Technical Impact Report

Landscape Led Design

Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
SCAPE
European Regional Development Fund


2 Seas Mers Zeeën
Water Resilient Cities

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INTRODUCTION

Each year, our environment suffers from climate-related natural hazards such as flooding and droughts. In the years to come, the impact of these problems will continue to increase, challenging our societies even more. Coastal areas are especially vulnerable to flooding, and coastal cities face a high risk of increasingly costly flooding as sea and river levels rise due to climate change. To cope with the issues of drought and extreme rainfall, extra buffering and drainage capacity is necessary.

Interreg's SCAPE (Shaping Climate change Adaptive PlacEs) project looks into the challenges of climate change in the 2 Seas area[1] and the problems concerning water management in particular. SCAPE seeks to address the challenges of heavy rainfall, the rise in sea level, salinisation, urban heat and extreme drought by developing an alternative strategy for water management based on Landscape Led Design (LLD, see below). The central question and baseline for this strategy can be formulated as follows: Can Landscape Led Design be used to design an adaptive water management system which mediates the problems of climate change?

To answer this question, pilot projects have been set up in Ostend ("City River" and "Gardens of Stene"), the Zwin, Brighton and Hove, Kent and Middelburg. The different pilots each have their own characteristics in terms of landscape, some areas being urban, others fringe or rural. Each project conducted two 'climate tests' as a tool to collect climate change parameters relevant for the pilot in a structured manner.

This iterative process of conducting climate tests has improved the strategy for water management so that it can be used as a guideline for future projects in similar cities with the aim of dealing with the issues caused by climate change and the challenges of water management in particular.

[1] "The [2 Seas] Programme area covers the coastal regions along the Southern North Sea and the Channel area. Four different Member States are involved: England, France, the Netherlands and Belgium, and the total area represents a total of 88,000 square kilometres. This makes it one of the largest cross-border Programmes in Europe." Source: https://www.interreg2seas.eu/en/content/programme-area

Landscape Led Design (LLD)

LANDSCAPE LED DESIGN (LLD)

Integral to the question at hand is the concept of Landscape Led Design (LLD). LLD uses the characteristics of the urban landscape – e.g. soil characteristics, the natural hydrological system, natural vegetation and current land use – as a starting point. Measures aim to enhance the natural systems rather than negatively affecting them.

Integrating a natural system into the urban landscape requires a specific design approach in order to strengthen the symbiosis. Conventional water management measures often do not take the landscape-specific characteristics into account, or they do so insufficiently. The SCAPE project wishes to build upon the principles of the European Landscape Convention (ELC) to implement a new approach in water management, thus coined as 'Landscape Led Design', or LLD. To achieve this, the SCAPE project developed a climate test that can be applied to any new project development. This test forms the basis for any on-site implementation and identifies the potential LLD solutions that can be executed.

question analysis climatetest 2

PROJECTPARTNER		**COMPANY/ORGANIZATION**	**PROJECTOMSCHRIJVING**	
PP2		**TMVW**	Uitvoering van wegenis- en riolerings-werken in de Victorialaan tussen de Fortstraat en de Liefkemores-straat (tot aan de Victorialaan nr.26/nr.47) met inbegrip van het aanleggen van een City River op het grondgebied van de stad Oostende	
		TOTALE OPPERVLAKTE PROJECT (m^2)	10.380,00	
1.	**AFSTROOM WATER VERMIJDEN OP HET TERREIN**			
1.1	**RELIEF**		**TOEPASSING PROJECT:**	
		KEUZE RELIEF TERREIN>>	VLAK TERREIN	
		Richtlijn: bufferen en/of het infiltreren: over de volledige lengte van de projectzone.	De buffers en de infiltrerende groenzones zijn over de volledige projectzone aangelegd.	(beschrijving toegepaste buffer/infiltratie project)
1.2.	**GROEN**		**TOEPASSING PROJECT:**	
		KEUZE BEPLANTING GROEN>>	BEPLANTING LAAG/MIDDELHOOG/HOOG	
		OPPERVLAKTE GROEN PROJECT(m^2):	1.094,24	(totale oppervlakte groen invullen in m^2)
		Richtlijn: de groenoppervlakte bedraagt 10,54 procent van de totale oppervlakte van het project (matig gunstige invloed op vertraagde waterafvoer en matig gunstige invloed op heatstress)	In dit project draagt de open constructie van de City River samen met de ondergrondse buffer ook in een belangrijke mate bij tot een gunstige vertraagde waterafvoer en een afname van de hittestress	(beschrijving toepassing beplanting project)
1.3.	**KLEUR(CONTRAST) MATERIAAL**		**TOEPASSING PROJECT:**	
		KEUZE KLEUR(CONTRAST) MEEST GEBRUIKTE MATERIAAL TOPLAAG>>	GRIJS	
		Richtlijn: de kleurkeuze van de verharding stimuleert het negatieve effect van de hittestress - keuze voor voldoende groenoppervlak is noodzakelijk	Er werd gekozen voor een combinatie wit-grijze beton in combinatie met graniet natuursteen, de waterloop en de	(toegepaste beplanting project)
2.	**WATERVOORRAAD: BUFFEREN EN HERGEBRUIKEN VAN HEMELWATER**			
2.1	**BUFFEREN VAN HEMELWATER**			
		VOLUME OPEN BOVENGRONDSE WATERVOORRAAD (m^3):	100	(invullen totaal volume in m^3)
		OMSCHRIJVING (OPEN BOVENGRONDS):	buffer Cityriver : 50 m^3 + 50 m^3piekdebiet	(beschrijving open bovengrondse watervoorraad)
		VOLUME GESLOTEN BOVENGRONDSE WATERVOORRAAD (m^3):	0	(invullen totaal volume in m^3)
		OMSCHRIJVING (GESLOTEN BOVENGRONDS):	geen	(beschrijving gesloten bovengrondse watervoorraad)
		VOLUME ONDERGRONDSE WATERVOORRAAD (m^3):	500	(invullen totaal volume in m^3)
		OMSCHRIJVING (ONDERGRONDS):	buffer GRES DN 1600 : 250 m^3 + opvang extra piekdebiet 250 m^3	(beschrijving ondergrondse watervoorraad)
		Richtlijn: er is een buffervolume van 600 m^3 voorzien, deze watervoorraad kan gebruikt worden voor hergebruik van hemelwater	De buffervoorraad staat eveneens in verbinding met een vijver in de buurt van een aangelegd park, er is voldoende watervoorraad voor gebruik beschikbaar	
2.2	**HERGEBRUIKEN VAN HEMELWATER**			
		MAXIMALE JAARLIJKSE OPVANGCAPACITEIT HEMELWATER VOOR DE PROJECTZONE (m^3)	8.304	
		MAXIMALE PIEKBUI (T100) OPVANGCAPACITEIT HEMELWATER VOOR DE PROJECTZONE (m^3)	ADVICE RANGE (MAXIMUM) : 851,16 m^3 - 1038 m^3	(simulatie T100 volgens bron STOWA 2018-12)
		VOLUME WATERVOORRAAD VOOR PIEKBUI (m^3):	300	44,06% peak-buffer T100 (12 hours heavily(intense) rain)
		VOLUME WATERVOORRAAD VOOR HERGEBRUIK (m^3):	300	(totaal volume in m^3)
		Richtlijn: er is een buffervolume van 300 m^3 voorzien voor hergebruik van hemelwater, het hergebruik van hemelwater draagt bij tot een vertraagde waterafvoer		
		TOEPASSING KEUZE 1	controle waterkwaliteit - circulatiestroom - regelsysteem winter/zomer/shotbalken	
		TOEPASSING HERGEBRUIK WATERVOORRAAD KEUZE 1	circulatiestroom van 50l/s is voorzien in de City River, controle waterkwaliteit door periodieke staalname is voorzien, regeling niveau door schotbalksysteem, filters en periodieke waterzuivering is voorzien	(toepassingen beschrijven)
		TOEPASSING KEUZE 2	waterafname voor beplanting	
		TOEPASSING HERGEBRUIK WATERVOORRAAD KEUZE 2	beperkte waterafname voor de beplanting is voorzien	(toepassingen beschrijven)
3.	**INFILTRATIE HEMELWATER OP EIGEN TERREIN**			
3.1	**WATERINFILTRATIE (mogelijkheid waterinfiltratie volgens het type BODEM)**			
		KEUZE SAMENSTELLING BODEM >>	DOORLATEND HOOFDZAKELIJK ZAND	
		controleer eerst de grondwaterstand en maak verder een keuze tussen 'HOOG' of 'LAAG' >>	LOW	
			SALINIZATION PRESENT	INFILTRATION REQUIRED!
			drainerende GRES buis DN 800	
3.2	**WATERINFILTRATIE (mogelijkheid waterinfiltratie volgens het type VERHARDING)**			
		KEUZE VERHARDING >>	VERHARDING NIET WATERDOORLATEND	
		OMSCHRIJVING GEKOZEN VERHARDING	betonstraatstenen/ uitgewassen beton	
		richtlijn: andere maatregelen gewenst zoals buffer, aanleg groen,..	Er is voldoende buffer voorzien voor opvang van hemelwater, er is voldoende oppervlak groen voorzien	
4.	**BUFFEREN HEMELWATER MET VERTRAAGDE LOZING OPPERVLAKTEWATER**			
		BESCHRIJVING REGELING WATERTOEVOER/AFVOER):	regeling via schotbalken	(beschrijving regeling watertoevoer/afvoer)
5.	**LOZING HEMELWATER op RWA stelsel**			
		KEUZE LOZING HEMELWATER OP RWA STELSEL:	JA	
		BESCHRIJVING NOODZAAK AFVOER RWA:	overloop bij langdurige neerslag naar oppervlaktewater via coalescentiefilter, bij hoge peilen overloop naar RWA	(beschrijving afvoer RWA)
6.	**LOZING HEMELWATER op DWA of GEMENGD stelsel**			
		KEUZE LOZING HEMELWATER OP DWA of GEMENGD STELSEL:	JA	
		BESCHRIJVING NOODZAAK AFVOER DWA of GEMENGD STELSEL:	overloop bij langdurige neerslag naar oppervlaktewater via coalescentiefilter, bij hoge peilen overloop naar RWA, verder loopt het RWA stelsel over in een gemengd stelsel	(beschrijving afvoer DWA/GEMENGD)

Example format climate test

Climate test

The 'climate test' designed by the SCAPE project focuses on the design parameters of an LLD project. It takes the existing landscape as a starting point and assesses the impact of future climatic change.
At the basis of the design of the climate test was that the following parameters need to be addressed:

- Relief and soil: Are there options for infiltration over a smaller/larger stretch?
- Greenery and pavement: How can heat stress be addressed? Is irrigation required?
- Precipitation: What measures can be taken?
- Drought: Is water recovery an option?
- Water infiltration: What is the soil type at 5 metres? What is the groundwater level? Is salinisation an issue?

The climate test borrows its structure from Lansink's Ladder of Waste Hierarchy and applies it to rainwater. This hierarchy ranks the options for dealing with rainwater by environment friendliness, in order of preferred method:

1. Retention for reuse;
2. Infiltration on own site;
3. Buffering with delayed discharge into surface water or an artificial drainage route for rainwater; and
4. Discharge into rainwater drainage pipe (RWA) in the street. Only if the best available techniques do not permit any of the aforementioned drainage methods, may rainwater be discharged into the public sewerage system in accordance with legal provisions.

Doing the climate test a first time is meant to trigger investigations in a structured manner by addressing the successive questions in order. Conducting the test again is intended to achieve more detail for the plan. A rainwater study compares the technical feasibility and the costs/limitations associated with the implementation of the proposed techniques. Looking at the technical feasibility of reuse, infiltration or delayed disposal of water, a number of aspects need to be taken into account:

- First, the parameters of the environment in its broad context must be defined (relief, soil composition, type and amount of greenery, any paving present). These form the "landscape" in which the intervention is planned.
- These parameters are then combined with a number of climate aspects (e.g. precipitation, and drought on the basis of temperature and wind).
- Also, long-term forecasts of expected climate changes are available and can be useful to take into account while designing a climate-proof intervention.

The climate test (for an example, see the result sheet on page 8) allows for a structured design process, as it asks targeted multiple-choice questions to streamline the reasoning that happens when taking the possible consequences of climate change into account.

In the SCAPE project, the climate test was done twice for each project, with an interval of at least a year. The first test identified the challenges of the site, the directions to address these and the more detailed studies to be carried out. Based on the results of these studies, the second climate test focused on the actual measures to be taken.

Pilot project

East Bank, Ostend

Source: Google Maps

East Bank

SITE DESCRIPTION

The former industrial and harbour area of Ostend, Belgium – the city's so-called Oosteroever (East Bank) – is currently being redeveloped into a centre for housing and small industrial and business activities. Characterised by the area's former activities, the Victorialaan, with its plan area of 10,380 m^2 public realm, forms the ideal context for this kind of mixed-use urban development.

In the early phases of the project, a master plan was drafted that outlined the general ambitions for the reconversion of the site. An important aim was to preserve the new neighbourhood's relationship with its industrial and maritime history. This relationship is expressed in the functional design of the site: the permeability of the public space is just one of the elements reminiscent of its former functional characteristics.

Moreover, the master plan also expressed the clear ambition to make the area more adaptive to climate change, using blue and green infrastructures to counter the urban heat island effect in a nature-friendly manner. The blue infrastructure, integrated in the street design, was nicknamed the "City River". As the backbone of the Victorialaan's design, the City River will incorporate a continuous flow of water that runs through the area's five different zones. Each zone has a different atmosphere, e.g. swift-flowing water versus a pond, high-green versus low-green landscapes, benches, play areas, different types of lighting, etc.

The structure itself already provides some eco-services, and by connecting to the surrounding nature areas this new blue-green network will contribute to the neighbourhood's liveability and biodiversity. The choice to work with native species reinforces this.

DESIGN CHALLENGES

The key design requirements addressed during the subsequent climate tests were:

- Avoiding algae growth;
- Ruling out potential public health issues related to water reuse;
- Avoiding water shortages during long periods of drought;
- Ensuring the stability of the groundwater level while combatting salinisation;
- Including suitable and sufficient green areas into the design; and
- Making the project resilient to climate change.

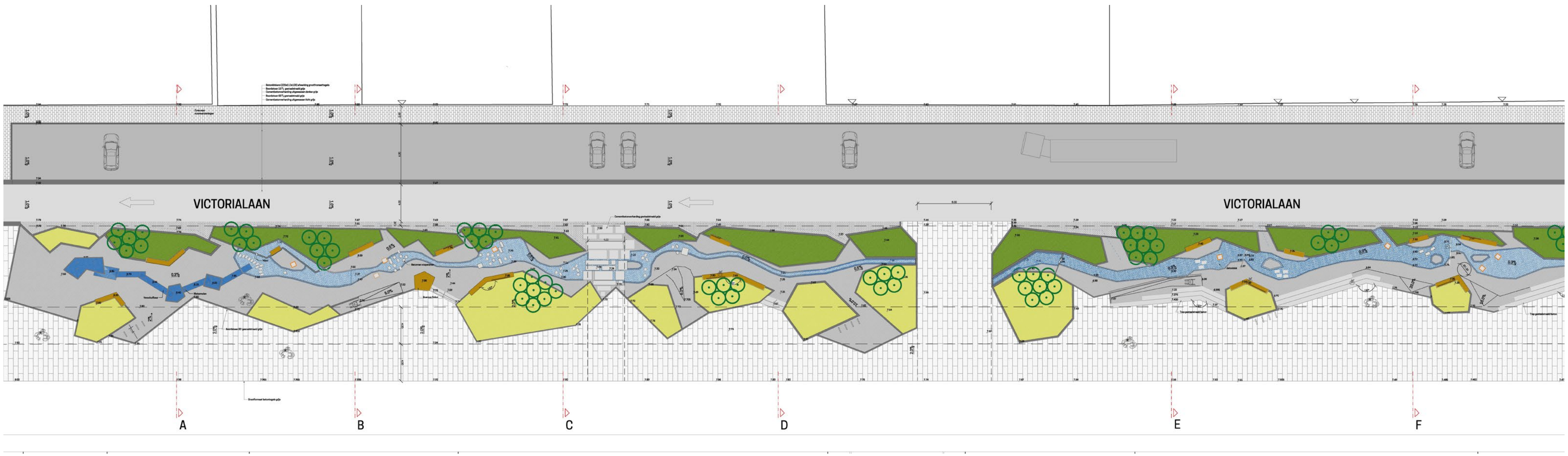
CLIMATE TESTS

A first climate test for the renovation of Ostend's East Bank took place on January 18, 2017 in Ostend. The test focused on plans for the Victorialaan area and forms the basis for all implementations to be carried out on the site. Twenty-one people, including 6 from the SCAPE partnership, participated in this climate test.

In translating the above requirements into action points, the decision was made to integrate a Water-Sensitive Urban Design (WSUD) strategy with a Landscape Led Design (LLD) strategy. The combination of the two approaches is valid and interesting because using the existing natural water system to create an urban water balance in the newly developed area strongly correlates with the LLD principle of allowing natural processes to guide human changes.

Based on the results of the climate test, the following design parameters were identified:

1. Avoiding excess water runoff: relief, green, colour of materials
    a. Using relief that will allow buffering and/or infiltration over the entire length of the project zone, and
    b. Using green planting to delay the discharge of surface water and to combat heat stress;
2. Water supply: buffering and re-use of rainwater;
3. Infiltration of rainwater on private terrain: soil, pavement;
4. Buffering of rainwater through the delayed discharge of surface water;
5. Discharge of rainwater into the RWA system; and
6. Discharge of rainwater into the DWA or MIXED system.



Plan of design

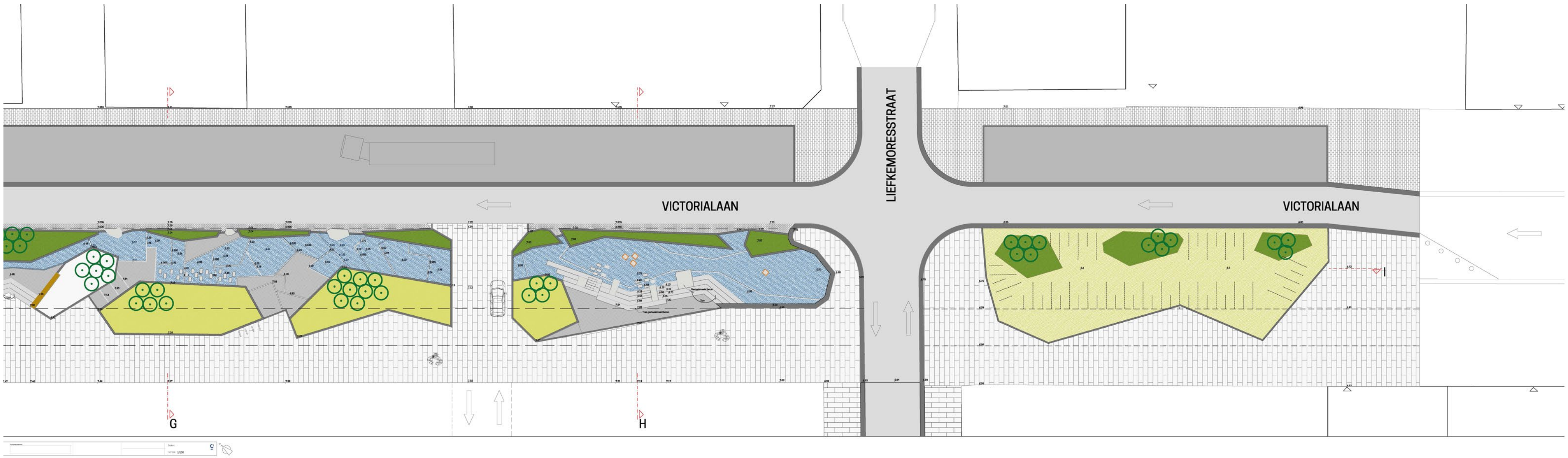
The urban landscape of Ostend's East Bank, configured by its former harbour activities, is the context for this climate-adaptive design. Flooding, drought and heat stress form the site's main challenges; technical solutions are combined with a more holistic design strategy to tackle these water-related issues. The methods used will not only enhance the visibility of water in public spaces but will also enhance the site's resilience to flooding and drought.

The result of this first climate test was a list of things to do: to further investigate, answer questions that had been raised, fit the relevant ideas into the design, and further detail the plans.

LLD MEASURES

In the second climate test, held in November 2019, the implementation of the above requirements was further discussed, resulting in the subsequent list of LLD measures to be incorporated at the site.

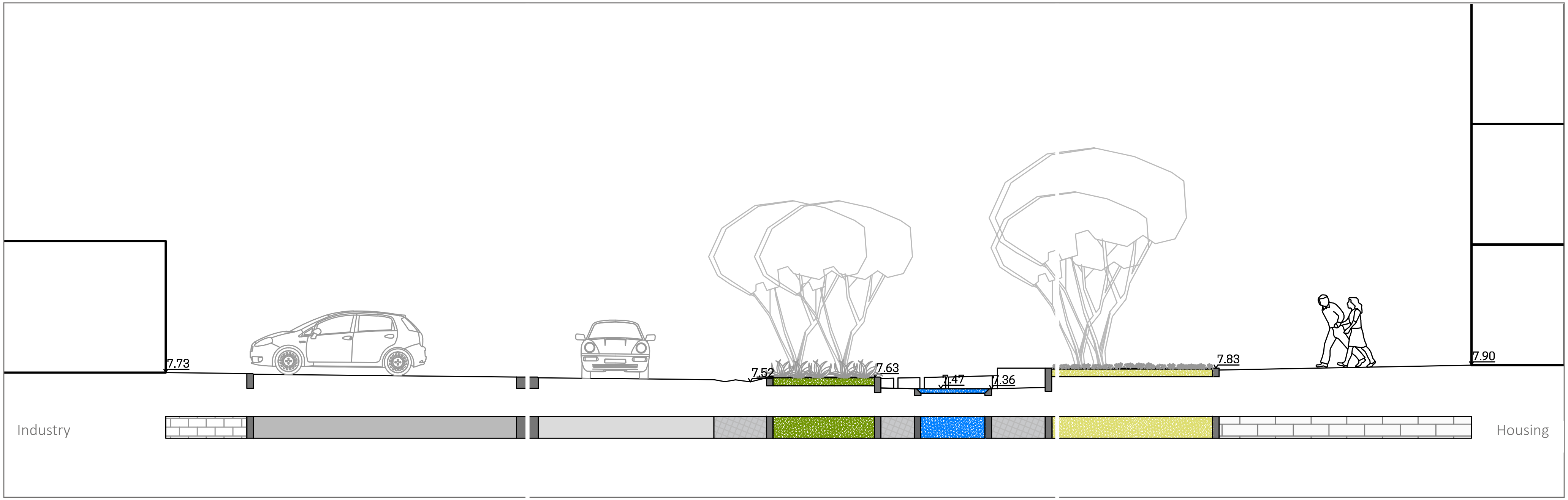
- **Streets and pavements:** The material used to construct streets and pavements will be semi-permeable, raising the site's resilience to heavy rainfall. The pavement and permeable pipes of the sewerage system (see below) aim to infiltrate as much water as possible to diminish the impact of rainfall backing up and flowing inland where flood risks are high.
  A second important benefit of rainwater infiltration is that it replenishes the groundwater. A higher water table makes it easier to deal with drought. Yet the salinisation of the groundwater, related to sea level rise, creates a fragile balance between fresh and brackish water. Allowing more fresh surface water to infiltrate into the ground can profoundly counterbalance salinisation.



Plan of design

- **Sewage system:** Periods of heavy rainfall, which will likely increase with continued climate change, are a major challenge for the present sewerage system. With the installation of permeable pipes, the current sewerage system will be adapted to better handle the excess water. Moreover, all pipelines throughout the entire site are interconnected and placed horizontally.
  This connectivity (e.g. between the streets H. Baelskaai, Fortstraat and Liefkemoresstraat) further helps to maximise infiltration.
  During the climate test, this expected increase in rainfall resulted in the ambition to be able to buffer a once in 20 years' downpour. Security measures were taken into account to deal with potential overflow. Two pipes were added to direct the water to the nearby docks, while an extra pipe was attached and connected to the standard sewerage system. The possible overflow of water in the entire system will be monitored.

- **Buffer capacity:** In order to ensure a highly resilient, adaptive site that meets the ambitions above (buffering a once in 20 years' downpour), a buffer capacity of 500 m³ will be constructed, with 300 m³ below and 200m³ above ground. The water runoff from the street will be captured in the above ground buffer and will overflow into the underground buffer.



Section of design

- **Continuous water (stream and buffer) above ground:** A second water-related ambition is to realise a continuous above-ground water stream that has an educational aspect. Creating increased awareness is an important feature of SCAPE. The design of the City River offers the possibility to visually showcase dry and wet periods: in cases of heavy rainfall, the fluctuation of water is highly visible, while in dry periods the stream will be smaller. To fill this buffer capacity, the interconnected area must be large enough. That is why the Victorialaan is interlinked with the Fortstraat and the water systems of the various developments along the Victorialaan.
  The continuous flow of water is set at 50 l/s in the daytime, and 25 l/s at night. The constant stream of water runs through five different zones.

- **Green spaces:** The blue infrastructure will be implemented together with green spaces. The vegetation and green spaces, integrated on the site, were carefully selected to mitigate the so-called urban heat island effect, thereby creating a more comfortable living climate. In this context, the vegetation is directly integrated into the design of the site and offers not only an extra feature but also enhances the site's climate resilience. All vegetation will be adapted to the local and coastal climate. Moreover, on a functional level, the green infrastructure will separate the redevelopment area from the industrial sites on both sides of the Victorialaan and will be connected to the new developments on the Dr. Eduard Moreauxlaan. In this way, the green areas will be interconnected, enticing people to explore and providing an accessible walkway towards the protected dune area nearby.

Visualisation of design

Visualisation of design

TECHNICAL EVALUATION

At the time of writing, this project is still underway, although as of March 2021 parts will start to be completed. So far no data are available that can be used to indicate whether the project has been worthwhile.

Water system

Nevertheless, the functioning of the new water system in the area is already a big improvement: all surface water of the 11ha area is now captured and infiltrated, reducing the pressure on Ostend's sewerage system to dispose water to the sea. Concretely, this means a reduction of the need for pumping and buffering facilities, and this in its turn allows the city of Ostend to further postpone (or call off) investments in extending them to adapt to climate change.

Prevented costs of damages

The costs of damages in Ostend of the storms and flooding in the first half year of 2018 were investigated. Insurance data made available by Assuralia was used for this. The total costs of damages that were filed were € 176,200,000 for 76,573 damage report files, so about € 2,301 per file. About 200 damage reports were filed from Ostend, so an estimate of the costs of damages in Ostend would be about € 460,214. Since the city of Ostend was primarily affected, and since the additional water buffering and the reduction on the pressure on Ostend's sewerage system achieved by the measures taken in the East Bank and in the Gardens of Stene will have most impact on the city, this number can be taken as an estimate of the prevented costs of damages by the SCAPE measures having been taken.

In the data, the cause of the damage has been made explicit: storm or flooding. Of particular interest is that the number of damage report files for flooding is only about 7% of the total but the costs of damages by flooding per file is much higher: about € 6,109 per file. This means that the estimate of the costs of flooding damages in Ostend will probably be higher than the one mentioned above that was based on an average cost per file over the country.

Economic impact

Also, we have noticed that since the start of the project the prices of apartments in the area have increased by about 20%, which suggests that the restructuring of the area has been a positive impulse for people to live and stay in the area. We expect this trend to accelerate when the project is completed. In future 10,000 people will live in this more climate resilient area.

Monitoring

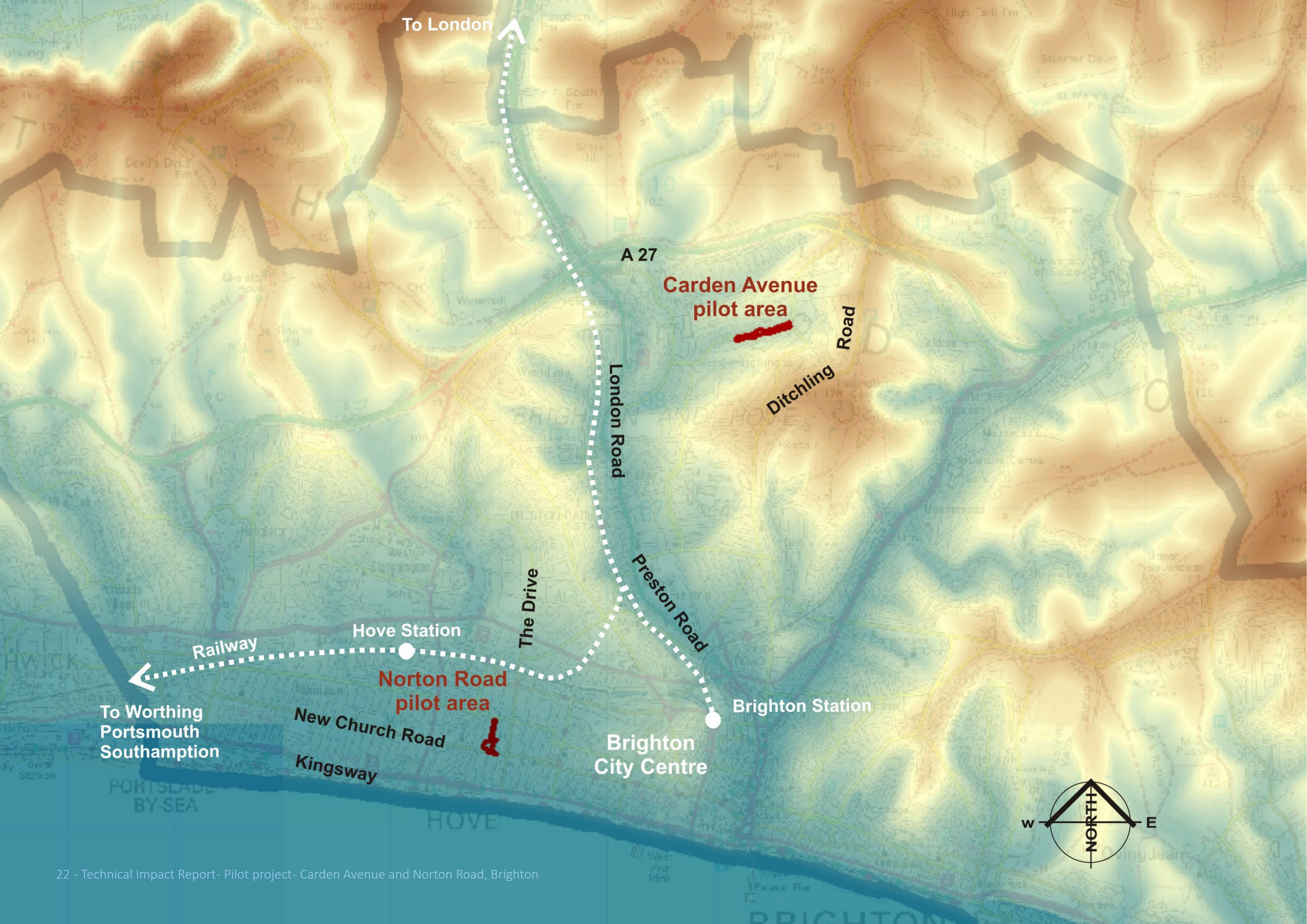
With respect to the technical functioning of the water system, we have been monitoring all its individual components from the time they were built and will continue to do so to fine-tune it. We have learned to adapt the levels of various overflows, both in the City River and in other surface water, so that we can retain as much water as possible in the system, e.g. for limited reuse. Linked to this is the ability to control the volume of water that is diverted to the drainage pipes, because this determines the amount of surface water that can infiltrate into the groundwater to combat salinisation as opposed to simply being flushed out to sea. We have already seen that the abundance of sand in the area may present a problem and have responded by installing additional filters to trap it. The ability to control the water volumes is also used during fine-tuning to adapt to uncertainties in the modelling.

Social impact

Apart from real estate prices and the functioning of the water system, there is an expected value gain from non-tangible effects that cannot be directly expressed in financial profits: the educational value of being aware of the water system when observing changes over time in the water level of the City River, the return of biodiversity to the area, improved air quality, the reduction of heat stress, and people's enjoyment of being in the area.

Pilot project

Carden Avenue and Norton Road, Brighton



To London
A 27
Carden Avenue
pilot area
Ditchling
Road
London Road
Preston Road
The Drive
Hove Station
Railway
To Worthing
Portsmouth
Southampton
Norton Road
pilot area
New Church Road
Kingsway
Brighton Station
Brighton
City Centre
NORTH
W
E

Carden Avenue and Norton Road

SITE DESCRIPTION

Pilots in two neighbourhoods of Brighton and Hove in the UK are exploring and testing Landscape Led Design (LLD) solutions that can be retrofitted to urban water management systems. They focus on innovative sustainable drainage systems (SuDS) that aim to increase the capacity of existing, traditional urban drainage systems to cope with extreme rainfall.

Brighton and Hove is ranked 8th in the top 10 Flood Risk Areas in England. Despite its coastal location, the principal flood risk in the city is not from the sea, but from surface water runoff resulting from very heavy rainfall. Surface water flooding arises when local drainage systems cannot sufficiently cope with the volume of surface water running downhill from intense rainfall. This can result in a rapid build-up of surface water which flows down roads, gardens and open spaces flooding properties in low laying parts of the catchment.

The two pilots chosen for this project exemplify different landscape characters. Both are located midway through their catchment areas in order to stop runoff before it reaches flooded properties.

- The Carden Avenue pilot aims to reduce water build-up in a known problem area for flooding. It is located on the outskirts of the city in one of the dry valleys along the edge of the South Downs. The main means of disposing of runoff from roads and buildings are via the underground water and sewer system and soakaways, respectively. Soakaways are holes dug into the ground that allow water to filter through it and infiltrate into the soil. The area is comprised mainly of privately-owned, two-storey houses with sizable front gardens, set back from wide roads lined by grass verges.
- The Norton Road pilot aims to reduce the flood risk to basement properties. It is located in the Hove coastal strip between the railway (north) and the sea (south). Water runoff disposal is via the gully system that runs into the sea. The area comprises of mid-rise, high-density, mixed-use, largely pre-1914 neighbourhood with a significant presence of on-street car parking.

DESIGN CHALLENGES

The aim of the two pilots in this project is to:

- increase the capacity of the neighbourhoods' traditional, existing drainage infrastructure to cope with extreme rainfall;
- in the Carden Avenue case, to reduce the risk of contamination to the aquifer from which water for the city's consumption is currently extracted;
- respect the historic character of Norton Road; and
- enhance amenities for people who live and/or work in the immediate vicinity of the pilot areas and within the wider catchment (`co-benefits').

The concept is to reach these aims by designing Sustainable Drainage Systems (SuDS) following the Landscape-Led Design (LLD) methodology in order to mimic nature and make the developments behave, hydraulically, more like 'natural' landscapes. Rainwater is collected, slowed down, cleaned and stored in a variety of ways before it is released into the ground, a watercourse or the sewer.

CLIMATE TESTS

Before the first Climate Test was carried out on 26 September 2017, community consultation events for each of the pilot sites took place. The aim was to explain the project, identify concerns and gather local knowledge from residents and stakeholders; including detailed information about how surface water behaved in the pilot areas during heavy rainfall.

The first Climate Test assessed the pilot sites, performed SWOT analyses, made recommendations and identified potential additional benefits, such as:

- Explore opportunities to increase surface water storage and surface permeability: review existing data on catchments and surface water flow routes and consider potential uses of the landscape for more effective management of water, while seeking multi-functional benefits. Re-design and manage public spaces, roads and verges with opportunities for improved amenities, accessibility, sustainability and flood management.
- Proposals should be sustainable, maintainable and affordable, and should involve and collaborate with residents, businesses and schools.
- Working with partners including Southern Water to raise awareness in the wider catchment area on how the community can play a role in flood management (e.g. considerations around mis-connections of foul sewers, vehicle cross-overs, paving over gardens, the benefits of vegetation, etc.) (Carden Avenue only)
- Maximise opportunities around Hove Town Hall and car park to make better use of existing spaces; consider opportunities to redesign roads, parking and pavements for potential flood management measures; and consider potential to add capacity to the multi-storey car park to reduce on-street parking and provide flood prevention measures (Norton Road only).

Bus stop (to city outskirts) **Bus stop (to city outskirts)**

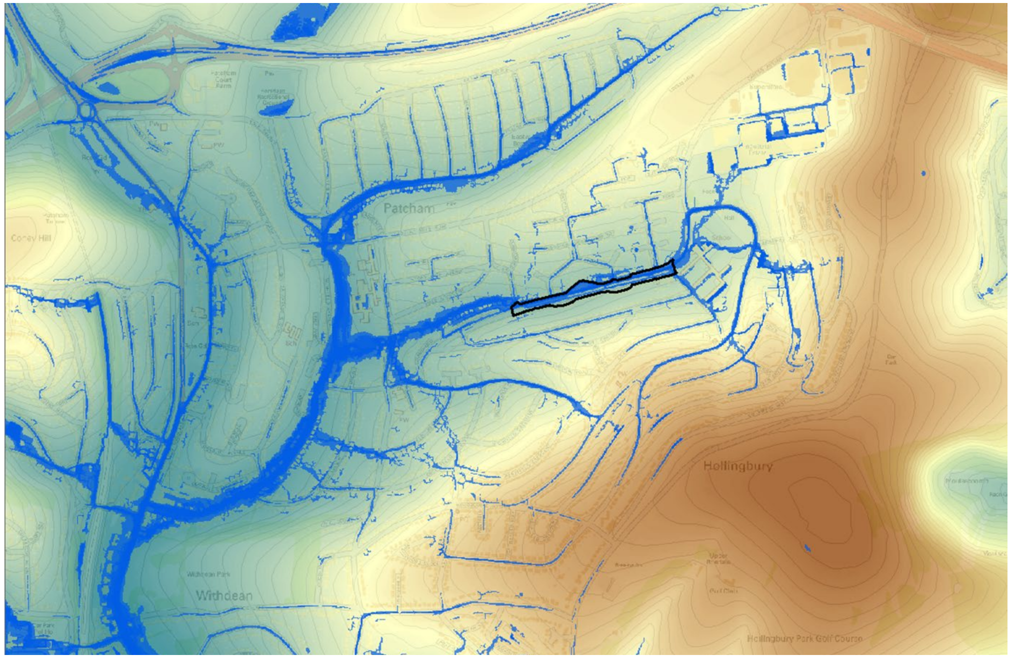
Carden Avenue **Zebra crossing** **Bus stop (to city centre)** **Bus stop (to city centre)** **Pelican crossing**

After the Climate Test was completed, Brighton and Hove City Council (BHCC) ran a competition for ideas that followed up on these recommendations. Representatives of the Expert and the Local Resident groups formed to support pilot development and implementation, became part of the competition's selection panel. Robert Bray Associates (RBA) was selected to develop concept designs for both Norton Road and Carden Avenue pilot sites. After RBA's concept design was developed, experts and residents were invited to view and provide feedback via drop-in exhibitions in venues near the pilot sites.

In the Carden Avenue case, concerns were raised about the safety of the incidental children's play area (which was removed from the design), and potential higher maintenance costs of the proposed design (see Technical Evaluation below).

In the Norton Road case, there were concerns regarding loss of car parking and the request for the design of the central channel to be extended.

A second Climate Test event was organised on November 6, 2019 to review the design proposal for Carden Avenue. For more information see Technical Evaluation below.



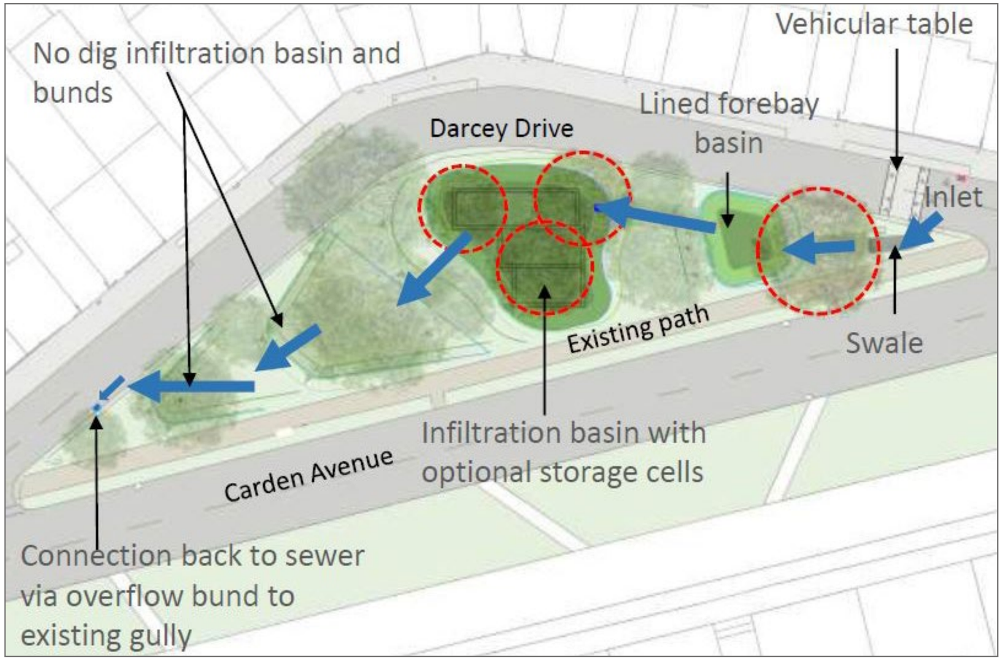
Surface water flow paths within the Carden Avenue catchment (in blue) and with location of Carden Avenue pilot.


Norton Road

LLD MEASURES

The proposed SuDS measures at Carden Avenue comprise of a sequence of one lined and one infiltration basin retrofitted onto existing grass verges along the steeper sloped section of Carden Avenue (not shown in the image) and the triangular verge at Darcy Drive:

- Carden Avenue has wide grass verges along much of its length. These offer opportunities for runoff management, using a series of basins or swales to collect, clean and temporarily store surface water allowing it to infiltrate slowly into the ground, adding capacity to the existing pipe drainage system during heavy rainfall.
- This series of basins are designed to temporarily store and treat polluted road runoff that is then released through to the aquifer below.
- The type of planting used in the lined basins is suitable for areas that may remain wetter than others.
- Options to use permeable surfaces under car parking areas to collect runoff, either through infiltration or as overland flow into basins, are included in the design.



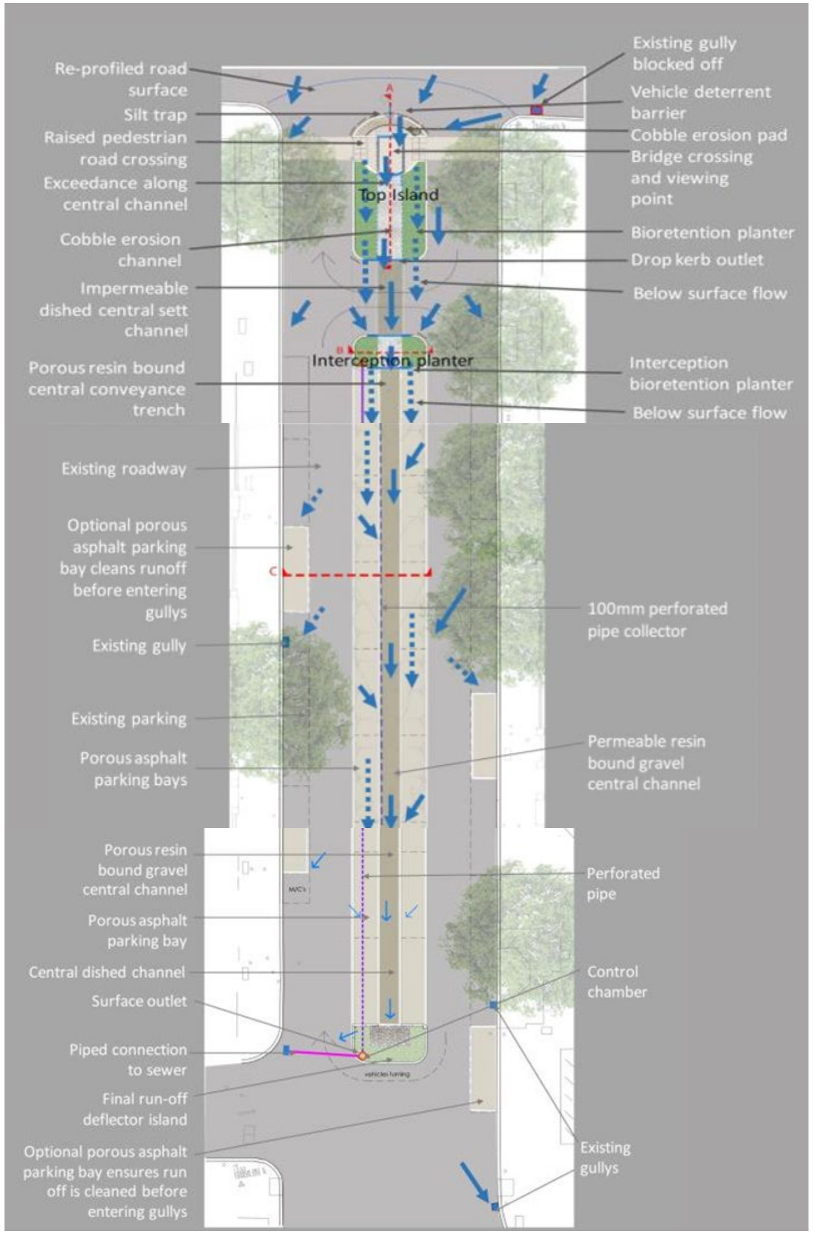
Darcey Drive design

Darcey Drive design: inlet to swale via lined forebay basin

Norton Road suffers from water runoff higher up in the catchment area not being able to enter the conventional pipe drainage system, so this surface water instead flows down the gutter on the eastern side of Norton Road, causing inconvenience and flooding of basements, particularly at the southern end of the road.
The design proposals are shown in the accompanying images to the right. Notably:

- The re-profiling of Eaton Road directs flows entering Norton Road at its upper (north) end towards its centre. The re-profiling of Norton Road includes a pedestrian crossing that helps to collect and direct runoff into a grated collection chamber at the top of the road that intercepts silt and debris.
- Once the grated chamber is full of water, it overflows into the first bio-retention planter. This planter infiltrates everyday flows and intercepts finer silt that could block infiltration surfaces along the road.
- Water then overflows again into a second planter, reinforcing the cleaning process. These planters and the pedestrian walkway enhance the character and functionality of the head of Norton Road. The planters will be planted with attractive herbaceous planting to assist in filtering runoff, and with trees or shrubs to provide visual interest and structure.
- The increased flows pass through the interception feature along a raised channel and flow down the re-profiled centre of Norton Road. This channel has a large flow capacity and a permeable surface to allow reasonably clean water to infiltrate into the storage capacity below the surface.
- In the event of very high flows some runoff may overflow sideways into the existing gutters, increasing the capture capacity of the road from a single channel to three, thereby significantly reducing flood risk.
- Tree planting at intervals enhances the character of the road.
- Water that cannot be stored within the trench profile is directed to the sewer in the same way that happens at present.

However, a sense check of the implementation budget for Norton Road resulted in costs being considerably higher than initially envisioned and thus not being viable as part of the SCAPE budget. Other funding is therefore being sought, and Norton Road was not further considered within the SCAPE context. BHCC placed a bid to the Environment Agency fund to implement the Norton Road pilot.



Design Norton Road

TECHNICAL EVALUATION

Estimation of prevented flood damage

The economic savings from prevented flood damage due to BHCC flood management measures as described above were estimated for the Carden Avenue pilot:

- These SuDS flood management measures could cost approximately £100,000. This is three times less than the provision of traditional tank storage with catchment drainage pipes at this location, which would cost approximately £300,000. In addition, the SuDS measures provide approximately $28m^3$ of additional storage volume over the required catchment volume.
- The SuDS measures would have prevented damage to 22 properties caused by the known flooding event of 2014-5. The costs of this flood per property are estimated at £20,000, for a total damage cost of £440,000 that could have been prevented.
- There are at least 160 properties located within the surface flow path of the catchment area below the Carden Avenue pilot project. A very significant flooding event of between 1 in 1000 years (0.1%) and 1 in 100 years (1%) could cause the majority of these properties to flood to a similar extent. So approximately £3,000,000 of damage could be prevented by these SuDS measures in an extreme event.

Maintenance is different but not more expensive

Required maintenance costs of the SuDS features are estimated to be not more than the normal site management costs. It amounts to checking inlets and outlets, removing silt at inlets, litter removal and grass cutting. The grass within the SuDS features should preferably be wild and left longer than usual, for ecological reasons and because in this manner it acts as a filter for runoff, slowing the flow, cleaning the runoff and encouraging infiltration. This means that maintenance is different than normal but is not more expensive than normal.

Filtering basin on Darcey Drive after rainfall earlier in the day

Monitoring is needed for evaluation

For future evaluation of the measures' technical operation, wireless sensors have been installed. A flow control monitoring device is placed at the upper basin; the level rise in the infiltration basin will be monitored by a pressure sensor device in the ground; and another flow sensor has been installed at the final outlet of the system. Together these will allow full monitoring to determine the effectiveness of the system at Darcey Drive.

Effectiveness of measures taken

The full effectiveness of the SuDS designs will only be known once they have been constructed and monitored. Having said that, modelling for a 1 in 100 return period design storm suggest that, as a minimum, Phases 1 (Darcey Drive) and 2 (top of Carden Avenue) will accommodate and remove 433 m^3 of road surface water run-off during extreme rainfall.

1400 inhabitants and 160 properties within 10 ha will become more climate resilient as they are in the catchment area that will benefit from the reduction in water runoff that is being redirected/stored by the basin system.

As a first observation on the operational effectiveness of the phase 1 Darcey Drive SuDS, a resident reported informally that the infiltration basin was 2/3 full after heavy rain and drained 2 hours afterward. The photograph on the previous page shows the filtering basin after rainfall earlier in the day.

Lessons learned

Lessons learned from undertaking the Brighton and Hove pilots:

- Utility companies lack knowledge and experience regarding SuDS measures:
  - Assume you will have to take time to explain SuDS drawings to utility companies (most did not seem to have come across similar examples before).
  - Make sure to involve the right people in the various utility companies from the start (silo working means the road works people will not be in-sync with the strategic planning people).
  - The timetable was delayed while resolving issues with below-ground services.
- Involving residents requires work:
  - Residents in different parts of the catchment area can have conflicting views and priorities.
  - There is a general resistance to change and a wariness of the new (even by those who experience flooding).
  - It is important to keep local councillors informed and supportive.
  - A flooding event is only the start of a longer-term range of hardships experienced by affected households. They may thus need further support.
- The soil type at Carden Avenue is chalk, which can be more permeable than sand or loam. This option is not available in the LLD modelling, so in the Climate Test results are only approximated.
- Regarding planning:
  - Be flexible, proactive and accommodating if faced with unforeseen risks and challenges to project implementation (e.g. the COVID-19 pandemic).
  - The lack of expertise in the Council at that time led to the outsourcing of the detailed design.
  - The delivery plan was split into 3 phases to reduce the risk of non-delivery: Phase 1 only includes Darcey Drive, as it can be seen as an independent unit that is still representative for the approach. The detailed SuDS design for Darcey Drive was finalised and the implementation of the main landscape works completed in late 2020.
  - Implementing SuDS measures in urban Norton Road is more expensive than initially thought.

Pilot project

Gardens of Stene, Ostend


Torhoutsesteenweg
Pensjagersstraat
Fietsenstalling
Fietsenstalling
Uitkijkplatform
Sint-Andreasinstituut
Boomgaard
Pergola/Buitenklas
Steensedijk
Sandershoeve
Oudstrijdersplein
Kerk
Poldertuin
Voedselplatform
Toekomstig fietspad
Oude pastorie
Samentuin
Speelweide
Kruidentuin
Cohousing
Boldershof
Stenedorpstraat
Bijenhal
Akker Landschap
Waterweide Landschap
Provinciegeleed
Schorredijk
Hoeve Schorredijk

Gardens of Stene

SITE DESCRIPTION

The Gardens of Stene (Tuinen van Stene) is a 35 ha polder landscape project situated at the outskirts of Ostend, Belgium. To many people, even the locals, the project is little known. As part of the Green Ribbon (Groen Lint) multi-use green area that is being built around Ostend, this polder landscape is being transformed into a food and landscape park that explores new synergies between recreation, nature, urban agriculture, renewable energy and much more. In this context, the Gardens of Stene is a laboratory for local dynamics and serves as an example for later projects in the Green Ribbon and elsewhere. At the same time, it provides buffer capacity for excess surface water coming from inland sources before that water can be discharged into the sea, thereby reducing flooding in the city of Ostend.

The value of the Gardens of Stene are reflected in both the top-down and bottom-up visions incorporated in the design. The ambition behind the project is to maximise results in different areas of innovation, while providing combined functions such as local food production with new forms of local involvement, and recreation and education with ecological system services, all with respect for people and planet.

DESIGN CHALLENGES

The main challenges of this project are:

- buffering excess surface water before it reaches Ostend;
- mitigating salinisation in the area;
- retaining fresh water;
- preserving the existing landscape;
- combining multiple functions: small-scale food production, ecosystem services, recreation, enlarging citizen awareness, energy production, etc.; and
- bringing together all stakeholders.

The importance of water storage in the polder area is great. Most surface water flows naturally along open water streams and then in covered channels through the city of Ostend to the harbour, where it is flushed to the sea when tides permit. When there is an excess of this water and it cannot be flushed to the sea, its level rises and causes flooding at the lowest point, which is inside the city of Ostend. The Gardens of Stene are the last buffer area (offering ‘pot polder’ flood protection) before Ostend.

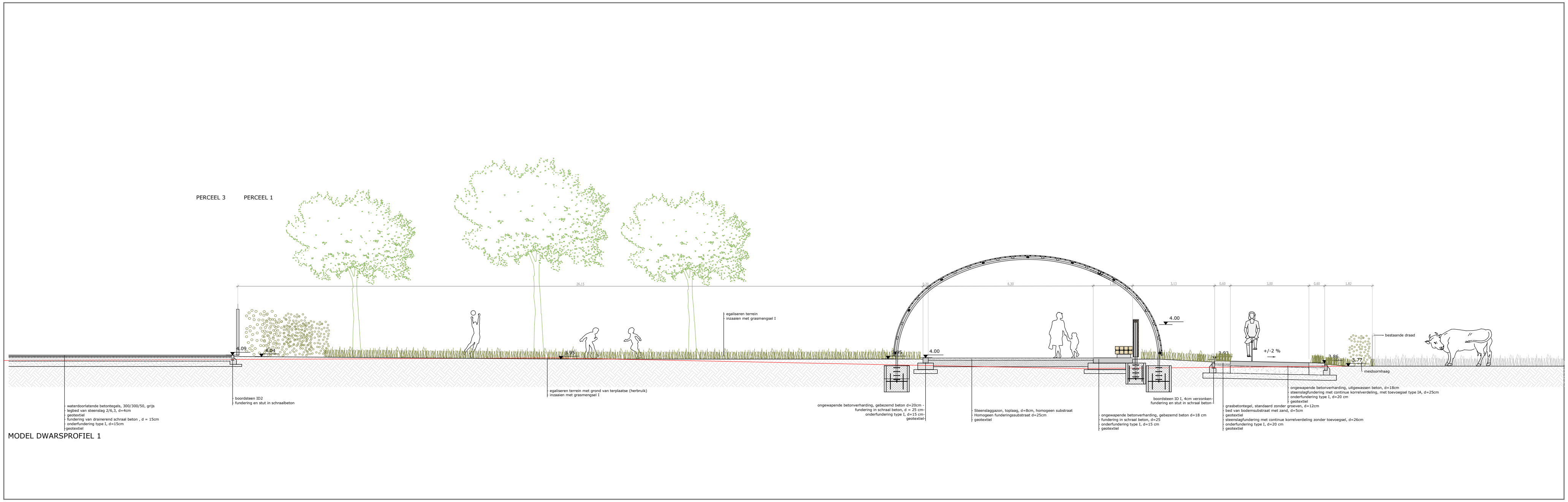
CLIMATE TESTS

To assess the project, a climate test for the Gardens of Stene took place on January 18, 2017 in Ostend. Twenty-one people, including 6 from the SCAPE partnership, participated in this climate test. This first test concentrated on understanding the project goals, on its challenges, and on the landscape and site characteristics using a manifold of maps. A brainstorming session was held on how to improve the water system, the results of which were:

- to increase the water level to 2.00 m TAW – an increase of 50 cm in winter and 5 cm in summer with respect to the situation at that time and to the bordering polder water, the 'Provinciegeleed';
- to build a dyke around the village of Stene (Stenedorp) to protect it against this water rise;
- to slope the banks of the canals and open up covered canals to further increase buffer capacity;
- to retain more water in the Gardens and uncouple the Gardens from the sewage system; and
- to do away with water-level-controlled drainage and instead use windmills to pump water into the area and bulkheads (schotbalken) to let surplus water out as needed.

Restructuring the area by means of adapted water level management and adaptation of the banks was expected to result in greater storage capacity, have a positive effect on the ecological value (higher diversity) and offer opportunities for water-bound food cultivation.

The second climate test detailed the above points.



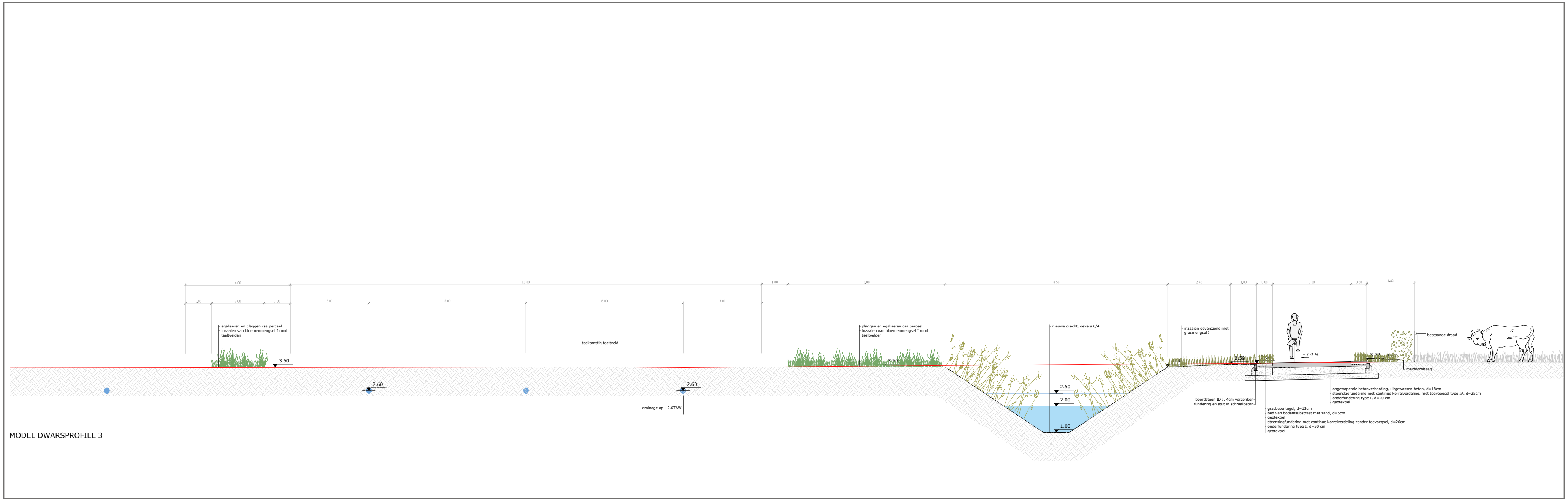
Section of design

LLD MEASURES

The Gardens of Stene offer the opportunity to showcase and implement Landscape Led design (LLD) solutions and their effectiveness to mitigate climate change effects in rural areas and urban outskirts. Water is now retained in closed catchment basins instead of infiltrating into the soil. Biodiversity has been enhanced by introducing a variety of fruit crops and rotating the crops on the fields. Furthermore, with nearly 90% of the surface area of the Gardens being green, heat stress has been reduced. The activities listed below have further contributed to the area's ecology, recreational services and flood resilience.

Increasing buffer capacity: The ground water level is now kept at 2.00 m TAW; this is higher than the Provinciegeleed, which receives the Gardens' overflow water. Raising the water table, creating new waters, sloping banks and deepening existing canals has increased the buffer capacity of the area to 12,000 m^3, of which 1282 m^3 can be reused in local agriculture areas. A peak buffer capacity of 300 m^3 is available – enough for a 2.54% T100 heavy rain shower; the total yearly water catchment is estimated at 144,000 m^3. An eco-hydraulic study was used to determine the most suitable profiles of the banks.

Increasing the buffer capacity has strengthened the hydro-physical structure of the area. Moreover, the ecological value of the area is enhanced by this increased buffer capacity as well.

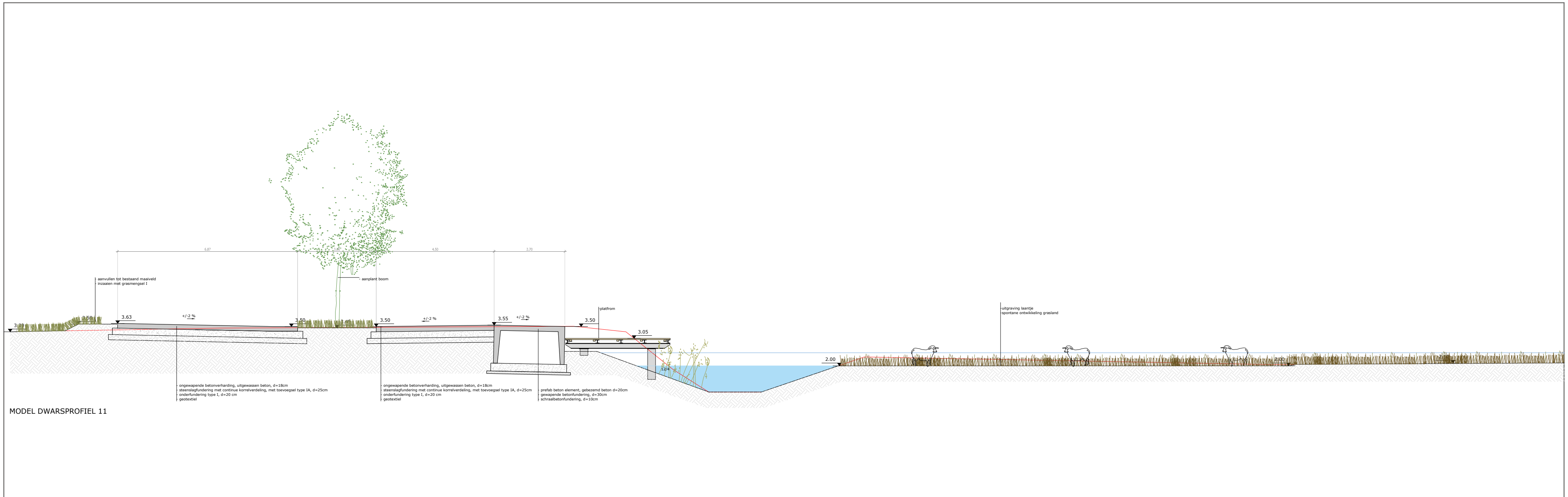


Section of design

New varieties: In a wet environment such as a polder, grassland can be maintained by grazers. The use of animals for meat production is also an ideal starting point for reintroducing old local West-Flanders breeds into the production chain. New and old varieties respond to niche markets, and farmers can benefit financially from the added value of the product.
New crops also enter into this wetland area. Hydrophilic crops such as typha (lisdodde), with its nutrient-rich roots, can play a role in the narrative of the bio-based economy. At the same time, these crops create a landscape transition in the wetland area.
Yet the increased buffer capacity must not over-rinse or wash crops away as water levels rise. Finding the equilibrium between these two is necessary.

Importance of the water network: The network of canals and gullies is functionally important for water management. To prevent the canals from clogging up they must be maintained regularly. Also, as mentioned above, a higher water level in both summer and winter is important, as this will prevent the groundwater from receding too deeply. Extracting irrigation water from the surface is therefore not a desirable option; it must be obtained by harvesting rain. Depending on the groundwater level, it is sometimes considered necessary to work with closed catchment basins.

Strengthening the historical link with the polder dyke: Although the polder dyke borders the Gardens of Stene, it is not considered linked to it in the current landscape. Yet the dyke and the Gardens of Stene are historically inseparable. A number of minor interventions can restore and strengthen this link.
On the banks of the Provinciegeleed, along the dyke, the banks will be smoothed, as



Section of design

was done along the watercourses throughout the polder. This strategy will enhance the landscape and ecological qualities of the area. The transition between the polder and the provincial gully is also scheduled to be restored.
By means of a platform on the bank, the Provinciegeleed will be made accessible again. This platform will be a public access point to the water and can eventually serve as a boat launch for exploring the Provinciegeleed.

Restoring the link with the village of Stene: The polder and the polder village are inextricably linked, but this historical link is spatially absent today. With the Gardens of Stene an attempt is being made to restore this link and to strengthen it again. An important sight line and entry to the polder is situated near Hoeve Sanders in Stene. Here the bicycle route along the Ostend Green Ribbon exits the Gardens of Stene to continue in the direction of De Schorre.

Experiencing the landscape: An element that will accentuate the experience of the landscape is the construction of a viewpoint that will serve the dual function of being a bridge over the Provinciegeleed as well as an observation cabin with posted information about the area. This has not yet been realised. From the viewpoint one will have an overview of different facets of the food production in Ostend, both within the Gardens of Stene (water meadows, test fields, allotment gardens, etc.) and outside, with the orthogonal production landscape of the Snaaskerskse polder visible at the far side of the Provinciegeleed.

Crops

Polder

TECHNICAL EVALUATION

Water system

The water-related infrastructural works of the project have been completed. Through the widening and sloping of all water streams, the area's buffer capacity has been significantly increased to 12,000m^3, contributing to the goal of avoiding flooding in the coastal area, in this case in the City of Ostend. The volume of excavated soil is 22,000m^3 but that includes the slow banks and new creeks.

Prevented costs of damages

A first estimate of the prevented costs of damages in the Gardens of Stene is €2,301,138. This is based on three kinds of damage:

1. The economic loss of €300 for each of the 275 food producing members of BuitenGoed: €82,500;
2. The water damage to properties in the Gardens: insurance data available for the City of Ostend with 70,000 inhabitants give a yearly damage cost of €540,000; per inhabitant this is €7.14. For the 985 inhabitants of the Gardens of Stene this would be a damage cost of €7,033 in total which is very unrealistic. Another estimate of the water damage is based on the estimated cost per inhabitant of €2,250 as used in the estimates of the East Bank. With 985 inhabitants this gives a damage cost of €2,216,250;
3. The loss of water that is needed for maintaining green space and that is available now from precipitation: for Ostend with 250ha of green space the cost of water for green is €17,058, so for the Gardens of 35ha this amounts to €2,388.

Food production

Food production is already a great success. The 275 members of the popular cooperative BuitenGoed produce their food in the Gardens. This organisation, embedded in the Ostend community, engages its members in the production process, thereby enhancing the awareness of food production and its relation to water management, biodiversity and climate change.

Improvements after monitoring

A study was done to the need for water in the Gardens of Stene. Recent measurements suggest that the amount of salt in the soil is increasing. The problem is the salinisation of surface water used in food production. A higher ground water level in the food gardens, occupying already 1,200m^3, therefore seems to be required to balance the infiltration of sea water. Measures that were proposed include:

- Raising the water level in the whole area even more, using windmills to pump water from the Provinciegeleed and integrating 3 extra weirs. But this also increases the risk of flooding in the Gardens itself.
- Finding rooftops in the neighbourhood from which the runoff is not being used to supplement the water in the Gardens. This water can then be kept in closed catchment basins for reuse to prevent it from getting salty. The roofs of the greenhouses are an obvious option. Those of the neighbouring Saint Andreas Institute and of the village of Stene are options as well, but these places may want to use the water themselves in the future.
- Uncovering more gullies in the area to further increase buffer capacity.

It was decided to go for a combination of these measures: raising the water level to 2.50m above TAW and installing closed catchment basins with a total volume of 360m^3.

Pilot project

Essenvelt, Middelburg

0
50
100
200

Essenvelt

Essenvelt, a newly constructed, climate-resilient residential neighbourhood incorporating ca. 400 homes in an area of ca. 20,000 m^2, was designed in cooperation with the Scheldestromen Water Authority (Waterschap Scheldestromen). Based on the principles of Landscape Led Design (LLD), the neighbourhood's climate resilience was achieved by researching and implementing innovative solutions in landscaping features that reduce the impacts of flooding and other climate-related hazards.

SITE DESCRIPTION

Essenvelt lies at the edge of the city of Middelburg and borders on the fringe of Vlissingen. One of the main aims in Essenvelt's design was to define Middelburg's urban boundary and give form to the buffer area between Vlissingen and Middelburg. This was accomplished by means of a green zone that includes green areas, water and buildings. The neighbourhood's substrate is characterised by higher, dry, sandy soils interspersed with lower, wet, clay and peat soils. This soil structure is due to the presence of the remains of an old creek ridge which likely had been partially excavated in the past.

DESIGN CHALLENGES

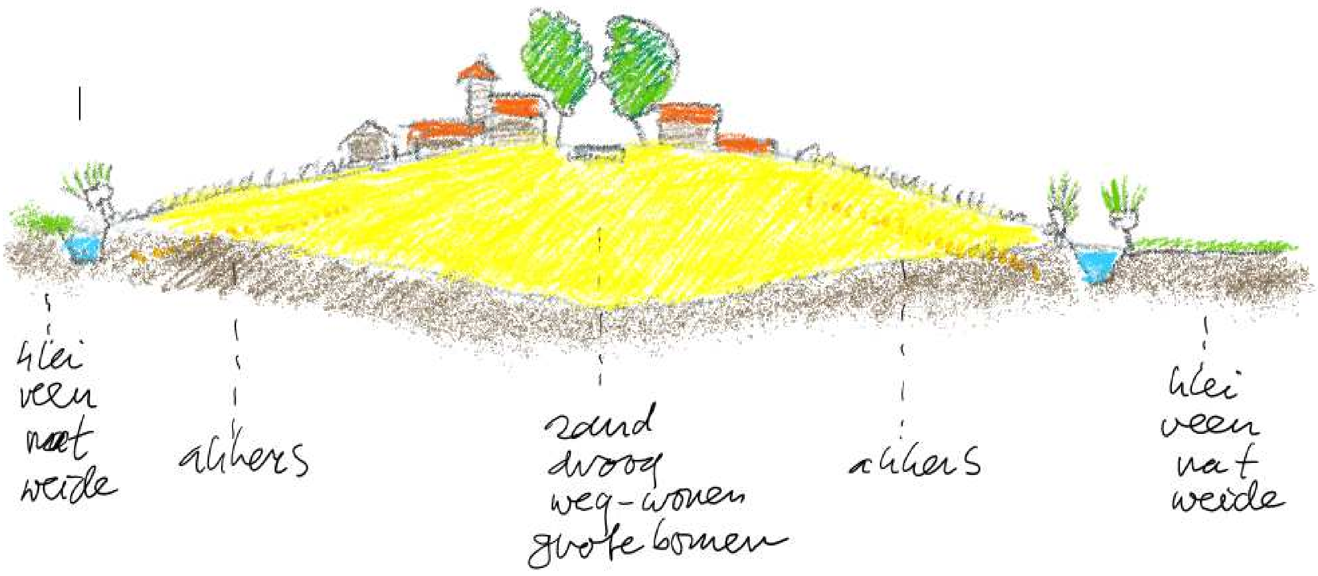
The starting point for the design of the new development was the existing plan for the neighbourhood, dating from 2012. The plan stipulated that a green articulation zone must remain between the cities of Middelburg and Vlissingen. The urban development structure had also largely been previously determined; it involved zoning regarding housing types and densities, the traffic structure and the water system. However, this plan, and particularly the envisaged water system, no longer seemed appropriate due to recent insights into the effects of climate change, namely periods of heavier rainfall alternated with longer periods of drought. The plan was therefore due for a review and faced the following design challenges:

- Adjusting the existing plan for the water system based on recent insights, assuming a one-hour, 100 mm rain shower per day;
- Counteracting the advance of saline groundwater caused by increasing drought, rising sea levels and subsidence;
- Avoiding heat stress in which more heat was retained whereby night-time temperatures remained higher;
- Maintaining the current landscape and water system; and
- Creating as much biodiversity as possible.

On-site investigations examined the local relief, geology, geohydrology, soil and water management. This research showed that Essenvelt is situated on a partly excavated, higher and sandy "creek ridge" adjacent to wet, clayey and peaty depressions. Geohydrological research has shown that the area is very susceptible to saline seepage, that infiltration of fresh rainwater to deeper layers is prevented by impermeable clay layers in the subsoil, and that raising the site with sand is necessary to lay a functional foundation for a sustainable residential area.

Landscape of Essenvelt

Working with water and landscapes is nothing new for Zeelanders. Their ancestors originally lived in the elevated zones formed by sand ridges and dunes; the fertile, low-lying salt marshes were regularly inundated by seawater. Since the early Middle Ages, the Zeelanders have been building and improving dykes that have become highly effective at keeping out the sea. Canals were dug to drain the marshes and convert them to farmland. This drainage system was further perfected by professional water authorities, which set legally binding water management regulations to control water levels and protect against seawater with dykes, drainage canals, sluices and mills. Over the course of the centuries, an almost entirely man-made landscape has emerged between the villages and towns – one of polders, dykes, ditches and canals, criss-crossed by roads. This is the landscape in which Essenvelt has been built.



'nieuwe kreekruggen'

CLIMATE TESTS

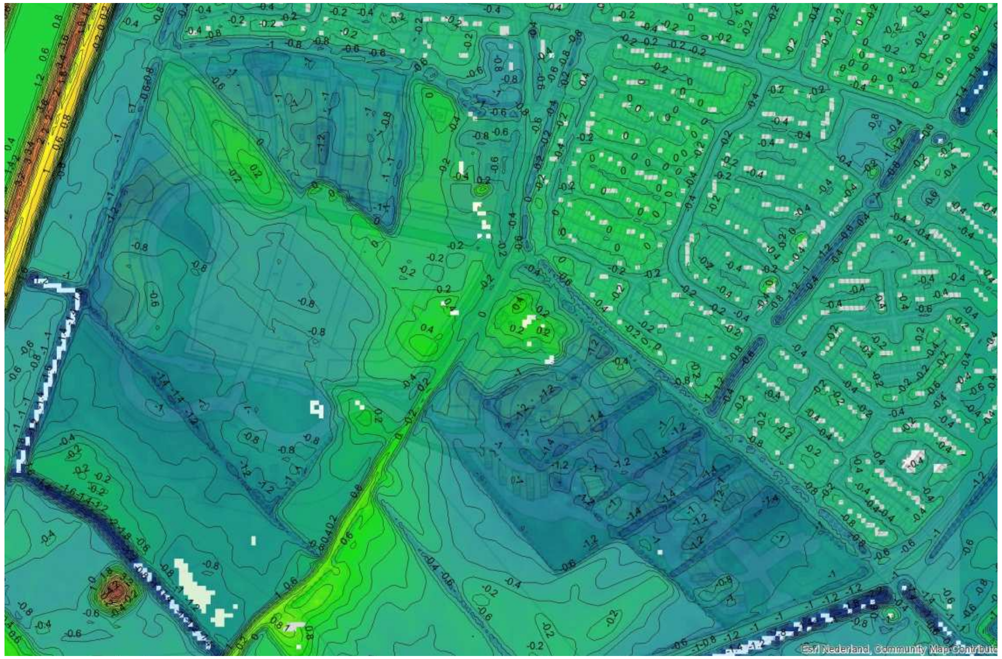
A first climate test for Essenvelt was organised on May 12, 2017. Priority was given to integrating and further detailing a sustainable water system based on the latest insights. All relevant disciplines from a water perspective were present: urban design, climate adaptation, soil, hydrology, landscape design, purification technology, urban water, civil engineering, sewerage, green management and environmental health. In each of three workshops, a specific aspect was investigated: possibilities for the Essenvelt water system, prevention of a heat island effect, and options for black and grey water purification.

The main conclusions of the workshops were that a hydrological study of the neighbourhood's water system was necessary and that deciding on measures to limit the heat island effect could be postponed until later design phases. It was recommended to design the Essenvelt neighbourhood from large to small based on a vision for the existing water system, soil structure and green structures of Middelburg and the surrounding area.

Water system recommendations

In addition, the first climate test resulted in the proposal of a number of concrete implementation measures that can lead to a more climate-adaptive water system:

- Allowing rainwater to accumulate as much as possible in the creek ridges and, if possible, infiltrate the thin peat layers to limit subsidence;
- Considering a cut-off wall to capture seepage;
- Discharging water above ground and infiltrating it as much as possible, by limiting pavement, applying a gentle slope in the street surface and using water-per meable pavement;



Height differences

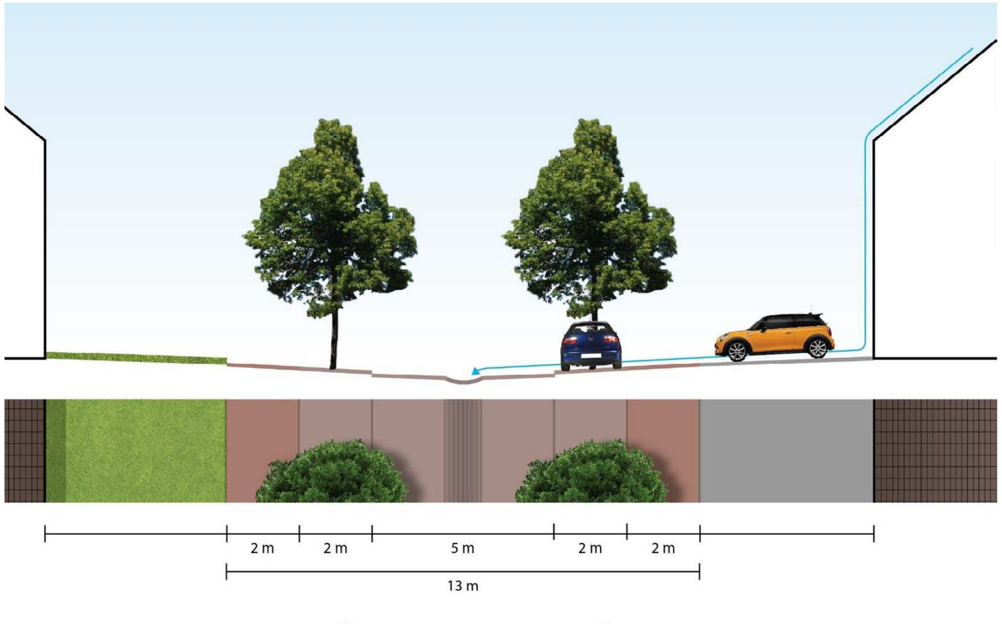
New creek ridges

- Using fresh (rain) water to flush the surface water system;
- Ensuring "water-neutral" buildings by capturing rainwater runoff from homes in local buffer facilities and reusing it, for example in gardens, toilets or washing machines.

Heat island recommendations
To limit the effects of prolonged heat, the recommendation was given to create green facades and/or provide white buildings and houses with green roofs. In addition, it was suggested that when laying out the public greenery, the direction of prevailing winds should be considered, as well as creating shade for water bodies that could serve a potential cooling function. Note that according to recent insights, standing water does not provide significant cooling.

Black and grey waste water system recommendations
Grey waste water could be purified in helophyte filters and then infiltrated into creek ridges. It could also be infiltrated into existing peat layers to prevent the layers from drying out, or used to irrigate the adjacent public gardens.
The second climate test determined what recommendations from the first test would be followed and incorporated into the design.

Visualisation of discharging water above ground



Section of street

LLD MEASURES

The newly created landscape is strongly linked with the old landscape; the characteristic creek ridges are reflected in the new neighbourhood. Essenvelt will be designed with, among other things, nature-friendly banks and reconstructed old creek ridges for the purposes of water collection and recreational facilities.

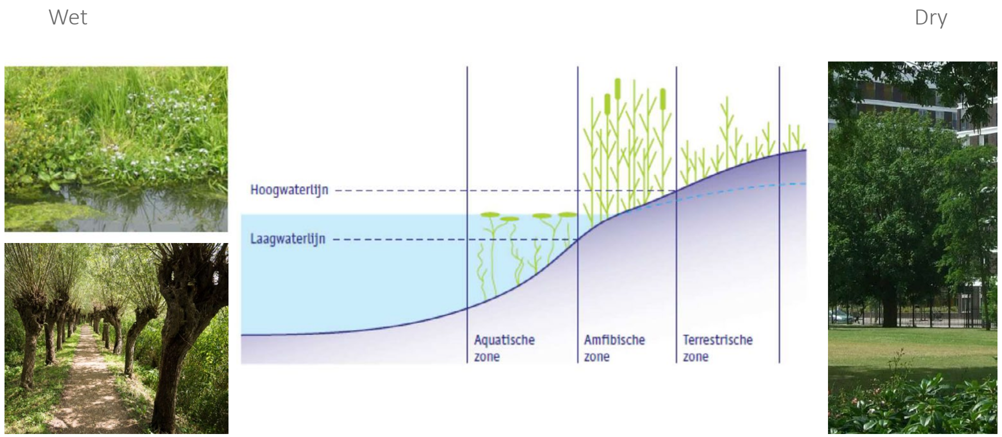
Utilising existing creek ridges

The elevation differences between the higher creek ridges and lower basins are embraced and enhanced in the plan area by locally raising the ground level with sandy material and by keeping the land lower on either side of these higher ridges, especially where drainage ditches and basins are located. This creates a characteristic alternation of higher and lower, of drier and wetter – attractively blending the three creek ridges, with their roads and buildings, with the lower and wetter zones situated on either side of them.

No rainwater sewer, but above-ground drainage and infiltration

The resulting height differences will allow rainwater to run off superficially into the surface water. Therefore, no rainwater sewer has been installed; the landscape regulates the drainage. This also ensures that fresh rainwater infiltrates where possible and stays in the area for as long as possible. It was agreed with the municipality that no water-permeable paving will be used – partly to avoid the need for management and maintenance, and also due to the relatively high water retention capacity of the surface water and green areas.

Flower meadow and natural river banks



River banks with planting zones

Awareness

The water system is designed to be visible. When people see the water every day, they will become aware of the water system's presence and functioning. Home designers as well as residents will receive information about how water management works in their new neighbourhood and what contribution is expected from them (collecting rainwater on roofs, in gardens, rain barrels or basins, managing banks, etc.). It is expected that they will understand, recognise and appreciate the uniqueness of their neighbourhood and home as something valuable.

Limiting the heat island effect

To limit heat stress, trees have been included in the design of the main and side streets. Because the construction areas had already been established in the zoning plan, it was not fully possible to take the prevailing wind direction into account in the design.

Play elements for childeren in plan

References for playing with water

Resultaten									
Klimaat en kosten	Co Benefits								
Maatregel	Oppervlak	Storage Capacity (m3)	Return time factor (-)	Groundwater recharge (mm/y)	Evapotranspiration (mm/y)	Heat Reduction (°C)	Cool areas (-)	Construction	Maintenance
Adding trees to streetscape	9726,31	486	0,04	7	9	0,05	3	110880	38
Create extra surface water (m2)	20441,34	6132	385,47	56	82	0	0	4599302	1840
Infiltration fields and strips with surface storage	66434,22	26571	876,95	177	-6	0,36	0	3986053	33084
Urban forest	13831,6	2766	26,08	4	8	0,07	1	13832	692

Results using the Deltares Climate Adaptation Tool/ Climate Resilient Cities Toolbox (explanation is given in the text)

Variant	Aanlegkosten	Beheerkosten (jaarlijks)	Schade (jaarlijks)	Contante waarde over 100 jaar
0: traditioneel, gemengd stelsel	129.110 €	996 €	1274 €	244.380 €
1: Traditioneel, verbeterd gescheiden stelsel	122.070 €	1.015 €	1.628 €	249.698 €
2: Beperkte aanpassing inrichting	103.245 €	1.024 €	662 €	190.572 €
3: Klimatologische verbeteringsmaatregelen	136.220 €	2.084 €	116 €	250.519 €

Results using calculating software of isso.nl (explanation is given in the text)

TECHNICAL EVALUATION

Water system

None of the measures designed and used for landscape and water management in Essenvelt is unique; they all have been implemented before in other places. The combination of these measures is, however, a step forward for new residential areas in wet, clay field areas. The approach of applying 'new creek ridges' can be called innovative, as an example of utilising known and local landscaping solutions for new climate challenges.

The climate-proof water system, which is beautifully integrated into the existing landscape, with local retention capacity and above-ground drainage to the lower-lying areas, will increase awareness and real estate value.

Some remarkable examples of implemented measures are:

- Level-controlled drainage is applied to prevent the subsoil from drying out in the summer season and becoming too wet in the winter months.
- Fresh rainwater is discharged at the surface and where possible infiltrated into the soil, and otherwise discharged to surface water.
- Rainwater is reused in homes, for example in gardens, for toilets or in washing machines; this is mandatory in Essenvelt.
- Where possible, sidewalks and walking routes are carried out in (water-permeable) semi-paved surfaces.

Status

At the time of writing this report, the area is being prepared for construction. Most of the earthmoving has been done, including building the water structures and raising the site. Monitoring of the water system has started. Culverts and bridges have been constructed. Monitoring of the water system has started. Yet it is still too early for a cost-benefit-based evaluation of the water system.

Prevented damage costs

Some initial studies were done to estimate the cost savings due to prevented damage by climate change in the Essenvelt neighbourhood:

- Using climatedamageatlas.com, an estimate of the pluvial damage by flooding and hail can be obtained. It uses the local weather patterns and, the predictions of climate change. For Middelburg the average damage cost is estimated to be €2,300 per inhabitant. For Essenvelt with a projected number of inhabitants of 1,200, this would amount to about €2,760,000 of prevented damage costs.
- Using the Deltares Climate Adaptation Tool/Climate Resilient Cities Toolbox one can estimate the construction and maintenance costs of the measures that are taken to adapt to climate change. For Essenvelt these measures include adding trees, creating more surface water and creating an urban forest. The estimated costs are in € and are in the last two columns of the table on the top of the previous page. The total construction costs for these measures are estimated to be €8,710,067.
- Using calculating software of isso.nl a cost indication of climate measures in urban areas can be obtained. For Essenvelt, construction, yearly maintenance, yearly prevented damage, and value in 100 years were estimated (the last 4 columns in the table at the bottom of the previous page) for four variants: a traditional mixed sewer system, a traditional but enhanced system with separate treatment of pluvial water, one with a moderate adaptation to climate change and one with extensive adaptations (the 4 rows in the table). The resulting table shows that the sewer system can be constructed by taking moderate or extensive adaptation measures; that these are about equal in construction costs and slightly more expensive in maintenance costs; but that these substantially prevent damage costs.

Measures not taken

Furthermore, a few measures that were proposed will either not been implemented or will be implemented differently:

- Infiltrating fresh and oxygen-rich rainwater runoff into creek ridges proved impracticable. The infiltration would have taken place via gravel piles into the deep creek ridge layer. This layer however, contains oxygen-poor water, and mixing oxygen-rich water into it would cause a chemical reaction that would immediately clog the gravel piles.
- No helophyte filters will be installed to clean the wastewater from the houses. On the one hand, the plan does not provide for space for this. But the decisive factor was the water authority's argument that the existing sewerage treatment plant has sufficient capacity and that therefore the investment would not be worthwhile. Due to the low traffic intensity, the rainwater that runs off the secondary roads does not need to be cleaned and can be added to the surface water.

Pilot project

Zwin, Knokke-Heist

Zwin

SITE DESCRIPTION

The Zwin is a 158ha tidal nature area on the North Sea coast at the Belgian-Dutch border, between Knokke-Heist and Cadzand/Retranchement. It is located at a former estuary inlet which connected the North Sea with the inland port of Bruges. The Zwin project enlarged this nature reserve by annexing a former 120ha upstream polder and moving the major sea dyke land-inward. A new pumping station was installed in this dyke to divert inland water to the tidal Zwin area in the event of heavy rainfall. To ensure sufficient water supply to the pumping station, modifications had to be made to the watercourses in the Zwin polders behind the dyke: widening them and reversing their flows from land-inward to the historic sea-bound direction. The project also provided an opportunity to give nature and recreation a boost.

DESIGN CHALLENGES

The major challenges of this project included:

- Excess water in the inland polders in times of heavy rainfall;
- Progressive siltation of the Zwin area due to the lack of water flow;
- Salinisation of and lack of fresh water in the Zwin polders because of drought;
- Preservation of the area and the inland civil engineering and defense monuments;
- A heat-island effect in the Knokke-Heist coastal urban area; and
- An increase of invasive species due to rising temperatures.

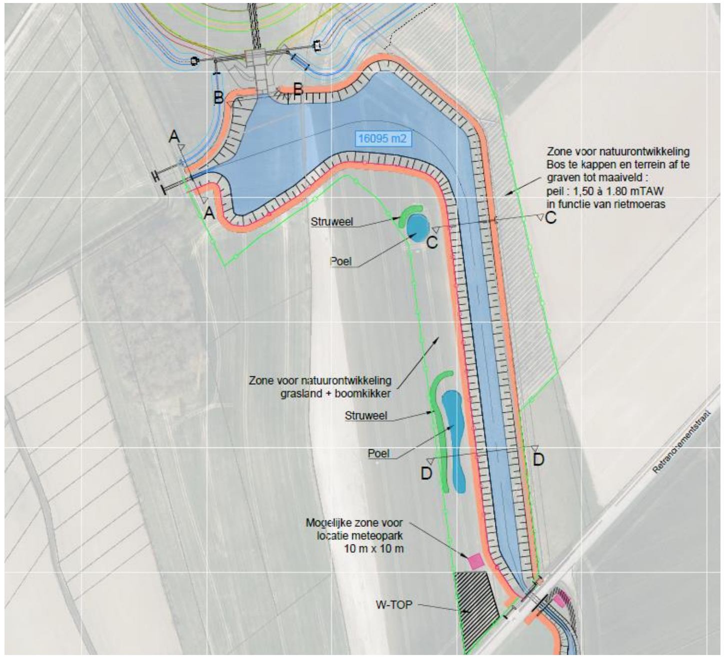
CLIMATE TESTS

A first climate test was organised in August 2017. At that time, the last preparations were being undertaken before the start of the work, and a brainstorming session was held to discuss the project's challenges and their potential solutions. In May 2019, when the work had been completed, a second climate test was held to compare the situation before and after the project and to determine whether the Landscape Led Design (LLD) approach had increased the area's resilience.

LLD MEASURES

Extension by annexation of a former 120ha upstream polder: The extension increases the Zwin's water capacity and its tidal flow, preventing further siltation and possibly reversing existing buildup. By also deepening and lengthening the gullies in the annexed polder, three times more water can enter the area from the sea. The extension furthermore increases the area dominated by nature and thereby its biodiversity.

Pumping station and tributaries: The new pumping station replaces a passive outlet and protects the East-coast polders from flooding after heavy rainfall and from salinisation by inadvertent water inlet through the passive outlet. The addition of a 16ha pumping buffer basin upstream of the pumping station allows it to operate more smoothly. To guarantee sufficient drainage of flooded polders, the tributaries



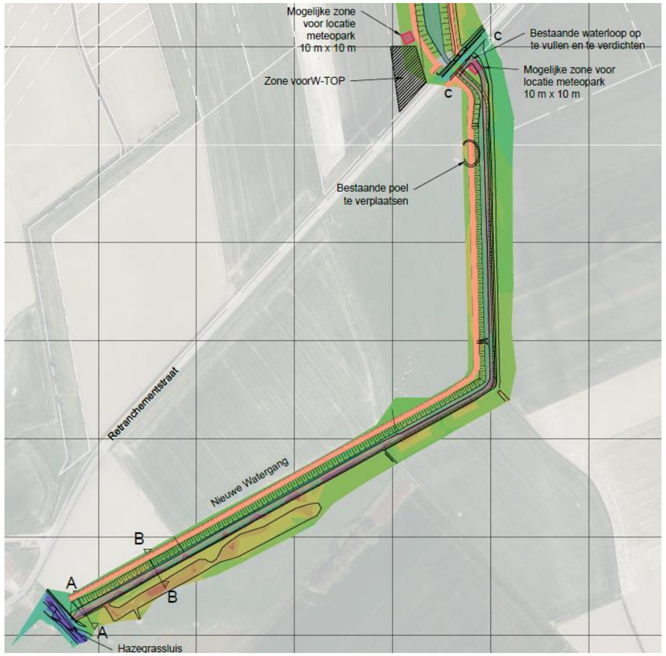
Ground plan for the new pumping buffer

Pumping station

in the polders were widened and brought to a water level of 0.8m TAW, including where these cross the former Burkeldijk overpass and the monumental Hazegras defense work. The flow of these water courses was reversed; they no longer drain gravitationally to the Leopold canal in the south-west but instead flow in their original north-eastward direction to the Zwin area. By giving the water buffer an elongated form, by widening the gullies and by reversing the water flows, the original "estuary watercourse" appearance of the creek area has been restored.

Nature development: Increasing the dynamics of the system by extending the area should have a positive impact on nature. The new buffer zone and redeveloped water courses are equipped with gently sloped banks (approximately 1:3), which have been sown and planted with local reed fringes. Around the buffer zone, pools were created and planted with shrubbery and reeds. The gentle slopes make it easier for the water courses to adapt to silting and erosion. In the annexed polder, bird islands were created. North-west from Retranchement, east of the water courses, new dunes were made.

Recreation: The project also includes new bicycle and hiking trails created from sand and silt from the Zwin, as well as new lookouts and a wooden boardwalk through the marshland. These are meant to attract more people and make visitors aware of the original historic landscape and the natural dynamics at play in the area.
Please refer to virtualtour/het-zwin for a virtual tour of the project area. The numbers refer to particular project elements.



Ground plan of the new water course


New water courses around Hazegras lock

TECHNICAL EVALUATION

The second climate test involved an evaluation of the measures that were taken during the project's construction. The results for the project's main challenges are discussed below.

Status
All works have been done and monitoring the water system has started. The total system has a size of 333ha, composed of the original Zwin tidal area of 158ha, the annexed polder of 120ha and the area of the inland canals and works of 55ha. Floodings within the nature reserve are not harmful but surrounding agricultural lands are affected; about 400 people live in the area in which the water level is under control of the new pumping station.

Reduction of heat-island effect in neighbouring urban area
There was hardly any improvement here. More water doesn't necessarily cool, but it does make temperatures more constant.

Avoiding elongated periods of drought
The new buffer zone and the widening of inland water courses provide sufficient fresh water for agriculture. Having increased the water level by 0.5m in winter supplements this. The long-term effects of the latter, e.g. its effect on invasive species, must be further investigated. The freshwater buffer zone and higher water level in the tributaries also counter salinisation. The supply of fresh water from inland sources must still be ensured by later projects.

Avoiding flooding
The drainage capacity of the gravitational system via the Leopold canal was not sufficient. The new pumping station, the new water buffer zone and the reconstruction of inland water courses have corrected this system significantly and effectively. They also help to keep the water level constant.

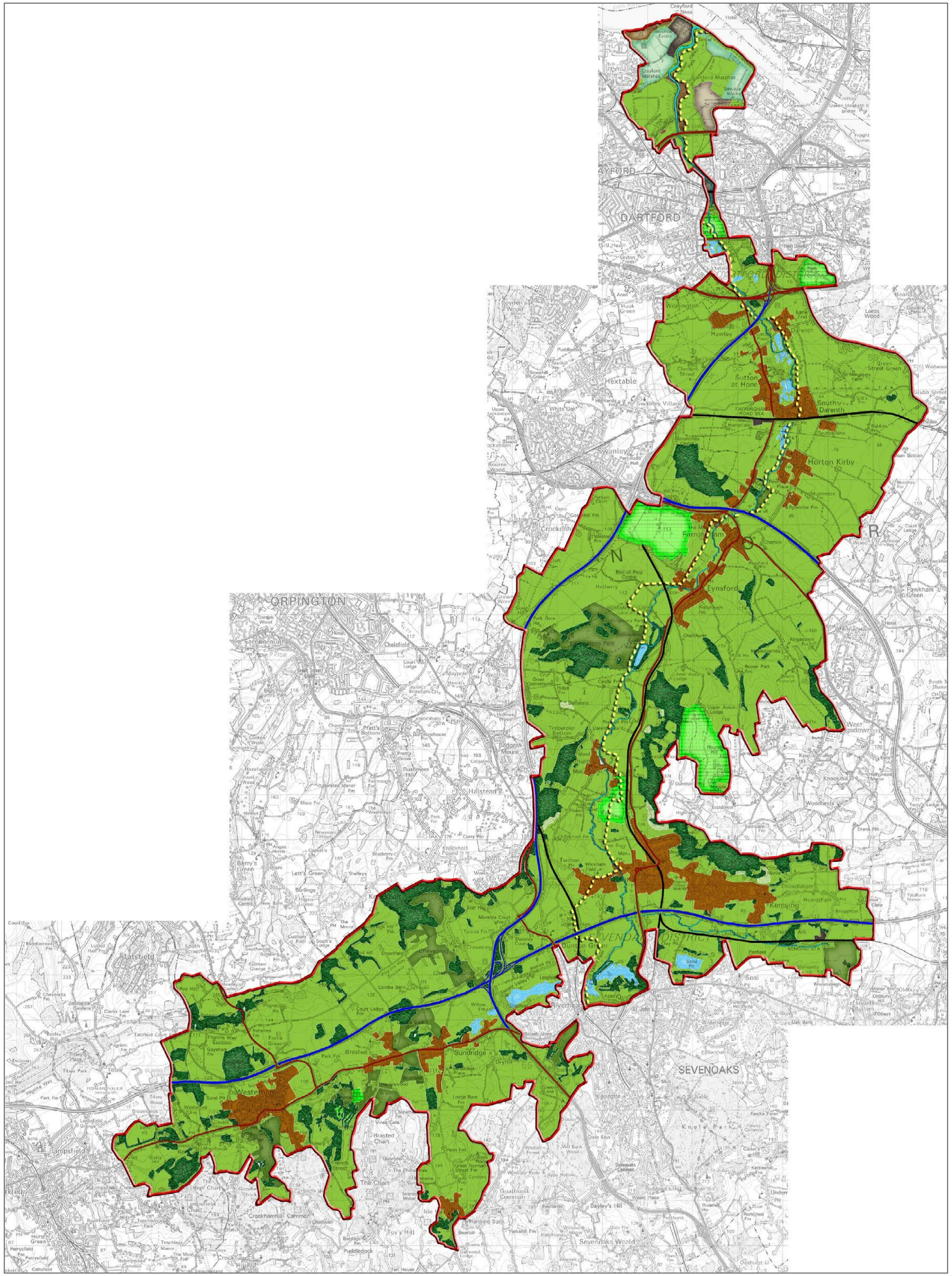
Prevented damage costs
Flooding would have put damage to the properties of the about 400 people living in the area. Assuming an average damage cost of €5,000 per inhabitant which seems reasonable for the on average larger and free-standing houses and farms, this would mean a prevented cost of €2,000,000. Prevented costs that are not included are of the damage done to crops by salinization after an inadvertent water inlet.

Rising sea level
The main consequence of sea level rise for the Zwin is increased salinisation, which has been sufficiently countered. The flushing of fresh water in the Zwin will have a negative effect on nature, but this has not yet been observed because in recent years summers have been very dry and water hasn't been pumped into the Zwin. It is not expected that the rising sea level will cause the Zwin to drown, since the area's elevation has increased by 20cm over the past 20 years.

Invasive species
Blue algae, crayfish and freshwater crabs are present in the area. According to the recommendations of the first test, only those most damaging to the indigenous species are removed. But it is still too early to predict further effects.

Pilot project

Darent Valley, Kent



Darent Valley

SITE DESCRIPTION

The River Darent is a typical chalk river, in the northwest of Kent, 30km southeast of London, running from Westerham, along Sevenoaks to Dartford where it flows into the Thames. The Darent Valley is vulnerable to changes in the natural environment being generally a dry and free-draining landscape and located in one of the driest parts of the country where predicted climate change will be most strongly felt. A changing climate will affect all characteristics and qualities of natural beauty in the Darent Valley and mitigation and adaptation have the potential to have a substantial impact on landscape qualities. However, there is recognition of the area's sensitivity, and it presents an opportunity to demonstrate how a landscape-scale response can be put in place.

The SCAPE River Darent pilot is part of a larger landscape scale project called the Darent Valley Landscape Partnership Scheme (DVLPS). It is an integrated collection of over 40 separate projects of which only some form part of the SCAPE pilot. However, together all the projects as part of the larger 'scheme' represent a Landscape Led approach to management of water, natural and cultural resources.

DESIGN CHALLENGES

The overall aim was to develop and implement a landscape approach to make the River Darent more resilient to the impact of climate change. This includes both low flows and increased extreme flood events, and is delivered in a series of integrated subprojects that respect landscape character, enhance the biodiversity value and protect the heritage features associated with the river and adjacent land.

Historically, abstraction of water from the chalk aquifer for irrigation and to meet the supply of a growing London population in an already over-abstracted catchment meant that during natural periods of drought between 1976 and 1991 parts of the river dried up completely. From a biodiversity point of view, the periods of low flows were devastating, and the river is only now returning to something like its previous condition. Key species such as water vole are present on the river, and macrophytes (aquatic plants) such as water crowfoot and starworts (see photograph) are well established again. However, it remains vulnerable to periods of drought when variations in temperature, flow and diversity can cause plant and animal communities to become stressed. This also makes it more susceptible to pollution incidents.

Conversely, the predicted increase and volume of flooding events does present a significant risk as demonstrated by the flood events in the upper Darent in 2014, and there is a danger that responses to this do not respect the landscape character and heritage of the valley.

The major challenges of this project included:

- Heat and drought
- Flooding
- Biodiversity reduction
- Respecting the landscape character and heritage

CLIMATE TESTS

The first Darent Valley Climate Test investigated the issues and brainstormed on solutions.
The second Climate Test evaluated the various projects and tried to answer for instance whether the projects have a positive/neutral impact on water movement in the Darent Valley, and how can the DVLPS projects be adapted, changed or influenced to reduce/mitigate/remove the negative impacts.

LLD MEASURES

The measures that have been taken in response to the impacts of climate change fall into two groups:

Improving the landscape's ability to contribute positively to mitigate against the impacts of extreme periods of drought and high rainfall.

These measures have generally focused on the Darent river channel itself and land alongside it. The aims of these measures have been two-fold.

1. Firstly, they aim to support maintaining sufficient water flow and retaining suficient water in the river channel during periods of drought, thereby reducing the negative impact on biodiversity within the river itself and on riparian land.
2. Secondly, they aim to buffer the impact of periods of high rainfall which can often lead to flooding of communities within the valley. This is done by reinstating the functionality of the floodplain's natural features such as water meadows to with-hold excess water and release it slowly back into the river the channel. These are delivered in a scenario where there is a need to protect and enhance landscap character within the protected landscape. Examples of this work have been completed at Preston Farm near Shoreham and will be completed later in 2021 at Filston Farm.

Darent dry riverbed 1977 (Jan Wilkes)

Aquatic plants are back again

Enhancing the ability of essential landscape conservation work to support aquifer recharge and reduce the negative impact that this work may have on water movement through the landscape.

These measures seek to integrate vital landscape conservation work with measures to increase the amount of water reaching the chalk aquifer beneath the landscape of the Darent Valley. This aquifer is exploited to provide drinking water for the large and growing population of London.

As the Darent Valley is a chalk landscape, the geology below ground is an important water source for urban populations. It also creates the distinctive landscape that is dominated by chalk grassland that is an important and biodiverse habitat. It is what creates the 'chalk downs' of the Kent Downs and the landscape character that is so valued.

There is potential that the removal of scrub growth that threatens these important chalk downs could reduce rainwater percolation into the aquifer and contribute to increased surface flow that may increase the likelihood of flooding. Conversely, the re-introduction of management to maintain high quality chalk grassland with a thick and diverse turf has the potential to 'hold' onto this water, both increasing percolation and reducing flood risk.

Measures are being introduced at several sites and are at varying stages of delivery. They include manual removal of scrub growth, installation of fencing to enable livestock grazing on sites (to prevent scrub regrowth and promote a diverse sward) and planting of hedgerows to intercept surface flow of water. These are at various stages of completion but combined across the Darent Valley landscape will have a significant impact.

Weir structure on the River Darent near Shoreham

Scrub encroachment at Kemsing Down

TECHNICAL EVALUATION

With the major modification being to extend SCAPE to the end of 2021, a full evaluation cannot yet be made. Several measures are still to be installed and the on-site evaluation of measures is still to be undertaken.

Resilience
With the measures taken, about 447ha of area will be more resilient. Note that the entire lower and middle catchment of the Valley has a size of 8,700ha. The amount of people affected in 7,320 and the number of properties is 204, with 119 with a medium to high risk. Note that the work has a broader impact on climate resilience in terms of water availability (in chalk aquifers) further downstream.
Anecdotal evidence of work completed at Preston Farm suggests that the re-introduction of the watermeadow system will be effective.

Avoiding flooding
Following the implementation late last year, a few flood events have been experienced and the functionality of the flood plain to hold water has been demonstrated.

Return of key species
The improvements to biodiversity will take some time to demonstrate, but the initial indications are that this will also be positive with increased sightings of key species such as lapwing and snipe.

Monitoring and modelling
The chalk grassland work has progressed well, but current assessment of chalk grassland turf to assist water retention and aquifer recharge is non-existent. A monitoring programme is in place which will hopefully confirm our expectations. Modelling of the impact has been initiated using HydroloGIS. For pluvial flooding this is done using a combination of Infiltration Test and Visual Assessment of Soil Structure (VESS). For fluvial flooding the additional storage capacity is calculated as in the case of the watermeadows. And the prevented flooding is estimated based on nationally and locally available data.

Cost of prevented damage
In terms of the cost of prevented flood events in Kent, based on the figures calculated by our partners at Brighton and Hove Council of a minimum of £23,000 per property, the potential cost saving is calculated as up to £2.7m for the medium-high risk properties in Eynsford and Shoreham.

Lessons learned
Looking back, it is probably fair to say that DVLPS underestimated the complexity of negotiating the work over such a large number of sites. However, despite the various obstacles that have appeared in the way, good progress has been made. In addition, DVLPS feel that they could have better demonstrated how the measures being delivered through SCAPE have been integrated with other projects and measures that are being developed alongside without funding through Interreg 2 Seas. This would have better demonstrated the multiple other issues and considerations that must be made when delivering a complex landscape-scale project.


OVERZICHTSKAART

Conclusions and Lessons Learned

Landscape Led Design

SCAPE has demonstrated how Landscape Led Design (LLD) can help different landscapes within the 2 Seas area adapt water management systems to cope with the challenges of climate change. In all pilots the existing landscape played a decisive role in determining the design response.

SCAPE has shown how the Climate Test can be an effective tool to support the LLD process. In particular, how the Climate Test can be used by experts and partners in coastal regions interested in adopting the LLD approach. Several public bodies have already registered an interest in doing so.

Projects and pilots

The SCAPE pilots have evidenced how the LLD approach can be applied to landscapes with different population density, proximity to the sea, soil type and water management regulatory systems and procedures.

Having two Climate Tests per pilot carried out at different stages of the design development process enabled partners to assess the design challenges and make adjustments/improvements to the design before implementation. These also provided the opportunity for SCAPE partners to learn from each other and from other experts and stakeholders involved in the pilots and consider alternative options and solutions.

Evaluating the SCAPE project on the effectiveness of its design approach was not easy.

- It required that pilots be implemented before the end of the project in order to enable SCAPE partners to measure their effect. Not all projects were delivered as originally scheduled, facing unforeseen delays; evaluation is still ongoing.
- Measuring the effectiveness of design solutions used in the pilots in preventing damage caused by flooding depends on extreme events actually happening during the monitoring phase. Given that extreme flooding events are rare and the intensity of rainfall can vary resulting in water flows that are difficult to predict, modelling can be a useful alternative to assess performance. Although modelling tools are still in their infancy, modelling played an important part in the assessment of proposals for the Carden Avenue pilot. Developing more adequate modelling tools could be a project all on its own. For more information on the modelling tools used in SCAPE please refer to the models used in the Essenvelt and Carden Avenue pilots. To gauge the complexities of using modelling in dense urban areas see the Norton Road pilot.
- The impact of design solutions upon the water system and local heat prevention was identified but these were not the only ones impacted. Additional benefits were observed in relation to biodiversity, inhabitant well-being, and property values (as in the East Bank and Gardens of Stene pilots) as well as preserving historic landscapes and/or integrating historic monuments (as in the Darent Valley and Zwin pilots). Finding ways of assessing performance across such a range of benefits proved to be a challenge.
- The SCAPE pilots are purposefully diverse, with two urban, two fringe and two rural pilots. For example, preventing flooding in 100 properties located in dense urban areas or implementing climate resilience measures on a 1-hectare rural farmland property requires different measures that will result in different cost. The LLD successfully improved climate resilience in each case. In the absence of standard means for assessing pilot performance, a bespoke approach to measure the effectiveness of these design solutions had to be developed.

Although evaluating the effectiveness of the designs by modelling proved to be hard, they were judged to be effective not only in helping to assess flooding prevention and limiting damage caused by flooding, but also in terms of additional benefits including, for example:

- Eastbank: property values, recreation opportunities, children play opportunities.
- Carden Avenue: ground water replenishment, biodiversity, social cohesion.
- Gardens of Stene: food production, social well-being, recreation, biodiversity.
- Essenvelt: climate awareness, biodiversity, landscape preservation.
- Zwin: biodiversity, historic values, recreation.
- Darent Valley: historic values, people involvement, biodiversity, ground water replenishment.

Skills were shared and acquired by partners, experts in water management and local communities. This contributed to a better understanding and raised the profile of landscape led design measures among stakeholders that work with and to enhance nature and people who are unfortunately subject to flooding. These skills range from understanding how design can be led by the landscape and engaging with local people to modelling, monitoring and demonstrating the effectiveness of LLD design solutions.

The SCAPE project has fostered the intercommunity and international cooperation that resulted in the development, implementation and testing of the LLD design approach.

Recommendations

The method of evaluating the effectiveness of water management projects in adapting to extreme climate events can certainly be improved by considering, for example, the following:

- Longer projects.
  More time should be allowed for projects to be implemented and monitored.
  Extreme climate events don't happen often.

- Take additional benefits into account.
  Next to water safety and heat prevention the evaluation can include biodiversity, well-being, property values, health, recreation opportunities, food production, and implications on social cohesion.

- Develop better modelling.
  This could be an (EU) project on its own.
  Models can vary in accuracy: low-accurate models would require less input and could be used at the start of a design.
  Models could integrate effects in different areas by mapping the valuation of effects to standardized metrics and combining them.
  Gathering data could involve physical sensing, taking samples, doing interviews, conducting surveys, measuring yields, doing experiments, collecting visitor counts, etc.

- Measure and gather data from the start of the pilot.
  Sensing, measuring and gathering of data should be implemented as a standard routine in every project to acquire knowledge and to calibrate the newly developed models.
  Essential is that these are designed-in into the pilot from the start and that a baseline is established.


What are our objectives?
Reduce flooding
Protect and/or improve amenities, biodiversity, health and wellbeing
Benefit local economies
Save public money
Interreg
2 Seas Mers Zeeën
SCAPE
2 Seas Mers Zeeën
ter Resilient Cities

Colophon

This Technical Impact Report has been compiled by atelier GROENBLAUW (June 2021)

atelier GROENBLAUW

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Interreg EUROPEAN UNION
2 Seas Mers Zeeën
SCAPE
European Regional Development Fund

Disclaimer

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Source reference

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west-vlaanderen de gedreven provincie

FARYS

Flanders State of the Art

WaterschapScheldestromen

Oostende DE STAD AAN ZEE

KENT DOWNS Area of Outstanding Natural Beauty

MIDDELBURG

Brighton & Hove City Council