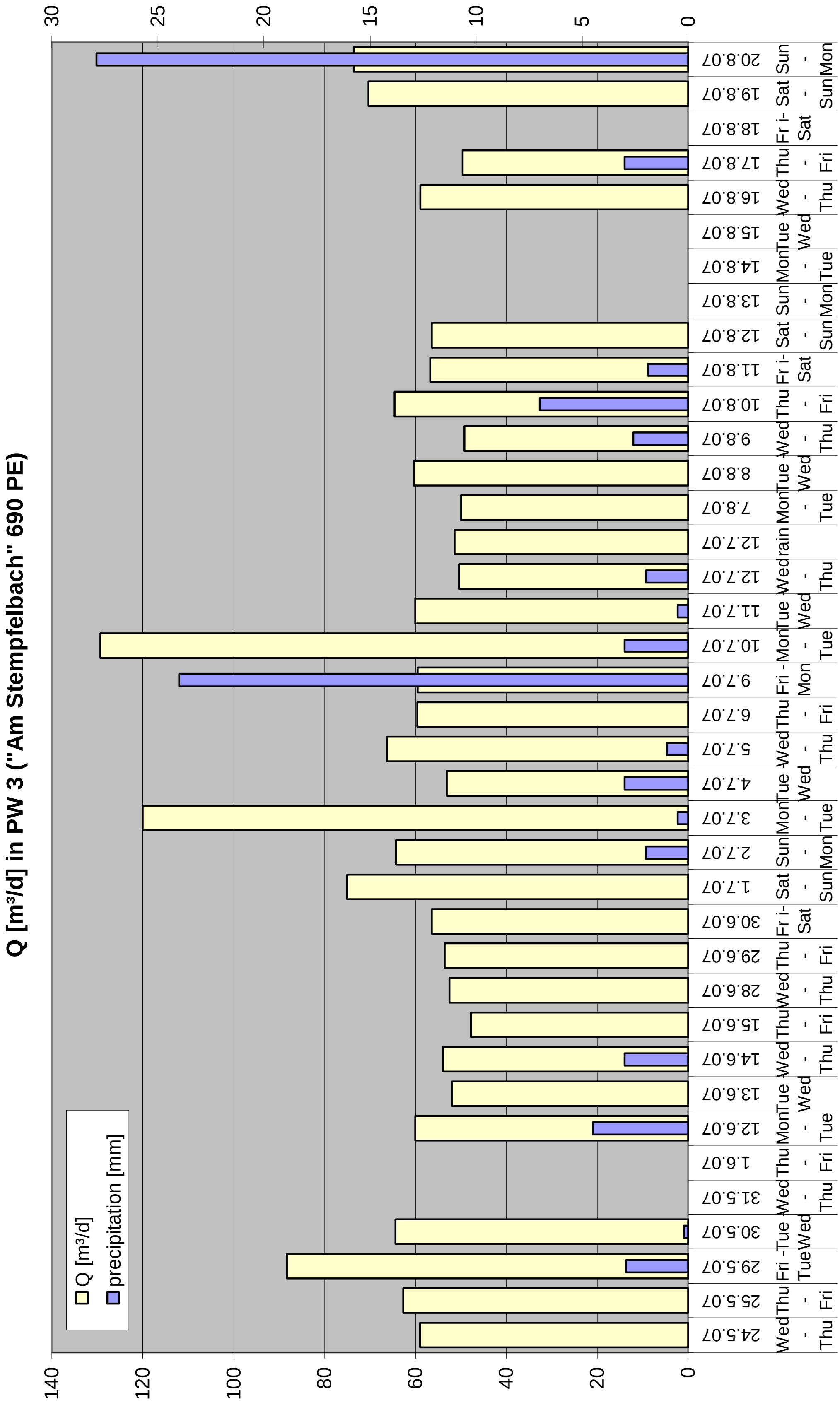

Fig. 7-38: Daily discharge Q(m³/d) in PW 3 and rain (mm) from 23.5. to 20.8.2007

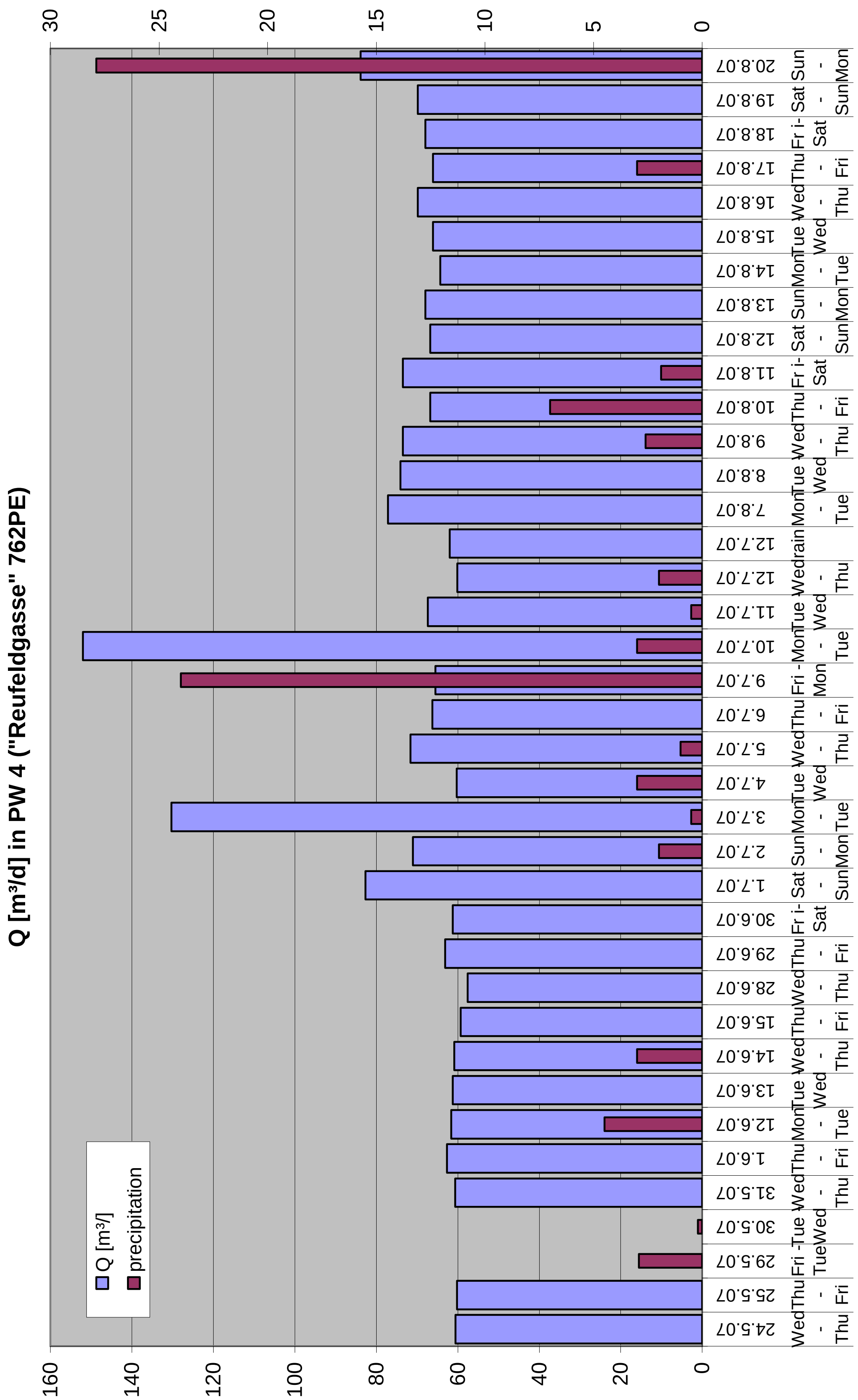

Fig. 7-39: Daily discharge Q(m³/d) in PW 4 and rain (mm) from 23.5. to 20.8.2007

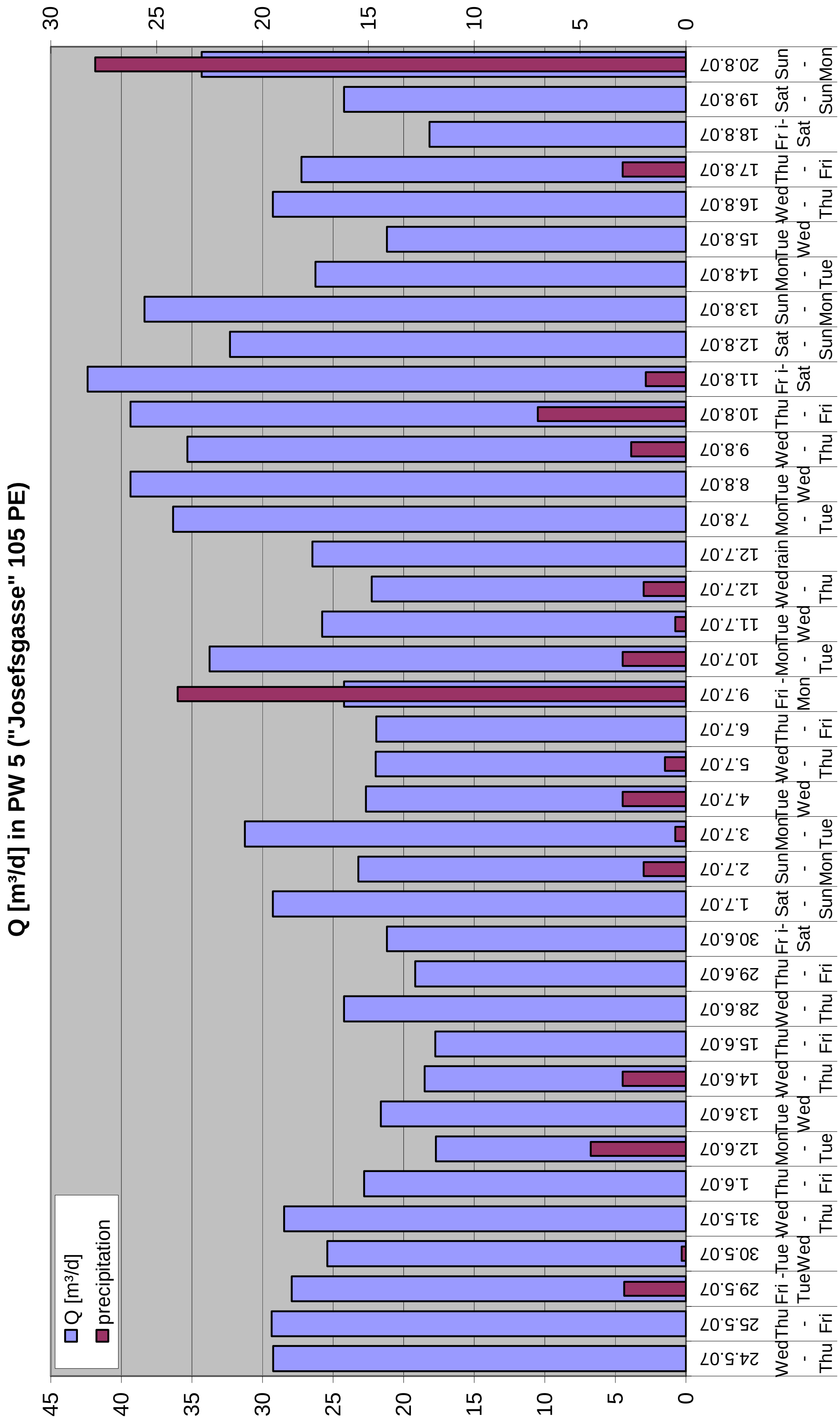

Fig. 7-40: Daily discharge Q(m³/d) in PW 5 and rain (mm) from 23.5. to 20.8.2007

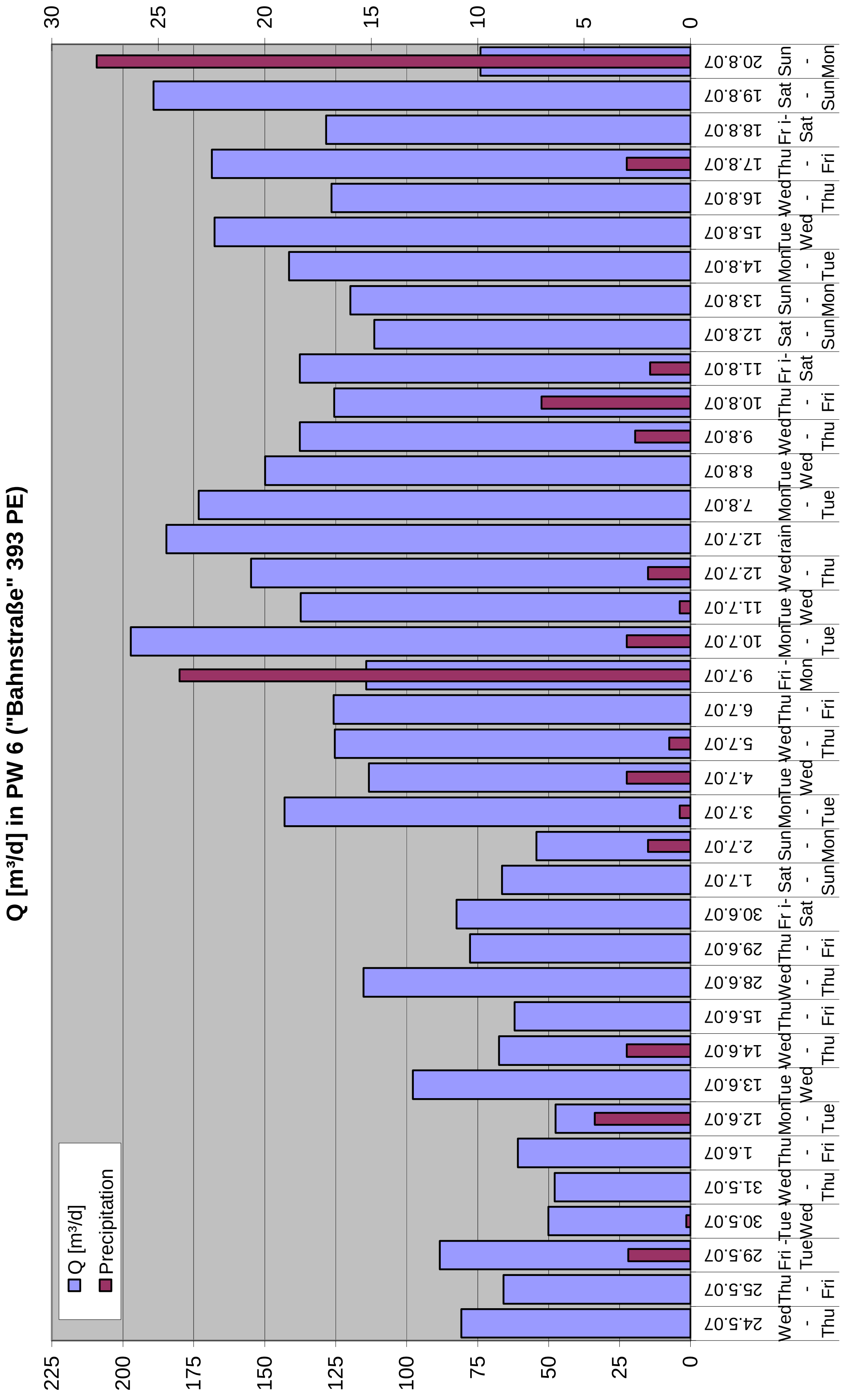

Fig. 7-41: Daily discharge Q(m³/d) in PW 6 and rain (mm) from 23.5. to 20.8.2007

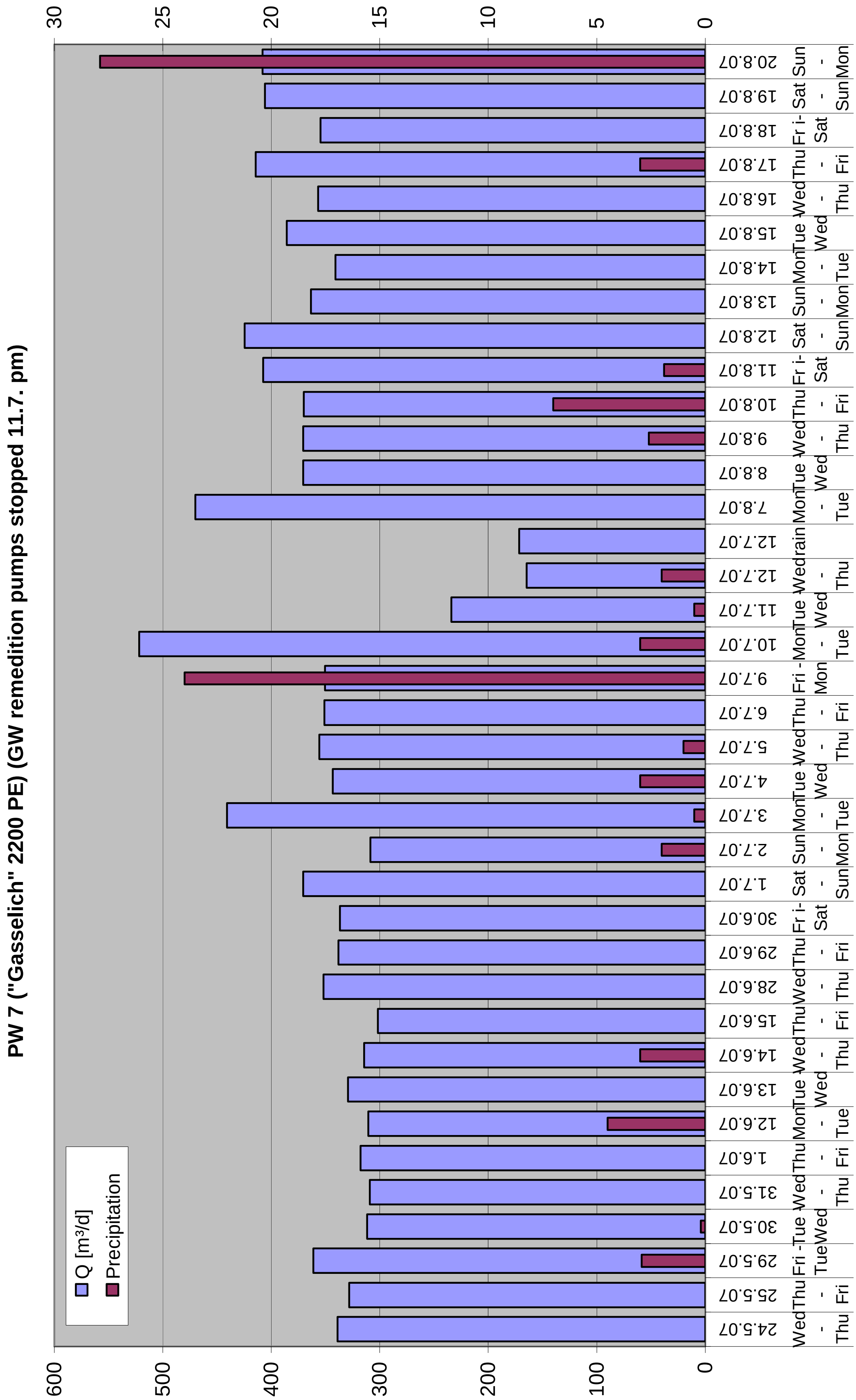

Fig. 7-42: Daily discharge Q(m³/d) in PW 7 and rain (mm) from 23.5. to 20.8.2007

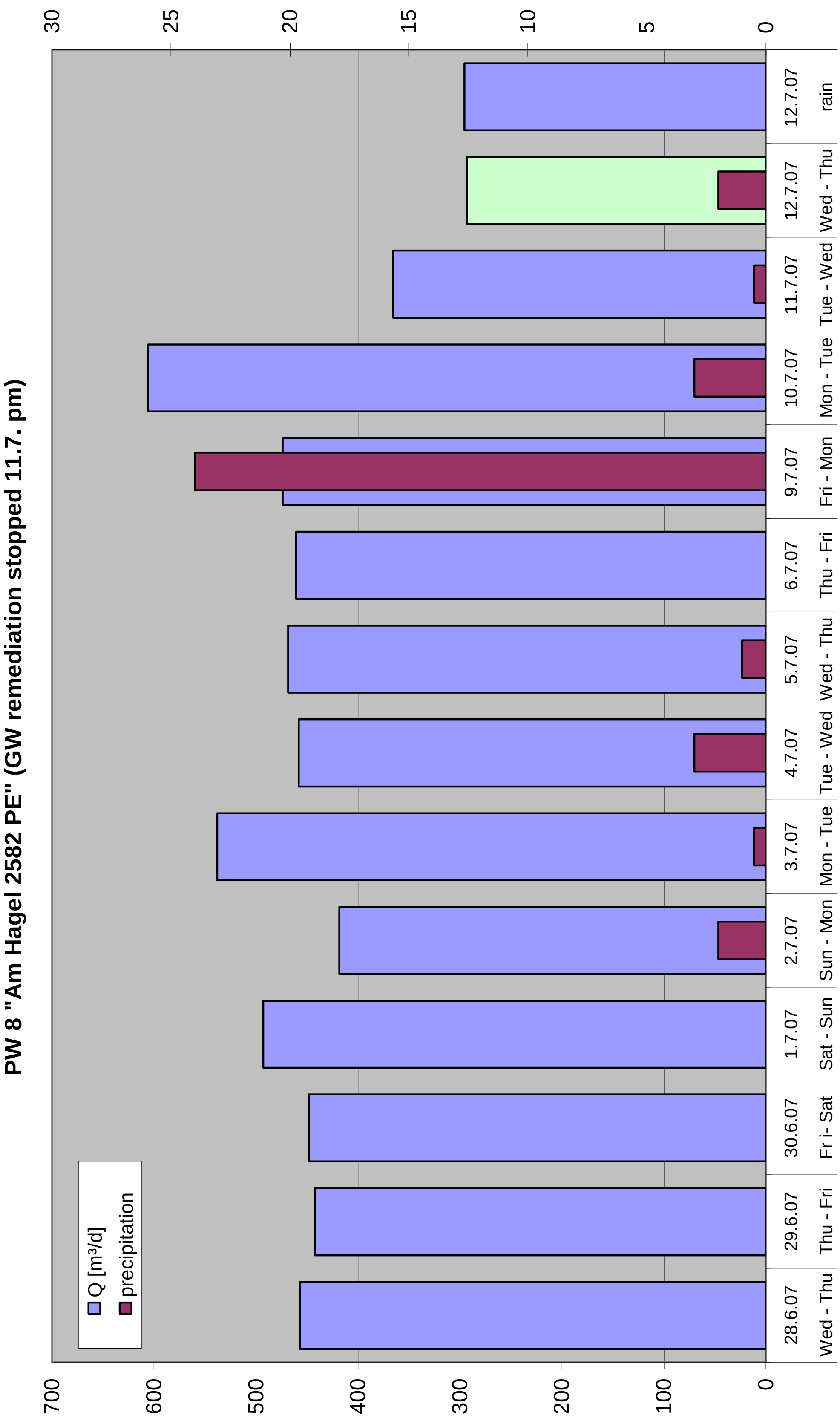

Fig. 7-43: Daily discharge Q(m³/d) in PW 8 and rain (mm) from 28.6. to 12.7.2007

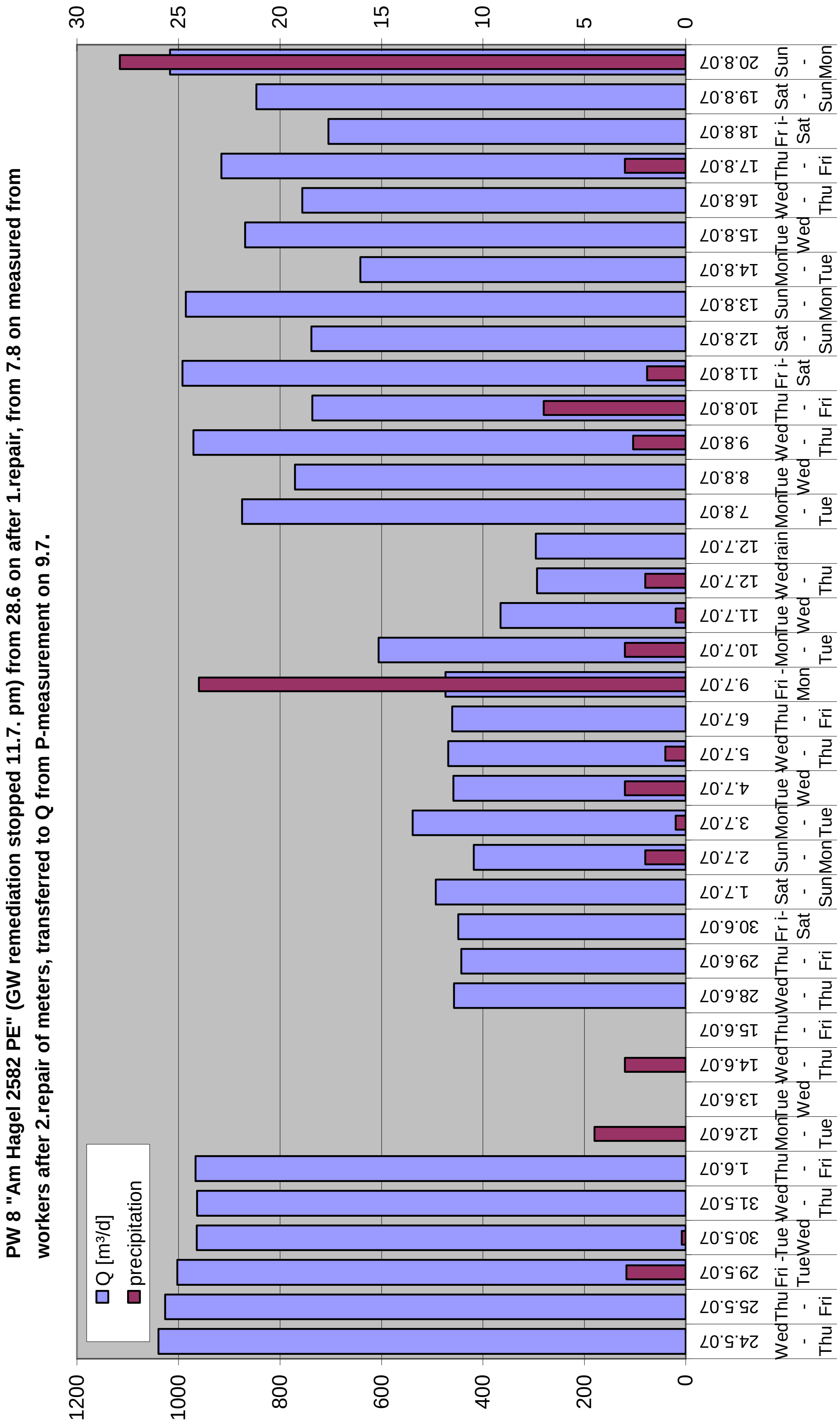

Fig. 7-44: Daily discharge Q(m³/d) in PW 8 and rain (mm) from 23.5. to 20.8.2007

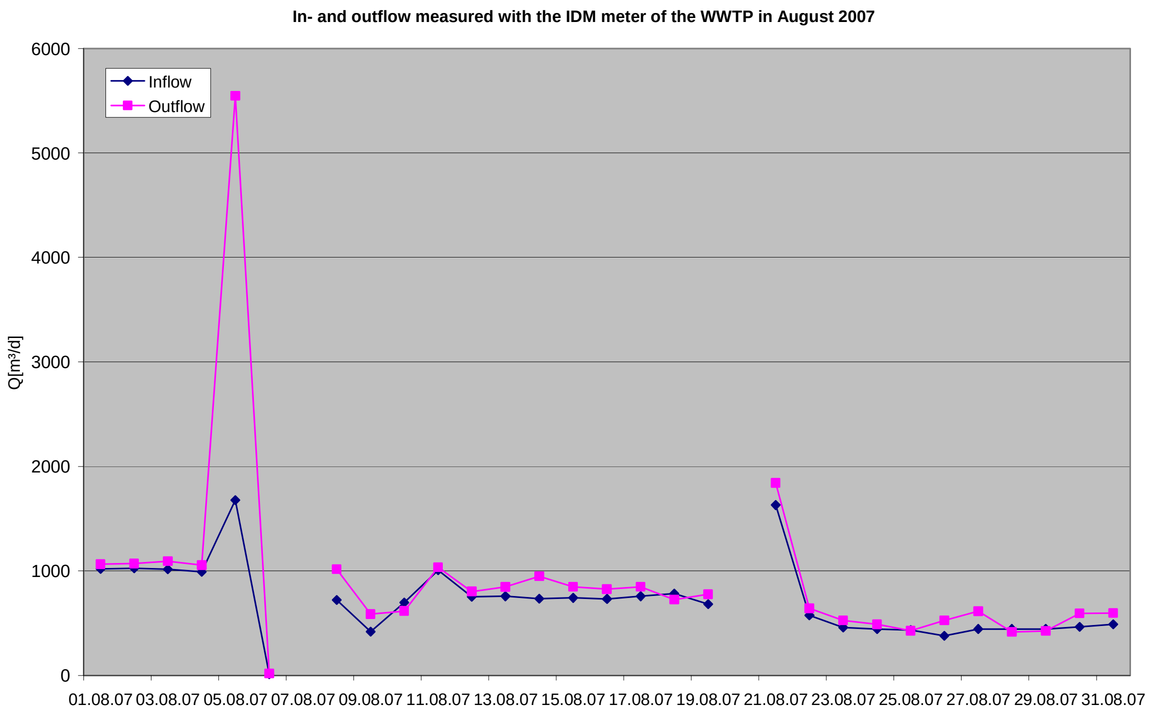

Fig. 7-45: In- and outflow according to the IDM monitoring in August 2007

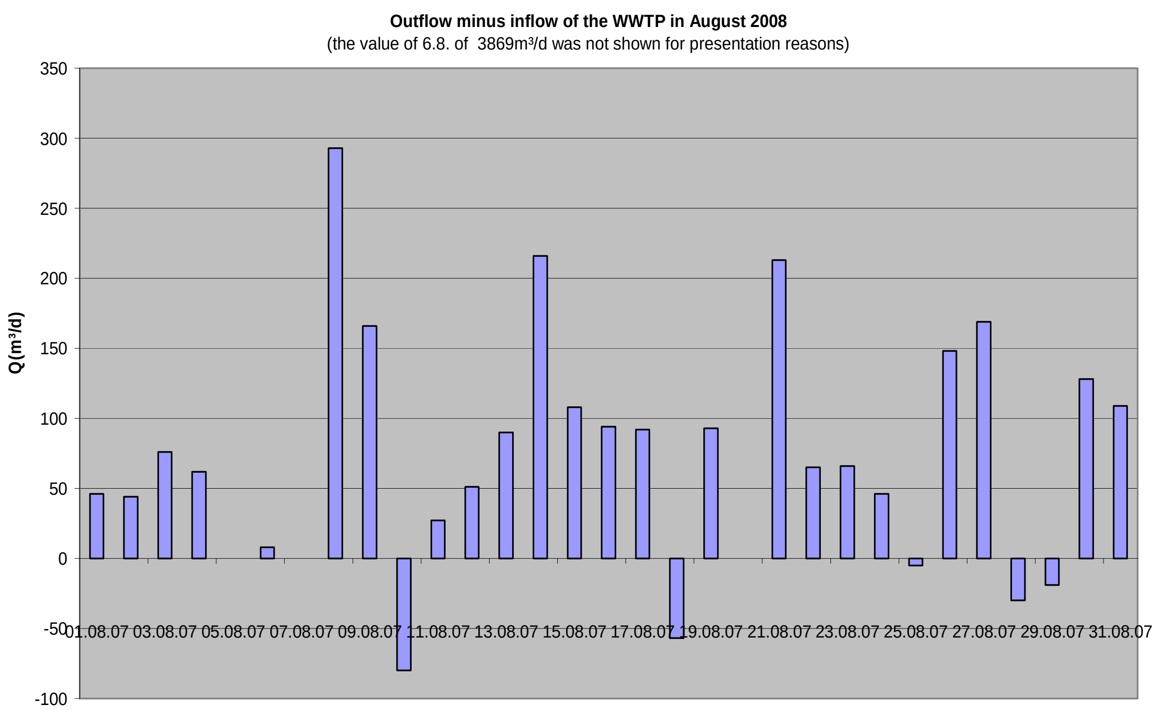

Fig. 7-46: Difference between outflow and inflow (Qout – Qin) according to the IDM monitoring in August 2007

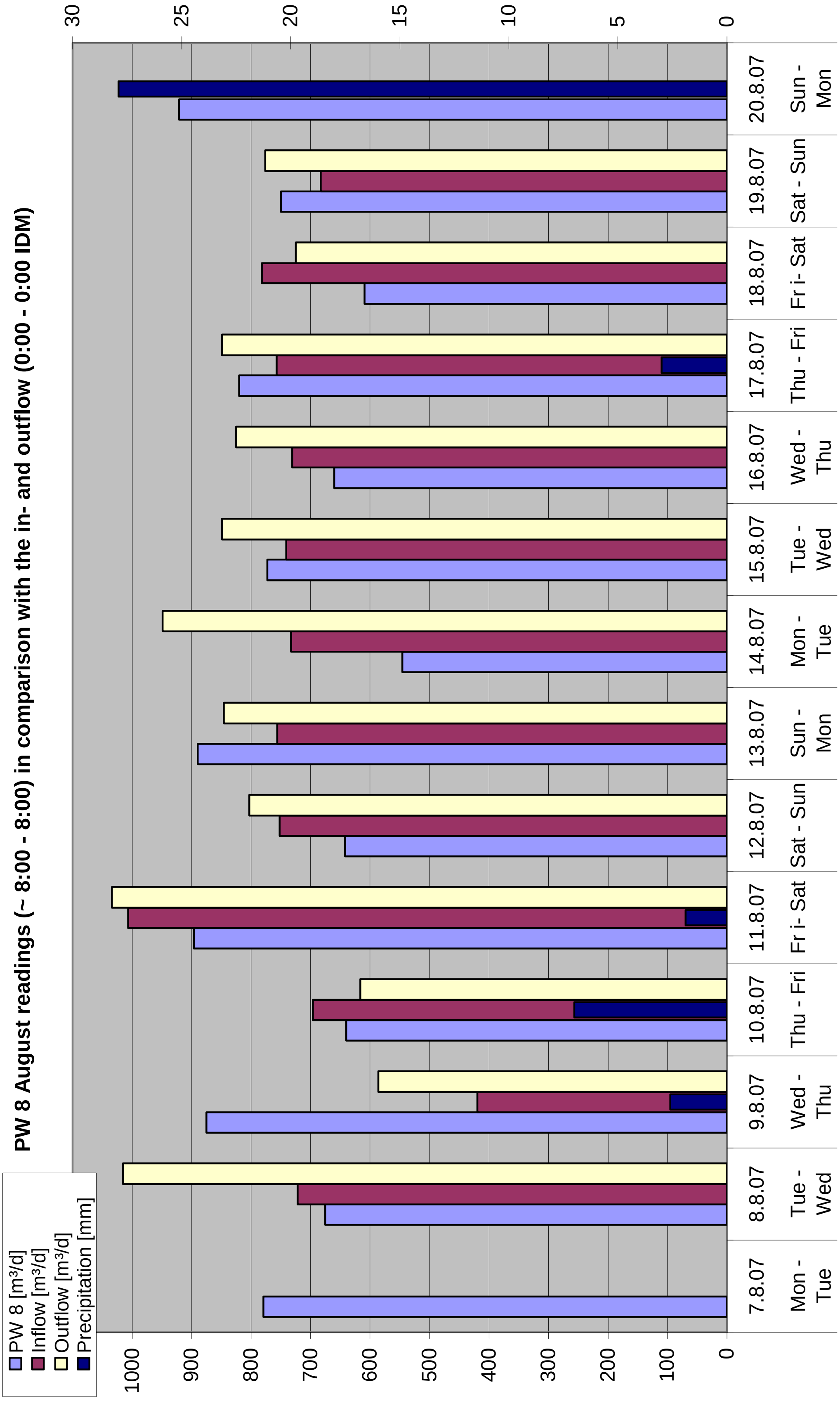

Fig. 7-47: PW 8 August readings in comparison with the in- and outflow data in August 2007

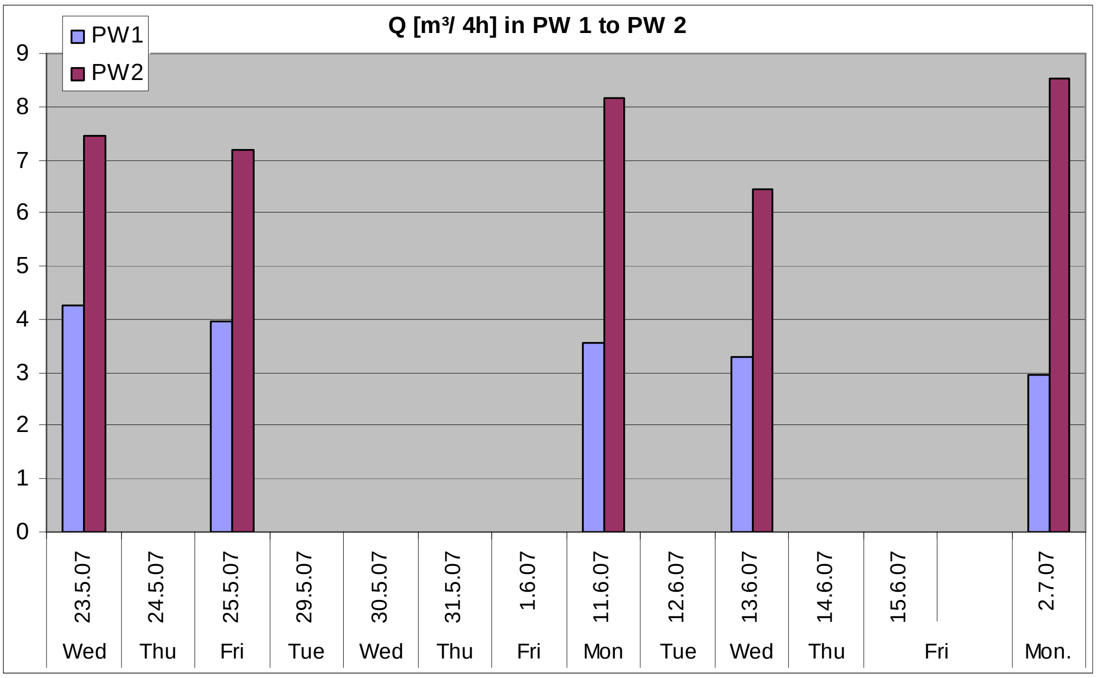

Fig. 7-48: Discharge Q [m³/ 4h] calculated to 4hours in PW 1 flowing to PW 2 (Schönfeld)

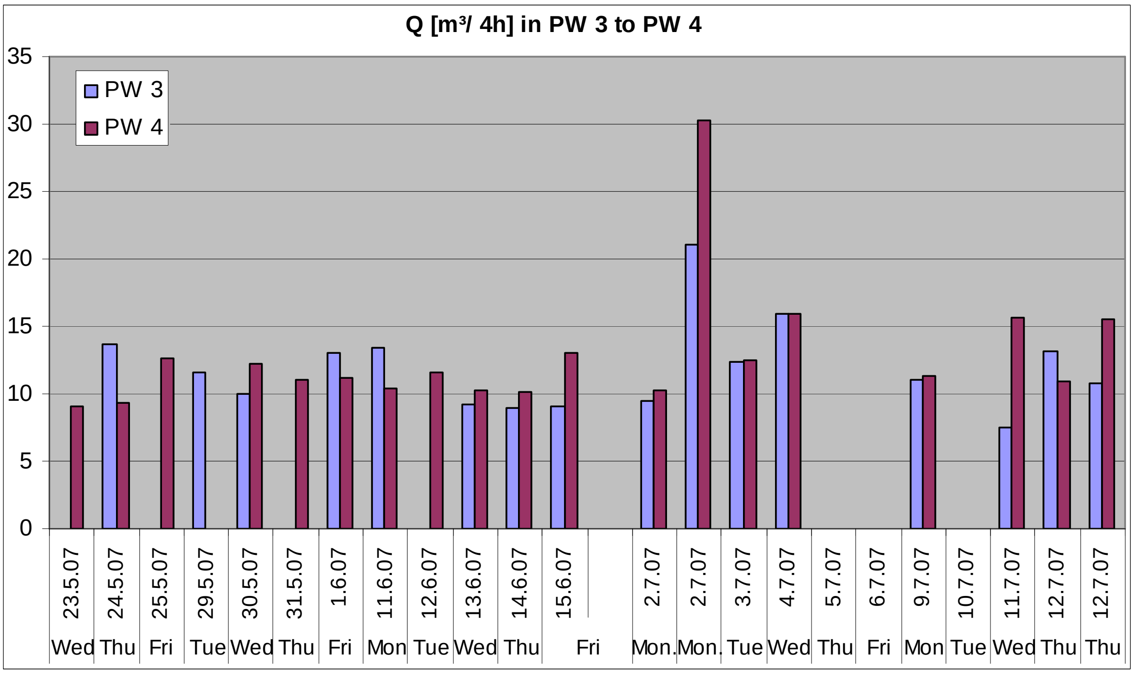

Fig. 7-49: Discharge Q [m³/ 4h] calculated to 4hours in PW 3 flowing to PW 4; below the information of the time shifts in minutes of the meter reading between PW 3 and PW 4

Time shifts of counter readings [min] between PW 3 and PW 4									
24. Mai	25. Mai	11.6.	12. Jun	13. Jun	02. Jul	03. Jul	04. Jul	09. Jul	all other dates
50	40	20	40	20	30	120	60	40	< 20

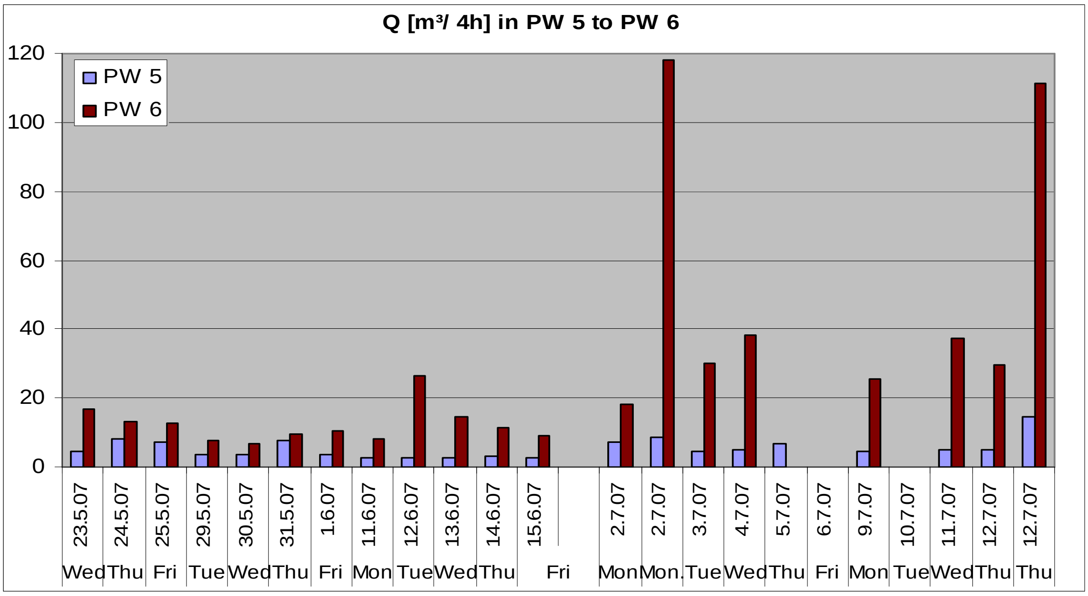

Fig. 7-50: Discharge Q [m³/ 4h] calculated to 4hours in PW 5 flowing to PW 6; below the information of the time shifts in meter reading in minutes of the meter reading between PW 5 and PW 6

Time shifts of counter readings [min] between PW 5 and PW 6			
24. Mai	03. Jul	04. Jul	all other dates
35	70	-30	2 - 10

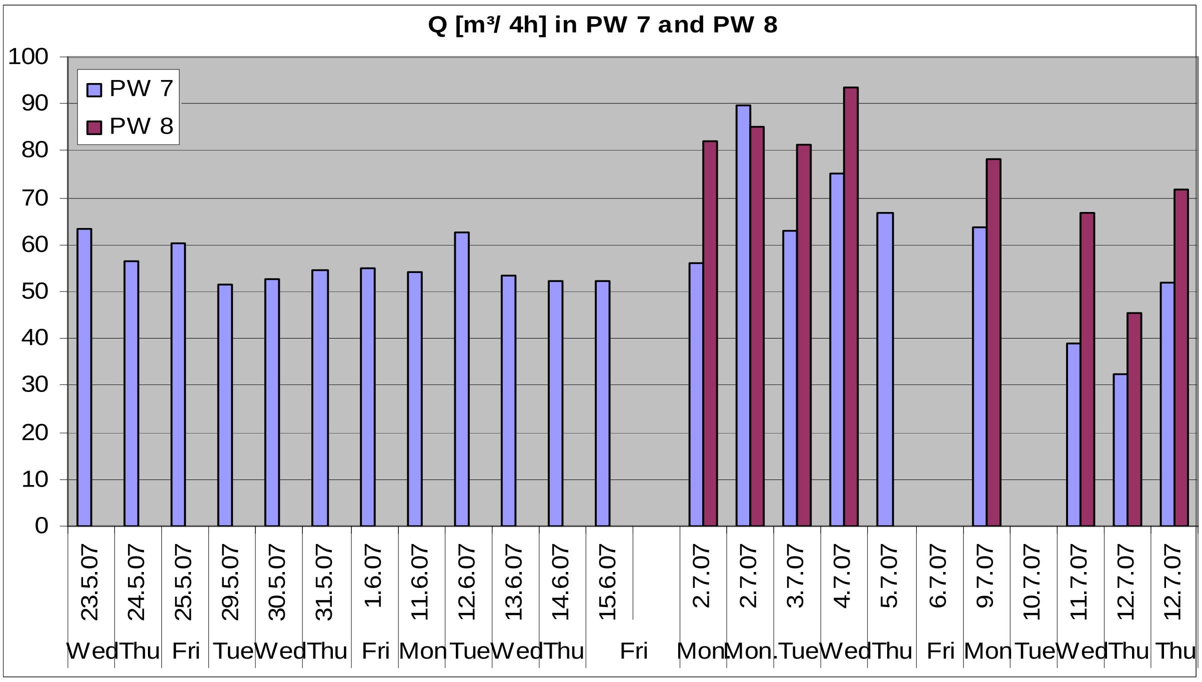

Fig. 7-51: Discharge Q [m³/ 4h] calculated to 4 hours in PW 7 flowing to PW 8

Time shifts in readings between PW 7 and PW 8 as well as between PW 4 and PW 7

Time shifts [min] between	23.5.	24.5.	13.6.	15.6.	3.7.	4.7.	9.7.	all other dates
PW 7 and PW 8	15	35					30	4 - 10
PW 4 and PW 7	25	35	-30	-120	-120	30	-30	< 15

	bill number	67640205	57179936	65474667	65467623	67645008	
		PW 3	**PW 5**	**PW 6**	**PW 7**	**PW 8**	**WWTP**
		Stempf.	Jägerweg	Bahnstr	Johann.	Loimersd.	outflow
	Sum 2003/04	**3429,25**	**754,3**	**1267,73**	**12938,7**	**29015,5**	
	1.8.04 - 30.9.04	703,5	82	242	2147,2	5123,3	
	1.10.04 - 31.3.05	628,4	192,6	4825,8	4019,4	10519,6	
	1.4.05 - 31.7.05	4822,2	392,5	1501,6	5822,5	15118,6	
	Sum 2004/05	**6154,1**	**667,1**	**6569,4**	**11989,1**	**30761,5**	**4863**
SUM 2005/06	1.8.05 - 31.7.06	**972,5**	**424,1**	**957,1**	**6937,9**	**17495,4**	**5391**
without winter:	1.10.05 - 31.3.06	909,2	478,9	661,4	6037,3	16196,6	
5 months	1.8.06 - 31.12.06	711	260,9	807,5	3761,5	12107,1	
7 months	1.1.07 - 31.7.07	986,2	355,5	842,2	8174,8	19559	
	Sum 2006/07	**1697,2**	**616,4**	**1649,7**	**11936,3**	**31666,1**	**5772**

additional pump stations like listed in the EVN bills:	(rain channel?) **Blumenweg**	**waste water! Kapellenweg**	(rain channel?) **Ringstraße**
Sum 2003/04	**462,4**	**860,88**	**391,3**
1.8.04 - 30.9.04	68,5	88,7	64,8
1.10.04 - 31.3.05	232,5	396,5	141,4
1.4.05 - 31.7.05	254	406,7	175,9
Sum 2004/05	**555**	**891,9**	**382,1**
1.8.05 - 31.7.06	**991,9**	**833,5**	**225,6**
1.10.05 - 31.3.06	1659,5	511,9	171,7
1.8.06 - 31.12.06			
1.1.07 - 31.7.07			
Sum 2006/07			

Fig. 7-52: Yearly electricity consumption [kWh] of the PW pumps according to EVN bills provided by the community Lassee (01.08.2004 to 01.08.2007); no bills for PW 4 were available

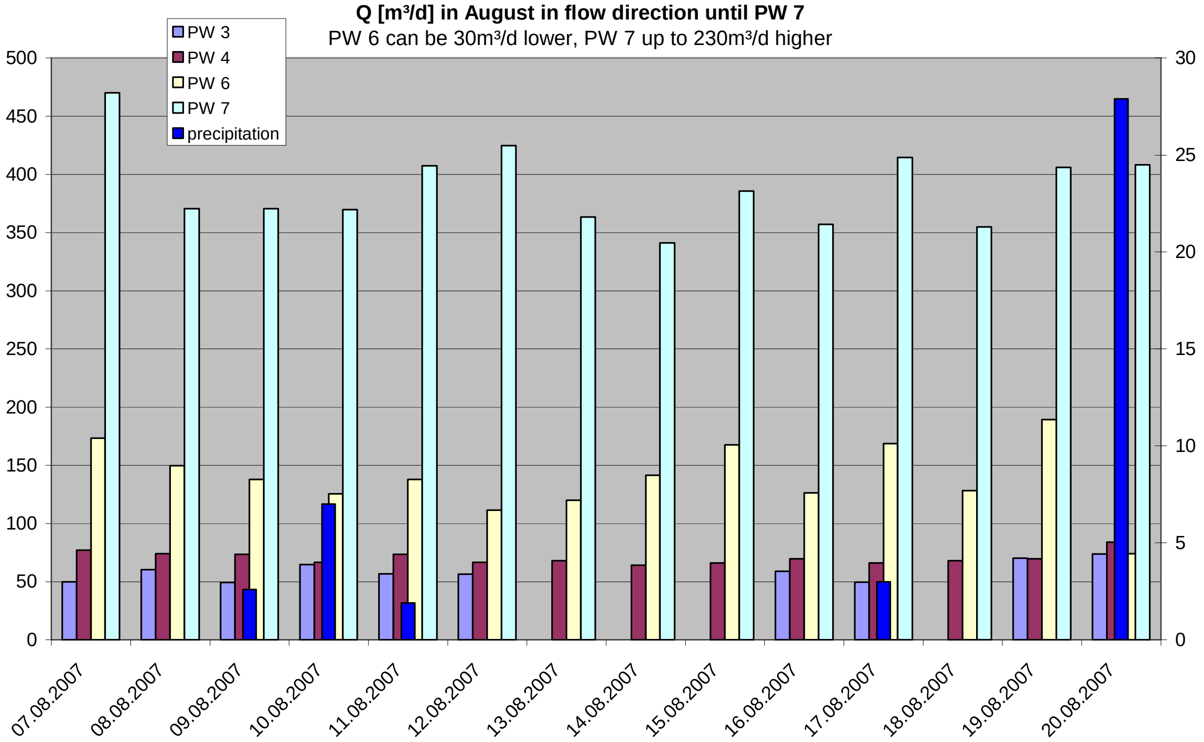

Fig. 7-53: Q(m³/d) in August of all PW in Lassee (without PW 8) arranged in flow direction

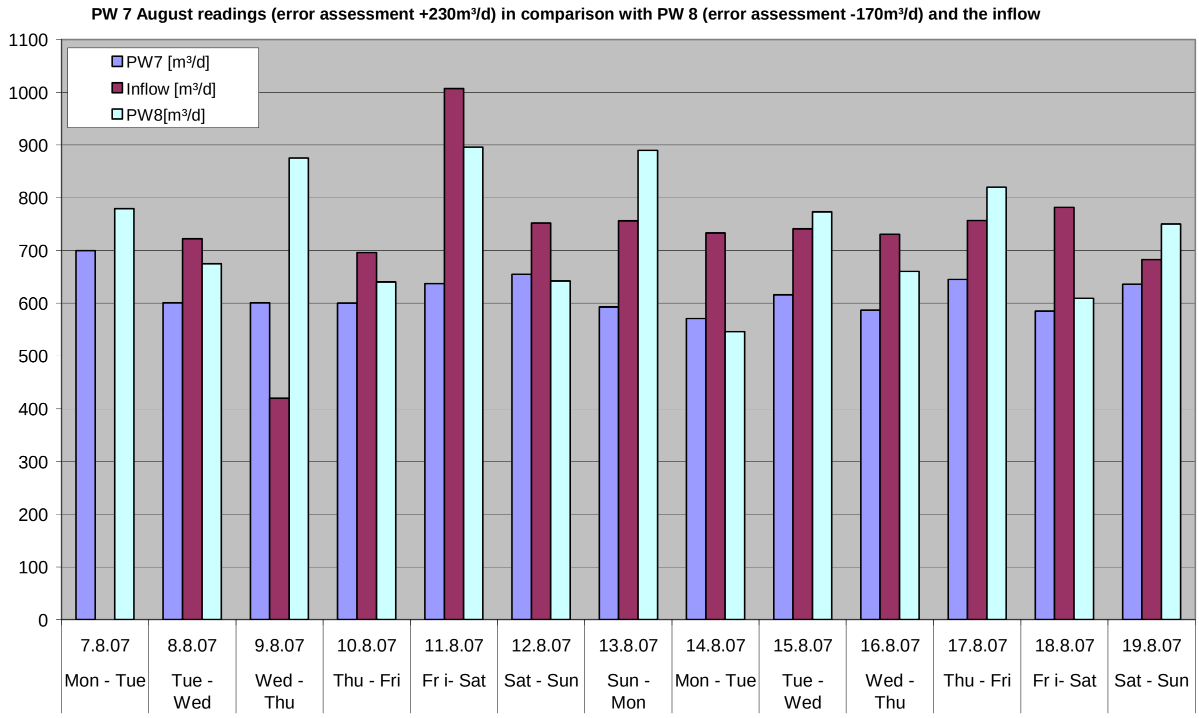

Fig. 7-54: August readings of PW 8 in comparison with the inflow and PW 7 (incl. error estimation of +230(m³/d) in PW 7)

Tab. 7-4: Laboratory analysis of the PW samples in mg/l, extreme values are marked grey, and ratio calculations of TKN/NH4-N, P/PO4-P, NH4-N/PO4-P, TKN/P and % org.N in COD

Analyse of PW samples in [mg/l], extreme values are marked grey / sample of 12.7.were taken before the heavy rain event

by BOKU SIG laboratory Vienna, Muthgasse

ID and sampling date		NH4-N	TKN	PO4-P	Ptot	COD	TOC	SS	pH	µS/cm	°C	TKN/NH4-N	P/PO4-P	% org.N of COD	NH4-N/PO4-P	TKN/P
22523	Zu 24.05.07	11,4	20	3,7	4,7	199	140	W				1,75	1,27	4,32	3,08	4,26
22524	Zu 25.05.07	11,3	22,9	4,3	5,9	287	140	W				2,03	1,37	4,04	2,63	3,88
22525	Zu 02.06.07	11,9	22,2	4	5,1	240	120	T				1,87	1,28	4,29	2,98	4,35
22526	Zu 03.06.07	14,3	23,9	4,7	5,6	235	125	P				1,67	1,19	4,09	3,04	4,27
22527	Zu 04.06.07	14,9	24,3	3,7	4,9	242	123					1,63	1,32	3,88	4,03	4,96
22528	Zu 05.06.07	14,1	23,6	3,7	4,3	191	88					1,67	1,16	4,97	3,81	5,49
22529	Zu 06.06.07	12,6	22,8	3,7	4,8	245	92					1,81	1,3	4,16	3,41	4,75
22530	Zu 15.06.07	12,9	23,2	2,5	3,5	229	88					1,8	1,4	4,5	5,16	6,63
											aver.:	1,78	1,29	4,28	3,52	4,82
								SS	pH	µS/cm	°C					
22531	PW 4 13.06.07	69,9	98,9	9,3	12,3	753	266		7,48	2500	16,6	1,41	1,32	3,85	7,52	8,04
22532	PW 4 14.06.07	69,5	92,5	7,7	10,3	851	271		7,7	1700	18	1,33	1,34	2,7	9,03	8,98
22533	PW 4 15.06.07	67,2	94,6	8,5	11,8	601	190		7,93	1650	15	1,41	1,39	4,56	7,91	8,02
22833	PW4 2.7						303	400		1870	18					
22834	PW4 3.7						247	330		1854	18					
22835	PW4 4.7						234	382	7,34	1634	18,1					
22836	PW4 10.7						193	225	7,67							
22837	PW4 11.7						261	352	7,46	1865	18,1					
22838	PW412.7						508	685	7,65							
22537	PW 5 15.06.07	60,3	88	5,1	7,8	1130	384		8,2	1748	19,7	1,46	1,53	2,45	11,82	11,28
22839	PW5 3.7						354	350		1605	20,3					
22840	PW5 10.7						237	170	8,06							
22841	PW5 11.7							250	7,36	1848	20,2					
22842	PW5 12.7						481	650	7,84							
22534	PW 6 13.06.07	59,2	112	12,2	16,3	3910	1430		5,4	3910	19,1	1,89	1,34	1,35	4,85	6,87
22535	PW 6 14.06.07	65,2	101	11,2	15,1	1290	426		7,2	2860	19,5	1,55	1,35	2,78	5,82	6,69
22536	PW 6 15.06.07	99	130	7,9	10,4	653	223		8,36	1930	19,5	1,31	1,32	4,75	12,53	12,5
22843	PW6 2.7 A						345	465								
22844	PW6 2.7 B						227	345		1966	30,7					
22845	PW6 3.7						151	120		2100	29,3					
22846	PW6 4.7						144	180	7,47	1750	29,2					
22847	PW6 10.7						91	160	8,09							
22848	PW6 11.7						171	240	7,65	1950	26,7					
22849	PW6 12.7	33			31,5		2690	280	4,44							
22850	PW8 3.7						114	80		1421	17,1					
22851	PW8 4.7						66	120								
22852	PW8 11.7						216	350		1765	19,5					
22853	PW8 12.7						333	500				Averages of the PW:				
Average of PWs:		65,41	102,43	8,84	14,44	1312,57	390,96	315,9	7,41	1996,1	20,66	1,48	1,37	3,21	8,5	8,91
									normal ratios			WWTP	WWTP	WWTP	WWTP	WWTP
									(Lindtner et al., 2002):			~1,7	1,56	4%	4,9 - 6,7	5,5 - 7,5

*All PW samples were taken in the afternoon, mostly between 15:00 to 16:00

WWTP samples (22523 - 22530) were taken of the 24h sampler of the WWTP (time correlated)

Tab. 7-5: Laboratory analysis of the PW samples on heavy metals in mg/l

Nox, heavy metals and hydrocarbons (mineral oil)		**NO3-N** mg/l	**NO2-N** mg/l	**Pb** µg/l	**Cd** µg/l	**Cr** µg/l	**Zn** µg/l	**Cu** µg/l	**Ni** µg/l	**KW** mg/l	
ID / date	treshold values:	25		500	100	500	2000	500	500	10	**WWTP**
22523	Zu 24.05.07	<0,1	<0,003								
22524	Zu 25.05.07	<0,1	<0,003								
22525	Zu 02.06.07	<0,1	<0,003								
22526	Zu 03.06.07	<0,1	<0,003								
22527	Zu 04.06.07	<0,1	<0,003								
22528	Zu 05.06.07	<0,1	<0,003								
22529	Zu 06.06.07	<0,1	<0,003								
22530	Zu 15.06.07	1,6	0,13	2,2	<3,0	3,4	148	17,5	6,4		
22531	PW 4 13.06.07	<0,1	<0,003	5,2	<3,0	6	357	36,6	9,8		
22532	PW 4 14.06.07	<0,1	<0,003	3,1	<3,0	<3,0	223	199	4,1		
22533	PW 4 15.06.07	<0,1	<0,003	9,4	<3,0	<3,0	285	685	4,3		
22833	PW4 2.7										
22834	PW4 3.7										
22835	PW4 4.7									<0,5	
22836	PW4 10.7										
22837	PW4 11.7									0,7	
22838	PW412.7										
22537	PW 5 15.06.07	<0,1	<0,003	3,3	<3,0	15,9			5,1		
22839	PW5 3.7										
22840	PW5 10.7			11,5	<3,0	4,7	272	47	6,7		
22841	PW5 11.7										
22842	PW5 12.7			11,8	<3,0	9,8	478	55,9	10,4	<0,5	
22534	PW 6 13.06.07	2,6	<0,003	3,5	<3,0	11	361	47,7	15,8	<0,5	
22535	PW 6 14.06.07	<0,1	<0,003	5,7	<3,0	6,1	409	62,5	8,8		
22536	PW 6 15.06.07	<0,1	<0,003	2,2	<3,0	<3,0	270	31,3	4,6		
22843	PW6 2.7 A										
22844	PW6 2.7 B										
22845	PW6 3.7										
22846	PW6 4.7										
22847	PW6 10.7			4,1	<3,0	6,2	162	34,5	8,9		
22848	PW6 11.7										
22849	PW6 12.7			3,5	<3,0	20,5	274	38,8	10,5	<0,5	

*All PW samples were taken in the afternoon, mostly between 15:00 to 16:00
WWTP samples (22523 - 22530) were taken of the 24h sampler of the WWTP (time correlated)

Tab. 7-6: Loads in the pump stations in [kg/d] according to the laboratory analyses

Loads in the pump stations PW (kg/d)													
PW / Date	NH4-N	TKN	PO4-P	Pges.	COD	TOC	NH4-N/PO4-P	TKN/P	NH4-N/TKN	PO4-P/P	pH	µS/cm	°C
PW 4	kg/d	kg/d	kg/d	kg/d	kg/d	kg/d	ratio	ratio	ratio	ratio			
13.6.07	4374	6188	582	770	47115	16644	7,52	8,04	0,71	0,76	7,48	2500	16,6
14.6.07	4165	5544	461	617	51000	16241	9,03	8,99	0,75	0,75	7,7	1700	18
15.6.07	3986	5611	504	700	35645	11269	7,91	8,02	0,71	0,72	7,93	1650	15
2.7.						21213						1870	18
3.7.						28645						1854	18
4.7.						15018					7,34	1634	18,1
10.7.						29340					7,67		
11.7.						18573					7,46	1865	18,1
12.7.						30546					7,65		
PW 5											8,2	1748	19,7
15.6.07	1129	1647	95	146	21154	7188	11,88	11,28	0,69	0,65		1605	20,3
3.7.						10903					8,06		
10.7.						7999					7,36	1848	20,2
12.7.						10707					7,84		
PW 6											5,4	3910	19,1
13.06.07	3992	7553	823	1099	263672	96432	4,85	6,87	0,53	0,75	7,2	2860	19,5
14.6.07	5540	8582	952	1283	109609	36197	5,82	6,69	0,65	0,74	8,36	1930	19,5
15.6.07	6676	8767	533	701	44035	15038	12,53	12,51	0,76	0,76			
2.7.07						21149						1966	30,7
3.7.						30695						2100	29,3
4.7.						18488					7,47	1750	29,2
10.7.						28390					8,09		
11.7.						13653					7,65	1950	26,7
12.7.	5110			4878		26481	1,44	1,62			4,44		
PW8												1421	17,1
3.7.						53971							
4.7.						31188						1765	19,5
11.7.						80052							
12.7.07						97619							
						Average:	7,62	8	0,69	0,73			
						Normal ratio (Lindtner et al., 2002):	**4,9 - 6,7**	**5,5 - 7,5**	**0,57**	**0,64**			

Tab. 7-7: Pump volume calculation according to the readings of the table below in m³/d

	Pumpvol (m³/d) ~ 15:00 - 15:00			**PV=kWh(Date) * PV/(kWh)**						**PV /kWh)**
	12.6.-13.6.	13.6.-14.6.	14.6.-15.6.	1.7. - 2.7.	2.7.-3.7.	3.7.-4.7.	9.7.-10.7.	10.7.-11.7.	11.7.-12.7.	
PW 4	62,57	59,93	59,31	70,01	115,97	64,18	152,02	71,16	60,13	61,23
PW 5	17,28	21,6	18,72	24,63	30,8	22,77	33,75	26,38	22,26	100,92
PW 6	67,4352	84,96835	67,4352	61,3	135,22	122,44	197,15	150,03	154,86	93,66
PW 8				421,13	473,43	472,54	605,99	370,61	293,15	40,18

Tab. 7-8: Meter readings at sampling days in the afternoon in kWh

Countdifferences FROM DAY TO DAY				Afternoon (15:00 - 15:00)		
calculated for 24 h						
	1.7. - 2.7.	2.7. - 3.7.	3.7. - 4.7.	9.7. - 10.7.	10.7. - 11.7.	11.7. - 12.7.
PW4	1,14332	1,894	1,04819788	2,48276	1,16210526	0,98204
PW5	0,24407	0,3052	0,22561308	0,33443	0,26135831	0,22061281
PW6	0,65455	1,44375	1,30724842	2,10492	1,60187354	1,65344467

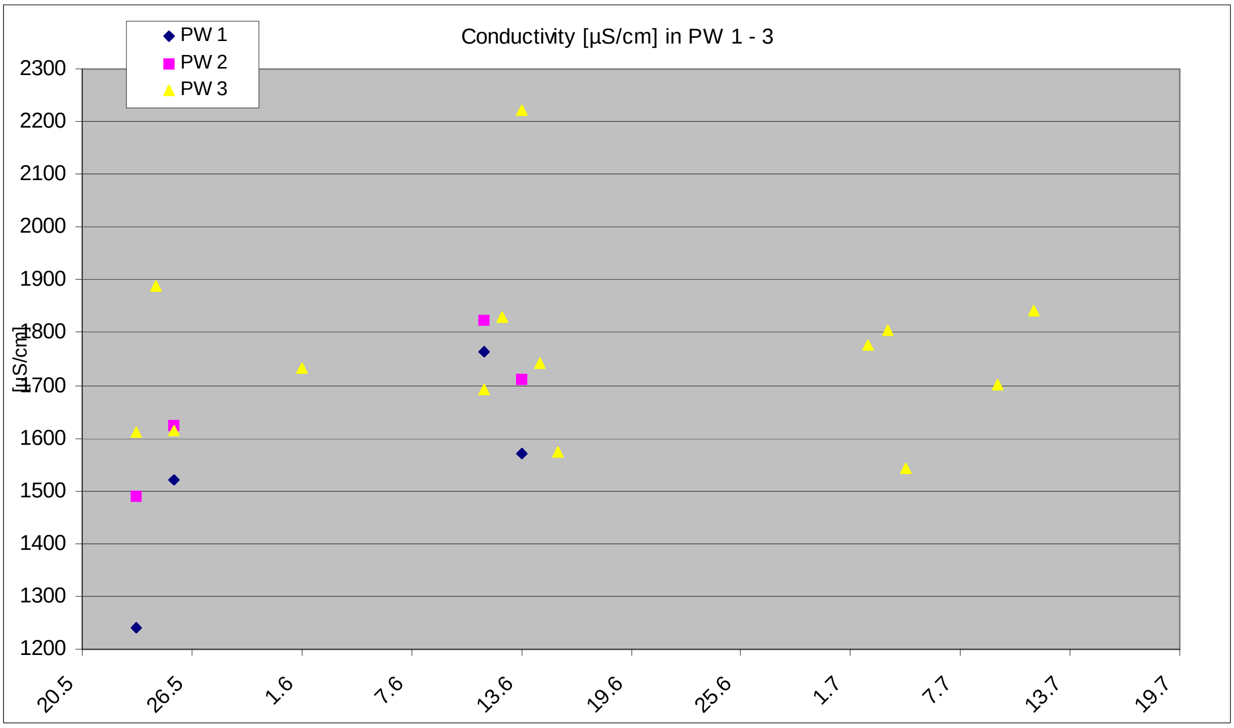

Fig. 7-55: Electrical conductivity (µS/cm) in PW 1, PW 2 and PW 3 from 23.5. to 12.7.07

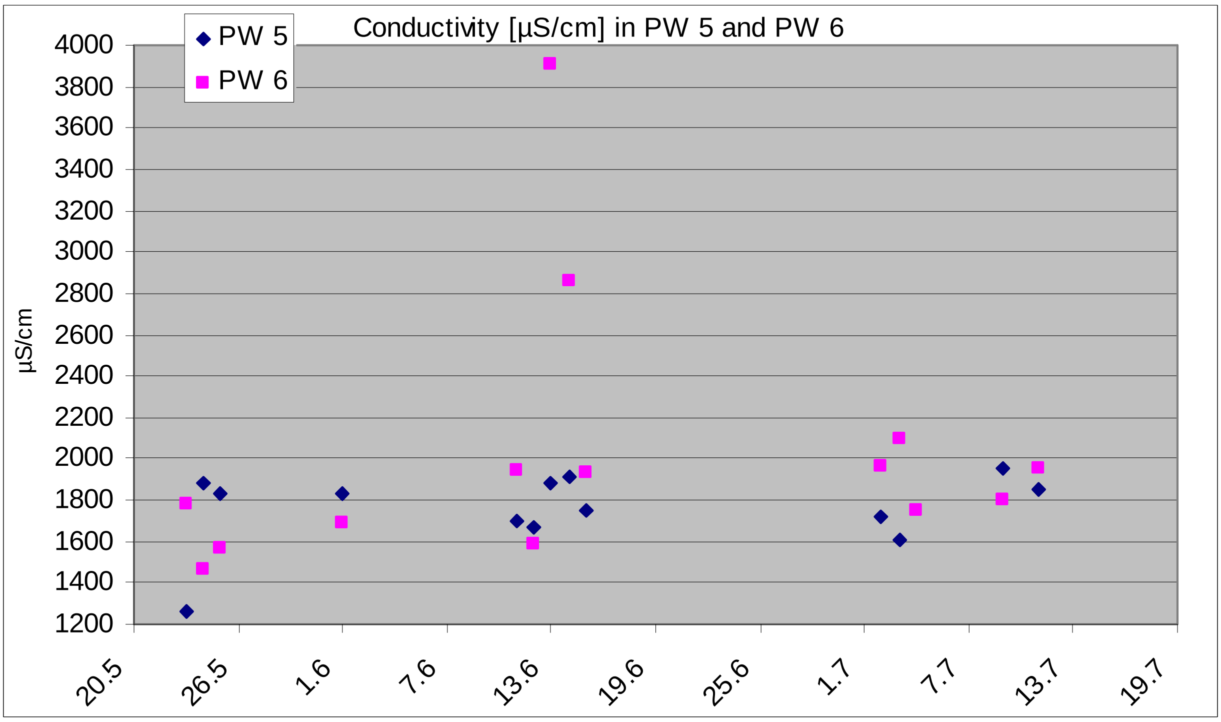

Fig. 7-56: Electrical conductivity (µS/cm) in PW 5 and PW 6 from 23.5. to 12.7.07

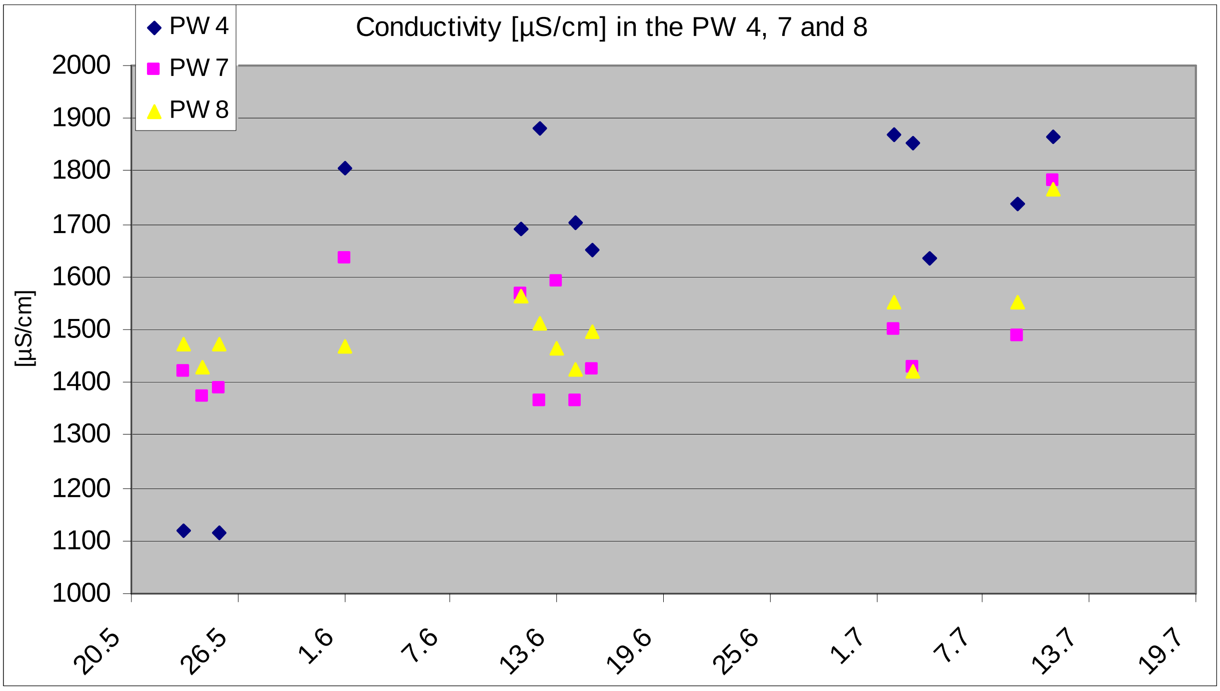

Fig. 7-57: Electrical conductivity (µS/cm) in PW 4, PW 7 and PW 8 from 23.5. to 12.7.07

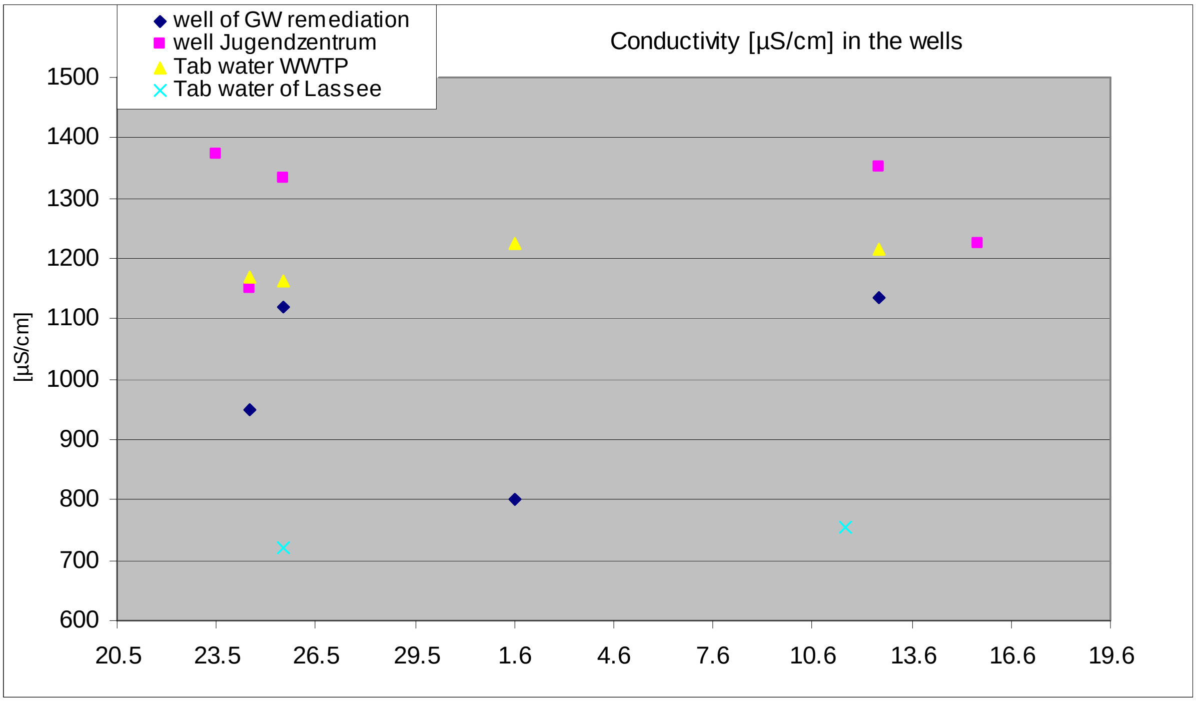

Fig. 7-58: Electrical conductivity (µS/cm) in two different wells, the tab water of the WWTP owned well and Lassee tab water at 23.5. to 25.5., 1.6. as well as 12.6. and 15.6.2007

Tab. 7-9: Estimation of salts in (g/d) from human excretion according to Geigy (1977):
left table lists anions and cations in urine, right table in faeces and the sum of both urine and faeces

Inorganic Substances in Urine		
Assumption: 1,4l/d*PE urine excretion		
Element		Mass
	Average Valu	Average Value
	mmol/d	[g/d]
ANIONS		
Chloride		4,8
Sulfur		1,32
Phosphorus	58,9	1,82
Bromide		0,0037
Fluoride		0
Jodide		0
Borat		1
Potassium		2,7
Sodium		5,14
CATIONS		
Calcium		0,238
Magnesium		0,131
		[mg/d]
Iron		0,1
Copper		0,036
Manganese		0,02
Nickel		0,0026
Zinc		0,353
Cobalt		0,073
Lithium		0,8
Rubidium		2,4
Molybdenium		0,081
Selenium		0,03
Chromium		0,0084
Caesium		0,013
Arsenic		0,18
Antimony		0,0015
Lead		0,035
Cadmium		0,0021
Mercury		0,001
Sum in urine [g/d]		**16,788**

Inorganic Substances in Faeces		
Element		Mass
	Av. value	Av.value
	mmol/d	[mg/d]
ANIONS		
Bicarbonate		n.s.
Chloride		n.s.
Phosphorus	20	619,46
Jodide		0,017
Potassium		440
Sodium		150
CATIONS		
Calcium		670
Magnesium		120
Iron		192
Copper		1,96
Manganese		3,69
Zinc		10,6
Chromium		0,06
Lead		0,32
Cadmium		0,16
Mercury		0,001
Sum faeces [g/d]		**1,879**
Inorg. Substances [g/d]		**18,667**

n.s.: not specified

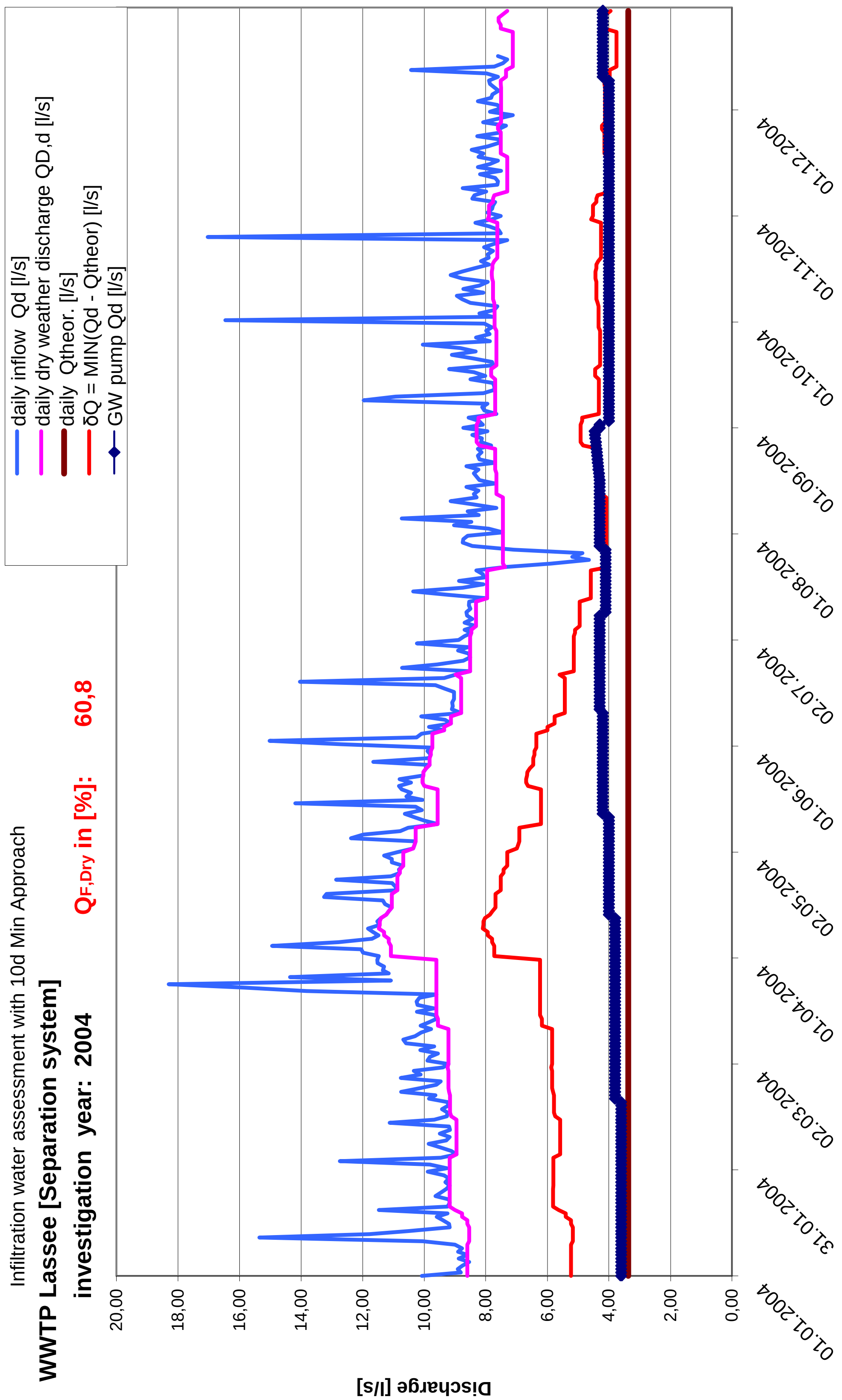

Fig. 7-59: Advanced “Moving Minimum Approach” to assess the GW remediation 2004

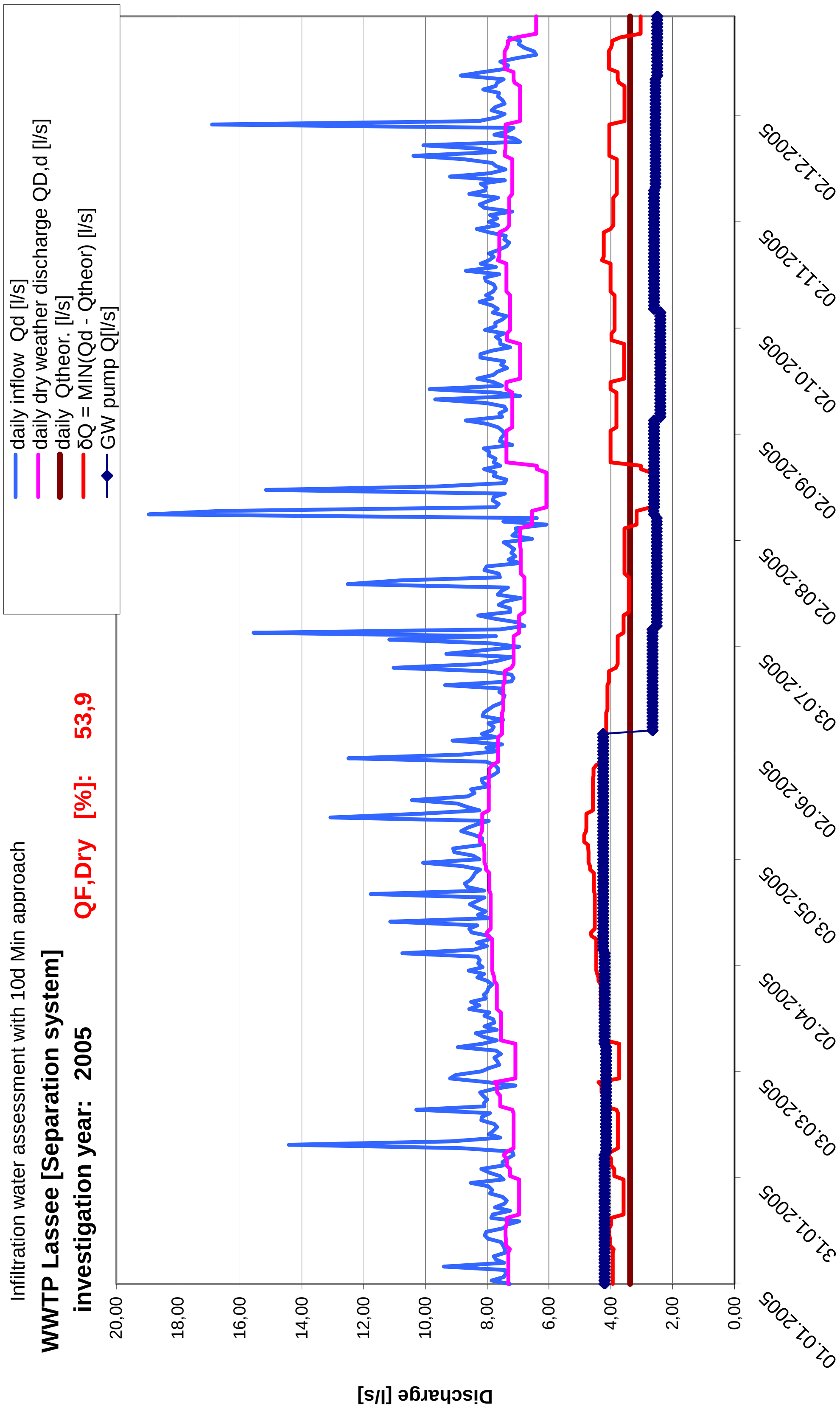

Fig. 7-60: Advanced “Moving Minimum Approach” to assess the GW remediation 2005

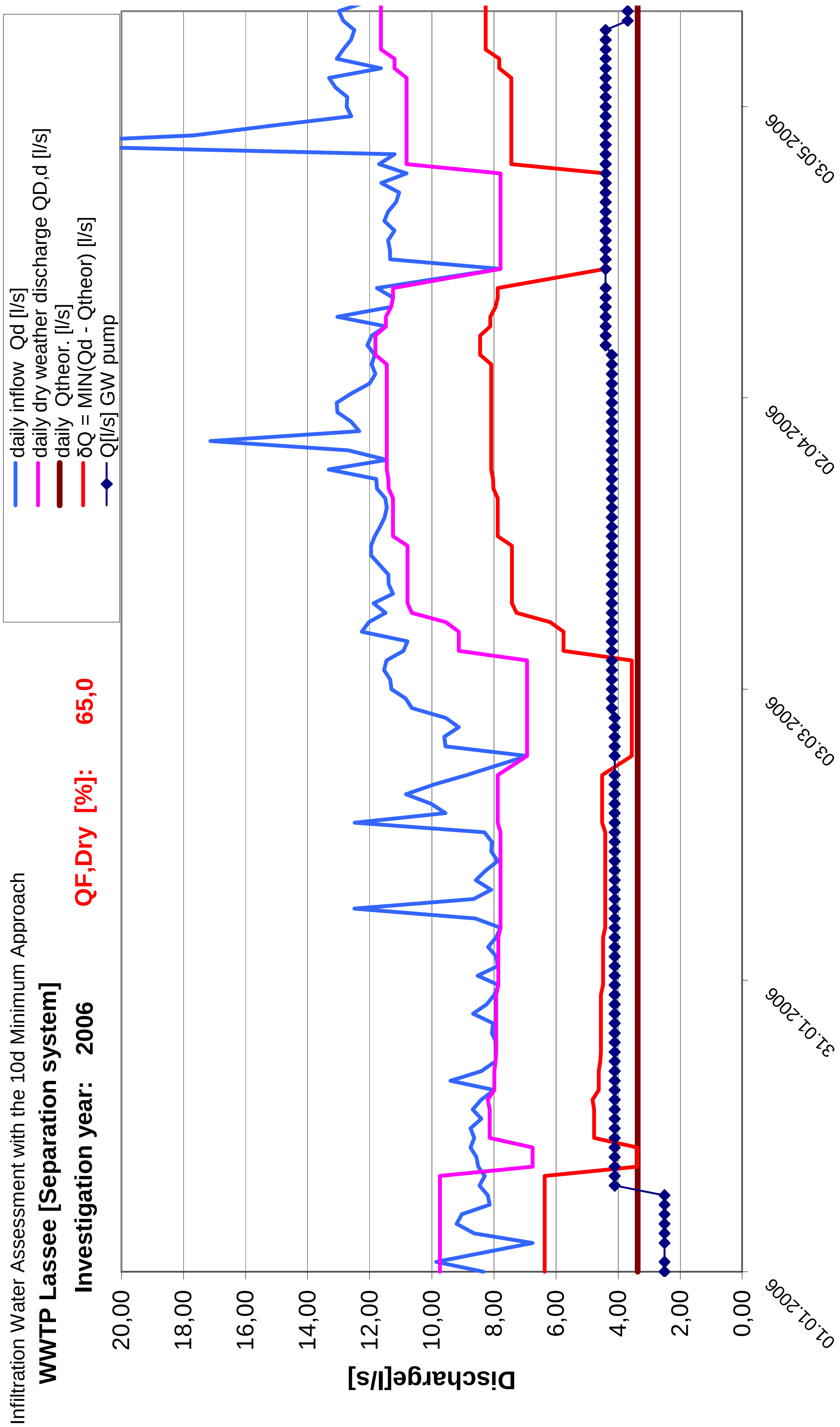

Fig. 7-61: Advanced “Moving Minimum Approach” to assess the GW remediation 1st half 2006