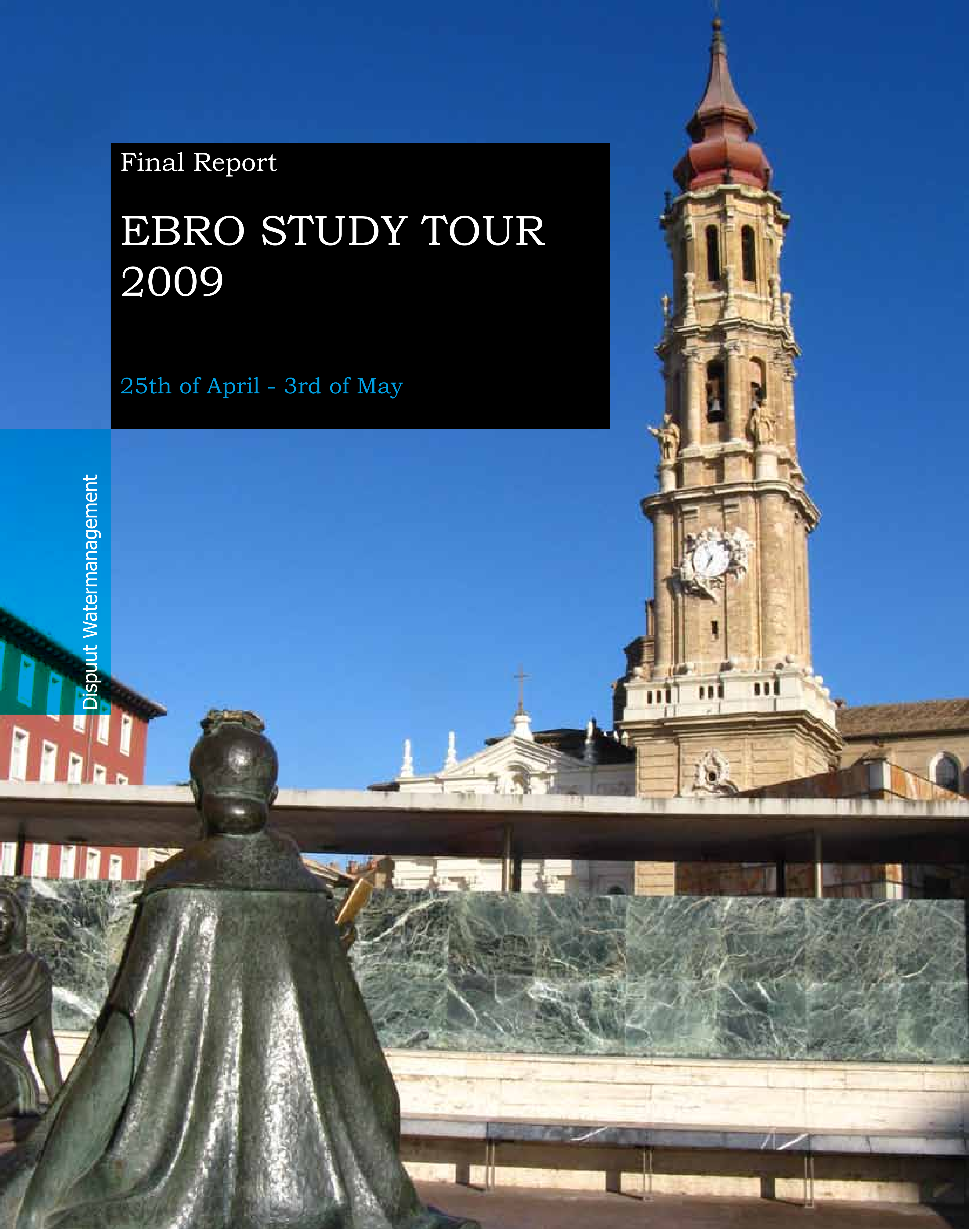
Final Report

EBRO STUDY TOUR 2009

25th of April - 3rd of May

Dispuut Watermanagement



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Final Report Ebro Study Tour 2009

This is a publication of the Dispuut Watermanagement and contains a description of the projects, experiences and impressions of the Ebro Study Tour 2009.

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Preface

We should at least try to convince you that the process of choosing a destination for this year's study tour was a very difficult one, and that we practically sagged under the tonnage of ideas for alternative destinations (Morocco, Switzerland, Italy, Bulgaria, Romania). But, the realistic considerations have prevailed… We could try to convince you, but you know that with the unceasing sunshine, vivid cities and delicious assortment of tapas and wines, Spain and the Ebro river, crossing through the beautiful regions of Catalonia and Aragon, were an easy choice to make.
Yet, little of our attention was devoted to the touristic attractions Spain virtually brims with. We considered Spain as a welcome contrast to the northern part of Europe, a country where water resources are less abundant. At the point of preparations we were aware that the Spanish national hydrological plans, the Ebro water transfer in particular, have raised ardent discussions. The Ebro as one of the biggest river catchments in Spain was our natural choice and we were all looking forward to experiencing an instructive and inspiring week visiting various projects related to our studies in water management.
All of us were putting a lot of effort into planning the tour and organising everything that was necessary to make the tour a success - transport, accommodation, sponsors, and, most importantly, participants and interesting projects.
Still, at the beginning of our trip, we faced some challenges when the car rental company had only one minivan for us (the confirmed reservation had disappeared in the local reservation system) and we lost two participants (one had missed the train in Delft and the other one had to fly to Palma de Mallorca due to bad weather conditions at Barcelona airport). With such a beginning we could only expect that the hydrologists we have arranged meetings with will turn out to be flamenco dancers. But after we retrieved the missing participants and sharpened our skills to argue in French virtually all was back to normal and we could only follow what we have planned-Spanish water management at its best.
The projects we have arranged were all a full success. We will not give further details here since the rest of this report is devoted to the projects we have visited and the impressions we have taken home.
Looking back we are happy that the Ebro Study Tour was appreciated by the participants and that we spent a great time in Spain and that all our hosts were very enthusiastic to receive us and offered us excellent opportunities to learn about water management in the Ebro catchment.

We hope that you enjoy reading this report as much as we enjoyed our time in Spain!

Study Tour Commission 2009

Back row from left to right:

Efthymia Foka
Bart Bergmans
Robin Harder

Front row from left to right:

Anke Poelstra
Philip Stive

Introduction

It is already some weeks ago that we have been to the Ebro basin for a study tour, and quite an intensive study tour it was. We have seen a lot of projects, usually two per day. In the programme booklet I wrote - or at least intended to write - that I won't pretend to be an expert on Spanish water management because I am not.

Now I know much more about it. We have seen the big city of Barcelona and the smaller but still big city of Zaragossa, we have travelled from the cradle to the "grave" of the river, from the Pyrenees to the sea, and in-between we have visited dams and reservoirs, irrigation systems, drinking water production plants, nature areas, and offices from which the water is managed, ranging from the big and impressive to the not so big and impressive. And we have seen something of the country in which and for which the water is managed: Spain. Personally, I have seen Spain mostly during day time. Some of the participants, however, extended the study tour to the nocturnal hours, and indeed each hour of the day constitutes a worthy object of study.

What have we learned and was it fun? A lot and yes. We have seen what dryness means, we have seen old and new irrigation systems in operation, seen an ultra-modern desalination plant and much more. We could wonder whether it is economically feasible to construct new high-tech irrigation systems or whether there are perhaps good social grounds for this – to prevent depopulation of the countryside. We could ponder over the question why to grow subsidised rice in the Ebro Delta if rice can be grown much more efficiently in countries such as India and Bangladesh – to feed the birds? We have discussed the effects of deforestation and reforestation in the Pyrenees on the discharge of the Ebro. As I understood it, trees use a lot of water and all this water does not end up in the river. From a scenic point of view, the Pyrenees were the highlight of the study tour.

The study tour was very well organised. All projects were interesting and the organisers managed to find hosts who could give interesting presentations and guide excursions excellently. Special thanks should go to Robin and Bart, who were driving the vans while the rest of us were happily dosing away. The task for me as a "supervisor" was very limited indeed: thank our hosts on behalf of TU Delft and ask questions if the participants would not do so. However, my colleague loved to say thanks and there were usually enough questions from the participants. The youth hostels were sometimes a bit noisy because of other groups, but I must say that I still feel more at home in a youth hostel than in an old people's home. A study tour is a great opportunity to get to know each other a bit better.

That is all folks. See for more details on the study tour the other rest of this report.

Erik Mostert

Travel Scheme

24-04-09 Travel day Group A

25-04-09 Travel day Group B

Delft - Paris - Perpignan - Barcelona

26-04-09 Free day in Barcelona

27-04-09 Desalination plant, drinking water treatment plant

Barcelona - Tordera - Barcelona - Zaragoza

28-04-09 Hydrografic Confederation of the Ebro Catchment

Zaragoza - Embalse de La Loteta - Presa de la Loteta - Zaragoza

29-04-09 Field trip to the Pyrenees

Zaragoza - Ontinar de Salz - Embalse de la Sotonera - Biescas - Embalse de Búbal - Embalse de Lanuza - Lanuza - Zaragoza

30-04-09 Agrifood Research and Technology Centre of Aragón

Zaragoza - Campus del Aula Dei - Laguna de la Playa - Bujaraloz - Irrigation Canal Junction - Zaragoza

01-05-09 Visit to the Ebro Delta

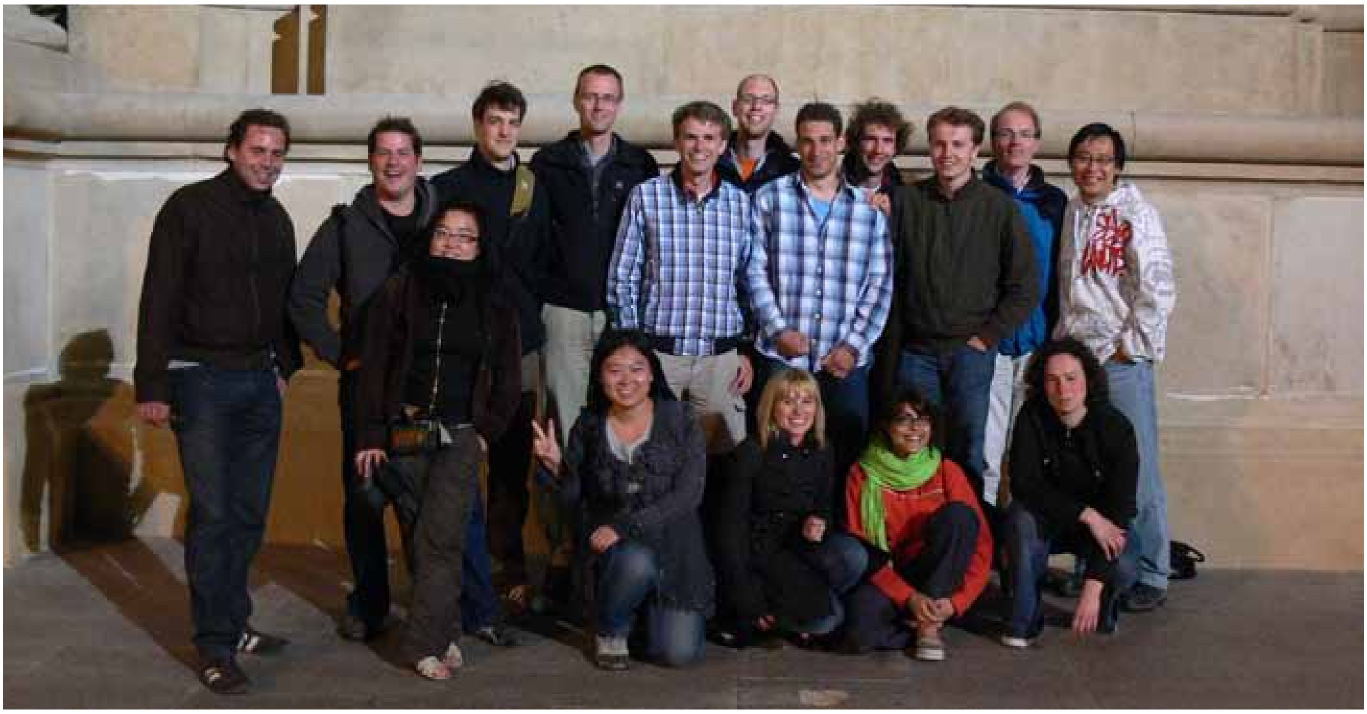
Zaragoza - San Carles de la Rápita - Deltebre - Barcelona

02-05-09 Free day in Barcelona

03-05-09 Travel day

Barcelona - Perpignan - Paris - Delft

Participants



Back row from left to right:
Nikolaas van Balkom
Bart Bergmans
Robin Harder
Thom Bogaard
Mark de Koning
Gerben Tommassen
Koen Hilgersom
Philip Stive
Mark van der Valk
Erik Mostert
Xingcan Cui

Front row from left to right:
Hyo Mee Duerinck
Bingjing Zhang
Lucyna Magda
Efthymia Foka
Anke Poelstra

Special Thanks

This Ebro Study Tour would not have been possible without the help of the sponsors and funds, which we would like to thank very much for the financial support:
PWN Waterleidingbedrijf Noord-Holland
Vitens
HKV Lijn in Water
Deltares
Evers + Manders Subsidieadviseurs
VSSD-SRF (StudieReisFonds)
Universiteitsfonds Delft
CvB Fonds TU Delft

Furthermore, we would like to thank everyone who was involved in the projects - be it by giving a presentation or talk in the field, by accompanying us in the field, or by organising the program of the day in the background. We very much appreciated the enthusiasm and expertise of our hosts, as well as the perfect organisation of all our visits.

Last but not least, we would like to thank Cristina and David for tips, hints and translations, Thom and Erik for accompanying us and safeguarding the scientific level of the study tour, and of course the participants. We, the committee, had a great time with everyone of you and hope to see you in the future!

Desalination Plant 'La Tordera'

27th of April 2009

The first project to visit was the desalination plant 'La Tordera', which is located near Blanes and the river 'Tordera' some 50 km north-east of Barcelona.

Water supply at the Tordera Delta

Before the commissioning of the 'La Tordera' desalination plant, all the water required for urban, industrial and agricultural use was extracted from the Tordera aquifer and treated in three local treatment plants; 25 hm^3/yr for domestic uses, 7 hm^3/yr for industry and 9 hm^3/yr for agriculture.
This extensive water extraction advanced salt water intrusion in the delta and, without the construction of the desalination plant, would have led to degradation of the delta and salinisation of the drinking-water wells. The desalination plant thus is a key element for the recovery of the Tordera Delta.

The desalination process

The desalination process starts with the intake of seawater using ten deep wells that are located parallel to the coastline and whose depth is approximately 150 metres. To make sure that seawater and not fresh-water is abstracted from the aquifer, only the lower 50 metres of the wells are permeable. Solid particles that are retained on the permeable coating of the deep well act as a first filter.

Reverse osmosis membrane cut open

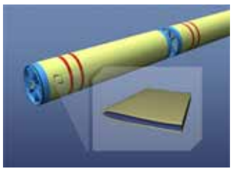
The seawater is then pumped approximately 2 km to the seawater inlet tank in the desalination plant where an initial chlorination of 0.5 g/m^3 takes place to supress bacterial growth in the treatment plant.

From the inlet tank, the water is pumped to the pre-treatment which consists of sand filters and cartridge filters. Cartridge filters are microfilters that offer finer filtration than the sand filters and have a grade filtration of about 20 microns. At the end of the pre-treatment several control instruments are installed (temperature, turbidity, conductivity, redox potential) which ensure that on entering the reverse osmosis process the water has suitable qualities.

Fact sheet desalination plant 'La Tordera'

		Phase 1	Phase 2
production	total production	28.500 m^3/d	57.000 m^3/d
	water abstraction	64.000 m^3/d	128.000 m^3/d
	reject water production	35.500 m^3/d	71.000 m^3/d
	recovery	45%	
water abstraction	number of wells	8+2	16+4
	depth of the wells	150 m	
	nominal flow per unit	740 l/s	
sand filters	number of units	4+0	8+0
	filtration	11.25 m^3/m^2 h	
microfilters	number of units	2+1	4+1
	cartridges per unit	12	
	filtration capacity	20 mm	
pumps	number of units	4+1	8+1
	nominal flow	670 m^3/h	
	nominal pressure	68 kg/cm^2	
	energy consumption	3.06 kWh/m^3	
RO membranes	number of racks	4	8
	number of modules	4x82	8x82
	number of membranes	4x82x7	8x82x7
storage tanks	sea water tank	1000 m^3	
	remineralisation tank	1000 m^3	
	reject water tank	340 m^3	
	neutralisation tank	540 m^3	
	product water tank	3600 m^3	

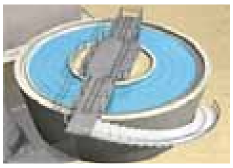
Note: all illustrations were taken from the webpage of the Catalan Water Agency (ACA) [http://aca-web.gencat.cat/aca]



The osmosis process basically consists of pumping water at high pressure against a semi-permeable membrane, thus retaining the salts dissolved in the water. The water pressure is increased to 68 kg/cm^2. Currently, there are four racks installed with 80 membranes each. The recovery is around 45%.

The concentrate leaves the racks at a slightly lower pressure than when it entered the membranes. Energy recovery takes place physically with the installation of pelton turbines. By this means, the energy requirement for the desalinated water can be lowered to 3.06 kWh per m^3 permeate.

The reject water is sent to a tank with a capacity of 340 m^3 from where it is transported to the seabed via an ocean outfall located at 150 metres distance to the coastline where there is sufficient turbulence to ensure good mixing of the brine with the surrounding seawater.



The permeate is further treated in order to become suitable for human consumption. In particular, the permeate has a low pH and its mineral content is insufficient. To this end, lime and carbon dioxide are added to the permeate to adjust its hardness and acidity. Finally, the water is stored in a product water tank where it is chlorinated once again to ensure that it remains disinfected on its journey to the tap.

The drinking water that leaves the desalination plant is distributed to three drinking water treatment plants in the vicinity where it is mixed with the drinking water produced from the respective drinking water treatment plant. At these plants, new buffer tanks had to be built in order to balance the continuous supply from the desalination plant with the variable water demand.

Furthermore, a new power plant had to built which delivers electricity solely to the treatment plant.

The price of the desalinated water from the 'La Tordera' plant is an estimated 80 eurocents per cubic metre.

Pumps (red) in the foreground and cartridge filters (white) in the background

Impressions of the day

Visiting a country like Spain, which was immersed into admirable sunshine and soft breeze in spring, can always brings people excellent mood and pleasant experience. We were the lucky guys! The time we visited the drinking water treatment plant and water desalination plant in Barcelona was definitely some time worthy of remembering. To most of the people who may not know the exact treatment technology the tour was an open-sight visit, but for those who followed the subject of sanitary engineering at TU Delft, this trip was absolutely interesting and valuable. The description that we got in the treatment plant was in detail and we were free to ask any questions that we wanted.

The trip on 27th of April only revealed a corner of the drinking water treatment stage of the city of Barcelona. And we feel a little bit pity that there was no chance to visit some wastewater treatment facilities there. But anyway, we already learned a lot! Especially to those who had the professional background in this subject, this was a valuable trip without any doubt. At the same time to other people who did not have the expert knowledge in water treatment, it was an interesting experience to see how the water that we drink in Spain is being produced. Here we want to deliver our sincere gratitude to those who organized this wonderful trip, so beautiful and so well. Thank you so much for your effort that was put into this activity. And also may thanks to those who gave us impressive presentations in the treatment facilities, thank you!

Drinking Water Treatment Plant 'Sant Joan Despí'

27th of April 2009

The drinking water treatment plant 'Sant Joan Despí' takes water from both groundwater wells and the Llobregat River and supplies it to 3 million customers in the Barcelona area. The plant is owned and operated by Aigües de Barcelona. Until 1955 the area was supplied with solely ground water, but increasing water demand made the use of surface water necessary. Since then the Sant Joan Despí treatment plant has had several expansions towards the current maximum capacity of about 460,000 m^3/day. This allows the plant to supply water to 36% of the Barcalona area.

Llobregat river, alternative water intake besides groundwater. No water was taken from the river at the time of our visit because the turbidity was too high.

The treatment plant first had a traditional treatment scheme: pre-chlorination, coagulation/flocculation, sedimentation, rapid sand filtration and post-chlorination. Since then the plant has been expanded with flocculation aids, granular activated carbon filtration, ozonation and dual instead of single media filters.

River water intake depends on quantity and quality. There are high concentrations of sodium, potassium, chloride and sulphates from of natural origin, and the water is relatively hard (calcium and magnesium). Furthermore, especially during winter, there are elevated levels of organic contamination, microorganisms and ammonium (2-3 ppm NH_4^- during the winter period) due to upstream discharge of sewage.

Given sufficient quantity and quality, the water is taken in from the Llobregat River and passes through bar screens to prevent objects larger than 8 mm to enter the treatment plant and damage installations like pumps. Then sand and gravel is allowed to settle in mechanically cleaned sand traps and the water is pumped up. After pre-chlorination, coagulant and flocculation aids are added to the water. As coagulant, cake alum, aluminum polychloride or iron chloride is used depending on the circumstances. Polyelectrolytes are used as flocculent aids. The water is allowed to settle in 88 rectangular upflow settling tanks with a combined surface area of 8,800 m^2. The water is passed through 20 dual media filters with a surface area of 100 m^2 at a velocity of about 10 m/h. The thickness of the filter bed is 1.2 m (0.6 m sand and 0.6 m gravel). The filters are backwashed every second day with air and clean water. The backwash-sludge is treated on-site and the liquid obtained after centrifugation is returned to the intake if its quality is sufficient.

Sampling taps for water quality measurements. An impressive number of 450 compounds is analysed day and night every 1 to 2 hours.

Because of the new treatment steps added to the process scheme, the water has to be pumped up again. For this purpose, four archimedean screws with an individual capacity of 2m^3/s were installed. Three ozonisers produce 32 kgO_3/h each, which is added to the water in four contact chambers. After this the water is distributed among the granular activated carbon filters. The 20 filters of 100 m^2 each have 1.5 m of granular activated carbon with a contact time of about 12 minutes. The filters are designed to allow an increase to a filter bed of 2 m without major modifications. The plant has a furnace to regenerate the activated carbon, but this furnace is no longer in use so the carbon has to be regenerated elsewhere. There are plans to build a new furnace.

On top of the sedimentation tanks.

After the granular activated carbon filters, the water is stored in a 10,000 m^3 clean water tank. Since post-chlorination is done in the clean water tank, a minimum contact time is required. Walls are installed in the tank to ensure this. The water is finally pumped up to supply tanks, which are located at a height of 100 m at Espluges.

Currently a new line of treatment is being built consisting of UF, UV, RO and remineralisation. In the future, this line will treat 50% of the water and will enable meeting lower guideline values for THMs, which would be impossible with the current setting.

Operator room at the Sant Joan Despí drinking water treatment plant



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Visit to the Water Board of the Ebro Catchment (CHEBRO)

28^{th} of April 2009

We started this day with visiting the Confederación Hidrográfica del Ebro (CHEBRO).

History

The CHEBRO was created on March 5^{th} 1926. It was the first of its kind in Spain. The creation followed after a time when the need to develop a national water policy in Spain gained a lot of support. In 1902 the first National Hydraulic Works Plan had passed, and following this National Irrigation Congresses were held to discuss the advisability of creating local associations of irrigation syndicates.

Responsibilities

A hydrographic confederation has the responsibility for a hydrographic basin of a river. A hydrographic basin is the area of land on which all the water converges through a network of tributaries to a single main river, which drains into a body of water. It is therefore a natural territorial unit, which does not coincide with political or administrative boundaries.

Ebro Basin

The Ebro basin is situated in the northeast part of Spain and has a total surface of 8,500,000 ha. Its natural boundaries are the Cantabrian Mountains and the Pyrenees to the north, the Costero-Catalana chain to the east, and the Iberian System to the southeast. The basin is drained by the Ebro river, which has a total length of 910 km. It starts in the Cantabrian Mountains and flows into the Mediterranean Sea 60 kilometres south of Tarragona. All the tributaries contribute to a total river system with a length of about 12,000 km. The amount of rainfall varies greatly throughout the basin. In the Pyrenees around 1,500 mm falls from the sky annually, but in the middle of the basin the land only receives around 300 mm annually.

The annual demand in the basin is about 8,000 hm^3. Most (86%) is consumed by agricultural activities. The reason for this is the high amount of irrigated land in the basin, about 913,000 ha (2009). The supply guarantee for agricultural demand is limited, depending on the precipitation regime. The difference between a dry and wet year is around 60%!

Core problems and challenges

Due to this high amount of irrigation activities in combination with limited water resources, controlling and combating pollution is the biggest unresolved issue in the basin. On the borders of the basin, in the Pyrenees and the Iberian System the water quality is very good, but in the centre of the basin water quality is very low. The high amount of fertilizers used combined with low discharges make drainage canals very polluted for example. Salinisation of the water is another problem. The ground is very saline since the valley used to be a sea millions of years ago. Since there is not a lot of rainfall, or no irrigation, in large parts of the central valley the salt reaches the surface and will eventually end up in the rivers. The pollution has reached such a high level that often the water from the rivers does not fulfil the minimum requirements for use in the public water supply! Much of the work of the CHEBRO at this moment and in the coming years will focus on supplying quality water to the inhabitants of the centre of the basin. This can be achieved for example by raising the levels of efficiency regarding water usage, increasing the minimum environmental flow in the rivers and limiting the use of fertilisers and herbicides in order to reduce their presence in the return flow from irrigation.

The Control Room

After the presentations, we made our way to what we can call the control room of the CHEBRO. When we walked in we were immediately amazed by the impressive sophisticated level of this. About six persons were sitting behind computer screens facing a wall with a large map of the Ebro basin that was covered with lots of indicator lights.

It is to be noted that before the river-basin organizations like the CHEBRO were founded no information of any kind was available about the water system in the basin and the basin was totally unmanaged. Ever since there has been put a lot of effort to make up for this. As an example, civil works were built together with machinery to manage water, the water system was mapped, research centers on irrigation and laboratories were set up and studies were done on the water dynamics.

Nowadays the use of modern technologies makes the water management in the Ebro basin ready to face the 21st century. Several information systems make the basin to a well managed one. Amongst them are the automatic hydrological information system SAIH, which links weather-forecasts to water availability, the decision-support system SAD for flood control and the integrated water quality management and waste control system SAICA.

These are just a few of the tools that came together in the control room that we were standing in. We got a presentation of these systems and what they could control from the room. The visualization of the map on the wall and the computer screen in the wall provided us a good insight in what was actually happening.

Of course management and maintenance of the water management works still need to be done in the field and we could not see from here how the organization was doing this work in the large area of the basin. Though, from the control room we could see that the CHEBRO is doing a lot on modernisation with respect to the integrated management of the basin.

Huge map of the Ebro catchment on the wall. Indicator lights reveal the status of the different elements of the automated hydrologic information system

Impressions of the day

After our visit to the La Loteta Dam, we finally had the time to get a closer look at the city where we arrived the day before. Zaragoza revealed itself as a beautiful city with a lot of historical remnants. The El Pilar cathedral in this was a shiny centre in the late-afternoon sunshine.

We visited the city in groups. Probably most of the participants of the tour did not expect that Zaragoza had so much to offer and a lot of faces showed signs of astonishment, for example by seeing the size and riches of El Pilar, the big square in front of it (Plaza del Pilar), the roman theatre and all the other churches, monuments and ancient buildings. Of course the warm weather forced us at a certain moment to sit down somewhere at a terrace and have a beer.

At night there was the first leg of the Champions League semifinal between Barcelona and Chelsea. In Barcelona. Although we just left that city one day earlier and it would have been great to be in Barcelona during this match, it was also great to witness the atmosphere in Zaragoza. Here the match lived as well and a lot of people were excited to watch the game. For this reason part of the group went to a bar in the city to watch. Others stayed back at the hostel where the old basement was furnished as a lounge area and provided with a large screen. After the heavy day it was quite relaxing to watch the game from those comfortable couches heaving dinner at the same time.

Visit to the La Loteta Dam

28th of April 2009

After the presentations at the CHEBRO in the centre of Zaragoza, we had to take the van to go to the La Loteta dam 44 km North-West of the city. Of course this was not a too hard drive to make considering the relatively short distance compared to other drives during the Ebro tour. The hardest part appeared to be getting our vans out of the underground car park. Cars parked around our vans left the vans a lot less space compared to how we left them, making it almost impossible to turn them out of the parking places. In the end we managed to do so compressing only one litter bin, thanks to our fantastic drivers Robin and Bart.

Inlet and outlet tower of the 'La Loteta' dam

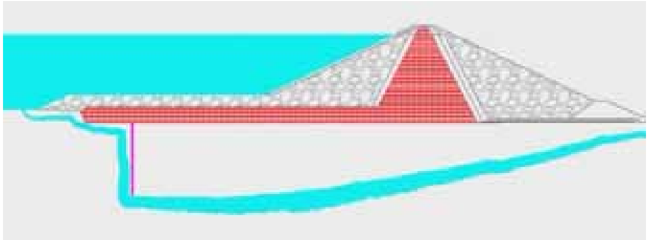
Near the site of the La Loteta dam we got a presentation and saw a video on the aims, design and construction of the dam. Afterwards we went to see all aspects (the reservoir, pipes and pumps) of it in reality.

The La Loteta dam has a twofold function: to regulate the Canal Imperial de Aragon and to provide the City of Zaragoza with quality water.
Therefore a location has been chosen close to both the Canal Imperial de Aragon and the City of Zaragoza. The dam is about 34m high and has a storage capacity of more than 100 hm^3, which is enough to supply the City of Zaragoza for a whole year.

The natural filling sources come from the Alpin basin and the Carrizal stream. Water from the Canal Imperial de Aragón is pumped from the outlet into the reservoir. Hence, technically it is called a derivation formed reservoir.

General presentation about the 'La Loteta' dam

A particular aspect of the La Loteta construction is the fact that it is build on considerable proportions of gypsum and other salts and the consideration of possible karstification. Therefore the dam is designed to prevent water flowing through the ground, reducing the hydraulic gradient, and prevention of dissolving salt content. This is done with an impervious blanket and a continuous diaphragm wall to reduce the hydraulic gradient to 0,2%.



Cross section of the 'La Loteta' dam showing the impervious blanket to reduce the hydraulic gradient

On the economic level, the aim was to find all fill materials as closely as possible to the site. All materials were taken from a radius of 6km from the building site.

Panoramic view of the 'La Loteta' dam and reservoir

Deltares

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Werken tussen wetenschap en praktijk

Op 1 januari 2008 hebben WL | Delft Hydraulics, GeoDelft, de unit Bodem en Grondwater van TNO en delen van Rijkswaterstaat hun krachten in een onafhankelijk instituut voor deltatechnologie, Deltares gebundeld.

Deltares biedt innovatieve oplossingen voor water- en ondergrondvraagstukken, die het leven in delta's, kust- en riviergebieden veilig, schoon en duurzaam maken.

Door de koppeling met de kennis van WL | Delft Hydraulics op het gebied van watervraagstukken, die van GeoDelft op het gebied van dijken, wegen en ondergronds bouwen, die van TNO op het gebied van ondergrond en grondwater en die van RWS op het gebied van integraal waterbeheer, ruimtelijke ontwikkeling en bestuurlijke processen ontstaat een internationaal toonaangevend instituut op het gebied van deltatechnologie waar technologie én maatschappij centraal staan.

Deltares is op zoek naar talentvolle mensen. Bij Deltares kom je terecht in een informele dynamische omgeving. Onze professionals doen praktijkgericht onderzoek en geven specialistisch advies in binnen- en buitenland aan opdrachtgevers die de allerlaatste kennisontwikkelingen toegepast willen zien. Ze adviseren de overheid en relaties bij het zoeken naar oplossingen die rekening houden met maatschappelijke ontwikkelingen.

Projecten bevatten altijd nieuwe uitdagingen. Door kennis en ervaring te delen verleg je grenzen en breng je ideeën tot leven. Kennisontwikkeling doe je in-house of in samenwerking met collega's uit het netwerk.
Iedere medewerker - zowel in het primaire als in het secundaire proces - draagt bij aan onze innovatieve oplossingen. Je collega's zijn divers: starters, bèta- en gamma-specialisten, economen, ecologen.... Nationale en internationale professionals zorgen voor een goede sfeer op de werkvloer en maken werken bij Deltares tot een wereldse ervaring.

Bij Deltares kun je zelf je carrière uitstippelen. Of je nu projectleider wordt of expert op je vakgebied of een beetje van allebei, dat is je eigen keuze. Zoek je een functie bij een Nederlands topinstituut met een internationale reputatie? Kijk dan bij onze vacatures. Ook biedt Deltares jaarlijks plaats aan vele stagiairs.

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Field Trip to the Pyrenees

29th of April 2009

The program for today is to learn more about the river Ebro and one of its water sources, the Pyrenees. Two experienced Spanish hydrologists, José M. García Ruiz and Carlos Martí from the Instituto Pirenaico de Ecología, C.S.I.C., learned us about the hydrological situation of this part of the Spanish water system.

The first stop was a village still an hour away from the Pyrenees mountain peeks. Around 1955 lots of these villages were built in Spain. Because of the financial and political situation these villages were build for farmers. The government provided them with a house, 10 ha of land and a cow.

Main city square of Ontinar de Salz

However, the farmers were used to grow dry-land-crops (non irrigated crops), but in this area there was not enough 'natural' water to do this. With only 200 -300 mm of rain every year and a with a saline soil, the farmers were forced to grow different crops and irrigate their crops. The farmers grow maize, alfalfa and near the cost rice.

These days already many farmers left the driest areas, resulting in ghost cities. The farmers that stayed have now 40-60 ha of land to maintain. Because of the fertilisers they use, the farmers add even more nutrients to the ground, resulting in an increasing demand for water. A lot of farmers also still flood their entire land for irrigation, which is a water spilling method. Luckily the Spanish government subsidises the build ing of sprinkler systems. To overcome all these water shortage and salinity problems, a lot of water is used from the Pyrenees and is stored in big reservoirs in the area.

This brings us to the next stop, the Embalse (reservoir) de la Sotonera. The dam holds 180 hm^3 of clean and clear mountain water. Although the best place to build reservoirs is up in the mountains, the reservoir is built in the lowlands. This is because people in the mountains do not want to 'suffer' from water reservoirs that hold water that is used for the farmers 'downstairs'.

Embalse de la Sotonera

More of these dams are build in the Ebro river basin. From the dams water is distributed with canals to the farmers land. The state maintains the main canals and the farmers are in charge of all the rest. The government controls the water but farmer syndicates divide and distribute the water.

Small subordinate irrigation channel near Ontinar de Salz

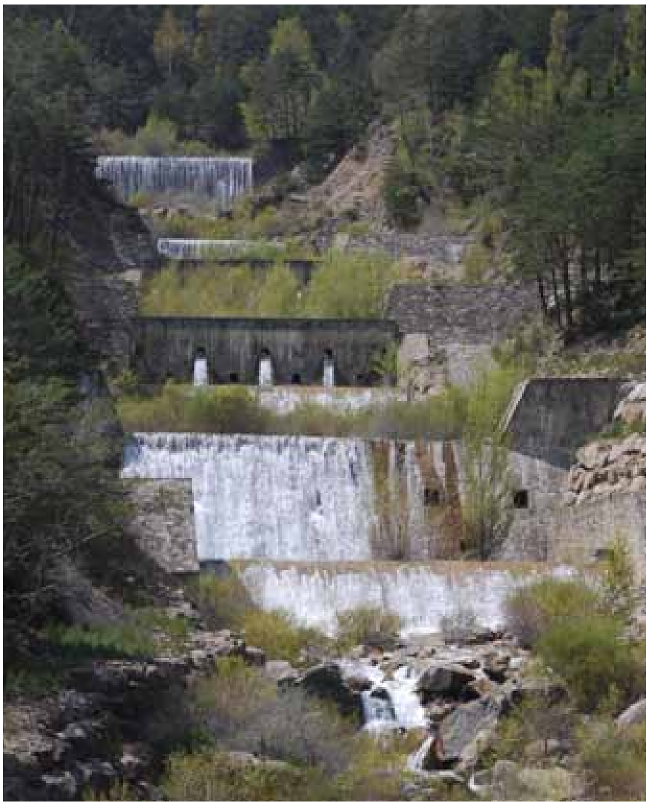
After visiting the dam we went to the location of the Biescas campsite disaster in the central Pyrenees. Most of the water in this area is discharged trough a stream with a slope of 20%. In the earlier days this location was also known for its floods and high levels of erosion. After another flood it was therefore decided to have the houses removed and new forest was planted in the area. Also 40 check dams were installed to retain the sediment and a canal with the capacity of 125 m^3/s was constructed. Its capacity is very high compared to the yearly average flow of 1 m^3/s.

For many years all problems seemed to have been solved. Then, in the eighties, someone wanted to construct a campsite located on the alluvial fan at the outlet of the 18•8 km^2 catchment and only one person opposed. As a result this campsite was put in place in 1987. A few years later, on the 7th of august 1996 in the middle of the day the unexpected thing happened. This sub catchment encountered a 250 mm rain event that was not in line with the statistics. This resulted in a discharge of no less than 300 m^3/s! The pressure of the collected sediment behind the dams and the high water level destroyed most of the dams. (Afterwards experts also concluded that the dams were weakened by the fact that the cores contained sand rather than concrete.) The water, carrying a lot of sediment, flowed out of the catchment and directly towards the campsite killing 87 people. This could have been much more had not most of the people left the site during the day.

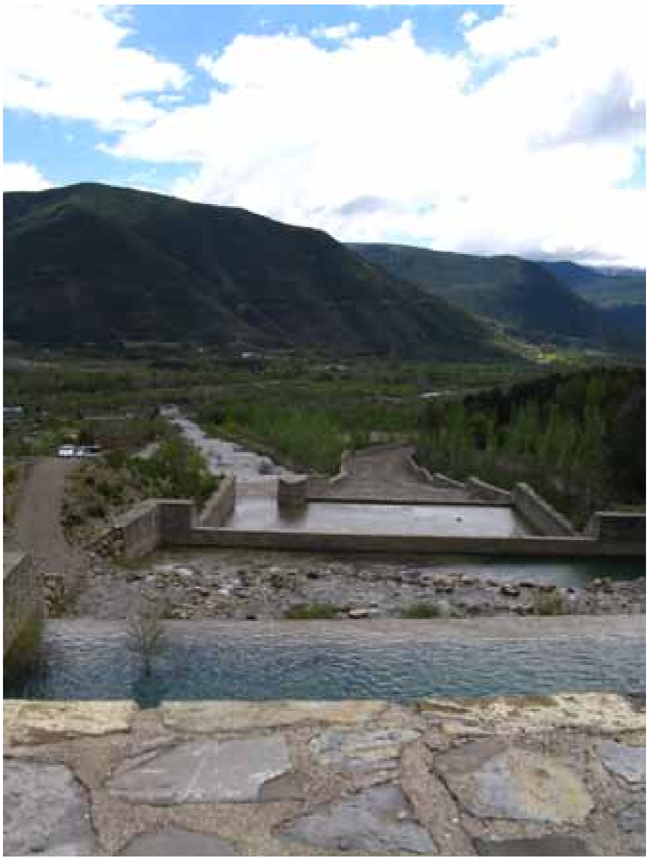
Nowadays the dams have been rebuilt and the capacity of the canal has been upgraded with a spillway capable of discharging 250 m^3/s. Also regulations for the location of campsites have been altered.

At the last stop we learned about the importance of vegetation in relation to runoff.

The runoff strongly depends on the amount of snow. However, there is a clear decline in the snow accumulation. Snow also melts earlier (May instead of June) and (peak) flows are smaller. This pattern has a large influence on the filling of the reservoirs.
The smaller flow isn't related to a change in precipitation or increase in temperature. To investigate this pattern measurements were taken in three catchments which are located close to each other (see Table on next page).



Series of check-dams in a mountain torrent near Biescas



Normal riverbed to the left and emergency spillway at the right

Catchment	Area describtion	Vegetation	Runoff	
		Coefficient	Pattern	Coefficient
San Salvador	Forest	95%	one peak, March-April	12%
Arnas	Mountainious	60%	several peaks, Dec & March	70%
Araguas	Covered with shrubs	85%	evenly distributed peaks	23%

Different runoff patterns as function of the catchment type

Much cultivated land has recently (since 1950) been changed into nature, this was also the case for the Araguas Catchment. This smoothens the runoff pattern and decreases the runoff coefficient. The absence of a high peak in May-June and the lower total inflow cause the earlier filling of the reservoirs. This makes it more difficult to provide enough water when needed for irrigation.

Búbal reservoir with snow-covered mountains in the background

Impressions of the day

Another one nice day starts in Zaragoza. Everybody managed to wake up on time. Mr. Jose Garcia Ruiz and Mr. Carlos Marti came to pick us up from our Hostel in order to start our filed trip in Pyrenees.

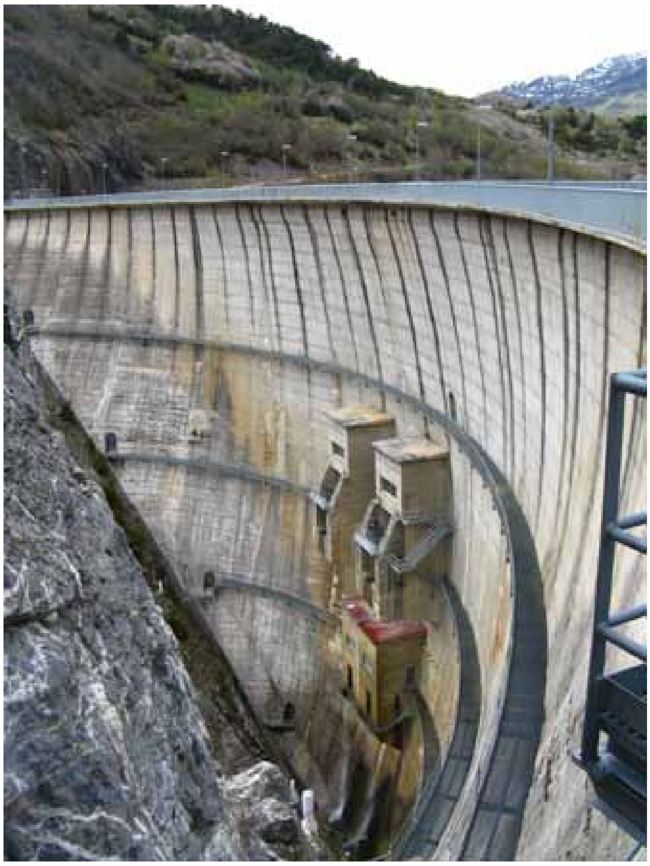
First stop was in a small village that was built in the end of the 60s' in order to provide housing to the farmers of newly irrigated areas.

Second stop at a reservoir. Stop to fill our reservoirs with coffee and continue to the Pyrenees.

The scenery of the Pyrenees was amazing and all the "wannabe" photographers were taking pictures all of the time even on the lunch break. A nice moment was when Erik Mostert said "I prefer the lunch at the faculty's cantina". Hope it was just a joke. Most of the student remembered their childhood although they had a pretty nice scientific excuse. Some were trying to find out the depth of the sedimentation dams and others were trying to figure out the velocity of the river….

Next stop was to visit a reservoir and an abandoned village (Lanuza). A group of adventurous students decided to follow the difficult path (stream crossing, steep slopes, and bushes with thorns). The scenery was reminding the musical "The sound of Music" so they decided to act like that singing and dancing around, while trying to "survive".

The end of this night was a nice Chinese and Greek dinner. Although it took some time to be prepared people seemed to be satisfied, or very hungry.



Dam of the Lanuza reservoir

Quotes of the day

Philip about the thermometer in the car:
"It sometimes shows -8 °C as well."
Koen responds:
"It isn't a Mitsubishi Colt, is it?"

At the Chinese-Greek dinner
Nikolaas makes a comment on Philip's 15 minutes dish:
"Are you not a little ashamed of your dish?"

Visit to the Agrifood Research and Technology Centre of Aragón (CITA)

30th of April 2009

Introduction

Spain has 13 local governments of which Aragón is one. The region has the largest agricultural centre in Spain, and CITA is a part of this centre. CITA has been founded in 1964 as CIDADE. From 2002 on it is called CITA.

CITA aims at providing research and technologies to the agriculture and food sectors in the Aragón district, where the Ebro River is located. As more than 10% of the Ebro River basin is irrigated land, irrigation activity is an important issue in this area.

There are 260 people working at CITA. Furthermore, the institute has 3 experimental farms with 100 ha of irrigated land and 1400 ha of dry land and there are 300 ha of mountain livestock and fruit species, on which research is done. On the farms, there are 22 lysimeters. Next to that, remote sensing applications are used. The biggest problem that is encountered in the area is nitrogen fertilisation.

The irrigation pattern in Spain

Spain is a country with an area of 504,782 km^2. It has a Mediterranean climate with dry summers mixed with cool Oceanic zones and big areas of steppe. The big areas with general low precipitation, high summer temperatures, and severe summer drought lead to the demands of irrigation in the country. The total irrigated land in Spain is 33,443.7 km^2 by means of 3 irrigation types: surface irrigation, sprinkle irrigation, and drip irrigation, accounting for 59%, 24%, and 17%, respectively. The mean water supply for irrigation in the country is 7,042 m^3/ha (704 mm). The irrigation water comes from surface water (71%, including 3% inter-basin transfers), groundwater (28%), and recycling & desalination (1%).

The irrigation pattern in the Ebro River basin

The Ebro River is the most important river in Spain. The Ebro River basin has an area of 85,534 km^2 with a population of 3,019,176. The uneven spatial and temporal distribution of the rainfall in the basin calls for irrigation in the basin. In the centre of the Ebro River basin, high temperatures and low rainfall lead to a high demand for irrigation.

The total irrigated land in the Ebro River Basin is 7,386.6 km^2. Surface irrigation, sprinkle irrigation, and drip irrigation account for 62%, 28%, and 10% of the total irrigation types, respectively. The mean water supply in the Ebro River basin is 8,033 m^3/ha (803 mm). The irrigation water comes from surface water (91%) and groundwater (9%).

The area of Aragón is semi arid. The rainfall is about 250-400 mm on annual basis, and evaporation is 1100 mm. For irrigation, canals running down from the Pyrenees are used. These canals are longer than 100 km and can therefore not be maintained by one farmer. There is only very limited groundwater, which is probably saline.

The irrigated area is divided in the traditional irrigation areas and new projects. There used to be enough water for the area, but with the new parts, there is more land. In the old area, barley was the main crop. There was only a good harvest once every three years. Because of the importance of cereals in the past, every village therefore had a silo, and farmers were obliged to sell cereals to the government.

When the Spanish kingdom became smaller in 1898 with the independence of Cuba, the country started to realise that it became more dependent on itself and could not rely on its colonies anymore. However, since Spain was hardly developed at that time, a change was needed. There were

Laguna de la Playa

Irrigated field (sprinkler irrigation)

thoughts about water for rural development, for which strong governmental intervention was needed, since only the government had the capacity for these kinds of collective water management projects.

The law said that irrigation districts, which were democratic associations, were mandatory, so these were therefore erected. Nowadays, these water boards have more tasks than just irrigation, and are a blend of private and public (the water basin authorities), with an elective board of farmers. They get their power from the central government.

There are a lot of problems with the irrigation system. Pressurised systems were introduced, because they are supposed to be more efficient. Also, there are too little farmers and surface irrigations take too long. Nobody can and wants to do it, which gives a social problem. The quality of the pressurised system is better, but that doesn't mean there is more water, since because of a bigger harvest, there is more evapotranspiration and less water in the basin.

ADOR - a tool for water management in irrigation districts

In order to have a bit more control and knowledge over the water, the ADOR tool was created. The tool traces how farmers use their water, so diagnoses can be made with it. Also, the tool shows any corruption. Of course, in order to make this possible, the tool needed the support of the farmers. Farmers speak a different language than scientists. Moreover, there are a lot of different farmers, even part timers. With training sessions with data from the farmers themselves, the confidence in the application grew. By adding features at the request of the farmers, the tool became more usable for the farmers. The tool is now bridging the communication gap that existed.

The tool has a matrix with types of water and prices for different uses. When there is a limited amount of water, first people get their water, then industry, then animals and last agriculture. This means that the ones with the most rights to water have to pay the most. Law allows trading of water, but it hardly happens. If it happens, most of the time it is done illegally. Sometimes it goes from one district to another when a farmer has land in both districts.

ADOR also gives the information on all the actors (even bank account numbers, since the farmers liked to keep their administration in the system) and catastral information.

There is also a diagram of the irrigation network for the farmers with different levels. This, however, is hardly used.

The software of ADOR is now used in about half the area. It has the advantage that it can also be used with minimal information. In the beginning, a small area was used for a try out. Now, it is used for 80,000 ha. However, version 2.0 has been stopped because of disagreement with the regional government.

Problems in irrigation activity

The irrigation water in the Ebro River basin is pumped from the middle of the Ebro River. The water quality in the upstream Ebro River is good, but in the middle part of the Ebro River, the salinity is much higher. The salinity in the middle part of the Ebro River is 1.2 ~ 1.3 dS/m in winter, while as high as 2 dS/m in summer. The salinity of the river has a great relation with the flow of the river. It increases if the flow decreases which brings a lot of problems to the crops.

Besides, some ionic compositions, like Cl^-, Na^+, Mg^{2+}, SO_4^{2-}, NO_3^-, and PO_4^{3-} in the river and groundwater also leads to the degradation in water quality.

The quality of the irrigation water directly affects the crops in the field. Therefore, measures have to be taken to reduce and to control the salinity and the pollution of the river. CITA is now taking the following methods to monitor the salinity in the river:

- Determine the trends in salt loads.
- Establish the evolution in irrigated surface (over saline/gypsiferous land or not; and other parameters) and relate it to the evolution of surface water salinity in different basins.
- Design trials that take advantage of the temporal variability: natural field irrigated conditions.
- Eliminate the variability and impose a soil salinity gradient by artificial means.

Water counter installation for one irrigated field

In the field

An irrigation network is created, consisting of pipes with 1,100 mm diameter. Every field gets 1.2 m/m^2. The sprinklers need 3 bar. There are pressure control devices that only the association is allowed to touch. Irrigation is on demand. When there are hard winds, there is no irrigation. Every night, there is irrigation in order to prevent the soil from getting a crust. Every field has a control in order to be able to divide the water within the field. In the future, this might be possible from home. The energy needed is coming from the sun. Losses are approximately 6 l/day.

The system can deal with a use of 85%. It is not very likely that will happen. When there is however more water needed, the manager can decide to cut water away.
Pumps are used to pump water from the canal to the basins, after which it goes through pipes and has enough pressure to reach the fields. The total storage capacity is 400,000 m^2. The future storage will be 1,000,000 m^2. The pumps have worked on diesel until now, but in November 2009, they will start to use electricity.

Impressions of the day

Queensday!
Again a very early day, since we had to arrive at CITA at 9AM. Although some of us had some nice social activities during the night, everybody was still able to ask some sharp questions during the first presentations, thereby surprising our hosts and themselves.

After some coffee and sandwiches, a field trip along some interesting irrigation projects was scheduled and everybody enjoyed the relaxing atmosphere of the surroundings of Zaragoza.
During the field trip the first messages of a bizarre (failed) attack on the royal family of the Netherlands reached the mobile phones of the participants.
Although this didn't disturb the rest of the tour, everybody was quite shocked seeing the footage at the end of the day on the Internet and the next morning at the front page of the Spanish national newspaper.

In the evening we had a nice meal and a lot of good wine with the whole group in a cosy Italian restaurant, celebrating the last evening together, since a few of us would leave the group the next day. Of course, after dessert; a group picture in front of the El Pilar cathedral!
Some of us really got the feeling and continued the night in some Zaragoza bars, but most of us were quite exhausted by again a beautiful but busy day in Spain and went to their beds early.

Diesel powered electricity generation unit

In March, the farmers know how much water there is to use, on which they choose their crops. Eventually, they pay for the water they use. There is a computer program that gives information about flow and pressure and use of water at any moment. With the knowledge of the water use, a prediction can be made for the next week, since the water has to be requested in advance. Because of storage, farmers never get less water than is promised. When the association asks for too much water, they have to pay a fine. There is payment per hectare and per m^3, and a discount for using limited water.

Large main irrigation canal (Canal de Monegros)

Control sluice at the junction of two main irrigation canals

Water en veiligheid

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HKV LIJN IN WATER doet onderzoek naar water en veiligheid en adviseert de Nederlandse overheid, provincies en waterschappen. Wij vinden het van belang dat besluiten over onze waterveiligheid worden gebaseerd op solide overwegingen en onderzoek en niet op dogma's of starre uitgangspunten.

Dat onze aanpak aanslaat, blijkt uit de groei van ons bedrijf en onze tevreden opdrachtgevers. Die opdrachtgevers zitten niet alleen in Nederland, maar in toenemende mate ook in het buitenland, met name in Duitsland, Oost Europa en Zuid-Oost Azië.

Wij zoeken studenten en nieuwe collega's die ook hun steentje willen bijdragen aan een veilige en zorgvuldig beheerde omgeving. Wij kunnen studenten volop mogelijkheden bieden voor:

- afstudeerprojecten
- promotiestudies
- grensverleggende onderzoeken

Visit to the Ebro Delta

1st of May 2009

On Friday the first of May an excursion to the Ebro delta was planned. Early in the morning we left Zaragoza, our place of residence of the last couple of days, to go to the Ebro delta. The guide for today was a local geo-hydrologist. During this excursion he would lead us to different spots in the area to show and explain several things.

At the first stop from a nice view point we saw a big part of the delta of the Ebro river. In this delta we have around fifty percent of agriculture and also around fifty percent of nature. The agriculture exists mainly of rice cultivation, which requires the rice fields to be irrigated. Because of the need for irrigation, canals and structures are build to make this possible. Nature can be found in the lagoons, shallow waters consisting of brackish water separated from the sea by a sand body.
To enable irrigation in the delta, the Tortossa dam is constructed. Fresh water from the Ebro river can flow into the irrigation canals by opening the dam. Most of the water in the Ebro delta flows to the sea under gravity. When gravity does not suffice, Archimedean screws, see Figure 1, are activated to get the water out.

Figure 1: Archimedean screws.
Water is brought from the irrigated fields to the sea.

The delta of the Ebro river was formed after the last ice age. The sea level was around 100 meters lower and over time it rised and sedimentation settled. Nowadays the delta downstream of the dams is subsiding because the Tortossa dam stops all the sediments. Because of the rising sea water level parts of the delta are flushed. If no actions will be taken, more parts of the delta will be recovered by the sea. Part of the people involved in managing the Ebro delta think about a technical solution to maintain the delta by bringing sediments again to the delta. For example this could be obtained by changing the dams. On the other hand, some former agricultural fields are abandoned and here it is allowed that the sea floods the land.

At the second stop we took a closer look to the rice fields. Figure 2 shows an impression of how they look like. The root zone of the vegetation contains always fresh water, which is important for the crops, and below the root zone there is salt water. The fresh water can be found till 3 or 4 meters deep looking at the rice fields.

Figure 2: Rice fields in the Ebro delta

The part of the delta where agriculture is located is separated from the sea by several sluices. These sluices are built to keep the saltwater from the sea out of the delta, see Figure 3. Fresh water excess in the delta can, by use of these sluices, be discharged to the sea when the tide is low. Nevertheless there is a salt layer under the rice fields located in the delta. If there is a situation that the roots of the rice crops reaches the salt water, a situation occurs which is not good for the growth of the crops. This situation could occur because of the tide of the sea. When it is high tide, salt water could enter the root zone. To avoid this, a layer of fresh water is kept on the fields to obtain a pressure as high that the water in the root zone is kept fresh. When the farmers keep a layer of water on their fields, the salt water will rise to at maximum 3 meters below surface. In this situation no problems occur for the rice crops. The depth of the freshwater layer on the fields is not regulated or so but farmers know this by experience.

Figure 3: Sluices that allow fresh water to flow towards the salt water side but prevent salt water to flow towards the fresh water side.

The irrigation part of the Ebro delta does not have large problems with contamination which gets in the water upstream of the Ebro delta. This is because of the low flow velocities direct upstream of the earlier mentioned Tortossa dam. Due to this low flow velocity most of the contaminated particles deposit before the dam. The mud before the dam is because of this highly contaminated and needs special treatment.

At one of the stops, we saw the natural parts of the delta. Here lots of different species of animals and vegetation can be found. This is also the reason that a lot of people interested in observing animals or vegetation make their way to the delta.

At the last stop we saw the so called 'ullals', see Figure 4. Ullal is a peculiar name for a series of small ponds, placed between the contact zone between the delta and the continent. These ullals are isolated artesian freshwater springs but are affected by the contaminated runoff from the fields.

Figure 4: 'Ullal'. Artesian freshwater springs in the contact zone of the delta and the continen.

After all it was again an interesting day on which we saw a lot of specific things in relation to the Ebro. We learned how a delta changes over time, which situations could occur there and how the people involved deal with this. This was also the last excursion of the Ebro Tour. From the delta we went to Barcelona where we spent the last day of the Ebro Tour.

Panoramic view of the Ebro delta

Panoramic view from the Ebro delta

Wetlands on the Ebro delta














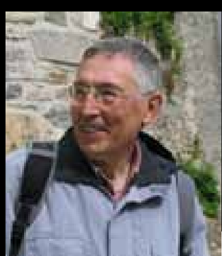
























POLICIA


Financial Overview

INCOMES		**Expected**	**Actual**	**Budget**
Participants				
	Students		€ 3'220.00	€ 2'990.00
	Staff		€ 1'110.30	€ 1'260.00
	Subtotal		**€ 4'330.30**	**€ 4'250.00**
Funds				
	Universiteitsfonds	€ 450.00		€ 450.00
	CvB fonds	€ 300.00		€ 400.00
	VSSD-SRF	€ 197.17		€ 150.00
	Subtotal	**€ 947.17**		**€ 1'000.00**
Sponsoring				
	Sponsoring	€ 400.00		€ 1'500.00
	Sponsoring via Dispuut Watermanagement	€ 3'998.76		€ 3'000.00
	Subtotal	**€ 4'399.06**		**€ 4'500.00**
TOTAL INCOMES		**€ 5'346.23**	**€ 4'330.30**	**€ 9'750.00**

COSTS		**Expected**	**Actual**	**Budget**
Transportation				
	Train Ticket		€ 3'146.10	€ 3'000.00
	Rental Busses		€ 1'808.00	€ 1'850.00
	Fuel		€ 362.63	€ 300.00
	Parking Tickets, Road Toll, etc.		€ 203.87	€ 150.00
	Subtotal		**€ 5'520.60**	**€ 5'300.00**
Accommodation				
	Accommodation Students		€ 2'332.53	€ 2'080.00
	Accommodation Staff		€ 304.80	€ 420.00
	Subtotal		**€ 2'637.33**	**€ 2'500.00**
Promotion				
	Program Booklets		€ 0.00	€ 50.00
	Final Report	€ 400.00		€ 450.00
	Subtotal	**€ 400.00**		**€ 500.00**
Other				
	Pullovers or T-Shirts		€ 0.00	€ 500.00
	Presents		€ 335.55	€ 200.00
	Borrel and Dinner	€ 120.00	€ 180.00	€ 250.00
	Excursions		€ 150.00	€ 0.00
	Various		€ 156.39	€ 150.00
	Subtotal	**€ 120.00**	**€ 821.94**	**€ 1'100.00**
Subtotal		**€ 520.00**	**€ 8'979.87**	**€ 9'400.00**
Unforeseen costs			€ 176.36	€ 350.00
TOTAL COSTS		**€ 520.00**	**€ 9'156.23**	**€ 9'750.00**

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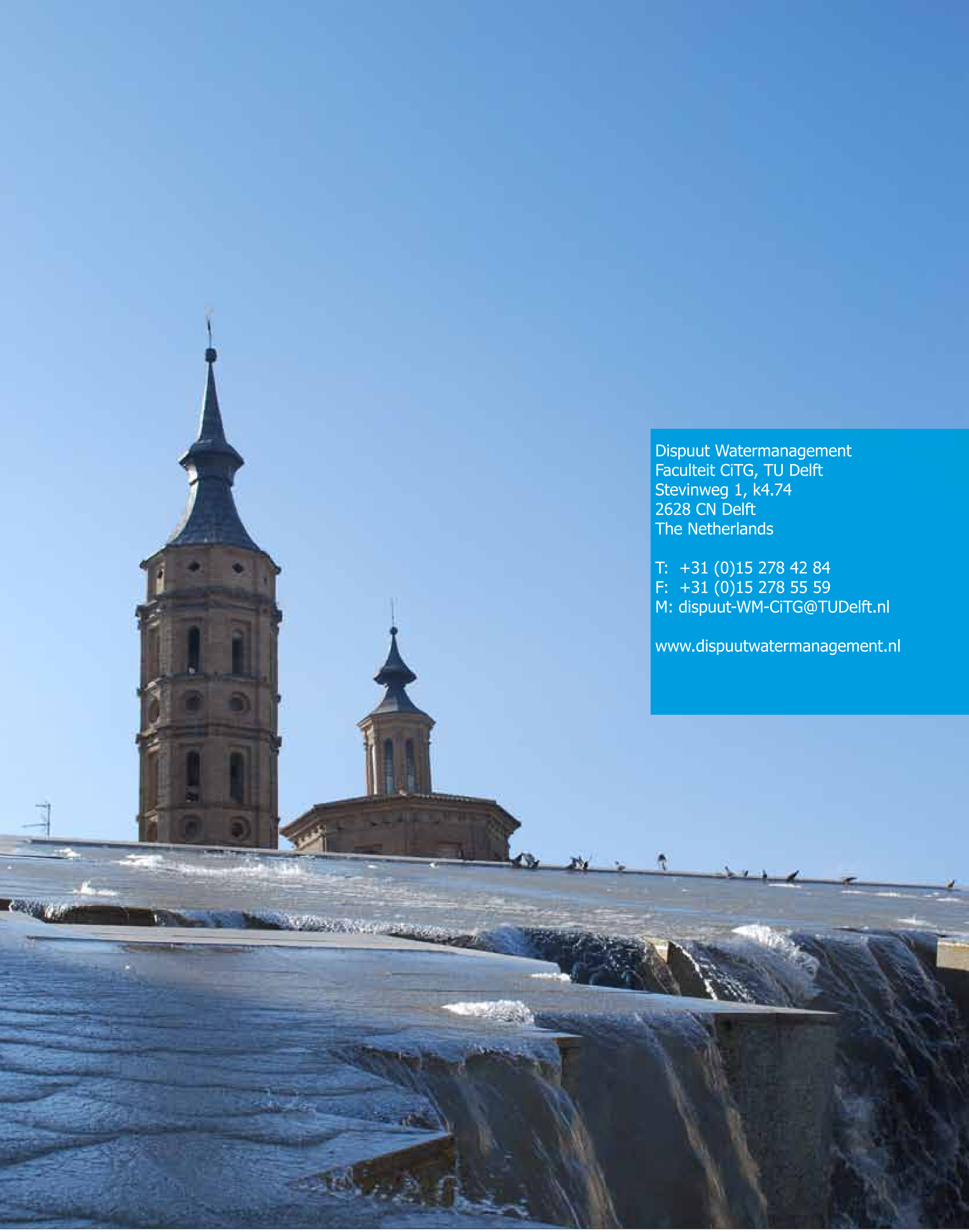

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