

# Water Concept Kronsberg

Part of the EXPO project

-Ecological Optimisation Kronsberg-



Hannover



Stadtentwässerung  
Hannover

A company owned by the municipality of Hanover

# Foreword

With the new suburb of Kronsberg, the Regional capital, Hanover, is presenting a building project in which the World Exhibition theme of “Man – Nature – Technology” is being realised in a forward-looking manner. With the joint aims of ecological acceptability, and enduring and lasting development, the suburb is a veritable symbol of the local Agenda 21, to which the city of Hanover has committed itself.

In ecological terms, the water concept for the Kronsberg suburb is an essential component. It demonstrates that, even in building developments covering major areas, adverse effects on the natural water economy can be avoided. In an area for 15,000 inhabitants, built at high-density to conserve both space- and building-resources, no more rainwater will be diverted than before the building took place, thus contributing greatly to prevention of flooding.

Without water, the world would be devoid of life. Continuous urban development means that we must be able to justify our behaviour with water. On the Kronsberg, this is manifest in a number of ways. Water is used as a design element in public and private areas, as an artistic component; it shows drinking water economy programmes and is a part of teaching concepts in the schools and kindergartens.

The Kronsberg water project is being presented within the framework of the World Exhibition as part of the “Kronsberg – ecological optimisation” project.

This makes it possible to present the idea for water drainage and urban water systems for lasting future urban developments to a global audience.




*Herbert Schmalstieg*  
*Lord Mayor*

*Hans Mönninghoff*  
*Leader of the Council and Environment Manager*

*Fritz Tolle*  
*Municipal Waterworks Chief Engineer*



# Building Area Hanover Kronsberg (General view)

 Picture selection and project description  
see pp. 26-31



- 1** Retention areas
- 2** Anecamp rainwater retention basin
- 3** Gully-and-trench demonstration run
- 4** Water-dominated sloping roads with solar-controlled watercourses
- 5** Water as an objet d`art
- 6** Water-dominated inner courtyards
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## IMPRESSUM



# Municipal building, country planning, drainage taking account of flood precautions

The keynote of the UN conference in Rio de Janeiro in 1992, "sustainable development", is synonymous with development which simultaneously satisfies the needs of today's generations, without endangering the needs of generations to come.

This principle recognises that natural resources, as the basis of all life and economic activities, cannot be used faster than they can be regenerated, and may not be contaminated with harmful elements to a greater degree than nature can handle.

What continuous development means in concrete terms, and how it can be achieved, is for each individual society to decide for itself.

The City of Hanover has committed itself to continuous development, with the local "Agenda 21". With the Hanover 2001 programme, one which looks ahead to the city's development beyond the year 2000, are ex-

amples of local negotiations devoted to achieving environmentally acceptable, lasting and enduring development.

Indeed, as host city to the World Exhibition, Hanover is under a special obligation. Thus, to those EXPO-2000 visitors interested in the realisation of the theme "Man-Nature-Technology", the Regional capital Hanover presents the new suburb of Kronsberg as an integral part of the EXPO programme "The City and Region Exhibited".

The suburb stands for realisation of a continuing urban development, where care is taken of natural resources, but which respects high quality of life and demanding cultural aspects. It is not the aim to show a range of highlights, but the realisation of a forward-looking urban building project in life-size, where ecological, cultural, social structural and urban planning considerations were developed side-by-side, and can be transferred to other similar projects. In the forefront are town and country planning, ecology, technology, infrastructure and social facilities, and co-operative project development.

Competitions were sponsored, based on which a concept was developed for the new suburb of Kronsberg, covering the suburb, the EXPO grounds and the adjoining countryside. The new suburb of Kronsberg has a ground plan in the form of a grid, with avenue-like streets, squares and green inner courtyards. It stretches like a wide ribbon from north to south, and connects the existing suburb of Bemerode and the EXPO exhibition grounds.

In the long-term, Kronsberg is planned to have 6,000 living units for 15,000 people. So far, about 3,000 of these units have already been finished, and of them, more than a thousand are in use by EXPO 2000 exhibitors.

*Aerial view of Kronsberg, 1999*



Planning, organisation and realisation of this enormous building project carries on simultaneously at all levels:

### Ecological optimisation

With the design of Kronsberg suburb, account was taken throughout of all we know today of ecological factors affecting building and living, and social aspects. Optimal design of the living units, keeping waste to a minimum, public transport connections, cycle-paths, environmentally-aware site management during building, a “close to nature” water plan – these are all catchwords of the project.

### Forward-looking municipal building

The special feature of the project was the infrastructure measures carried out simultaneously right from the start. As the living accommodation was ready, so the infrastructure was in place, and the suburb came alive immediately, and is green.

### The suburb with the short distances

Short distances connect living, working and leisure. The new urban tramway only takes 15 minutes to get from Kronsberg to the centre.

### Country planning and outdoor leisure facilities

Development of the countryside at the city boundaries has for Hanover a very special significance. Kronsberg is planned as a “garden city”. Lease-plots and allotments, parks in the various sectors and planted public areas for recreation and sports are provided for from the start. In addition to this, there are to be numerous nature areas and open spaces, including an ecological and extensive agricultural establishment, including a farm with educational facilities.

### Kronsberg as a social living environment

Town of the future: that is the town as a social and socially-acceptable living environment, of high standard. Those who live there, or use the town, help to form its characteristics, and just as it grows, so does its social structure, according to its inhabitants’ needs.

To realise the many different facets of the project, a comprehensive structure for communications is essential. KUKA, short for the Kronsberg Environmental Communications Agency Ltd., was founded for this purpose, with the help of sponsorship from the German Federal Environment Foundation.

KUKA shareholders are the Regional capital of Hanover, and the KUKA support group, which includes as its members the builders, electrical supply company, engineering and architectural offices etc., engaged in the Kronsberg project, and which is open to further membership.

The water concept is a constituent part of the EXPO project “Ecological optimisation Kronsberg”, registered on 26.07.97. For the actual realisation of the project, it is KUKA’s foremost aim to achieve high levels of awareness of the environmental demands of the Kronsberg with all operators and users. At the core, this means achieving changes of perceptions, attitudes and behaviour. In terms of content it is all about energy, waste, water, ground, countryside and agriculture.



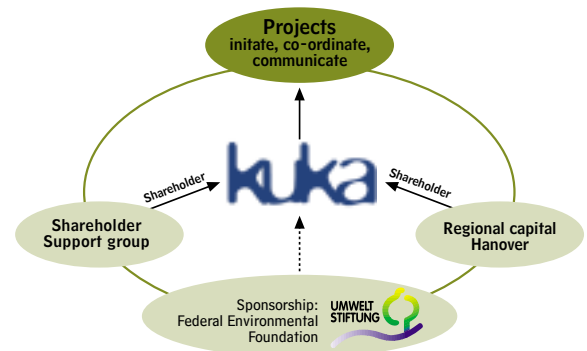
Close to nature water concept



Forward-looking municipal building



Country planning



Structure of the Kronsberg Environmental Communications Agency GmbH (KUKA)



Street-laid gully and trench system

## Drainage

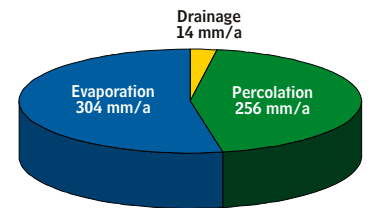
The new Kronsberg estate displays alternatives of an enduring municipal development.

Hitherto used as farmland, the new Kronsberg estate will eventually cover 150 hectares (1,500,000 m<sup>2</sup>, or about 440 acres). This land use, a result of surface-sealing for roads, living and commercial buildings, has unavoidable effects on the natural water system, as due to increased diversion of rainwater or decreased opportunity for it to soak away, there is increased incidence of high peaks of water drainage and less formation of new ground water. For this reason, care in how water is dealt with is an essential part of the concept for an environmentally-intelligent urban development. Ecologically-oriented urban development and water systems for new housing face the challenge of re-orienting themselves. Technology today normally gathers rainwater in housing areas in a system of pipes and channels it as fast as possible into a lake. This technology must now be viewed with suspicion, with the high costs associated with a pure water disposal system on the one hand, and the inherent dangers and disadvantages of formation of flood-water and reduction of ground-water levels, with their respective ecological implications, on the other. Rain is very much less to be regarded as a danger; its potential in urban development and design should much more be used to advantage. Occasion to turn this new direction to practical account has occurred in recent years through the extraordinary high water levels in Germany. The possibility to reduce the causes of high water and to alleviate the effects is already at hand in populated areas, in rainwater treatment. However, this will not solve the problem completely, though a consistent application of the lessons in future new building areas' water systems may be expected to make a major contribution to stemming the incidence of flooding.

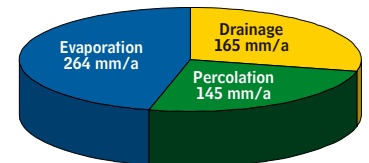
So far, however, there has been no realisation in a large new urban building project. In the suburb of Kronsberg, a water system is installed which enables rainfall to soak away – or be retained – in the area where it falls, and delays its delivery to the lake(s). With the gully-and-trench system, natural geological systems in Kronsberg are imitated.

The system ensures that formation of new ground water, as well as water transport via existing channels, goes on. It makes a major contribution to ecological ground-water and flood protection. Thus the water concept of the Kronsberg shows the way ahead in urban hydrology and drainage of built-up areas. The open rainwater gulleys become an important element of urban design – they help improve the urban atmosphere, moderate the temperature, and create leisure areas for the inhabitants.

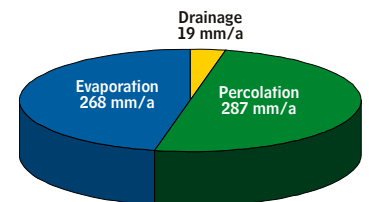
### Situation 1994



### Variant: standard rainwater drain



### Variant: gully-and-trench system



Water systems – the balance



## Building blocks of the water concept

The water concept for the Kronsberg suburb comprises the two main elements: the technical, building measures and the communications concept. With the assistance of diverse communications instruments, the content of the technical measures are passed on, to encourage a better, wider understanding of the role of the vital element, water.







*The sloping street  
Weinkampswende*



*Gulleys at Ellernbuschfeld*



*Retention areas at the foot of the slope*



*Rainwater reservoir Anecamp*

## The “Close to Nature” rainwater system

For the water system, the Kronsberg settlement is of particular importance, as the new groundwater formation rate at 194 mm/a is substantially higher than the Hanover average. The aim of the “close to nature” rainwater system is as far as possible to have the same natural drainage available after building as existed before. In the whole of the settlement, in principle, decentralised water retention areas are planned. As much rainwater as possible will be retained on private and public ground and be allowed to soak away, and only limited amounts will be drained off. This will be achieved by using the functional elements:

- Gully-and-trench system
- Sluiced channels
- Retention areas
- Rainwater reservoirs
- Outfall ditches

Water is channelled into green-planted gulleys and held there. It filters through a layer of humus into the ground store (the trench) which is filled with gravel, being cleaned in the process. It soaks away from the trench. Excess water is fed, much delayed, via a sluiced shaft into the sluiced channel and thence fed to the retention areas and the greenery. These form the basis in the streets and planted areas for long-term living with rainwater in the cities and towns of the future. The numerous water surfaces in the gulleys will encourage evaporation, influence the climate in a positive fashion and reduce the formation of dust. The retention areas, laid out like parks, and measuring up to 35 m wide, along with the rainwater reservoirs, help protect against flooding, as high rainfall will be fed gradually into the drainage ditches. This concept only increases the outfall and seepage marginally, and as a result, original conditions are largely preserved, whereas conventional rainwater drainage would increase the outfall by a factor of 10.



*The sloping street Feldbuschwende*

## Water as an artistic component in the “Quarter Parks”

The two “Quarter Parks”, each measuring 10000 m<sup>2</sup>, have special significance for relaxation in the suburb as the “green heart”. Each will be individually landscaped. In the northern park, rainwater sound openings will be installed, so that the pattering of rain can still be heard after the rain has stopped.



*Boxed-in drain with sound opening*

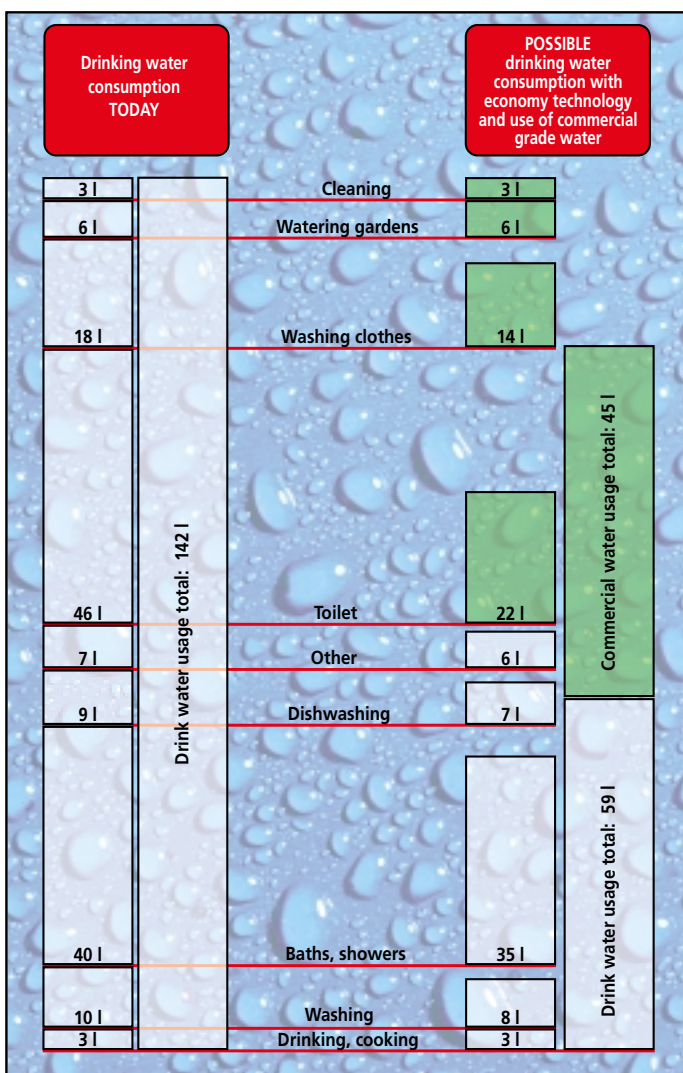
### Drinking water: domestic economy measures

Of the daily usage of 142 L of drinking water per person in Germany, most runs through the shower, bath, wash-basin and toilet straight to the drains. Only about three litres are used either for drinking, or for cooking. As water provider, the Hanover Municipal Water-works is aiming to reduce that figure to 100 L per person. The saving will be achieved by a full programme of drinking water economy measures. In the individual households, in the expansion phase, possibilities for the economic use of water have already been identified. Economy aerators have been installed in wash-basins. These reduce water-consumption greatly, although it is barely perceptible. Flow-limiters and flow stabilisers are also effective. Within the framework of the Regional capital Hanover

and KUKA energy economy programme, each household will receive two aerators free of charge. These economy measures have had their effects in other directions too; the pipes for drinking water are smaller than usual, and are laid exclusively for drinking water and not, as is more often the case, also for fire-fighting requirements.

### The rainwater concept for the primary school

In the Kronsberg primary school, water has a central significance. All the rainwater falling on the school plot is stored, fed through a seepage and collected in a tank. Open, surface rain-water ducts, retention and seepage areas in the school grounds are used as important design components, creating a habitat for plants and animal life in the school's gardens, and recreation areas. The sloping school roof is extensively planted, and rainwater thus flows off more slowly. The rainwater collected is used either as industrial water for toilet flushing, or in the school garden. Integrated rainwater usage makes it possible to save annually about 550 m<sup>3</sup> of drinking water. In the school itself, not only is the technology for saving water available; teaching how to use and conserve water is given special emphasis.



Kronsberg primary school

Water usage in German households in litres per person per day

# Environmental communication

## Communication concept: Water as part of environmental communication

The communication concept water is part of the environmental communication concept. Its target is to promote the enduring development at the Kronsberg via instruments of communication. Man, as the planner, builder and above all as user and inhabitant of this suburb, stands in the forefront of environmental communications concepts. Environmentally-friendly technology must be accepted – and to an extent understood – so that the joint aims of endurance and environmental protection can be truly realised. Environmental communication makes use above all of the instruments of information, publicity, advice, education and qualification. Every group connected with the suburb will be reached with the communication concept water.

These include:

- the residents
- building sponsors and owners
- the building artisans and craftsmen
- educationalists and consultants
- visitors
- specialists  
(scientists, architects, engineers)
- the specialist public and media

kronsberg  
aktuell

AUSGABE 9  
MAY/JUNI 2000



Landeshauptstadt

Hannover

VON A(USSTELLUNG) BIS Z(ELTKUNST)

MIT TWIPSY ZUM LETZTEN INFO-PICKNICK VOR DER EXPO

Straßennamen

Versuchschritten die Wirksamkeit von Auszubereiteten. Einige Investitionen vom Kronsberg zeigen ihre Wohnanlagen sowie Masterwohnungen, die nach der EXPO vertrieben wurden. Erläuterungen zu der Mikroklimate gibt es in dem Vorkursprojekt der Deutschen BaubiCoop an der Wuppertal-Universität.



## The environmental education concept for the suburb

The environmental educational concept is laid down as an essential principle, so that themes will be continued with no break from kindergarten through to junior school. The essential element is behaviour with natural resources. This means that water takes on a role of major importance.

## The water concept for the Kronsberg primary school

The example of the rainwater concept of the 4-class primary school shows how the “close to nature” idea of handling water can contribute to teaching the children about their environment. Learning material on the theme of water is collected in co-operation with the school teachers. The environmental subjects the children learn include water circulation, as exemplified by their part of town; the importance of drinking water; water – the habitat; wetlands; and the care of seepage areas.

## Qualifications for a career with water

The vast area with total coverage realising a “close to nature” rainwater system makes the suburb of Kronsberg an ideal subject for educational study for career qualifications for students of hydrology. Knowledge can be gained here on a practical basis, within the framework of education and further training.

## Information and advice

### EXHIBITION

An exhibition on environmental projects in the suburb is on view in the suburb’s central library. The significance of water to all of life, and how it is treated in the suburb, is visualised there.

### INFORMATION BOARDS

In various places in the suburb, boards are located, which draw particular attention to one or other aspect of the water concept. Simple, easy-to-understand sections of the overall system are presented.

### THE MAGAZIN „KRONSBERG AKTUELL“

The magazine appears six times a year. It reports on the latest developments in the suburb, and occasionally on matters of particular importance, e.g. water.

### SPECIALISTS AND RESIDENTS’ PROMOTIONS

Subjects of special interest to residents are dealt with in seminars. Alongside themes such as energy, water themes are becoming increasingly popular.



# Planning an realisation in the public domain

Planning area Kronsberg



## The starting point

The suburb was to have a consciously urban character, with appropriately-high building density. The building structure follows the 4 - 6% fall of the west slope of the hill on the principle of height and density reducing towards the crest of the Kronsberg. Thus, from west towards the east, there are three distinct zones of buildings with different numbers of floors, building density and building styles. The west of the suburb, alongside Oheriedentriff and the urban tramway, there will be a 4 1/2-floor-apartment block in rows and blocks, the highest buildings and thus the highest surface user. In the centre, 3 1/2-floor buildings in rows, with some individual buildings, will predominate, while on the upper edge of the development there will only be 2 1/2-floor terraces.

The water system in Kronsberg is very sensitive. It was clear from the beginning of the planning that the Kronsberg could only be developed if a water conservation system optimally tuned to the area were to be used.



### The demands of the water system

Since it was always planned to build on the Hanover Kronsberg, the planning decision of 1971 was that a maximum discharge of 200 L/s should be permitted from the drainage ditches into the Landwehrgraben. To avoid exceeding this amount, following the course of the drainage ditch, rather like pearls on a string, 3 rainwater reservoirs were planned:

- RAINWATER RESERVOIR ANECAMP**  
at the foot of the Kronsberg
- RAINWATER RESERVOIR OHE**  
to the south of the main road B 65
- RAINWATER RESERVOIR HASENKAMP**  
directly before the outfall into the Landwehrgraben

So far, it has not been possible to build the Ohe reservoir due to land ownership problems. The Hasenkamp basin is already working at absolute capacity. Only the Anekamp basin has any reserve capacity left.



Rainwater reservoir Anekamp





## The hydro-geological starting point

Initial hydro-geological studies in 1983 carried out by the Hanover University Institute of Hydrology (Prof. Sieker) concluded that conventional building on the Kronsberg would have a disastrous effect on the ground water system.

As a result, the Kronsberg development was put “on ice” for the time, but with the starting gun for the Hanover World Exhibition EXPO 2000, it was decided to examine the hydrological conditions of the Kronsberg more closely, and to quantify them accurately.

Directions of flow of groundwater were observed once more by the Institute of Hydrology in 1992 (Prof. Mull): for this, the few measuring locations available for groundwater were reinforced by a further 18 bores. The effects of a conventionally-drained development on the Kronsberg on the hydrological situation were assessed as follows (see table right):

## Concept

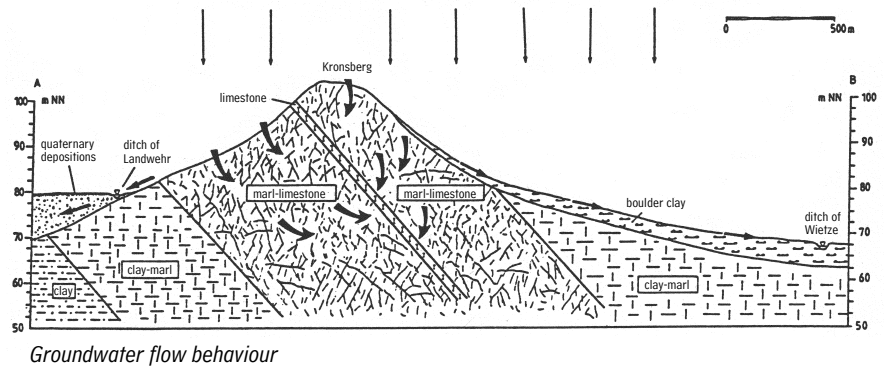
To forestall the prognostications of the survey, the following specifications were incorporated into the explanation of the application for change of use for the Kronsberg in 1993, for the building plans described.

For this reason, a drainage concept had to be worked out for the Kronsberg development, which would guarantee a minimum of disruption to the natural water system. This had to be designed so that the drainage for the complete area was as close as possible to that which it had been before development. This resulted in a figure of a one-year maximum high-water of 3 l/(sxha). This value was then used as a benchmark for the whole Kronsberg development.

The earlier survey results suggested deliberately allowing falling rain to soak away. However, the geology of the Kronsberg makes this difficult. The subsoil is mainly poorly permeable calcareous clay with permeability factor:

$$k_f = 3 \times 10^{-6} \text{ m/s bis } 10^{-8} \text{ m/s.}$$

It was the idea from the start to slow down the rain's reaching the nearest drain. For this reason, the concept had to include a combi-



- **SEELHORST**  
per planning variation: i.e. according to proportion sealed  
lowering by 20 to 30 cm
- **MASTRUCHER HOLZ**  
per planning variation: i.e. according to proportion sealed  
lowering by 50 to 100 cm
- **EILENRIEDE**  
Reduction in the underground drainage  
Reduction of basic outflow from Landwehrgraben, with the pre-programmed consequence of a drop in the groundwater level
- **OPEN DITCH**  
(can no longer be compensated by close-to-natural measures)  
Increase of high-water flows when rain falls and reduction of low-water flow during dry weather

nation of soakaway, de- and semi-centralised storage and delayed outfall. The result was a close-to-natural rainwater system with both above-ground and underground components as parts of the solution.

## Planning realisation

To maintain the grid layout specified for the urban development's ground form, the gully-and-trench system proved to be the most suitable.

Because of the size of the area being developed, with its extensive surface sealing, the “gully-and-trench” system on the Kronsberg is the actual object of the research project “Rainwater handling, Hanover Kronsberg” (flood precautions).

In the streets in the new development, the only gullies to be seen will be at road junctions. Above ground, at the roadsides, between pavements and parking spaces, there will only be 30 to 40 cm deep, green-

planted, gullies to be seen, which will gather rainwater on the surface.

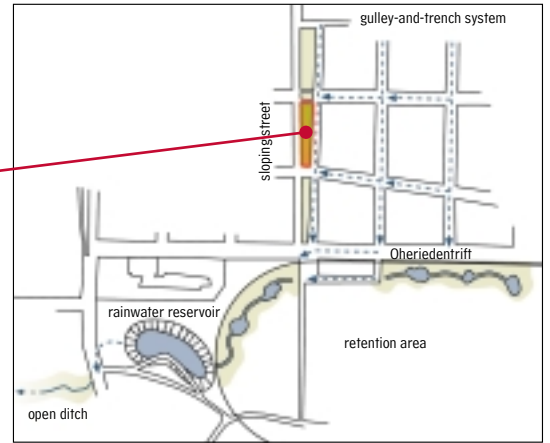
As it soaks through the gully floor (30 cm topsoil), the surface water is cleaned. The water soaks through a further, gravel-lined, ground reservoir, called a “Rigole”, or trench. As the water seeps through to the trench, the water level here rises gradually.

The water out of the trench reaches the sluice through a drainpipe. It can only escape from the sluice through a small pipe admitting 3 L/(sxha) into the rainwater drainage network. For this purpose, the municipality developed a specially-designed shaft with a built-in sluice. Water reaches the drainage network via the sluice-shaft. This is sized according to the sluice, and is located, as in traditional rainwater drainage systems, in the streets connected.

By comparison with the natural drainage behaviour, the lying time of the water stored in the trenches is simply extended. Thus the water flows only very slowly away from the-



Flow scheme of a sloping street  
(Photo: Feldbuschwende)



se gully-and-trench elements and the natural drainage behaviour that existed before the development can be copied, in other words, the rainwater basin at Anecamp and the ditches will be no more seriously loaded than before.

Over 5.5 km of roads (=about 3 m.) the gully-and-trench system has been laid on both sides of the road, because of their layout. The city is carrying out a project which, for its size and the pressure of time, is unique.

The gully-and-trench system was laid down for public traffic areas at the building planning stage. It will be laid parallel to the road in green strips between the pavement and the parking spaces. There is a strip of 2.0 m gross width available here. Surface area requirements of an average 10% of the adjoining area is adequate. As far as rain measurement is concerned, the channels stack only about 16 cm.

To achieve large and even coverage, the bases of the gullies and trenches need to be horizontal. Cascades cannot therefore be avoided in streets leading uphill. If during torrential rain the gullies and trenches should be full, the water will flow via an emergency overflow on the sluice shaft direct into the public drainage system.

The gully-and-trench system is being used to even out the formation of new groundwater and the outfall of drainage to the original levels.

**RAINWATER DWELL TIME IN THE GULLEY:**

1-year max. rainfall (T=15 min)  
t = about 1 hour  
5-year max. rainfall (T=15 min)  
t = about 2 hours  
can vary considerably, according to the arrangements of lead-ins

**RAINWATER DWELL TIME IN THE TRENCH:**

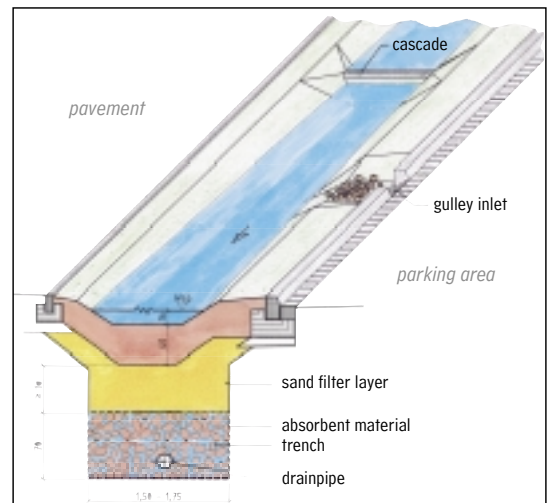
1-year max. rainfall (T=15 min)  
t = about 16.5 hours r 15,1  
5-year max. rainfall (T=15 min)  
t = about 29.3 hours r 15,0,2

Gullies are dimensioned for 1-year max. rainfall, the trenches for 5-years max. rainfall. The newly-laid water retention areas at the foot of the hill west of the main roads Oheriedentrift and Kattenbrookstrift and the tram-tracks and the Anecamp reservoir, rebuilt due to the tramway extension, then as a “close-to-natural” catchment area, are all designed for ten-year maximum rainfall.

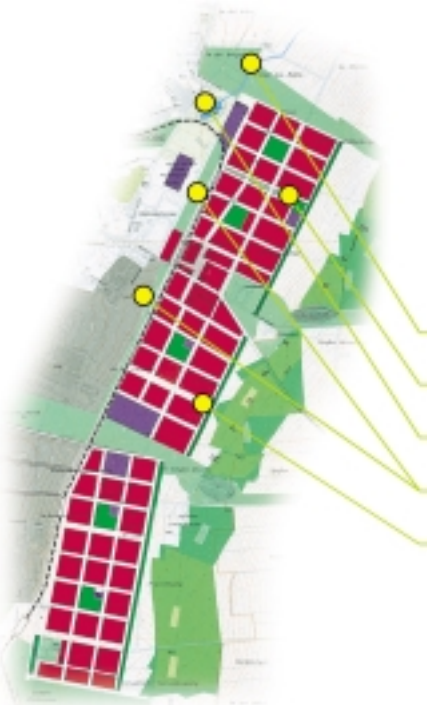
The 18 to 35 m wide occasional catchments are laid out as parkland. They serve to hold rainwater from the main roads Oheriedentrift, Kattenbrookstrift and Wülferoder Strasse, taking the outfall from the sluice network.

The open ditch at the foot of the Kronsberg, still runs in a regular channel. Creation of edging strips will allow the stream to develop naturally. In this way, speed of flow

will be reduced. For this, adequate edging has already been created over some 500 m. These serve at the same time as protection for the water against the surrounding use as pasture. Apart from crossing and inlet building works, no further works are planned. For the residents, an experience, and a recreation area, is taking shape at their front doors.



Gully-and-trench system – section through drain-gully



Water concept in the housing area

- back-to-nature for the open ditches
- road with a downhill slope (Feldbuschwende)
- rain retention reservoir Anecamp
- natural retention areas
- road with a downhill slope (Weinkampswende)



### Rainwater in the sloping streets and the retention areas

The sloping streets Weinkampswende and Feldbuschwende present the water theme in a very special way. They play an outstanding role in the handling of the Kronsberg water system, because the water is not allowed to soak away in trenches for functional reasons, but forms an integral theme of its own in town design.

Rainwater falling on blocks of buildings to either side is fed to 12 to 30 m wide avenues with trees, bushes and paths, where the water is channelled into above-ground streams.

In this way there are:

- permanent ponds
- gullies which occasionally carry water
- seating arrangements
- running streams
- natural pathways



*The sloping street Weinkampswende*

Public fountains, lakes, seats around small ponds and water games all give good reasons for stacking water in sluices. All these water elements help create a more healthy climate, because water helps to moderate temperatures and reduces dust considerably.

deliberately designed to allow the water to be enjoyed. They have a park-like character, and positively invite one to while away some time there.

With the help of photo-voltaic pumps, rainwater is returned time and again to the top of the street, so that it can be seen to flow in the artificial channels, when it has not rained for a long time.

At the start of EXPO 2000, about half of these areas are complete. The other retention areas are as yet temporary and in accordance with current water storage requirements. They will be finally designed and completed at the conclusion of EXPO 2000.

The retention areas at the foot of the hill are also designed to give the future residents a vision of the importance of water, actually the above-ground handling of water. The residents can enjoy slopes covered with vegetation and the watersides as nearby recreational areas. The retention areas are



*Feldbuschwende - sluice element*



*Weinkampswende - rainwater channel*



*Retention area at the foot of the slope*



*Photo-voltaic plant on the slope of Weinkampswende*



### Co-operation with the building sponsors

The original intention was to develop the whole project including services and connections through investors and building sponsors. However, in view of the situation in the housing market in late 1996/early 1997 and ecological considerations, the city of Hanover and the State of Lower Saxony felt obliged to relax the occupancy conditions for the apartments and to offer suitable sponsorship. Only in this way was it going to be possible to get the project on its way by the start of the World Exhibition EXPO 2000.

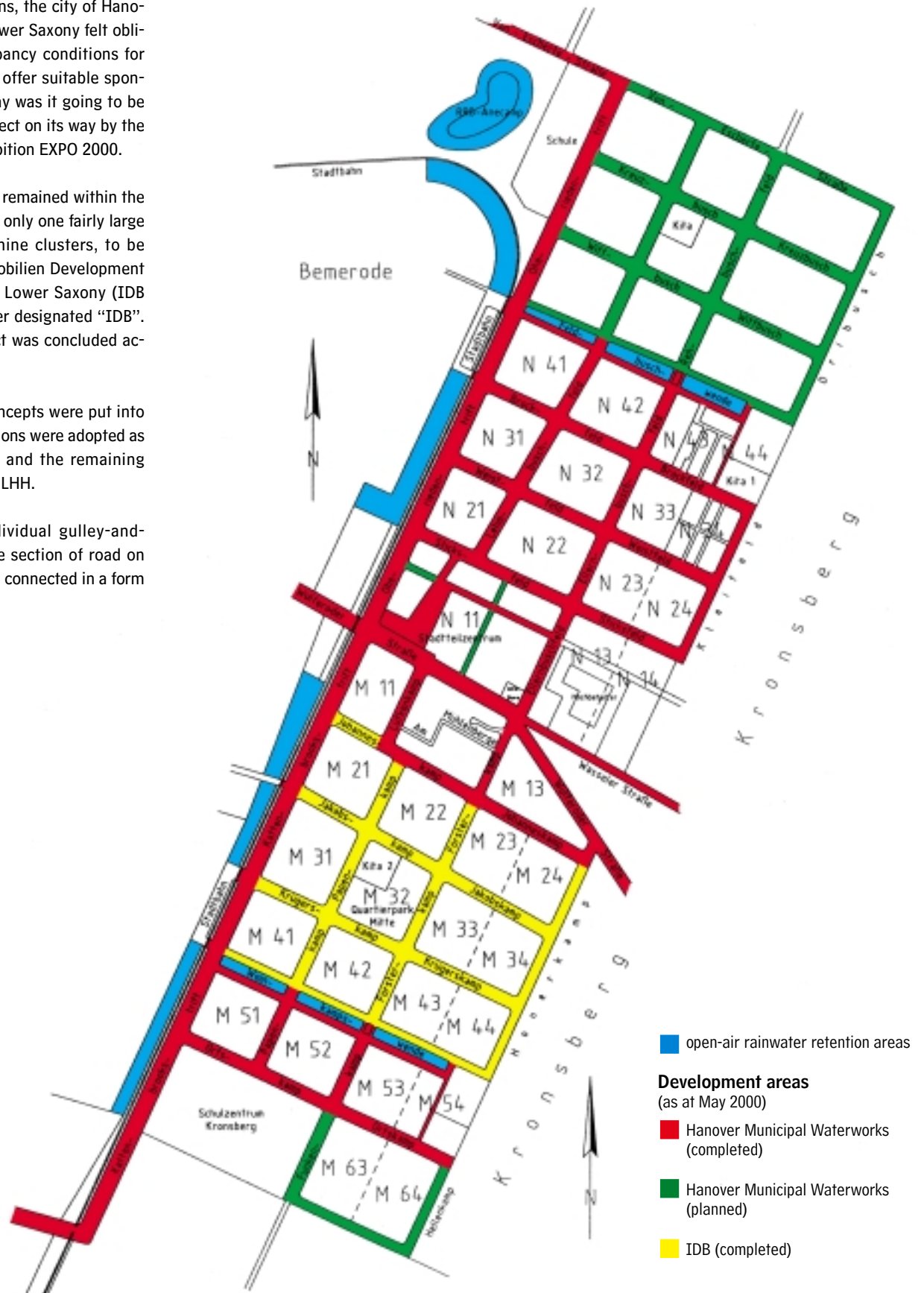
For development, there remained within the projected building area only one fairly large area, covering about nine clusters, to be developed by the Immobilien Development and Holding Company, Lower Saxony (IDB Kronsberg) – hereinafter designated “IDB”. A development contract was concluded accordingly.

When the rainwater concepts were put into practice, different solutions were adopted as between the IDB area and the remaining residential areas of the LHH.

Consequently, the individual gulley-and-trench elements of one section of road on one side of the road are connected in a form of “series” switching.

This means that now, all the rainwater from one section of the road on one side is led via the last downhill sluice shaft of the gulley-and-trench system into the rainwater

channel (sluice outfall channel). Through joining the areas to be drained it is necessary to fit a larger opening (14 mm) to the sluice.



## Demonstration run – Gulley-and-trench system

To gain additional knowledge and experience to enable the planning to be optimised and make the building more practicable, a full-sized demonstration run was constructed. The following questions in particular were to be examined:

- functional reliability when draining through small sluice openings
- optimising the gulley leads to suit the inclined plane of the building land
- simulation of rainstorms
- experience for the building work

Within the framework of the research project “The rainwater system of Hanover-Kronsborg”, sponsored by HM Bau, the demonstration run was observed by scientists from Hanover University.

Based on the flooding attempts on the demonstration section, theoretical starting-points for water leads, gulley soakaway and drainage via small sluice openings could be studied in virtual practice. This made the development of improved designs possible at an early stage.

As an example, the first design of gulley lead permitted a proportion of the surface water to run straight past the gulley. Not to have discovered this until completion of building of the first roads would have been fatal regarding the general credibility of the project.



*Gulley cascades*

### Experiences for the building work

Excavation and roadworks and MRS work interconnect in such a manner that it is impossible to nominate two different contractors to do the work. Civil engineers and the Municipal Water Authority therefore draft specifications for construction of roads jointly.

### Image / credibility

Active co-operation with Hanover University did much to reinforce credibility and to gain the trust of other town planners and with the developers even in the somewhat unusual plans for handling the rainwater system.

The fact that the demonstration run was the first visible building operation (drains you don't see...) encouraged a feeling of optimism in the town planners in regard to our activities.

If the demonstration run led to a certain solidarity of those involved from the city, its value cannot be estimated in terms of money. It certainly led to a better understanding, and lessened the tendency to look for the snags. It also meant that it was not repeatedly asked that justification be produced.



*The demonstration run*



*Rainfall simulation on the demonstration run*



*Gulley lead with ballast packing*



## Building guidelines

Two engineering offices were engaged as consultants both in planning phases and during the actual building.

To formulate the most important elements of the building of the gulley-and-trench system on the Kronsberg development, and to make quality control easier, a building handbook was assembled with tabular details and an explanatory text. It helped all those involved in the project in specification, tendering and building supervision, and was for information of the builders carrying out the work.

Specific help was given in the following areas:

- Specification for the selection of material, with hints as to installation and description of test criteria for the suggested materials.
- Building sequence description with hints for important basics for building the gulley-and-trench system.
- Quality assurance concept, covering training of the building firms and planners; timetable or sections for partial handover, and functional tests.

## Experience during building

Since autumn 1998, installation of the gulley-and-trench system has been proceeding both in the area for which the private developer is responsible, and in the area being developed by the regional capital of Hanover.

The following statements are restricted in general to experiences gained in the area being connected by the Hanover Municipal Water Company.

It is a first report on conditions; it is as yet much too early to make any general comment on operational reliability or on costs of operation.

### Specification, tendering procedure

Due to the close interconnection of the work to install the gulley-and-trench system with the road-building, it was clear to all partici-

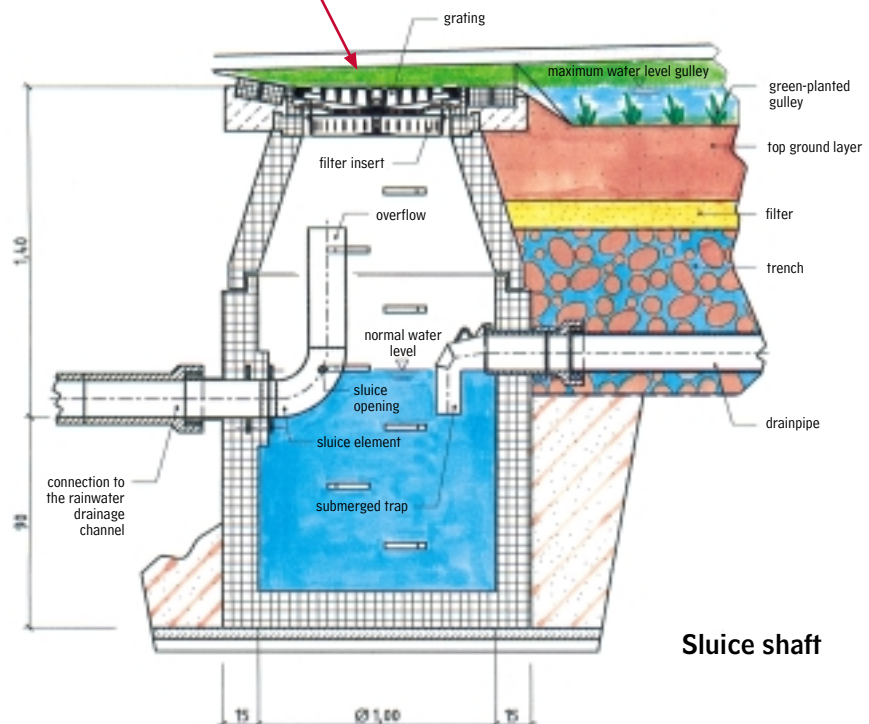
pants from an early stage that all this work should be in the hands of one building company only. Otherwise there were going to be major problems above all in scheduling the work, maintaining finishing dates and guarantee demarcation questions to be expected.

For this reason, for every building lot the specifications were drafted for the gulley-and-trench system in a joint operation with the office of the city of Hanover's civil engineer, which is responsible for road construction and development in this area.

### Sluice shaft

The sluice shaft used in conjunction with the gulley-and-trench system on the Kronsberg development must be capable of performing the following functions:

- Accepting the sluice element. Outfall control is through a hole drilled to 8 to 10 mm diameter, according to area connected. The function of emergency overflow is also ensured; excess water can run into the vertical pipe in the body of the sluice.
- Inlet from the drain into the shaft is closed by submerged trap to prevent ingress of floating particles and oil into the trench.
- Sufficient large openings in the shaft cover allow water to overflow out of the gulley if this cannot soak away fast enough, e.g. in torrential rain.
- Very high safety in operation of the complete system.
- Easy maintenance of the complete system.
- Use of standard building components.



Sluice shaft



### Design of the gulley inlets

To prevent the surface water running by the gulley inlets because of the gradient on the Kronsberg, the gutter paving was lowered by 4 cm in the inlet area. This was to be catered for in the inlet design.

### Design of the gulley

After the first gulleys were seeded with grass, it was clear there were going to be major problems with the planned vegetation planting and the stability of the slopes. Due to the amount of building work being carried out simultaneously in the immediate vicinity very serious damage was being done to the slopes. Consequently it was from the outset decided to carpet the gulleys with ready-grown turf. This step, admittedly rather more difficult in the first stage, proved to be a far better protection for the gulleys against destruction and erosion.

To protect the gulleys against being run over, the kerbs chosen were those familiar in the city. The gulley inlets were simply designed as blunt, 52 cm. wide interruptions in the kerb, with the intervening space filled with coarse gravel. The design of the gulley inlets as used up to July 1999 could not be called entirely satisfactory. Weaknesses were apparent in the loading of the individual gulleys due to long distances (6 m) between the inlets and the gravel beds in the inlets.

The kerb-breaks, together with the sunken guttering, form a good protection for the gulleys against being run over. However, practical experience when mowing the gulley-strips on the demonstration run have shown that the loose, coarse gravel in the inlet area poses too much potential danger.

Accordingly, the gulley inlet was thoroughly re-designed, and since July 1999, instead of the gravel bed, a cast concrete form has been used as gulley inlet. The form developed for the Kronsberg is similar to one

which has been installed in the Rummelsburger Bucht building project in Berlin.

By consistently following the established principles of rainwater handling, instead of ever faster disposal, water speeds are going back to a natural state. With the gulley-and-trench system, and its features of soakaways, storage and delayed outfall of rainwater, in spite of the large newly-sealed area, a natural rainwater flow is being achieved.



*The new gulley inlet*

1 – 6 Building sequence

1







## Realisation on plots in the private sector

In the Kronsberg project an overall water concept, covering private plots and public open spaces, was realised. The aim was to achieve a water balance after completion of the project corresponding to that in place before it was started.

For the public areas, the gully-and-trench system was adopted by the Municipal Water Authority, with retention areas.

The private plots, which cover an area of about 46 hectares (some 112 acres) were sub-divided and sold to various investors.

Realisation of the water concept was subject to keeping to various conditions, both in the private and in the public areas. When the soakaways were designed, the water was to be made enjoyable in as many ways as possible. And the drinking water economy measures included, rounded off the design of the suburb.





## Framework conditions

To attain the above objectives, binding agreements were made on various legal bases:

### 1. The building plan

Rainwater from sealed surfaces had to be channelled into a gully-and-trench system, there to soak away or be fed at a controlled rate into the public drainage system. The system brings together decentralised retention, as high a level of seepage as possible and strictly-controlled outfall into the public drains. Ground conditions at the Kronsberg where there is an average permeability of  $1 \times 10^{-7}$  m/s were taken into account (Planning Team – Water, 1995). Exceptions were permitted, as for example where all the rainwater falling on a plot could either be allowed to soak away or be led in a controlled flow to other areas.

Minimising measures, according to nature preservation law, were also imposed on plot owners, who were obliged to pave parking and access areas with permeable slabs and to plant roofs of underground garages not built over and roofs with an inclination of less than  $20^\circ$  in certain areas of the suburb.



*Parking place with permeable paving*

### 2. Drainage Regulations for the Regional Capital Hanover of 16.05.1991.

Permitted rainwater outfall and thus the controlled flow was laid down based on the retention of rainwater regulations. Allowed were  $3 \text{ L}/(\text{sxha})$ , this value related to the built-up and sealed areas as specified by the Planning Team, water (1995). Undeveloped areas were included, according to DIN-EN 725-4 (11.97) if, due to ground impermeability and slope, rain-water would be led into the soakaway.

To assess the soakaways, paper A138 of the Drainage Association (1.90) was drawn upon. Ever since 1996, on private land, in suitable framework conditions, soakaway of rainwater always takes precedence over feeding direct into drains. Drawing on the above paper was worthwhile.



*Carport with roof planting*

### 3. Lower Saxony Water regulations of 25.03.1999

After examining the permeability of the ground, the water authority stated that no legal authority was required to allow rainwater to soak direct into the groundwater.

### 4. Use of environmentally-neutral materials on Kronsberg,

e.g. not using PVC pipes for water drains. The specifications formed part of the plot sales contracts.

There were also technical reasons demanding exact and precise co-ordination between all concerned. These included for example:

1. The position of the connections was exclusively permitted in the plot access areas, and not in the area of the inlet to the gully-and-trench system. Furthermore, no connection was planned into the site access road Oheriedentriff / Kattenbrookstriff, as it had already been surfaced.
2. Planning of common soakaways for the housing terraces, otherwise a sluice drain adequate for the plot would hardly be practicable. Here, no actual specification could be laid down, so a simple suggestion was made.
3. The comparatively steep slope of the building land, with particular effect on the design and planning of the soakaways. As gullies and trenches normally have to be built horizontally – i.e. without slope – here, there were stepped systems and additional stacking regulators necessary. Yard drainage and rainwater channels lying below the flood level of the systems must be protected from overflow of rainwater. There were frequent problems with soakaways located centrally in yards when draining lower-lying paved or otherwise sealed areas.

4. The building schedule was extraordinarily tight, as it was necessary to have all building works completed in the  $2\frac{1}{2}$  years before EXPO 2000 began. Thus the exact sequence of building, the installation of drains, road construction etc., was laid down, and had to be maintained. Every delay or alteration would result in substantial problems.

There were no other specifications in the plot sales contracts. So the investors had within the above legal framework every freedom to size, design and construct the soakaway system as they wished, within the bounds of today's technology.

In the realisation, the above specifications were to be assessed and respected according to legal responsibility. The soakaways were the responsibility of the Municipal Water Company, the minimising measures for nature protection and use of environmentally-neutral materials were the province of the Environmental Protection Office.



*Pergola*

### Time frame

The first planning documents for realising the water concept on the private plots in the new Kronsberg suburb were put forward in autumn, 1997.

In March 2000, the date of this report, the planning concepts for rainwater disposal for 43 building lots were to hand. Meantime, 40 of the drainage systems requested have been examined and passed.

### Building situation in March 2000

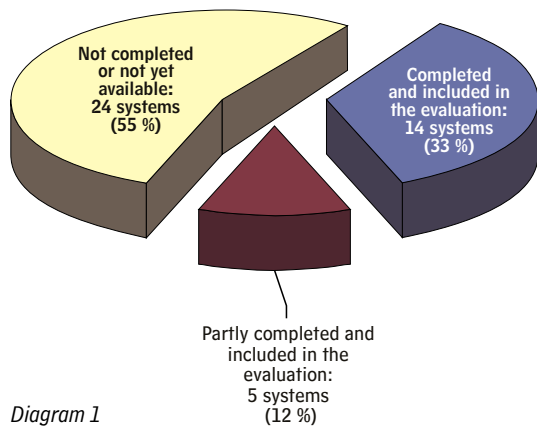


Diagram 1

Building of the soakaways began in the second half of 1998. *Diagram 1* reflects the state of building in March 2000. 14 of the soakaways were by this time complete, and a further 5 were partly complete, so that a total of 19 could be included in the overall assessment.

### Authorisation procedure

Comprehensive consultation with the planning offices on framework conditions was necessary. Detailed co-ordination between the various offices of the city administration, planning offices and builders (private sector, public sector and road construction) was another essential feature towards carrying out the project under the existing technical constraints with the precisely laid out schedule to which it was essential to keep.

Authorisation was given in each case as detailed specifications of the drainage systems were fulfilled. Other systems than the gully-and-trench system were, however, permissible. This was the background:

During authorisation procedure, a number of investors requested to be allowed to use systems other than the gully-and-trench. These requests were generally linked to a particular design wish for the seepage system, internal cost-analyses or usage conflicts of the areas in question.

As long as the alternative systems fulfilled the basic requirements of the building plan i.e. decentralised retention with optimum seepage and strict control of flow into the public drainage system, as in the gully-and-trench system, these would be approved. This also avoided right from the start the risk of legal challenges, which would probably have delayed the Kronsberg project until EXPO in any event.

A soakaway forms part of all drainage systems. Portions of one plot may be attached to different systems. A positive result of the authorisation of soakaway designs other than the gully-and-trench system, was the avoidance of a highly-formalised appearance, in favour of numerous attractively-designed fixtures (*Diagram 2*).

In two cases use was made of the “exception” to the building plan, to feed outfall rainwater in a controlled way into other areas, in this case the public rainwater retention areas, for seepage. On one plot, which according to the building plan had a permitted building factor of 1.0 and thus was to be totally built over, the rainwater is to be temporarily stacked in a channel then fed under control into the public system. In the second case, a small proportion of the rainwater (balcony drainage) was to be fed to a retaining channel, because on account of the building’s location, it would have had to be pumped uphill, expending unnecessary energy, to feed it into the soakaway.

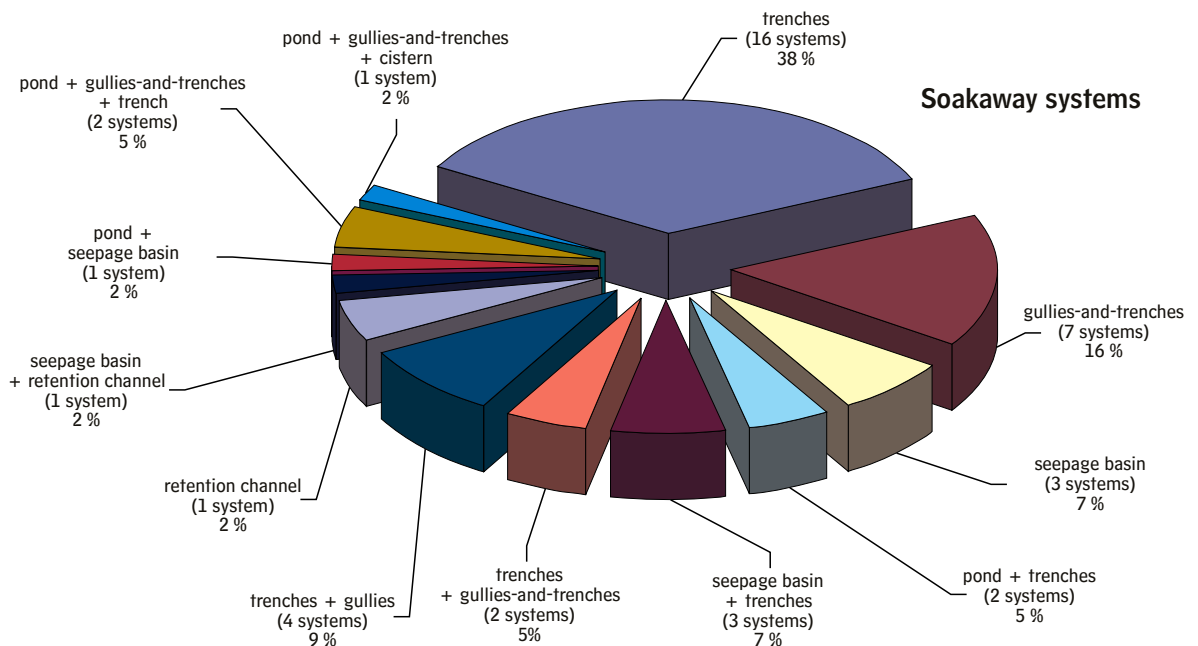


Diagram 2

## Realisation

In the suburb of Kronsberg, a number of different soakaway systems have been planned. In general, the building of the systems has corresponded to the drainage concept we put forward.

There were departures from plan in some cases in provision of inspection shafts and settling or pre-purifier arrangements. If an inspection shaft is not provided, underground soakaways such as trenches cannot be maintained. In addition, when settlers or pre-purifiers are not provided before the trench, the soakaway's performance is adversely affected which may lead to early failure of the equipment and thus to an expensive replacement of the whole system by the plot owner. The sluice can also be affected by inflow of coarse matter, causing blockage and thus making the system overflow.

To ensure controlled flow of rainwater from the plot into the public drains, these points must also be corrected.

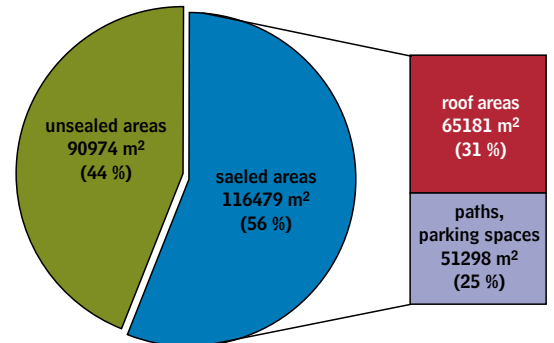
The average ground-seal figure for the plots is 56%. *Diagram 3* shows the division between roofed areas and sealed ground, i.e. paths and parking spaces etc.

In calculating the roofed areas of the individual plots, it is evident that the permitted building area is generally used to the fullest extent. In particular, those plots lying at the foot of the hill, with a maximum permitted building area of 60%, demonstrate a remarkably high sealing degree.

Where building density is higher, as e.g. in the terraced house estates, there were problems regarding use of ground, which affected the planning of the soakaways. Garden

areas of the terraced houses are generally under the 50 m<sup>2</sup> mark.

### Sealed areas (average values)



*Diagram 3*

Here, the tendency was more towards underground soakaways, to enable the unbuilt areas to be used in other ways. Owners have in some cases subsequently covered over the gullies, in order to enlarge the gardens, which are really quite small.



*Terraced house – garden area*

On some plots, it was discovered that some of the rainwater falling on sealed surfaces was flowing above ground into the public streets. This fault was mostly to be found around the entrance areas to the houses, and in the plot accesses.

There are also problems caused by the lack of, and limited capability of, the necessary water-stacking regulator equipment. Because of the inappropriate depth of fitting some of the sluices, and the fact that there is no access to the shafts, the settings of the sluices are impossible to check.

Limited functioning of the sluices is caused to a large extent by dirt in the openings, or the mechanism itself. This is often to be traced back to mortar scraps or earth from the building stage.



*Terraced house – garden area*



### Connection to the public drainage system

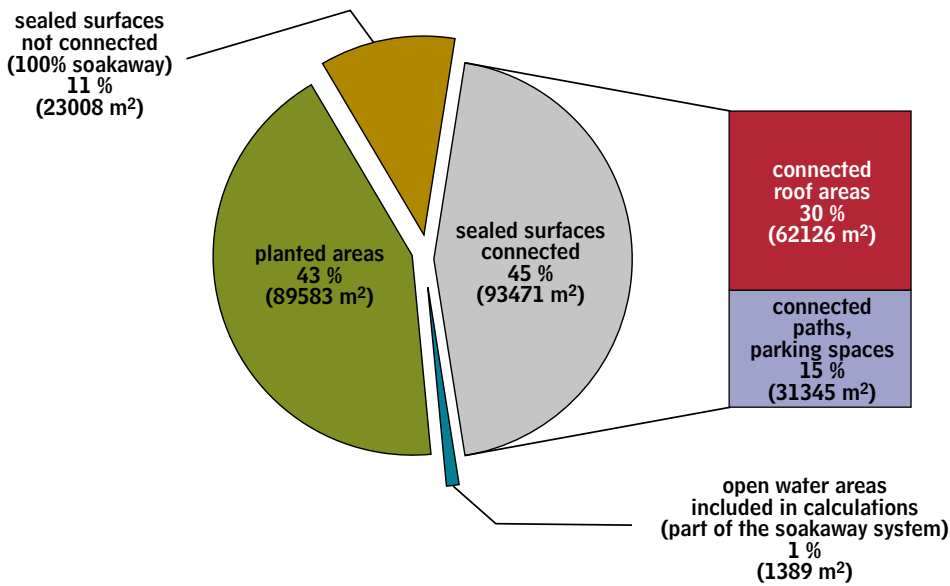


Diagram 4

The average proportion of sealed area connected to the public rainwater drainage via a soakaway is shown in *diagram 4*. Drainage of the sealed areas not having direct connection to the drainage system is assured entirely by seepage e.g. by rainwater being channelled to adjoining planted areas, or through choice of permeable surface material.

*Diagram 5* gives distribution of the sealed areas, split according to above- or below-ground soakaway or retention system. Above-ground systems are gullies, soakaway basins and the ponds; below-ground systems are the trenches and retention channels.

It will be seen that the larger part of the sealed surface is connected to an above-ground system. This is an important point especially relating to pre-purification of the rainwater. The connected roof areas run into the two systems in about equal proportions.

When channelling rainwater into an underground system, it was considered important that an alternative pre-purification stage should be available. Settlement shafts were installed here, with and without floating valves, gravel filters and rainpipe valves with cleaning filters, among others. Furthermore, yard-drains and channels in carriageway areas are to be installed as "Hanover model" i.e. with mud-trap and submerged valve.

The relationship between permeable and impermeable sealed areas can be seen in *diagram 6*.

On average, 61% of the surfaces have been laid as permeable surfaces, including a large part of the footpaths. For parking areas and accesses, stone setts have mainly been used. Permeable surfaces such as porous plaster, water-holding surfaces, wood paneling, honeycomb brick and gravel-based grassed areas are also to be found on the plots.

The building plan also prescribes roof planting in certain areas of the project (see paragraph 1, outline conditions). In addition,

### Distribution of connections

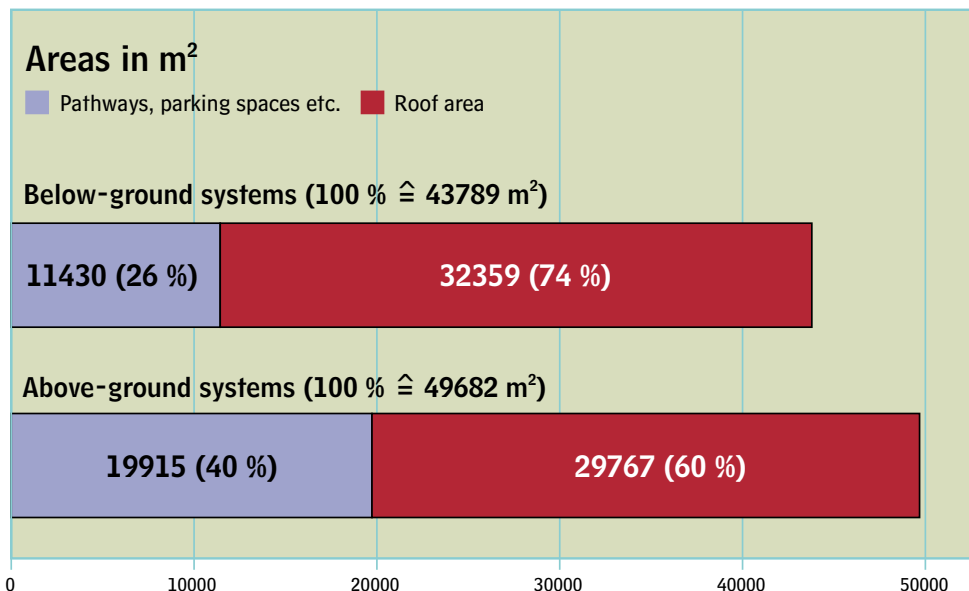


Diagram 5



Gravel gully

on some plots, roof planting has been planned and carried out, although not required by the building plan.

An overall view of the proportion of roof planting, and the number of systems which have been planted can be seen in *diagram 7*. Here, it must be remembered that the green roof proportion on the individual plots does vary between 2% and 100%.

Operation of the systems so far completed has been as far as we are aware perfect. On July 13th last year, on the Kronsberg there was registered, within barely an hour, 36 mm of rain. Statistically speaking, this is virtually a one-hundred year maximum rainfall. By comparison, from 01.07.1999 to 13.07.1999 inclusive, total rainfall was 40.2 mm. Average annual rainfall for the city of Hanover is 625 mm.

Since all systems were designed and built according to the rules of technology, and thus not for such a generous helping of rain, in theory, the systems should have overloaded. In fact, of the 16 systems then in operation, all functioned perfectly.

Not much can be said at this time regarding residents' acceptance of the soakaways. There have been discussions over possible regular water levels in some soakaways, and design of the slopes from the point of view of a possible danger of drowning for small children. One of the systems was subsequently redesigned, which means raising the floor level to meet with general approval.

The alterations have, however, yet to be made.

As part of the water economy measures, economy taps were specified for the buildings. The use of rainwater in place of drinking water was only accomplished in a few cases. Some of the rainwater in these properties then flows into the main drains sy-

stem. If this technology had been installed everywhere, due to the competition with the soakaway in respect of the water balance, the daily usage of rainwater would have had to be restricted to 1 L/m<sup>2</sup> roof floor area (Planning Team Water, 1995). Investors often preferred the soakaway system, given these framework conditions.

Permeable / impermeable sealed surfaces

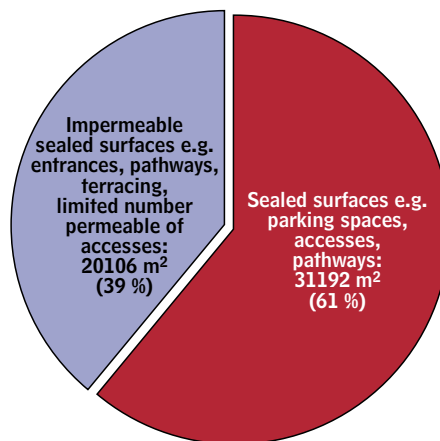


Diagram 6

Proportions of roof planting

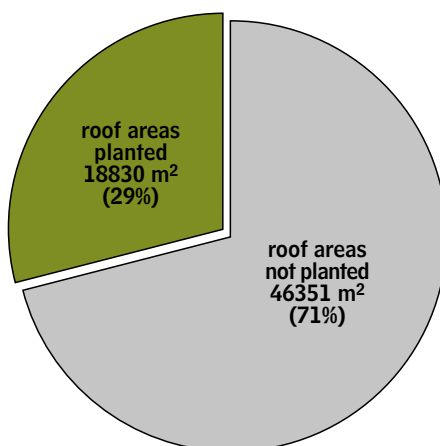
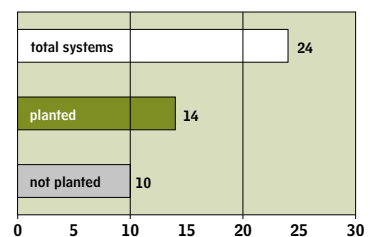


Diagram 7

Number of systems



## Brief descriptions of some individual projects

The many and varied building and artistic possibilities for the soakaways can best be appreciated by a visit to the various plots on the Kronsberg project. Four projects are described here, all of which include some special features. After that, a small selection of projects is shown in words and pictures,

simply to give an idea of what different systems have been installed on the Kronsberg, and to whet the appetite for a look round.

The systems presented were chosen purely at random, and were not subject to any sort of qualitative evaluation.

To make things easier, all the systems shown can be found on the map attached.

We cannot show all the systems, on all the other plots, for shortage of space, but they are all well worth a visit.

### NORTH QUARTER PARK (WATER – AN OBJET D'ART)

In contrast to most other creative artworks, where rain is primarily presented as an optical element to the resident or visitor, here in the North Park, the emphasis is on acoustics, whereby the flowing rainwater is intended to create a “hearing experience”.

The surface of this Quarter’s Park is made up of the central green area, and stone flags enclosing it, between the wide, green-planted gaps of which the rainwater soaks through below ground level.

Rain-water running off the surface is taken up by strips of greenery, with gravel and chippings underlay, distributed throughout the park and by a box-channel which runs the length of the park’s western boundary. The rainwater seeps through the strip of green directly into the trench. The box channel drains via ground outlets. In both cases,



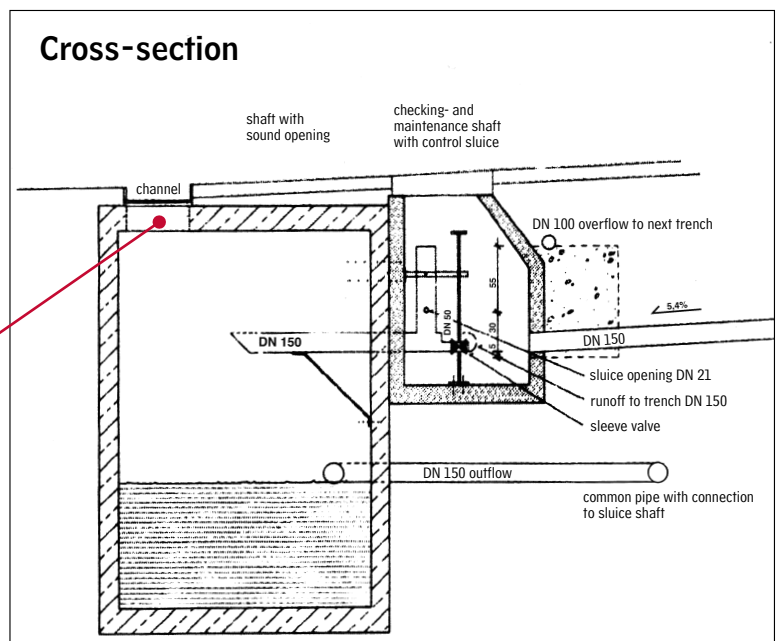
Quarter Park – general view

the rainwater makes its way from there direct into the main trench. From here, the rainwater is led via a checking and maintenance shaft at a controlled rate to one of four “sounding shafts”. When

it drips onto a lower-lying water surface, the dripping rainwater produces a sound which the relatively larger sounding shaft magnifies, and it can be heard through the sound openings.



Box channel with sound opening



Rainwater shaft with sound opening



EXAMPLE FOR A COMPREHENSIVE ENVIRONMENTAL CONCEPT (N13/14)



Terraced houses with roof planting

The energy-efficient development on the Kronsberg is something very special, because it represents a comprehensive environmental concept. The standard to which the energy-saving houses were built in the Kronsberg project was enhanced to include e.g. further improved heating insulation. On top of this, electricity will be generated by a solar generator and energy-saving domestic appliances will be installed. Naturally enough, the rainwater drainage system is part of the concept. Drainage is via a gully-and-trench system with soakaway and controlled outfall. A special feature of the drainage is the roof-planting, which actually covers the entire roof area.



Soakaway gully

SOCIAL AND CULTURAL COMMUNITY CENTRE (DRINKING WATER ECONOMY MEASURES)

Along with the primary school, the Community Centre here also has a rainwater system which can be used for saving water. Rainwater is used for flushing toilets and urinals.

The rainwater used for flushing the sanitary installations comes from the extensively-planted and gravel-laid roof surfaces via a filter into an underground water tank. Only

overflow water from the tank and the filter are allowed to soak away or are fed elsewhere.

The soakaway is a combination of trench and retention channel. Most of the rainwater which falls is stored and either soaks away or flows away under control. A water basin initially envisaged was not included for rea-

sons of expense. Rainwater originating from porous surfaces all goes to the soakaway. The vortex valve used to control rainwater outfall has no moving parts and is, apart from a diaphragm used as a sluice, almost maintenance-free.

On this plot some 11.6 hectares (about 29 acres), there are two identical rows of 8 houses. The individual houses have a common basement and are joined as well by an overall glazed roof, creating a "micro-climate" zone.

It serves as a roofed-over, planted inner courtyard, and has a variety of pools and different fountains. Some of the balconies and terraces are also within the zone.

The open space between the rows of houses is to be devoted to an orchard, a play-area and a lake area. Additionally, the houses are to have extensive and intensive roof-planting.

Rainwater falling on sealed areas will first be gathered in one of two tanks. The tanks are so sized that they will retain a proportion of the rainwater and an additional 35 m<sup>3</sup> (some 7,500 gals.) for the micro-climate zone (including ponds etc.) and the greenery.

EXAMPLE OF AN INNER COURTYARD DOMINATED BY WATER (M 52)



Micro-climate zone

As the tanks are not designed to retain all the required volume, when it rains heavily, rainwater will flow from the tanks into the ponds and be stored there temporarily by the increase in the water level of the pond. Drainage from the ponds is into a grassed gully, under which there is a trench. A following sluice then controls the rainwater's flow into the public retention basins. More water retention capacity could be created by using the play-area between lake and gully-and-trench system.



View of inner courtyard



In building plot **N 42**, a pond takes up most of the rainwater which falls. The rainwater is all channelled into underground pipes. Some permeable areas allow the rainwater to soak direct, or via planted areas, into the ground.



The Children's day-care centre **Kita 1** is drained by a gulley-and-trench system. Interior fall-pipes lead the rainwater from the gravelled roof into the gulley, from where it soaks into the trench below. The sealed pathways are also connected to the gulley. The few parking spaces are permeably-laid, so that water soaks away on the spot.







Three basins lined with gravel and bark slopes take most of the rainfall on plot **N43**. To protect the sluice, the outfall is via a coarse gravel filter. The remaining rainwater soaks away either where it falls or in the adjoining planted areas.



Plot **N22** is characterised by a wide-spreading and, on account of the steeply-sloping nature of the area, stepped trench system. Two shingle basins, known as “wadis” take up water. Most of the completely-planted roof surfaces, and parts of the road- and pathways have direct access to the trenches. Rain falling on the remaining roofs passes via the two basins to the trenches. Rain falling on other surfaces either soaks away on the spot or via planted areas and strips.

Rain drainage from plot **N21** is via a soakaway with drainpipes. Rainfall runs into the soakaway almost exclusively over paved gutters and a grassed gully. To cross lower-lying parking spaces, pipes cross them, aqueduct-style, at about 2.5 m above ground, and empty into the paved guttering. Rainwater on the parking spaces soaks away, then runs to a pumping-shaft and from there to the soakaway.

Pathways drain primarily into the greenery; roof terraces drain via fall-pipes into small gravel beds.





Rainfall on plot **M21** soaks away through a basin with trench below. Rainwater runs via open, tiled, guttering to a central soakaway and from there into the groundwater or into the basin. Rainfall on permeable sealed surfaces soaks straight into the ground.

From some of the roofs, rainwater is channelled onto the roof of the underground garage and used there for storage irrigation. Excess water is fed via an overflow to the basin.



Rainwater falling on plot **M42** soaks away through a pond and a trench system.

Part of the rainwater is directed straight into the trench via fall-pipes. The remainder reappears after a few days, and is then fed, above ground, to the pond through a system of gravel beds. Some permeable surfaces are drained direct into the groundwater by soakaways.





Plot **M 41** has a combination of pond, trench and gully-and-trench. Rainwater is led visibly through gravel or grass gullies to the pond or either direct or over a soakaway via mainly open-ended fall-pipes. Underground garage roofs drain visibly through gargoyles, also through box-drains and gravel beds into the pond. Smaller sealed areas drain direct into the greenery.

The **primary school's** drainage system comprises a number of gullies with a filter pond and a trench below. Rainwater from most of the planted roofs runs into a tank, to be used, and only overflow rainfall runs into the filter pond. All other surfaces drain either direct into the pond or via a metal box-drain, then round the school in gullies, and finally into the soakaway. At the end of each of the gullies there is a step, whereby the desired amount of water can be retained. Most of the rainwater flows above ground to the filter. The pipes which are laid below ground come to the surface in the middle of the greenery.



On plot **M 53**, rainfall from most of the surfaces, and especially the roofs, goes into a trench system comprising several parts. The remaining surfaces, mostly roofs, are either connected to a soakaway basin or drain direct or via adjoining planted areas. The soakaway basin has an overflow through which, in torrential rain, excess water flows straight to the trench system.





# Costs

## Economic and feasibility study

Decentralised rainwater management systems are only a proposition, when compared with conventional drainage systems, if the economics are right. This is why in 1997 Hanover Municipal Water Authority commissioned the Hydrological Institute at Hanover University to compare a theoretical conventional rainwater drainage system for the Kronsberg building project with the “close to nature” concept actually realised there, from an economic viewpoint. <sup>(1)</sup>

The economic evaluations were carried out with the help of suitable process parameters. Factors studied were economics

- a) from the point of view of the community, for the public drainage system,
- b) from the point of view of the individual plot-owner, and
- c) from the point of view of overall community economics.

**From the community viewpoint**, ignoring any ecological benefits, a straightforward cost comparison favoured the decentralised management system. Based only on the investment costs, it shows a cost advantage compared with the traditional drainage system of about 17%. Specific costs of investment for the area examined amount, with the decentralised management system, to about 61.- DM/m<sup>2</sup> sealed surface.

**From the viewpoint of individual plot owners**, the conventional solution is the more favourable, as Kronsberg building costs would have been some 25% less than they were with the decentralised management system installed. The private builders and investors can all confirm this cost relationship.

Costs for the two systems would only be equalised once rainwater disposal charges under the decentralised management system were reduced to 60%.

**From an overall economic point of view**, ecological and social aspects must be considered, as water management measures such as these are designed to contribute to quali-

ty of living, and must be so assessed. With the help of a cost-benefit analysis, it could be shown that decentralised rainwater management, both in financial i.e. cost terms and – especially – in ecological and social, financially non-quantifiable terms, had an advantage over conventional drainage systems.

In the final report on the research project, costs associated with the rainwater management project amounted to **20,384,000.- DM**

compared to conventional drainage at **24,656,000.- DM**

This cost advantage arises mainly from counting rainwater management measures as set-offs and replacement measures, as per nature preservation laws. Use of the gulley-and-trench system meant savings for the city of Hanover of some 6,300,000.-DM. These costs would have been matched by the costs of purchase of ground for compensation measures and its planting, if conventional rainwater drainage systems had been laid.

## Economic situation after evaluation of results of the municipal competition

The following table displays the costs of installation of the whole system, i.e. including site set-up, equipment and maintenance costs, excavation work, pipe-laying etc.

In total, Hanover Municipal Water Authority had some 7,000 m of gulley-and-trench system laid, in about 20 sections. The costs given are for the end costs (nett) for each section, divided by the trench length, in DM per metre; they are thus costs of installation which were attained within the framework of the open competition.

Based on the market situation, and the varying extent of the individual measures, the costs cover quite a wide range.

### MINIMUM COST:

Specific building costs of the sector cheapest to build

### AVERAGE COST:

Average of specific building costs for all sectors

### MAXIMUM COST:

Specific building costs of the most expensive sector to build

<b>MANUFACTURING COSTS FOR THE GULLEY-AND-TRENCH SYSTEM</b>	
Minimum cost	850,00 DM/m
Average cost	970,00 DM/m
Maximum cost	1150,00 DM/m

*Total costs of the gulley-and-trench system in DM/m trench*

On the Kronsberg, due to EXPO, the building costs for the gulley-and-trench system turned out to be some 300.- DM/m higher than originally budgeted. By contrast, the “normal” drainage costs for the years 1995-1997 on the Kronsberg were within budget.

Taking this competitive element into consideration, the scientific cost comparison now looks like this:

Gulley-and-trench system as installed by Hanover:

**22,686,000.- DM**

compared with a conventional drainage system:

**24,656,000.- DM**

With introduction of the split charges for soiled water and rainwater in 2001, the private plot owners will also get considerable benefit in their drainage charges: assuming agreement of the Hanover city council, these charges may be reduced to 30% where rainwater management systems are in operation.

<sup>(1)</sup>Final report of the research and development project “Rainwater Management Hanover Kronsberg (Flood Precautions)”. Full-surface rainwater management in a large-scale building project, with particular emphasis on flood protection aspects; sponsored by the Federal Ministry of Transport, Building and Housing and the Federal Ministry of Housing and Land (BBR); passed by the Hanover Municipal Water Authority to the Hydrological Institute of Hanover University for processing. Direction: Prof. Dr. Friedhelm Sieker; Management: Certificated Engineer Hans-Otto Weusthoff.



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