ENVIRONMENTAL REPORT
ISSUED BY STADTENTWÄSSERUNG MANNHEIM

EBS MANNHEIM²
Stadtentwässerung

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FOREWORD

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Over the last few decades, the quality of water in Germany's lakes and rivers has undergone sustainable improvement thanks to the joint endeavours of the federal and state governments and the municipalities. One key contribution to these findings is due to Eigenbetrieb Stadtentwässerung Mannheim (EBS), which is pursuing a consistently ecological strategy. Whether for sustainable energy recovery or resource protection, the Mannheim municipal services is a pioneer in these fields and relies on new processes that may point the way to the future for other wastewater companies as well.

By recovering energy from sewage sludge, utilising heat from wastewater, and even employing renewable energies for specific purposes, the clarification plant can operate with considerably fewer CO_2 emissions. EBS therefore helps to keep Mannheim on course to a better climate and achieve the ambitious CO_2 reduction goals set down in the municipality's climate protection concept. At the same time, the onsite generation of electricity and heat helps to cut costs – in view of rising energy prices a sensible move that protects the climate and limits the charges that citizens have to pay for their use of the sewer system.

By expanding its fourth treatment stage with activated carbon powder for eliminating trace quantities, EBS is embarking on innovative roads to safeguard the high quality of clarified wastewater.

After all, this owner-operated company is also integrated in flood protection, which is especially important for a city like Mannheim that lies on two rivers. In particular, the priority here is given to measures for rainwater percolation because these contribute to the maintenance of the natural water cycle.

This environmental report documents a large number of activities and measures serving to protect waters, resources, and the environment and presents the ongoing and future projects in the environmental and quality programme pursued by the Mannheim municipal services.

EIGENBETRIEB STADTENTWÄSSERUNG

Assignments and organisation

EBS has many assignments, and the most important is the collection and treatment of household and industrial wastewater as well as rainwater from the whole city area before discharging it into the natural water cycle, the waters entering the Rhine. EBS therefore fulfils its sewage disposal obligations for the city of Mannheim. This is aligned to the healthcare principles for the population and the greatest possible protection for people and the environment.

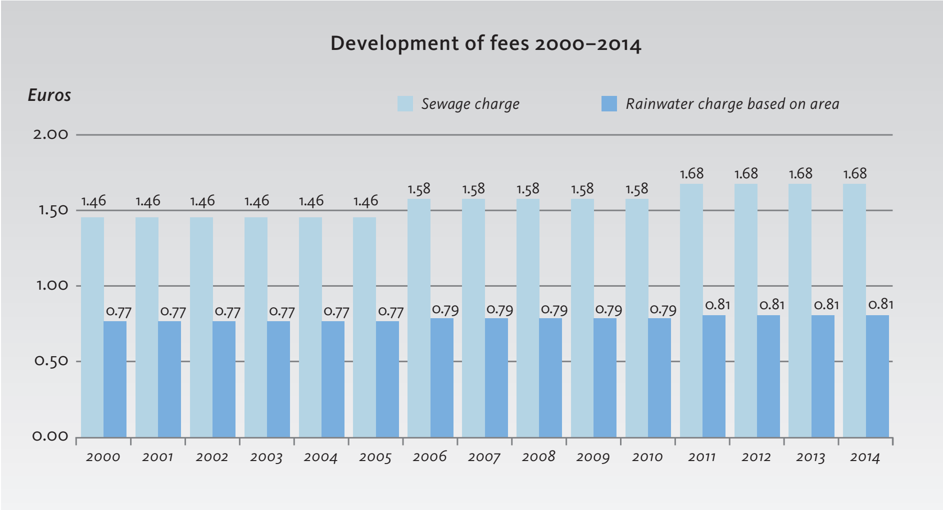
As an owner-operated municipal service provider integrated in the city authorities, EBS is assigned to the Citizens Service, Environmental, and Technical Services Department. The supervisory board is the Technical Services subcommittee consisting of local councillors. The regulatory authorities are the Regional Council Karlsruhe as the Higher Water Authority and the Green Areas and Environmental Protection Department of the city of Mannheim as the Lower Water Authority. These inspect and promote adherence to the legal requirements. Some of these monitoring functions, e.g. quality assured inhouse inspections for adherence to clarification plant thresholds, are undertaken by the Wastewater Chemistry Division as an expert body.

EBS is based at two locations. The new office and service building in front of the sewer maintenance yard at Käfertaler Straße 265 is home to Plant Management, the Commercial Department, and the Wastewater Collection Department. The Wastewater Treatment Department can be found in the clarification plant north of Sandhoven.

Environmental guidelines

Since 2003, EBS has been certified under the environmental and quality standards ISO 9001 and ISO 14001. One integrated constituent of the environmental and quality management system is the health and safety of personnel. As a municipal environmental company, EBS has set down a series of environmental guidelines. These include the use of environmentally friendly procedures and equipment for the protection of natural resources and waters, the reduction of CO_2 emissions and waste, the construction of rainwater percolation facilities for the protection of groundwater, and advice to customers on properly maintained private property drains and backflow prevention. Of course, EBS acts according to the principle of legal certainty and observes the current laws and regulations.

New office building and sewer maintenance yard on Käfertaler Straße



Environmental goals and measures

In line with its quality and environmental management system, EBS draws up every year a programme listing the environmental and quality goals and their measures. These environmental and quality goals were also incorporated in the impact targets introduced in 2012 for all Mannheim departments. EBS regularly analyses the KPIs and the implemented measures to assess the progress of accomplished goals.

One of the most important long term projects is the "Enhancement of cost efficiency through reduction of external energy purchasing" with the goal of operating the clarification plant as a "self supplying" unit. The increased use of internally generated biogas for heating purposes and the production of electricity goes hand in hand with the reduction of CO_2 emissions. In 2013, biogas generation, heat utilisation, energy saving measures, and the operation of a photovoltaic installation and water wheel helped to save about 35,000 tonnes of CO_2 emissions.

A further environmental goal that EBS has been pursuing since 2010 targets improvements to the protection of waters. This involves the additional use of activated carbon powder (ACP) for the elimination of trace quantities in wastewater. Following a successful two-year trial run on a split wastewater flow, the ACP system is now being expanded for the full flow. The goal of removing micropollutants from the waters entering the Rhine constitutes at the same time a contribution towards implementing the EU Water Framework Directive.

EBS expects process improvements and greater cost effectiveness from benchmarking. At two year intervals, the owner-operated company takes part in benchmark events for sewer construction, sewer maintenance, pump houses, analytics, indirect discharger inspections, and KPI comparisons between wastwater and water supply in Baden-Württemberg. By analysing KPIs for the systematic and continuous comparisons between operating parameters and those from other municipal service providers, EBS aims to refine specifically its own services.

Split rainwater charge

In addition to the wastewater charge based on freshwater consumption, Mannheim has been levying as early as 1971 a rainwater charge for the discharge of rainwater into the sewers – in accordance with the public sewage disposal statute (Wastewater Statute). Mannheim was therefore the pioneer of the split sewage charge, which is now mandatory following a court ruling.

On 1 January 2009, the rainwater charge was calculated no longer as a surcharge for fresh water consumption, but exclusively as a function of area. Previously, rainwater drainage had been added to the wastewater charge for private property whose drained area was under 1,000 m^2. Above 1,000 m2, rainwater drainage had been charged per square meter of drained area. Since 2009, this calculation system had applied to all buildings connected to the sewer system, irrespectively of their drained area.

The new system makes the charges fairer and creates financial incentives for owners to deseal their property and to utilise and percolate rainwater on site.

WASTEWATER DISCHARGE

The sewer system

The sewer system under the city of Mannheim today consists of 891 km of waste- and rainwater lines in public space. This does not include the service lines. Under the Wastewater Statute, the whole length of these lines up to the municipal sewer is the property of the land owner. The system carries predominantly combined sewage, i.e. it collects both waste- and rainwater.

The sewer system owned by EBS extends over 824 km. The sewer pipes range in cross section from 250 mm to 3400 mm. After growing for over 135 years, the sewer system includes sections whose ages vary greatly. The oldest sewers in the inner city were built in 1877, mostly of clinker brick. About half of the sewers were built within the last fifty years.

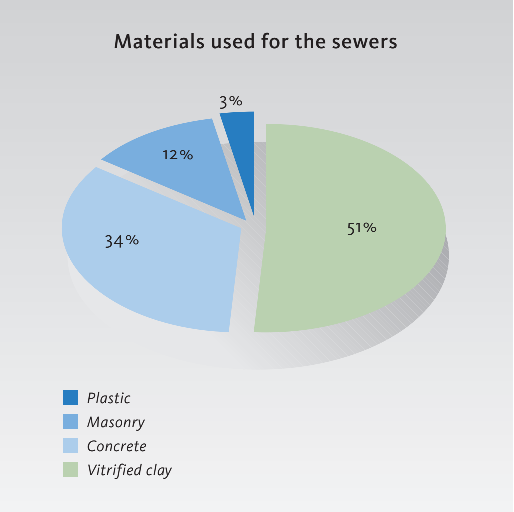
The sewer system consists of a wide range of materials. Vitrified clay is used for sewers ranging from DN 250 to DN 800. This material has been used for decades, so vitrified clay pipes represent the largest proportion of the sewers, covering a length of 423 km. Concrete and in-situ concrete are used for larger and main collectors over DN 1000. Their present length is 276 km. Sewers made of other materials like plastic or cast pipes range from DN 250 to DN 500 and currently represent a length of 23 km.

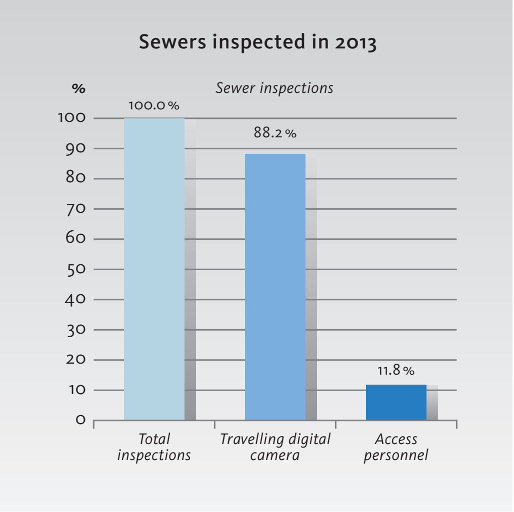
Maintenance and inspection

If the sewers are to maintain their operative state, they must be cleaned at regular intervals. Sewer Maintenance has six high pressure flushing vehicles and one suction vehicle. These combined vehicles are fitted with a high pressure flusher that cleans the sewage pipes at pressures up to 180 bar. Three vehicles use fresh washer for flushing. Three flushing vehicles with water recovery clean with filtered sewage. This saves not only drinking water, but also lengthy trips to the sewer maintenance yard or the nearest hydrant. After flushing, the detached deposits and the flushing water are taken back up in the combined vehicle through a suction device and disposed of in the clarification plant.

Under the Baden-Württemberg inhouse inspection ordinance EKVO, EBS is obliged to inspect the state of its sewage installations and sewer system at regular intervals. The sewer system can operate reliably only when its condition is inspected by access personnel or recorded by travelling cameras. The data collected from these inspections are immediately stored in digitised form in the TV vehicle and exported to the sewer database "Strakat".

In 2013, the inspected sewers amounted to 100%. Of these, 697 kilometres (88.2%) were inspected with the TV camera, and 127 km (11.8%) by personnel who could access the larger diameters.





Sewer inspection with TV camera

High pressure flushing nozzle cleaning a sewer

Sewer being laid in a pit

Customer services and complaints management

EBS has been running a complaints management system since 2002. Notifications of incidents affecting the sewer system from citizens, the police, the fire services, and municipal departments are forwarded immediately to the competent personnel at Sewer Maintenance. In most cases, after consulting with the caller, the personnel determine the cause of the trouble on site and, if possible, remedy it there and then. All key data and the measures taken are documented in the customer services report. The customer services report (see table of notifications) lists the various incidents (e.g. major building work or extreme weather situations) for that year. Following heavy rainfall in June 2010, many residents in the affected districts reported flooding in their basements, inner courtyards, or front gardens. Other customer calls were for domestic services, in particular defect backflow prevention. EBS responded to this with a citizen survey, informational events, and offers of advice on backflow prevention, flood protection, and rainwater percolation. The encouraging response to these offers show that these activities by EBS can bring about higher quality in private drainage systems.

Compared with the preceding years, the number of deployments to defect or clogged rainwater inlets and defect domestic services has been slowly falling since 2010, possibly as a result of less rainfall. Clearly for the same reason, the number of complaints about unpleasant odours and rats has been rising. On the other hand, in 2013, a year marked by frequent and heavy rainfall, complaints about defect rainwater inlets and domestic services increased, whereas there were fewer rats and unpleasant odours.

A review of the developments in the 2010–2013 period reveals an overall downward trend in the number of notifications.

Sewer rehabilitation

After the inspection, the video is played back to examine and assess damage to the sewers. Identified damage is assigned to one of the damage classes 0 to 5, depending on the size and extent.

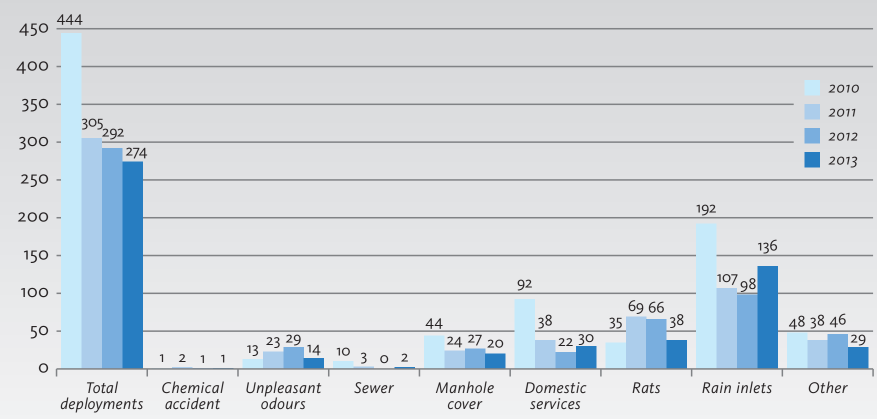
This damage classification helps to decide whether the sewer must be replaced following excavation or can be rehabilitated with inliners introduced underground. If the environment, e.g. traffic conditions, is not conducive to an open pit for sewer replacement, the sewer is replaced with a pipe driver or through a tunnel.

Local damage that does not affect the whole pipe run is repaired through a drive pit.

The Mannheim municipal services employ six different rehabilitation measures

- Sewer replacement (open pit or underground)
- Inliner rehabilitation
- Drive pit
- Robot rehabilitation
- Partial rehabilitation in accessible sewers
- Manhole rehabilitation

Sewer notifications 2010–2013



Percolation trough in the public roadside environment

Private property drainage

The care and maintenance of private service connections and sewers are the responsibility of the land owner. According to the Wastewater Statute of the city of Mannheim, this responsibility for private sewage systems extends beyond the borders of the private property and up to their connection to the public sewer. When wastewater leaks from damaged sewers, this can not only pollute the groundwater, but also hollow out sections of pavements and roads, causing them to collapse.

On 1 January 2014, a new law reforming the water laws came into force in Baden-Württemberg. § 51 regulates the changes affecting the inspection of private property drainage systems. Even though details on the type and scope of these investigations and their intervals have still to be specified, the principle still applies that pollution to the groundwater must be prevented. This, however, is possible only when the entire sewer system – public sewers and private property lines – are tight. Whereas the public sewers are cleaned, examined, and rehabilitated at regular intervals, this is not always the case for private sewers. The advice and information that the experts at EBS can offer citizens, companies, and business people not only affect the rehabilitation and tightness of private property sewers, but also backflow prevention, flood protection, and the legal regulations.

	2010	*2011*	*2012*	*2013*
Inliner rehabilitation	791 m	450 m	1067 m	1512 m
Drive pit	80 x	75 x	63 x	94 x
Sewer replacement	717 m	569 m	237 m	455 m
Hydraulic measures	911 m	444 m	528 m	734 m
New sewer construction / development	0 m	0 m	695 m	67 m

Scope of rehabilitation types

Rainwater percolation

Owing to the heavy level of sealing in the cities, rainwater discharges predominantly into the sewers. As a consequence, the groundwater table has been sinking constantly, and more so in the dry years. The European Water Framework Directive (WFD) demands percolation as the preferred system of rainwater drainage. Accordingly, § 55 (2) of the Baden-Württemberg Water Ecology Act prescribes that projects for new buildings include a rainwater percolation facility on the property. The aim of rainwater percolation is to reinstate the natural balance of the water cycle and to promote the replenishment of groundwater.

An additional problem is posed by the frequent bouts of heavy rain caused by the emerging climate change. The sewer system cannot collect these large quantities of rainwater in such a short time, and there is temporary flooding on roads and squares as a result. Public areas must be provided with retention capacities (e.g. roads or squares) that can be dammed without damage. Consequently, the only approach to a solution that experts can see involves cooperation between municipal services, city planning, and road planning. These plans are then no longer based on theoretical calculations for the sewer system, but on fundamental risk analyses that concentrate on institutions (e.g. hospitals) in need of special protection before this background.

EBS has realised various projects for local rainwater percolation in the public space. Development measures on Beim Hochwald and Krautgartenweg included the construction of percolation troughs in public green spaces. The land owners can discharge rainwater through lines into the percolation trough or percolate it on their property.

The positive effects are less load on the sewer system during heavy rainfall, and there is less flooding and backflow in the roadside environment. On the other hand, there are no longer any flushing effects in the sewers, but improved pipe materials are intended to compensate for this in areas of new buildings. In contrast to the old bricked or concreted sewers with rough surfaces, the new sewers of HDPE (high density polyethylene) exhibit only minimal surface roughness, and there are scarcely any deposits.

Rain overflow tanks in the clarification plant

Pump houses and storage capacities

Owing to the flat Mannheim topography, a larger number of pump houses are needed for the fast discharge of sewage to the clarification plant. At present, EBS has been assigned by the planning authority to operate 38 pump houses and service 32 pump stations.

During periods of heavy rain, 21 retention basins and drain channels and nine rain overflow tanks with a total storage capacity of 185,000 m^3 prevent flooding in the city. This storage capacity retains the rainwater after heavy rainfalls and later introduces it back into the sewers. If, in rare cases, the quantities of water exceed the limits of the available storage capacities, then the rainwater is directed into the rain overflow tank after it has been clarified mechanically, and from there through the rain outlets into the waters feeding the Rhine and Neckar.

The various storage capacities are spread over a large area of the city. The largest above-ground interconnected complexes of retention basins and rain overflow tanks can be found in the modified rain overflow tank in Sandhofen (19,000 m^3) and in the clarification plant (39,500 m^3). The largest underground rainwater retention basin can be found in the Vogelsang district, with a capacity of 16,000 m^3.

Recent calculations have verified that EBS operates storage capacity that is more than adequate. This offers the optimal conditions for the planned conversion of eight rain overflow tanks in the clarification plant for the expansion of the activated carbon powder system. And the remaining retention capacity of 171,000 m^3 still complies with the legal stipulations for preventing the discharge of dirt components into the Rhine.

Flood protection

Also Mannheim keeps a close eye on climate change and the resulting increase in extreme rainfalls. Primarily responsible for flood protection are the fire services, which coordinate the municipal management unit for disaster control. EBS is represented by executives and experts on this committee and provides the technical preparations for flood simulations. The task “Protective measures for the sewer system following a dyke break” utilises computer simulations to develop measures for the protection of the population and buildings in particular scenarios.

Flooding of the Neckar in 2013

WASTEWATER TREATMENT

The clarification plant

Situated north of Sandhofen, the central clarification plant treats every day an average 96,000 m³ of domestic, industrial, and trade sewage from the whole city area. It has been designed for a population equivalent of 725,000.

Wastewater and sludge treatment

In the clarification plant, the wastewater needs just 24 hours to pass through three stages before it is discharged, clarified and filtered, into the waters entering the Rhine.

- Mechanical wastewater treatment with coarse and fine screens, grit trap, aerated grease trap, and primary settling tank
- Biological wastewater treatment with nitrification, denitrification, and biological phosphorus elimination, and final settling tank
- Chemical phosphorus elimination (only as a supplement) through addition of iron salts
- Flocculation filtration in three layers with gravel, sand, expanded shale

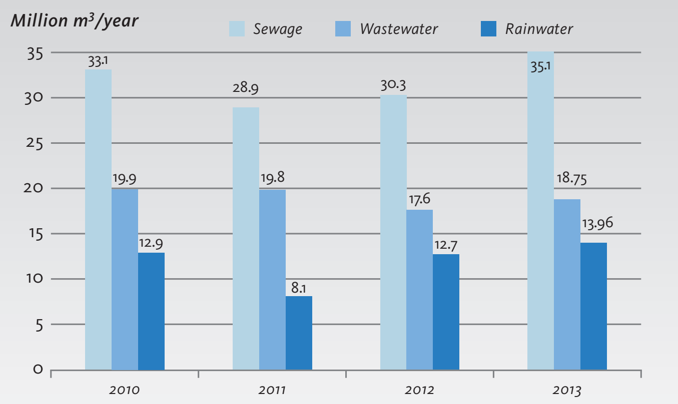
In the near future, 90% of the annual wastewater quantity will pass through the activated carbon powder (ACP) system as the fourth treatment stage for the elimination of trace quantities.

The following processing steps reduce the volume of the sewage sludge accruing from the wastewater treatment:

- preliminary sludge thickening, i.e. the separation of a large part of the water content
- sludge digestion in three anaerobic tanks at a constant temperature of 37 °C for a retention time of up to forty days
- digested sludge dewatering, reducing the water content from 94% to 70%
- thermal drying at temperatures up to 500°C until the residual moisture is reduced to 5%

About 10,000 tonnes of dried sludge granulate, or so called biosolid pellets, are produced every year, mostly serving as fuel or raw materials for the cement industry. From the spring of 2014, it is planned to recycle about 50% of the dried sludge in a sewage sludge gasifier on the clarification plant grounds.

Influent wastewater in the Mannheim clarification plant

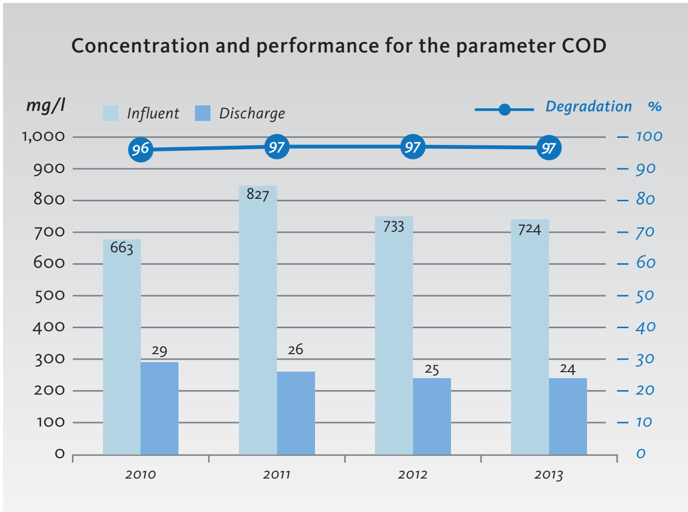


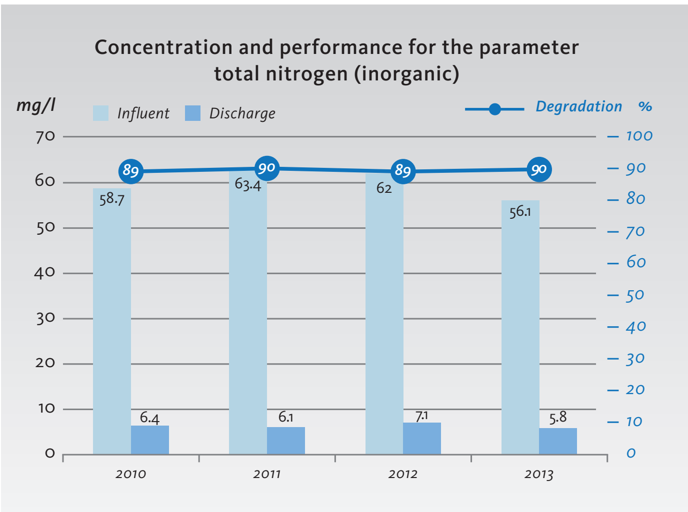
Aerial photograph of the clarification plant (2013)

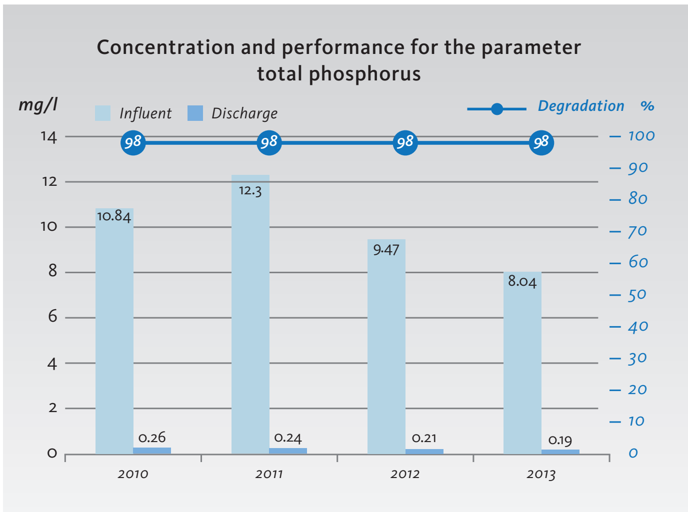
Environmental performance

According to the environmental standard EN ISO 14001, environmental performance is defined as the "[m]easurable results of the environmental management system, related to an organisation's control of its environmental aspects". Environmental aspects are constituents of an organisation's activities, products, or services that affect the environment.

At EBS, the measurable results of its activities mainly refer to the clarification plant performance (degree of degradation) based on the parameters COD (chemical oxygen demand), total nitrogen (inorganic), and total phosphorus relevant to the environment and permits. The degree of degradation is the most important indicator for the effective protection of waters.







EBS in the DWA performance comparison

Since 1974, the Baden-Württemberg branch of the German water management, sewage, and waste association DWA has been publishing annual comparisons of clarification plant performance throughout the state.

These comparisons are based on values that operating personnel had measured during inhouse inspections. The effectiveness of a system is assessed on the basis of the degree of degradation for several parameters.

Since the outset, EBS has been included in the DWA performance comparisons. The quality assurance and the continuous improvement of the technology and processes are reflected in the findings. For years, EBS has been assessed with the best degrees of degradation for the dirt component parameters, and heads the list of 38 large scale clarification plants in Baden-Württemberg.

The table presents the EBS performance next to the minimum requirements under the German Water Ecology Act WHG, the average values obtained from the clarification plants in Baden-Württemberg, and the self declared thresholds at EBS.

		Minimum requirements under WHG	2010			2011			2012			2013		
			EBS	Land B-W State	Declared values EBS	EBS	Land B-W State	Declared values EBS	EBS	Land B-W State	Declared values EBS	EBS	Land B-W State	Declared values EBS
COD	mg/l	75	29	21	60	26	22	60	25	21	60	24	20	60
COD degradation	%		95.7	95		96.9	95		96.9	90		96.7		
NH_4-N	mg/l	10	0.2	0.8	3	0.2	0.8	3	0.39	0.8	3	0.22	0.6	3
Oxygen demand level			1			1			1			1		
N_{tot}	mg/l	13	6.4	9.4	9	6.1	10	9	7.1	9.6	9	5.8	9.2	9
Degradation N_{tot}	%		89.2	76		90.3	78		88.6	78		89.7	75	
P_{tot}	mg/l	1	0.26	0.7	0.6	0.24	0.7	0.6	0.21	0.6	0.6	0.19	0.6	0.6
Degradation P_{tot}	%		97.6	89		98	90		97.9	90		97.6	90	
Nutrient load level			1			1			1			1		
Infiltration water content	%		1.4	45		0.8	40		6	39		11.3	47	

Clarification plant performance in DWA comparison

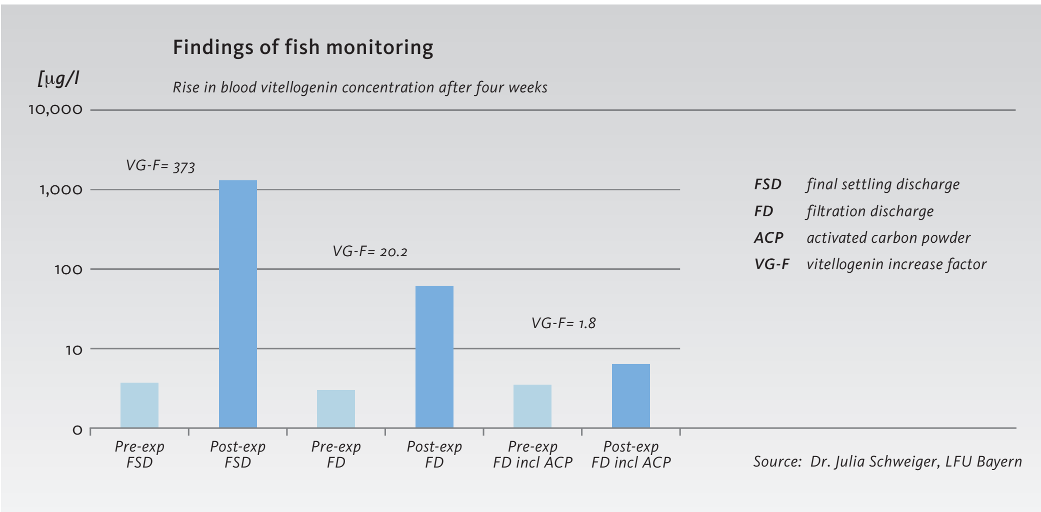
Elimination of trace quantities with activated carbon powder

Despite what appears to be improved water quality to the naked eye, our waters are not without pollutants. In addition to a great many chemical micropollutants like e.g. additives in household chemicals, care products, and cosmetics, also large quantities of drug residue like painkillers, antibiotics, hormones, and contrast media are carried every year into the rivers, and from there into the water cycle. They can promote multiresistant pathogens and deformities in fish. To date, conventional sewage treatment in clarification plant could extract only a very small portion of these trace quantities.

Since 2010, EBS has been operating in the clarification plant a pilot installation intended to remove trace quantities from wastewater. The use of activated carbon powder for eliminating trace quantities is a new technology. The first project to apply this on an industrial scale was led by scientists from Biberach University of Applied Sciences investigating the effects on a split sewage flow. The effectiveness of this method has been verified in a number of measurement tests.

Indisputable findings were also returned by the Bavarian state environmental agency LfU that monitored a fish population in the Mannheim clarification plant. After four weeks, the blood of male rainbow trout kept in biologically clarified wastewater was discovered to contain levels of vitellogenin, a parameter for the oestrogenic effects of hormonal substances, that was about 350 times greater (VG-F = 373) than the fish population kept in biologically treated and filtered wastewater that had been additionally clarified with ACP. This showed that ACP treatment can remove over 80% of these trace quantities in wastewater.

Following these encouraging findings, the ACP system was expanded for the full flow from 2014. In future, the activated carbon powder system will be able to treat 1,500 litres of clarified wastewater every second.



RENEWABLE ENERGIES

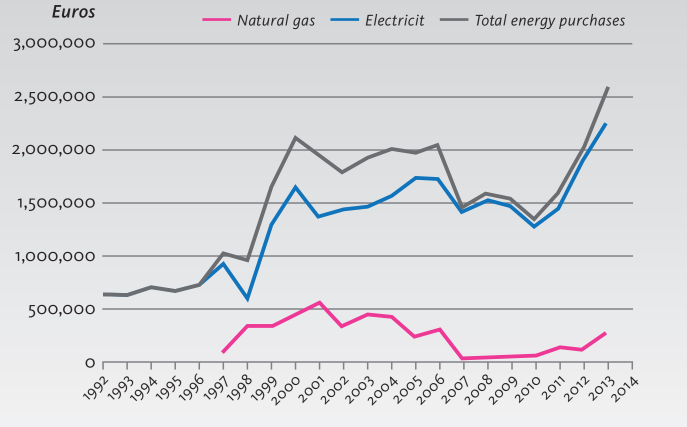
A clarification plant needs huge amounts of energy to operate. About 20% of the city's electricity consumption goes into feeding it. Every year, the Mannheim clarification plant consumes about 23 million kilowatt hours of electrical energy and about 29 million kilowatt hours of energy supplied by sewage and natural gas.

By introducing a large number of measures, EBS is gradually approaching its goal of operating the clarification plant as a self supplying system.

Sewage gas generation and utilisation

In order to reduce the rising energy costs, EBS is increasingly turning to the onsite generation of regenerative energies. At present, the digesting tanks are producing about nine million cubic metres of sewage gas every year. This is used completely for the generation of energy in the clarification plant. About one third of the gas quantity is fired in the hot gas generators for the sludge drying section. The rest is converted into heat and energy by four-stroke internal combustion gas engines. In turn, the heat emitted by the gas engines and the thermal energy gained from the sludge drying section cover all of the clarification plant's needs to heat up the digestion tanks, the buildings, and the hot water supply. At the same time, the gas engines in the combined heat and power (CHP) station serve as a backup power supply to parts of the clarification plant, maintaining the flow of wastewater during prolonged power outages.

Development of external energy costs for the clarification plant



In the space of just a few years, EBS is now paying nearly double the costs for electricity purchased from outside, from 10.48 ¢ per kWH in 2006 to 20.1 ¢ per kWh in 2014. This has resulted in the sharp increase to energy costs overall. Compared with electricity, natural gas prices have risen only by a little, so sewage gas is used to generate electricity for specific purposes. Accordingly, there is increasing use of natural gas in the sludge drying section.

Cofermentation

Since 2006, EBS has been utilising cofermentation to increase the generation of sewage gas. This involves collecting product residue from the foodstuffs industry or readily degradable organic substances together with the sewage sludge in the digesting tanks. The increased fermentation processes raised the sewage gas production by 80–100%. Since 2012, the market for cosubstrates has been developing to the detriment of EBS. The cosubstrates are no longer available to the extent or with the consistency they had in the last few years. The search has therefore started for other suitable substrates. At present, EBS is in talks with the Regional Council (RP) Karsruhe about the acceptance and pasteurisation of waste food. A system is already under construction. The company has applied to RP Karlsruhe for a permit to pasteurise Category 3 materials (including slaughterhouse waste and waste food from large kitchens) on the clarification plant grounds.

For EBS, cofermentation is an integral constituent of energy management because it increases the production of electricity and heat.

Sewage sludge gasification

The first construction stage for an external operator's sewage sludge gasifier is now running in test mode on the clarification plant grounds. The system has been designed to process 5,000 tonnes of sewage sludge and 800 tonnes of screenings every year.

The sewage sludge gasifier is a fluidised bed gasifier that extracts organic residue from the biosolid pellets at about 850°C, giving rise to synthesis gas. This is a lean gas that can be used to dry sludge and fuel gas engines. The remaining material is landfilled or used as recycled material in the building industry. The use of the phosphorus it contains could be an issue for the future.

Digestion tank

Sewage sludge gasifier

Water wheel in the discharge to the Rhine

On completion of the two successive construction stages, the sewage sludge gasifier will generate a total of 15.2 million cubic metres of synthesis gas every year. Together with the measures already implemented, these measures might be enough to cover far more than 90% of the clarification plant's energy needs. And the onsite utilisation of sewage sludge additionally saves transport routes and fuel. CO_2 emissions will then be reduced by about 40,000 tonnes per year.

Photovoltaics and hydropower

Since 2006, a photovoltaic (PV) installation fitted with solar modules covering an area of 2,300 m² has been producing electricity from solar energy on the filtering tank. In its first year of operation, the PV installation delivered about 238,000 kWh of solar electricity that is fed into the grid of the local utility at the subsidised prices. The electricity generated varies between 230,000 and 250,000 kWh per year.

Electrical energy is generated from hydropower by a water wheel in the clarification plant's discharger to the Rhine. Unlike the turbine, this so called Zuppinger wheel with curved blades is better suited to varying water levels. Its efficiency exceeds 80%.

Heat from wastewater

At present, EBS is managing two showpiece projects for heating buildings with thermal energy gained from the sewer. The first project was realised in the listed Ochsenpferch pump house. A heat exchanger was installed over a length of 42 metres in a sewer measuring 2.20 m across. The system started operations in 2011. Two years of operations helped to save about 10,000 litres of fuel oil a year, equalling CO_2 savings of about 28 tonnes a year.

The second project is running in the new EBS office building on Käfertaler Straße. Here, in the summer of 2013, a wastewater heat pumping system was installed that is used for heating and cooling purposes. For peak load periods, the building was fitted with a connection to the district heating system as well as an additional cooling system on the roof. Thanks to its innovative installations, the new building consumes 33% less than the requirements under the German energy savings act EnEV 2009 and was awarded the EU Green Building Label.

Heat exchanger in the sewer

Photovoltaic installation on the filtration section

LIFECYCLE ASSESSMENT

It is inevitable that the environment suffers under the activities and procedures involved in the collection and treatment of wastewater. On the one hand, the plant must consume water, energy, and resources. On the other, there is an accumulation of waste and other residue. The analysis of materials streams and their flow rates provides a basis for measures serving to lessen the impact on the environment.

EBS endeavours to keep the consumption of resources to the absolute minimum, for instance when drawing groundwater or purchasing external electricity. The waste quantities accruing from wastewater treatment, sewer cleaning, and sewer rehabilitation are reduced whenever possible and introduced to a recycling process. Some examples include the generation of synthesis gas from biosolid pellets and the use of clarified wastewater as process water.

However, when seen overall, the environmental impact of wastewater collection and treatment appears relatively small when they are offset by the benefits the sewer system and the clarification plant have for the health of the population and for the environment.

The lifecycle assessment also takes economic aspects into account. Here it can be seen from a series of measures that investments in environmental and climate protection pay off over the long term, e.g. energy optimisation measures targeting the “self supplying” clarification plant.

Consumption of resources

Water

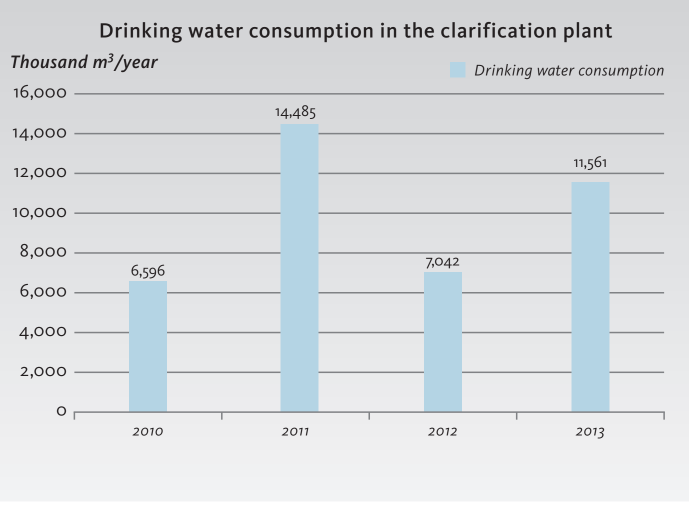
Sewer Maintenance draws the largest quantities of drinking water for flushing the sewer pipes. The three high pressure flushing vehicles fitted with water recovery help to reduce the consumption of drinking water. However, this resource saving technology can be used only on sewer pipes with diameters greater than 1 m that carry adequate quantities of influent.

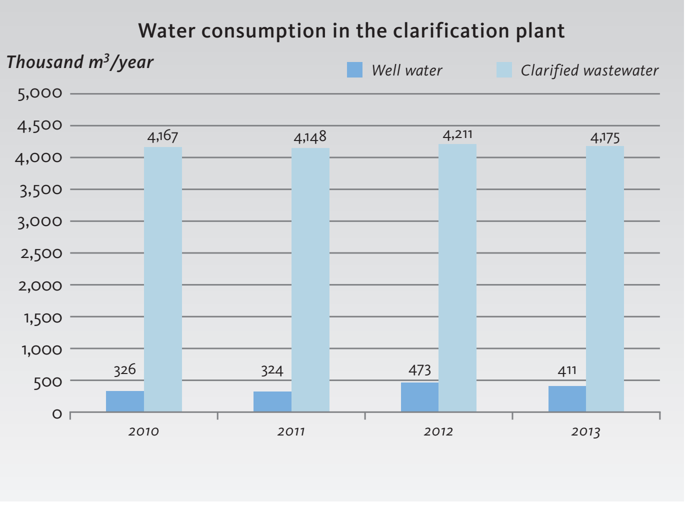
The clarification plant covers its water needs primarily from groundwater drawn by five pumps from two wells and from clarified wastewater.

The clarification plant uses part of the clarified wastewater as internal process water in the following systems:

- as cooling water in the sludge drying section BW 21
- for flushing the filters in BW 37
- in the grit washer (replacing well water)
- for flushing the rain overflow tanks

The sharp rise in drinking water consumption in 2011 and 2013 was partly due to rehabilitation work on the digesting tanks and concrete repair on the stacked sludge containers. The high pressure jets used to blast the facades could be supplied only with drinking water.





Gas tank

Combined heat and power station in a container

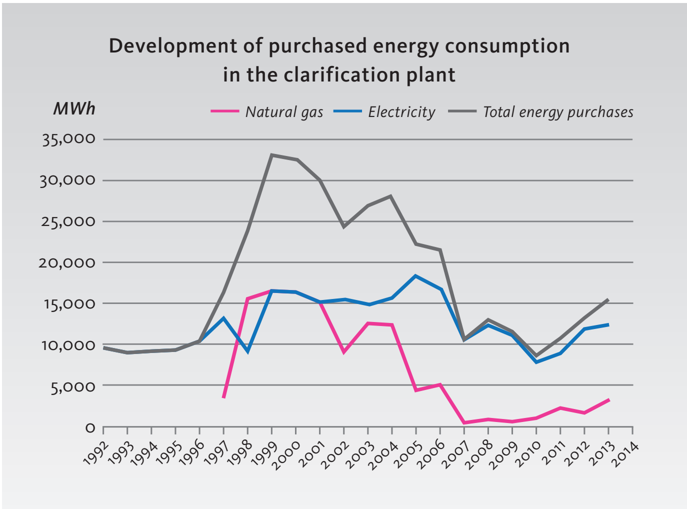
Plans to build a closed cooling circuit with adsorption refrigeration machines (cold generated from heat emissions) are to save in future about 90,000 m^3 of well water a year.

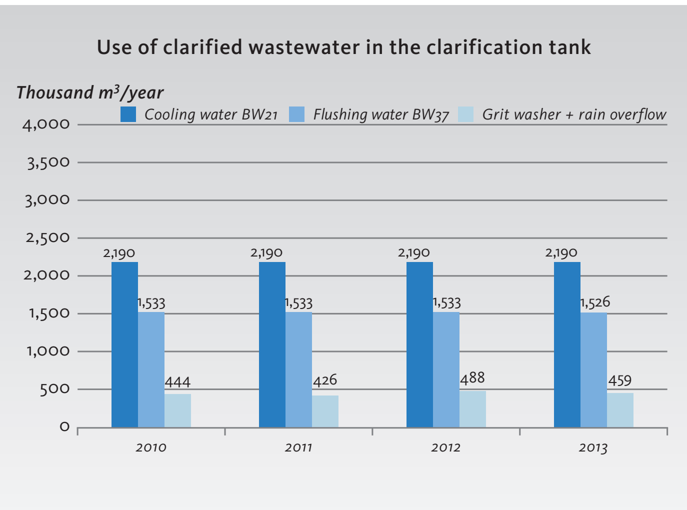
Energy – electricity and natural gas

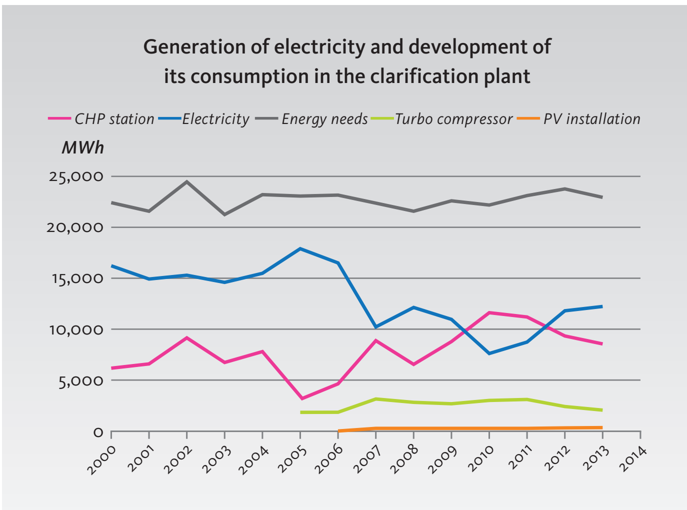
The trend of energy consumption in the clarification plant must be interpreted in conjunction with the measures for the inhouse generation of power. Until 2007, the production of sewage gas had helped to cut the costs of external electricity every year and had increased to such an extent that it replaced completely the natural gas purchased from outside suppliers.

Further savings in electrical energy could also be achieved in 2005 with the turbo compressor fuelled by sewage gas, in 2006 with the photovoltaic installation, and in 2012 with the water wheel. The slight rise in electricity and natural gas purchases from 2007 resulted from the declining production of sewage gas following shortfalls in cofermentation substrates.

In spite of the new additions to its installations, the clarification plant shows a slight drop in its energy needs. However, the development of the cosubstrates market has taken a turn to the detrimental of sewage gas production, so the energy this should have delivered had to be replaced with purchased electricity. From 2011 to 2012 there was a slight increase in electricity needs when new systems and installations started operations. Following energy optimisation measures, the electricity consumption in the clarification plant dropped from 23,746 MWh in 2012 to 22,962 MWh in 2013.







Resources

Fuels

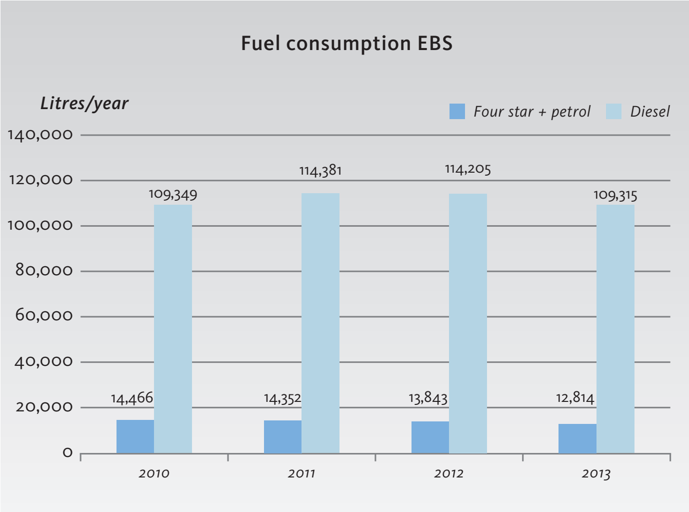
The Sewer Maintenance vehicles take the lion's share of the total fuel consumption (petrol, diesel). The high pressure flushing and suction vehicles are fitted with powerful diesel engines, so their fuel consumption is relatively high. The other fuels – petrol and four-star – are consumed by the daily business trips by car. Petrol consumption could be reduced after EBS had purchased cars of greater fuel economy and concentrated its operations at two locations (fewer trips).

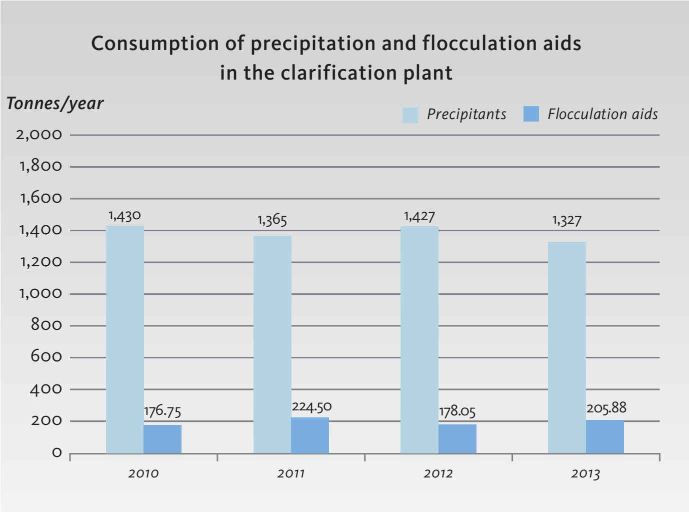
Precipitation and flocculation aids

Precipitation and flocculation aids serve to eliminate phosphates and improve the processes involved in the treatment of wastewater and sludge.

In the summer months when the wastewater temperatures are higher, the biological elimination of phosphorus is perfectly adequate, and less precipitation aids are used as a result. In winter, on the other hand, iron sulphate must be added if all of the carried phosphates are to precipitate out and the stipulated thresholds observed. The quantities consumed annually therefore depend greatly on the weather conditions.

Flocculation aids are added to the sludge treatment processes in equal quantities over the whole year. Flocculation aids are used to thicken and dewater the sewage sludge by increasing the volume of the sludge floc to an extent suitable for dewatering. The quantities used vary depending on the extent and consistency of the influent sludge. The growing trend can be put down to the increasing quantities of sewage sludge generated by cofermentation.





Dewatered sewage sludge

Organic residue washed out of grit

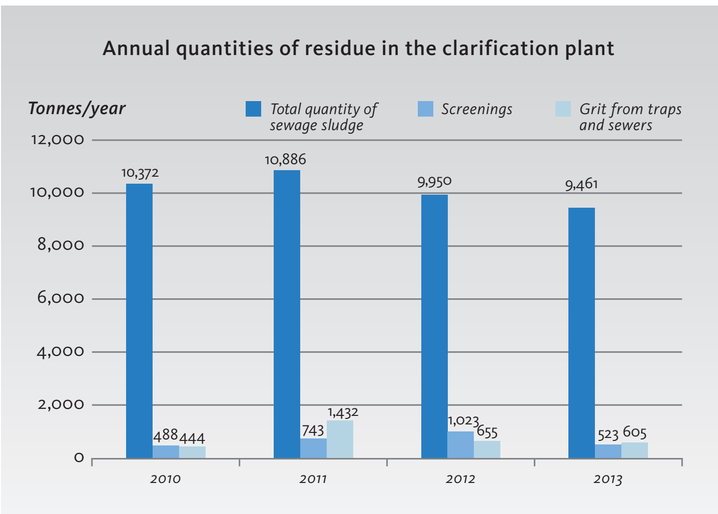
Waste

Sewage sludge and screenings

Since 2005, the dried sewage sludge has been used primarily as a fuel in the cement industry. As a consequence of cofermentation, the total quantity of sewage sludge had risen slightly, ultimately maintaining a relatively stable level of about 10,000 tonnes a year. In 2012, the cosubstrates market started on a course to the detriment of EBS. The quantity of screenings started to increase after the grit washer had been fitted with an organic filter. The collected organic solids had first been disposed of together with the screenings in the MVV waste incineration plant. The procedure has been changed, and now the collected organic matter joins the influent to the primary settling tanks and ultimately to the digesting tanks where they are converted together with the primary sludge into sewage gas and water.

Treated and sewage grit

Huge amounts of grit are produced when the clarification plant treats wastewater and the sewer pipes are flushed. Both the sewage grit entering the clarification plant and the contents of the grit trap are routed to the grit washer. This removes the organic constituents. The washed grit is transported to the landfill operated by AGB Mannheim and there used as a cover soil.



Annual quantities of residue in the clarification plant

ENVIRONMENTAL PROTECTION IN EVERYDAY OPERATIONS

En route for the benefit of the climate

The field of mobility has the potential to save fossil energy and hence CO_2 emissions that should not be underestimated. The use of bicycles and electric vehicles pays off for business trips, service trips, and ultimately the trips to and from work.

A total of 92 company bicycles have been provided for personnel to reach their assigned areas quickly on the expansive clarification plant grounds. They are serviced by an employee in addition to his work as a sewage technician. In 2010, two city bikes were bought for short distance business trips by the administration on Käfertaler Straße.

At present, there are five electric vehicles in use on the clarification plant grounds. The first electric car was acquired in 2001 (then without a cab), and the second in 2011. Both vehicles are used round the clock by shift personnel at the Processes Division. Two electric cars are stationed in the fitter's shop and transport tools and heavy replacement parts like pumps, units, etc. One electric car is used daily for cleaning various buildings and pump houses and for transporting cleaning agents, paper, and waste. This year, the fleet will be augmented with two new electric cars.

The reach of these electric cars depends on the temperature, terrain, driving style, and payload and is about 65 km. The top speed is 29 km/h when the maximum noise levels reach 62 dB. The refuelling point is any electric socket delivering 230 volts. The cars are "filled up" regularly at night. Under normal conditions, a single charge lasts for three days.

Biotope in the clarification plant

The Mannheim clarification plant lies in the heart of a nature reserve. By making every effort to treat this natural environment with all due care and attention, EBS fulfils the requirements stipulated for this location. Lined with trees and shrubs and featuring meadow orchards and ponds, the clarification plant grounds promote a healthy environment for a wide range of flora and fauna that are a rare sight elsewhere in the intensively farmed areas along the Upper Rhine. The green areas that must be retained as free spaces for further expansions are home to a flock of grazing sheep. Meadows with a variety of wild herbs promote biodiversity.

Electric car in front of the digestion towers

Sheep grazing on the meadow orchard

EBS IN FIGURES – 2013

General data

Catchment area	city of Mannheim
Area:	approx 145 km^2
Population	approx 327,000 inhabitants
Percentage of Mannheim households connected to the sewers	99.9%
Number of employees	244 (as of 12/2013)
Trainees	6

Wastewater charges

Sewage charge	€1.68/m^3
Rainwater charge	€0.81/m^2 per year

Wastewater discharge

Drained areas	approx 7,100 ha
Length of the sewer system (combined sewage)	891 km
Company vehicles	
– Cleaning vehicles (flushing vehicles, of which three with water recovery)	6
– Suction vehicle	1
– TV vehicles	2

Pump houses and rainwater overflow structures

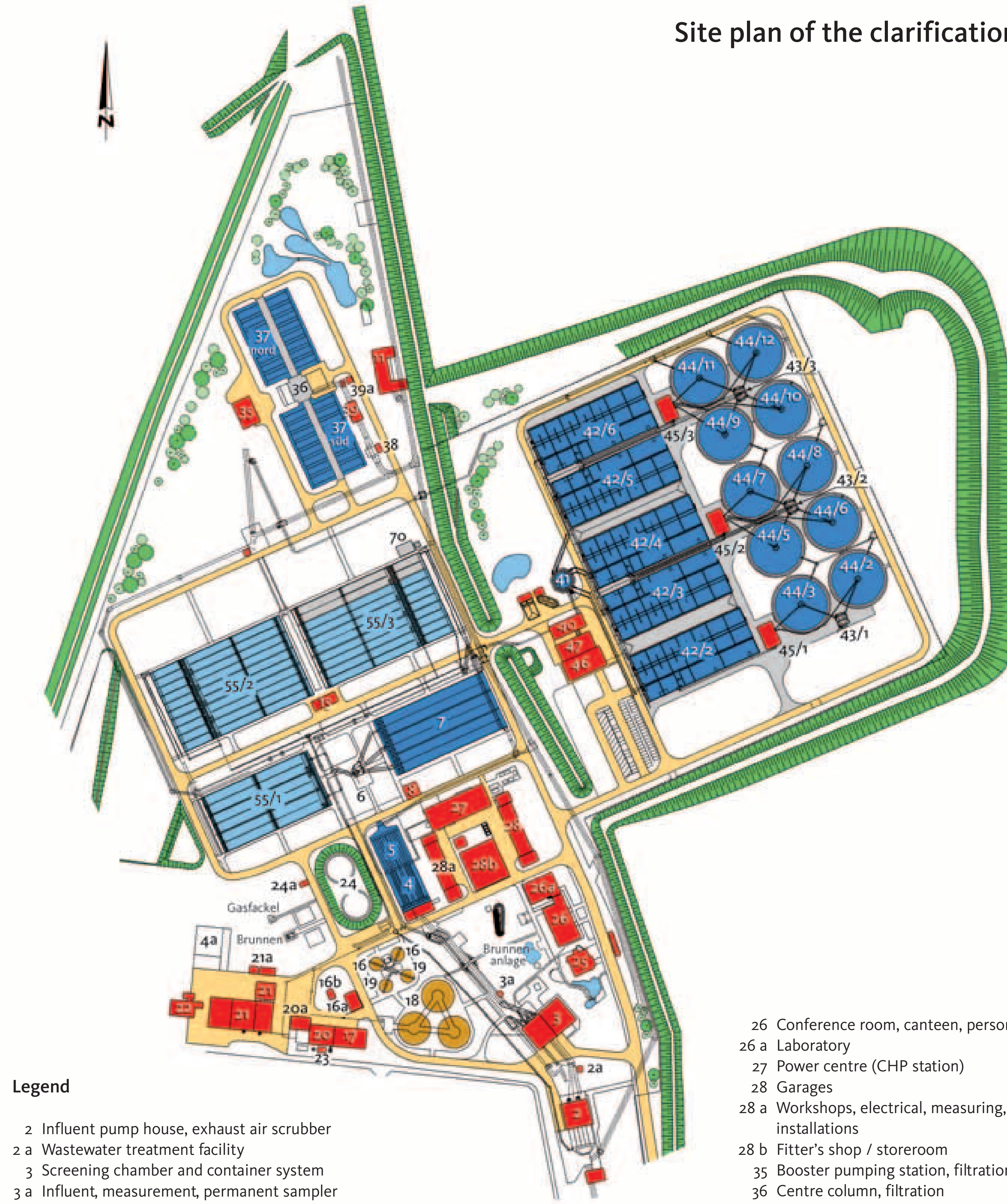
Rain overflow tanks	8
Rainwater retention basins	7
Rainwater retention sewers	4
Sewage storage capacities	10
Total retention capacity	approx 185,000 m^3
Pump houses	38
Pump stations	32

Wastewater treatment, clarification plant

Population equivalent	725,000 (PE)
Quantity of influent wastewater for biological treatment	
– Dry weather, max	1,250 l/s
– Rainy weather	4,000 l/s
– Max influent quantity incl clarification plant’s rain overflow tank	10,000 l/s

Sewer plan of Mannheim

Site plan of the clarification plant



Legend

- 2 Influent pump house, exhaust air scrubber
- 2 a Wastewater treatment facility
- 3 Screening chamber and container system
- 3 a Influent, measurement, permanent sampler
- 4 Grit trap with washer
- 4 a Grit storage area
- 5 Grease trap
- 6 Circular distributor to the primary settling tanks
- 7 Primary settling tank
- 8 Raw sludge pump house
- 11 High water pump house
- 15 Control station for rain overflow tanks
- 16 Stacked containers for raw sludge, excess sludge
- 16 a Preliminary centrifuge
- 16 b Cosubstrate system
- 17 Sludge pump house
- 18 Digestion tank
- 19 Stacked containers for digested sludge
- 20 Excess sludge thickener
- 20 a Flocculants and central pump house
- 21 Sludge dewatering and drying systems
- 21 a Overseer's office
- 22 Sewage sludge gasification
- 23 CHP station 4
- 24 Gas tanks
- 24 a Switch room for gas tanks / flare
- 25 Central control room, administration, truck scales
- 26 Conference room, canteen, personnel rooms
- 26 a Laboratory
- 27 Power centre (CHP station)
- 28 Garages
- 28 a Workshops, electrical, measuring, and control installations
- 28 b Fitter's shop / storeroom
- 35 Booster pumping station, filtration
- 36 Centre column, filtration
- 37 Filtering tanks / photovoltaic installation
- 38 Induction flowmeter
- 39 Water wheel
- 39 a Precipitant dosing outstation
- 40 Booster pumping station for biological stage
- 41 Circular distributor to the biological stage
- 42 Aerated sludge tanks
- 43 Distribution structure to final settling tanks
- 44 Final settling tanks
- 45 Return sludge pump house
- 46 Blower station, electric station
- 47 Precipitant dosing station
- 55 Rain overflow tank
- 70 Activated carbon powder system

Side arm of the Rhine in Ballauf-Wilhelmswörth (Mannheim-Sandhofen)

Disclaimer

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