



# ENGAGING WITH WATER: BUILDING WATER RESILIENT SPONGE CITIES

An approach on how a 'sponge' building and surrounded area can reduce water shortage and water overflow, while using water as a medium to connect nature, humans and buildings to enhance our well-being and simultaneously use it as an example on how to become more sustainable for communities and other stakeholders.

# Personal fascination



# WHAT IS HAPPENING TO OUR JUNE?

CHANGING WEATHER FORECAST: IT LOOKS LIKE ITS AUTUMN!



**Mensen lopen door de regen in Den Haag.** Beeld ANP

# Water problems around the world

## Problems, Questions & Challenges

Using water as a medium to connect humans, nature, and buildings

Enhancing biodiversity

A city that produces fresh water

Co-existing of humans and nature

Water scarcity versus water floodings

Recycling:  
Closing loops? More than just water cycles?

Affordability

Lack of incentives

Creating tangible examples of hope...

Social interaction

Using water to communicate

Activating stakeholders

Sense of well-being

Collective water management

Finances and political will:  
Doing it for the people?

Sponge cities

Using historic value for sustainable appreciation

## Water floods



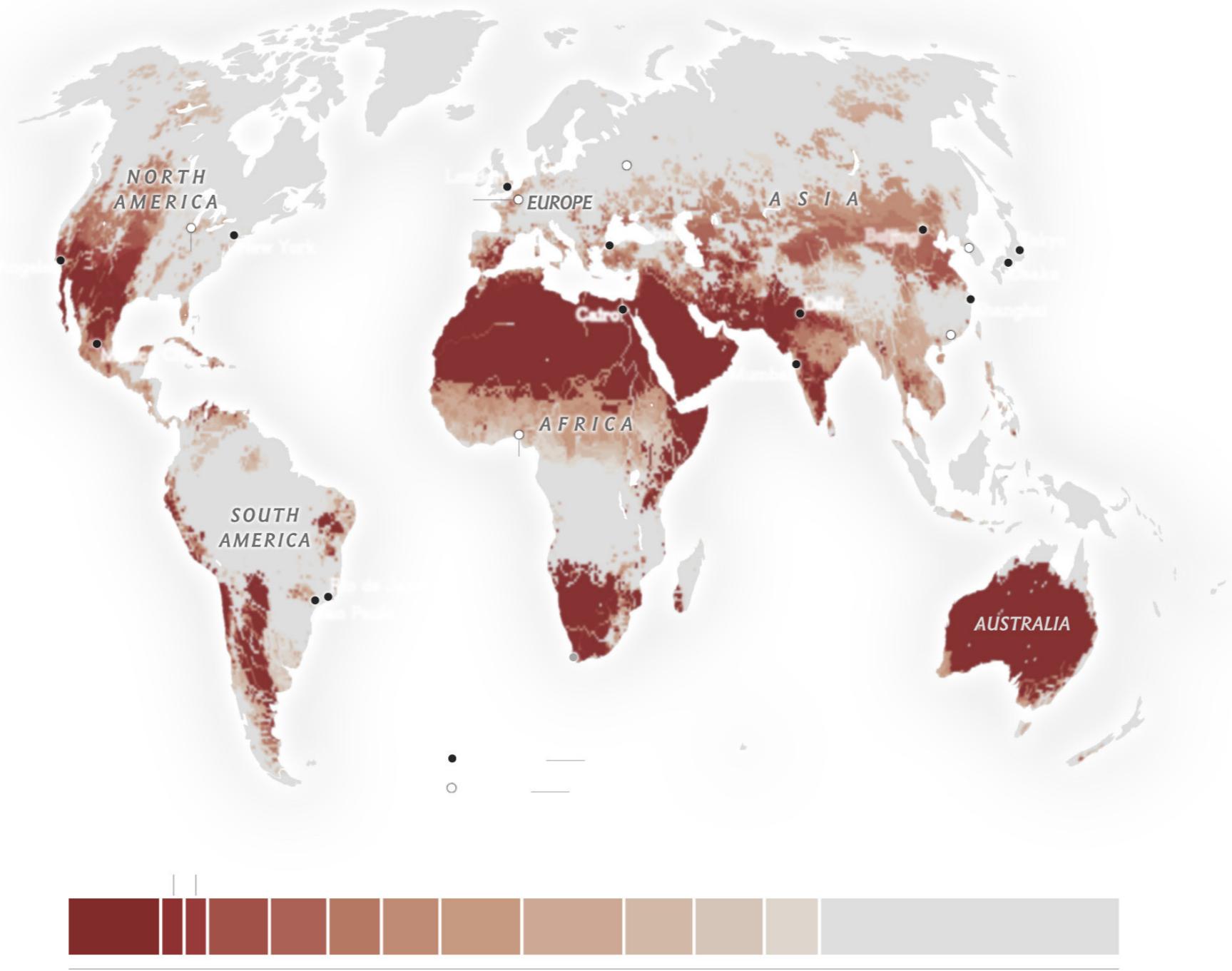
## Water scarcity



Increased heavy rainfalls and dry periods

# Water scarcity world map

Mostly in countries close to the equator with little to no rain



70% of the world's population suffers  
at least one month of water scarcity a year.

# Water riskfull well-developed cities

Where water problem should be solvable through interventions and investments...

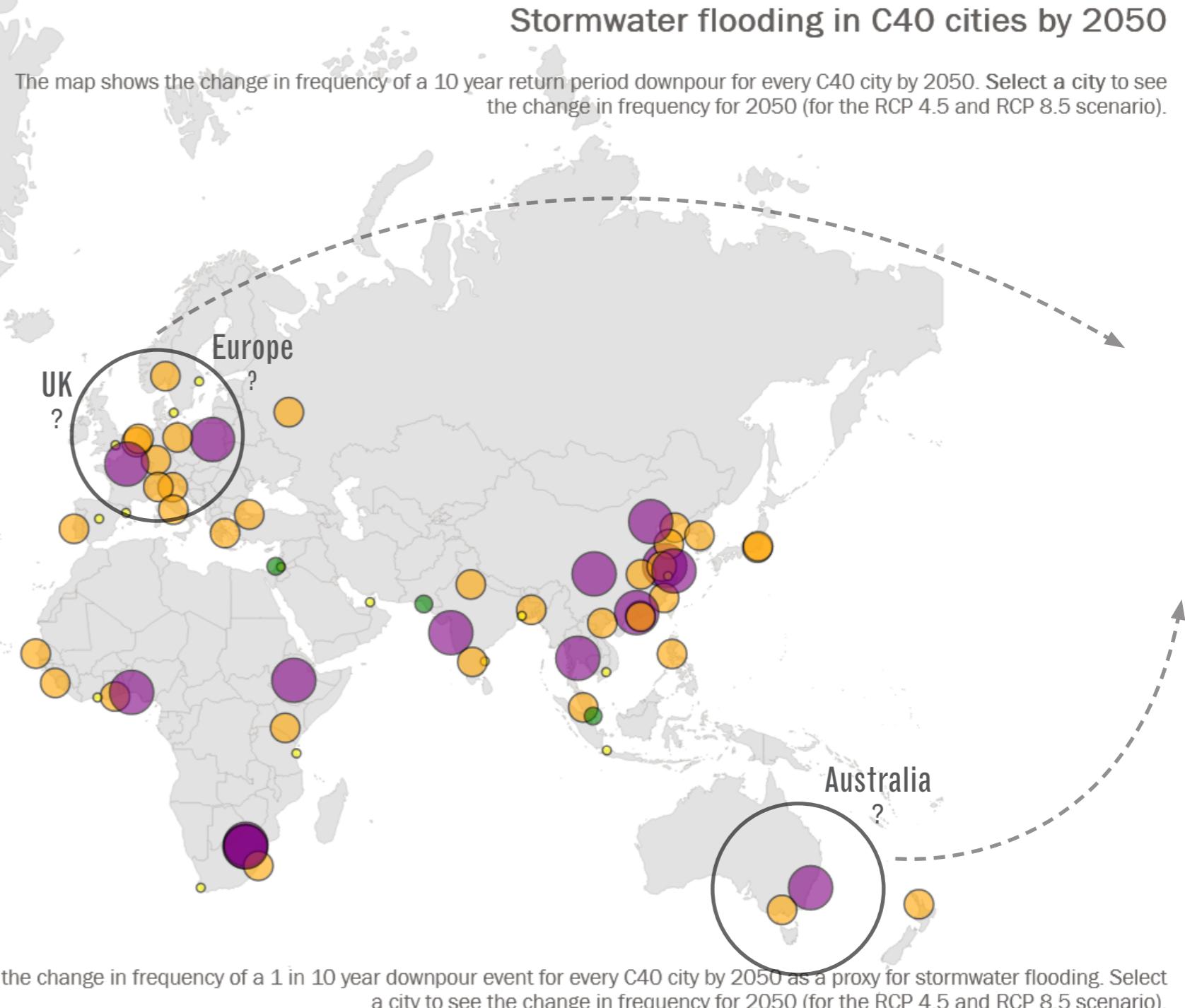
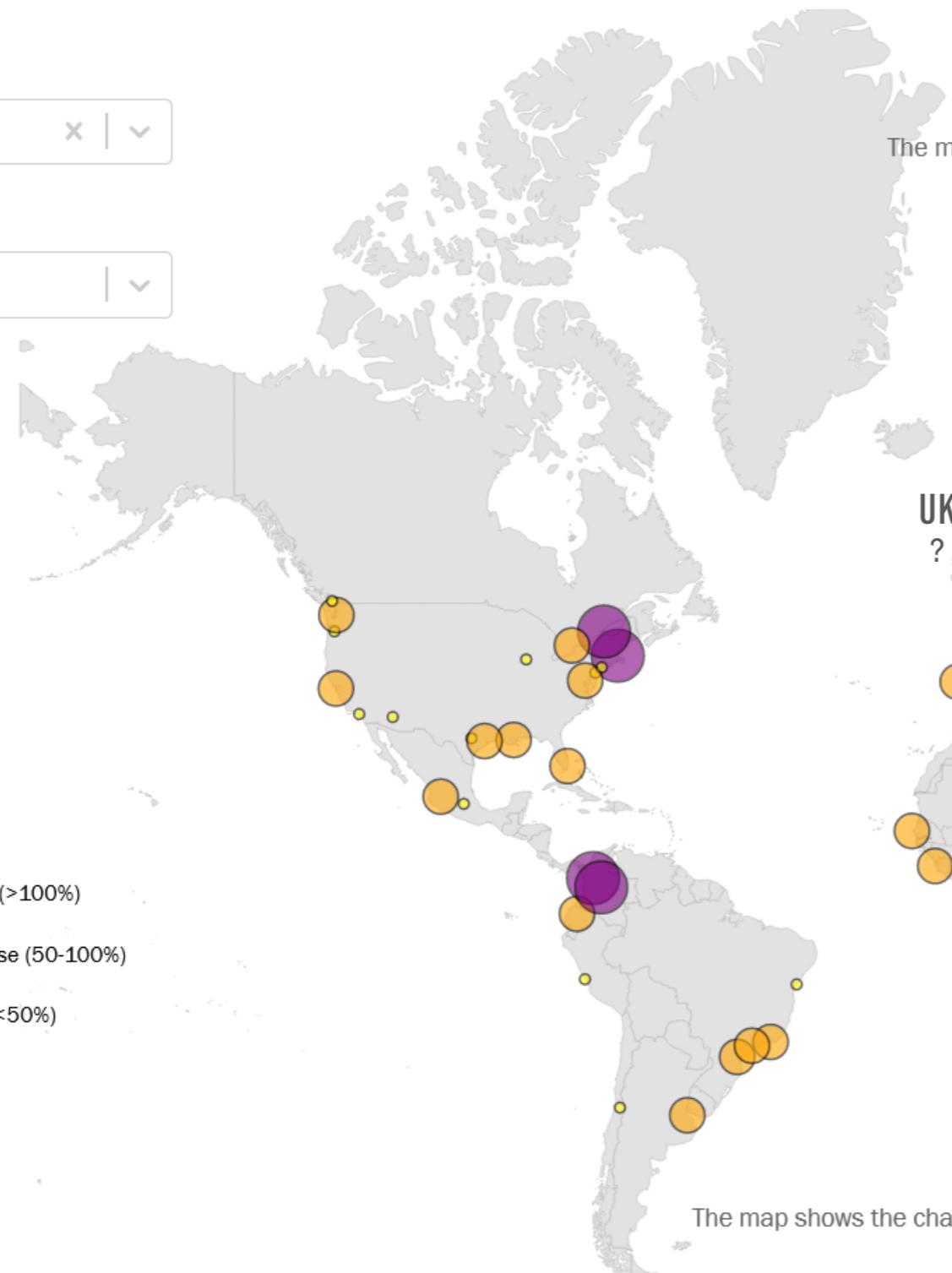
Select city:

Climate scenario:

 2050 RCP 4.5

Change in frequency

- Severe increase (>100%)
- Moderate increase (50-100%)
- Slight increase (<50%)
- Decrease



# City comparison

Riskful water areas are most impactful in large cities with densely populated areas. What developed big cities are at high risk of floods and droughts where it is quite difficult to intervene (regarding the existing city structure?)

1. Rotterdam



2. Amsterdam



3. Oslo



4. Stockholm



5. London



6. Venice



7. Melbourne

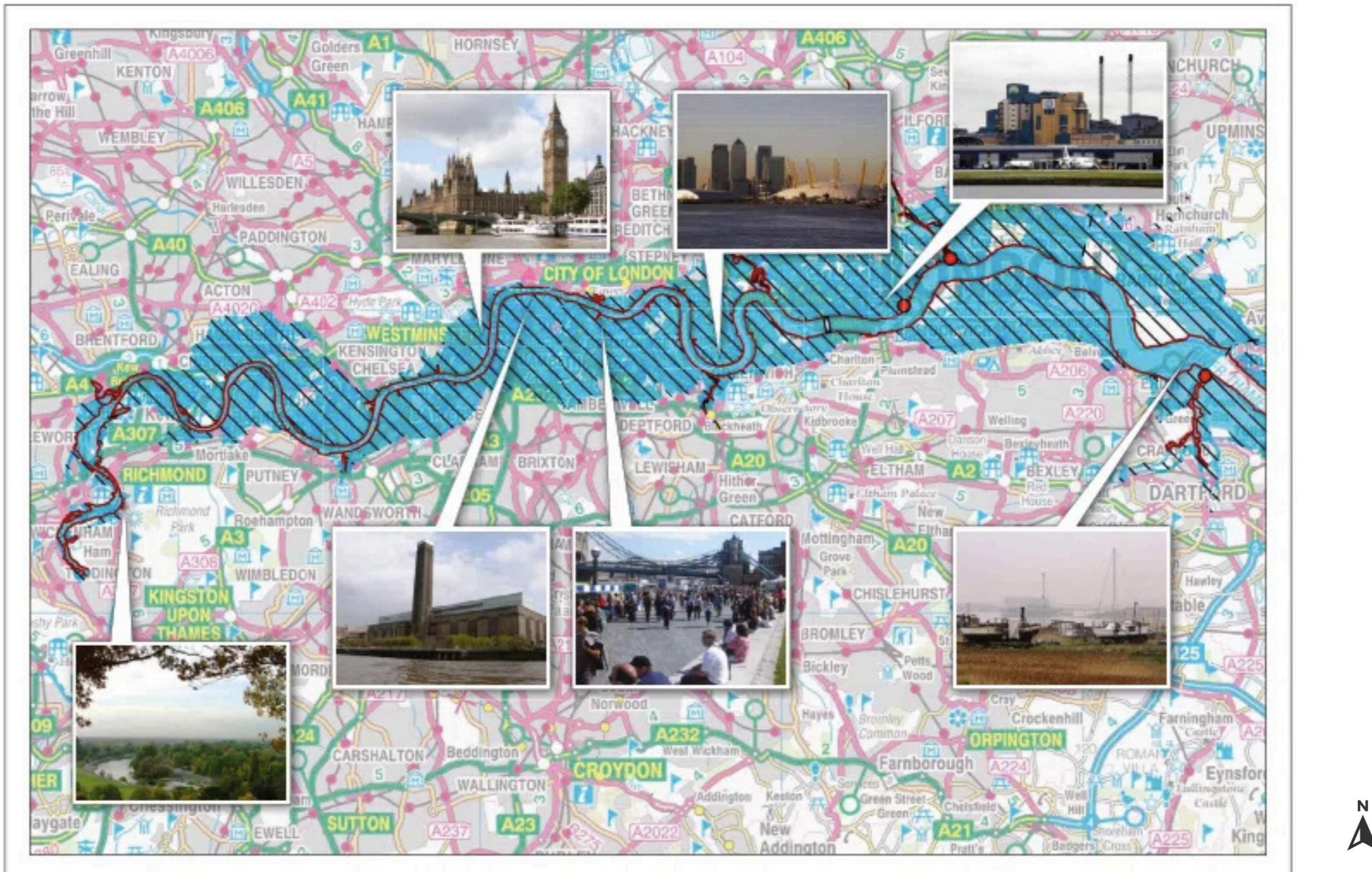


8. Sydney



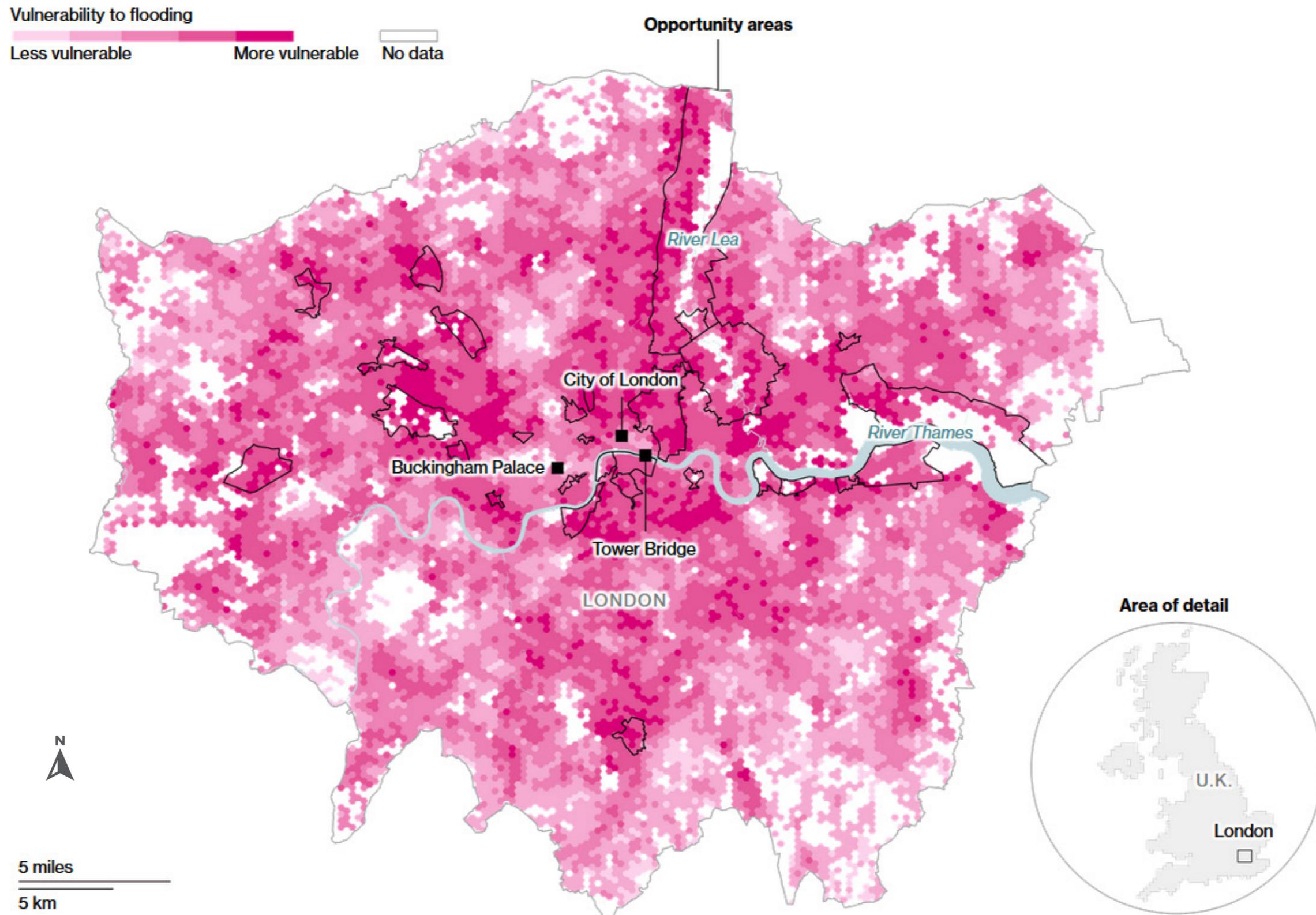
# Flood risk map London

Flood risk from sea level and river



# Flood risk map London

Great Authority of London: Environment Agency & Bloomberg Associates



# General Problem Statement

A disconnection between humans, nature and the built environment

The dependency of water as our basic need

Lost connection to water

Water design as symbol of the flow of life that promotes prosperity, progress, and technical power.



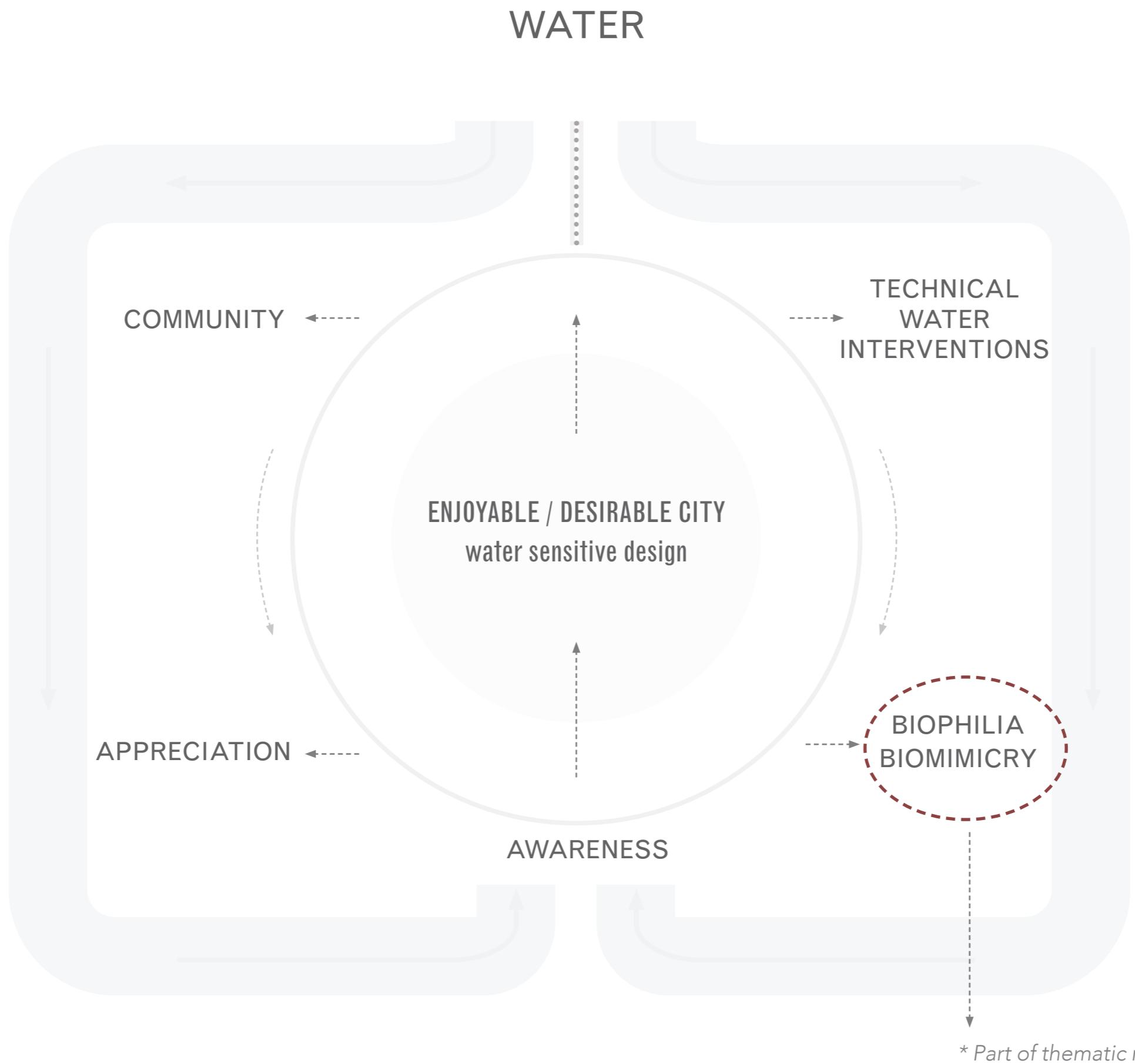
Lack of sustainable awareness...

...and social responsibility.



# Overall Design Objective

Oppurtunities: Using water as a medium to connect humans, nature and the built environment...



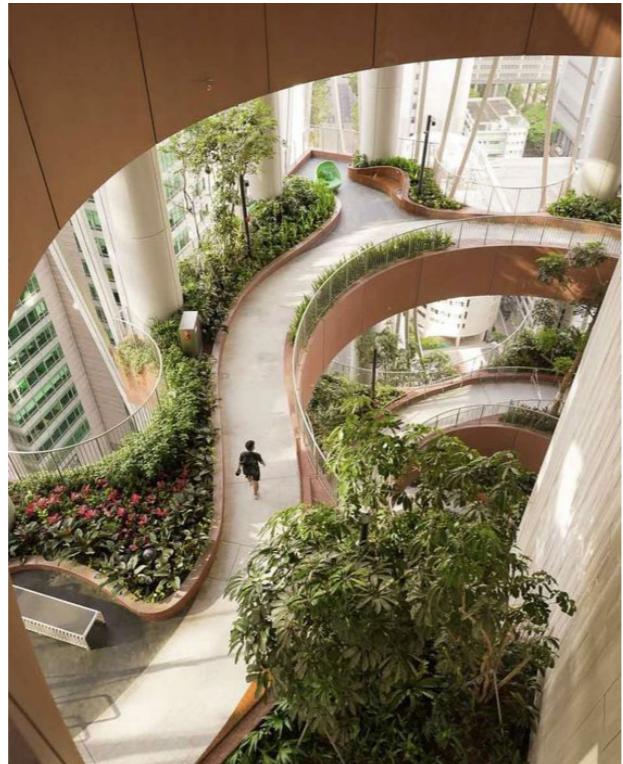
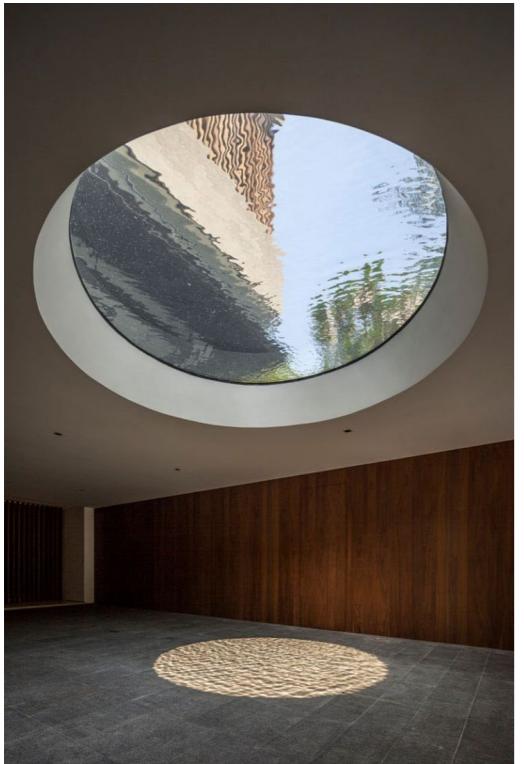
# Overall Design Objective

Positive effects of water on our health - connecting water on multiple scales

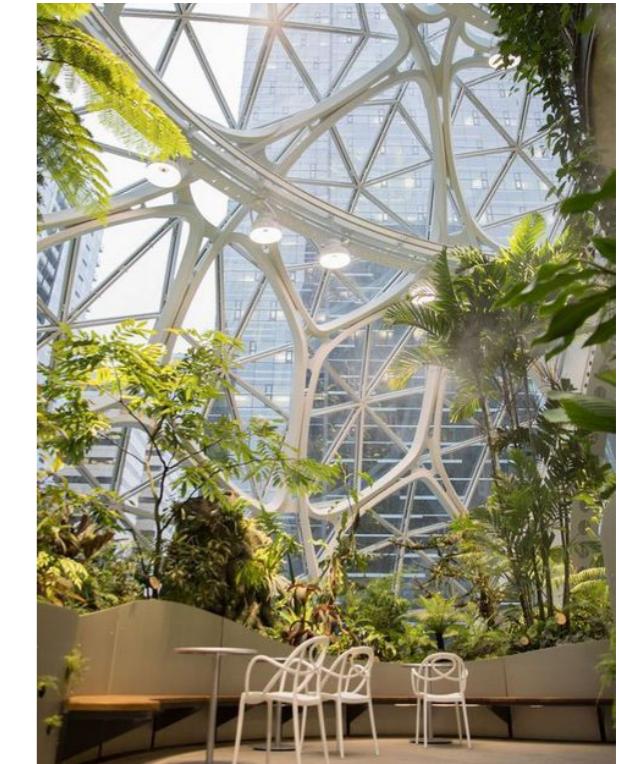
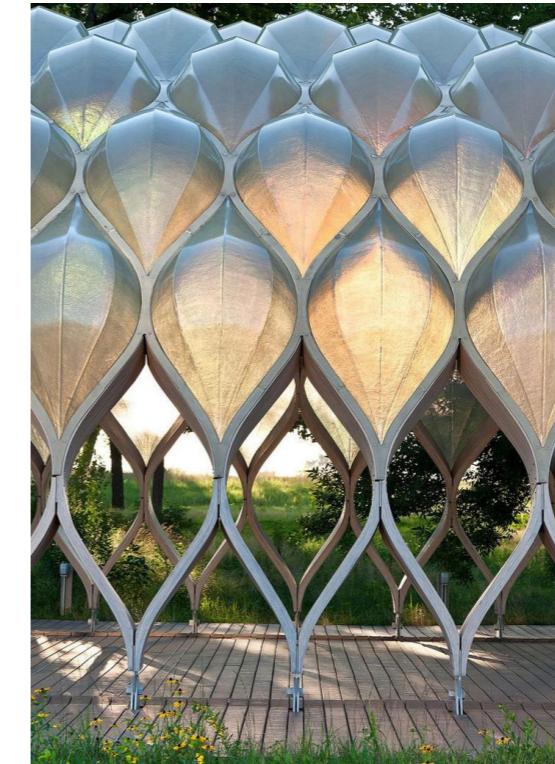
RESEARCH: ENJOYABLE / DESIRABLE SPONGE CITY



BIOPHILIA



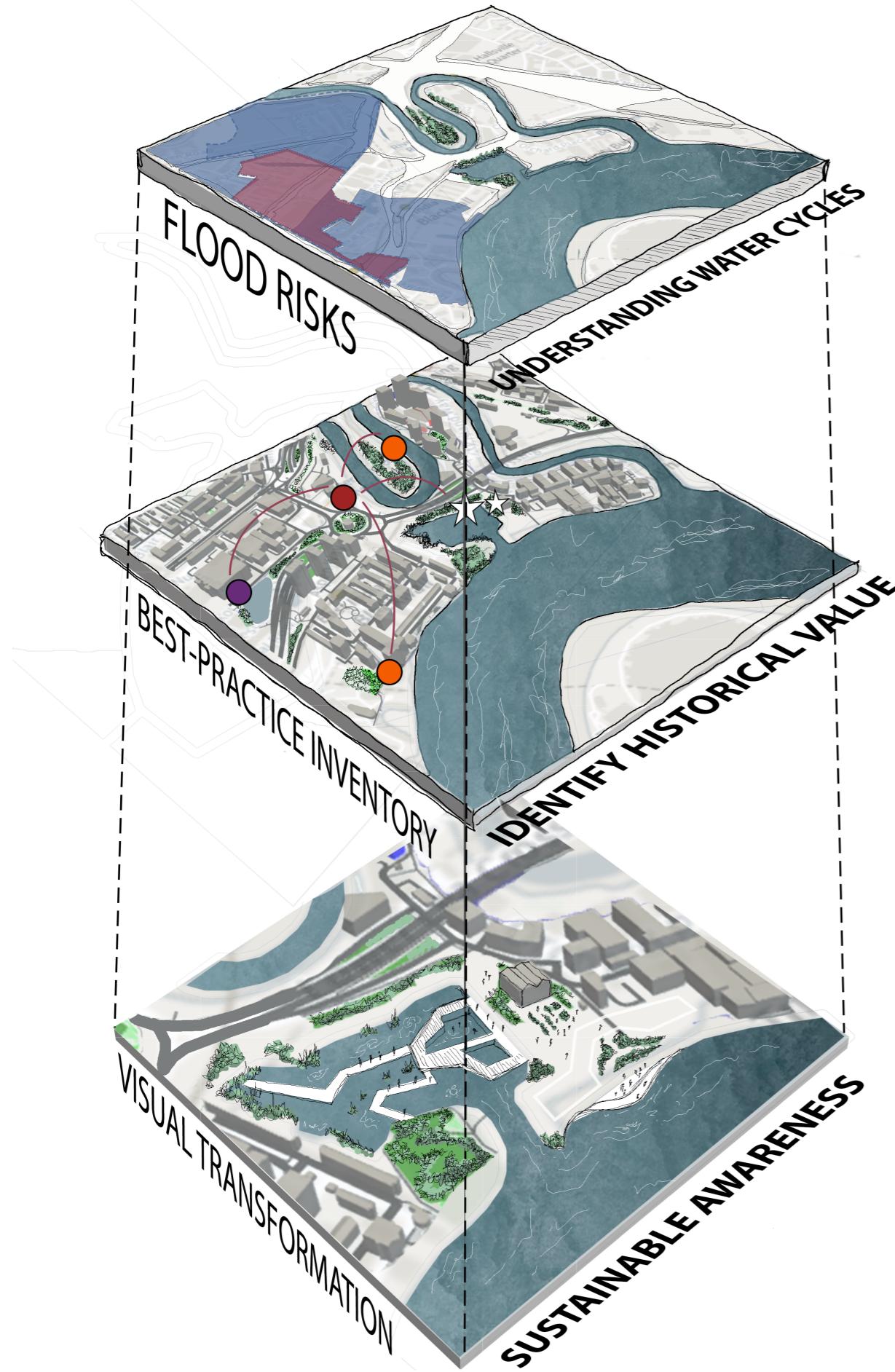
BIOMIMICRY



Visible, pleasant translations of creative sustainable knowledge and solutions that can be used as mediums to communicate the importance of implementing collective water systems in our everyday life.

# Research design tool: connecting scales with water sensitive designs

Using the water's qualities



## Landscape scale

- Identifying water problem areas
- Analyse city approach on water management
- Identify types of interventions applicable

## Urban square scale

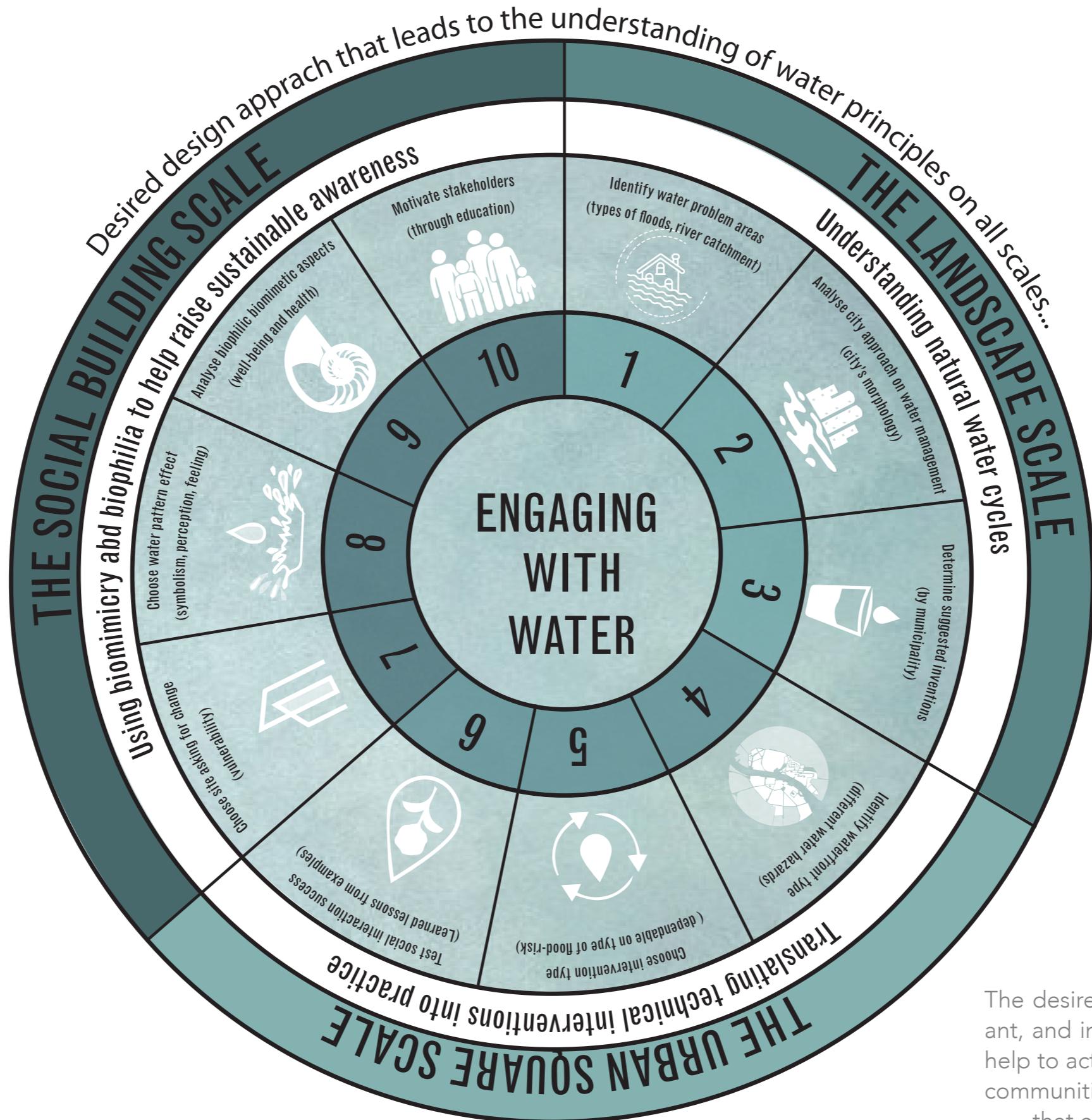
- Inventory local sustainable water interventions
- Analyse appreciated undeveloped historic / cultural amenity
- Identify missing public function in neighborhood

## Social building scale: a public building with housing

- Enhance human well-being using biomimicry and biophilia
- Activate all stakeholders through physical and visual interventions to create appreciation for sustainable interventions
- Include educational activities for communities about sustainable interventions to raise awareness

# Step-by-step design guide

Designing through three scales



The desired design outcome is a visible, pleasant, and impactful example building that might help to activate citizens to want to participate in communities and think of sustainable solutions that enhance a pleasant living environment.

# Discussion

Motivating stakeholders: BREEAM rules and awards

**To activate stakeholders, communicating and showing the way we consume and use water is crucial.**



*Involving ALL stakeholders*

hidden sewage systems



~~BREEAM outstanding award  
(example building)~~

*A motivating factor to reach sustainable goals, not the desired way of thinking about sustainability that should be reached.*

*Integration of landscape and architectural designs not researched, but of great importance to propose a well-considered water sensitive design approach that fits within the multiple scales of the landscape scale, urban square scale and social building scale.*



# STEP 1

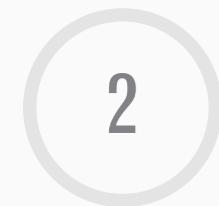
## THE LANDSCAPE SCALE

Understanding natural water cycles

From sea to land to rivers



Identifying water problem areas  
types of urban water floods...



Analyse city approach on water management



Identify types of interventions applicable



Identifying water problem areas

The city's morphology: identifying water risk areas



# STEP 1

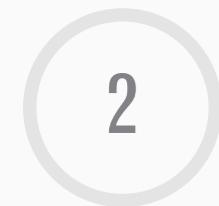
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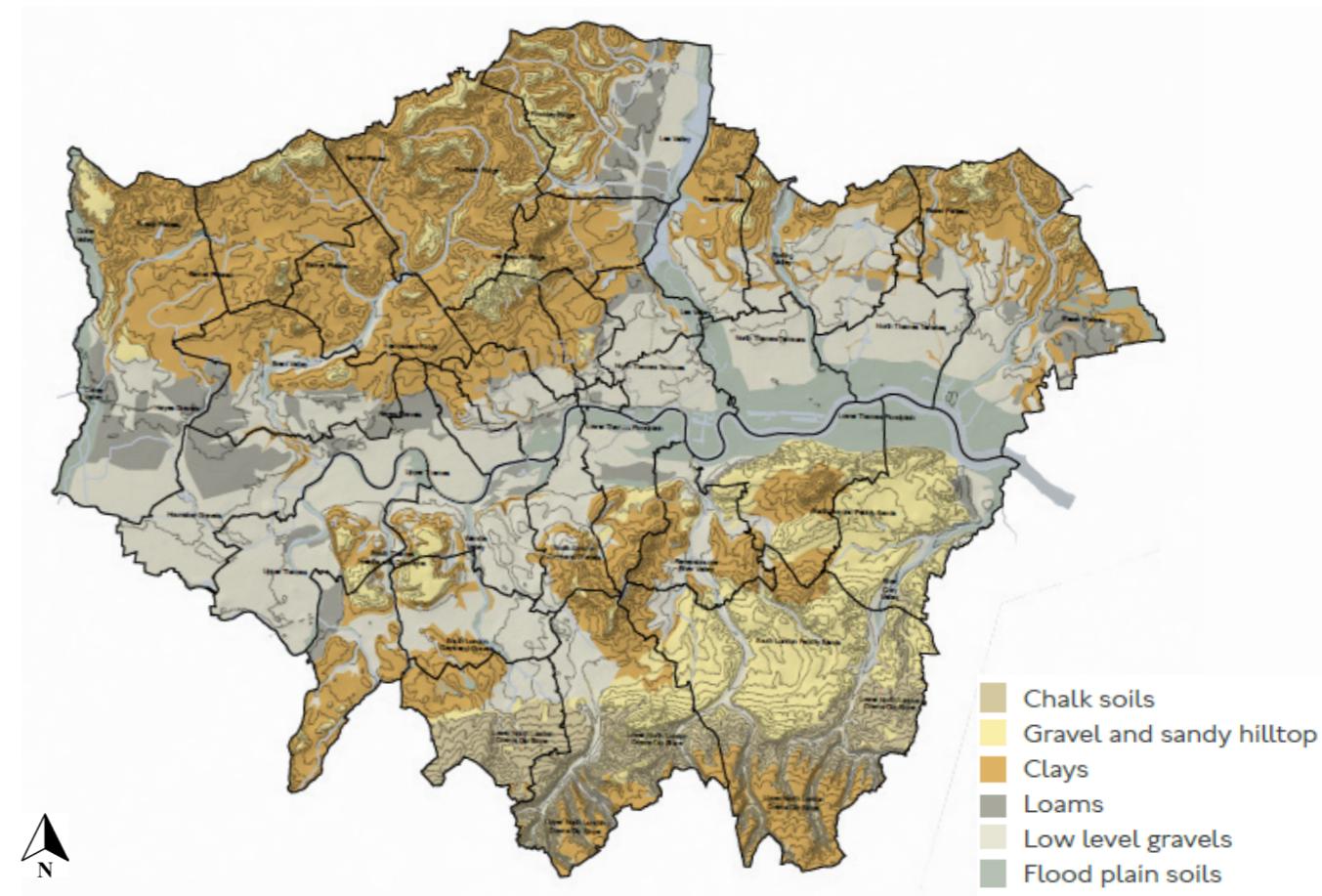


Identify types of interventions applicable



Identifying water problem areas

The city's morphology: identifying water risk areas



Types of urban flooding

- **Fluvial or river flooding**
- **Pluvial or overland**
- **Coastal floods**
- **Groundwater floods**

# Water Resilient Testing Framework

Designing through three scales

## Understanding natural water cycles

From sea to land to rivers

1

Identifying water problem areas

2

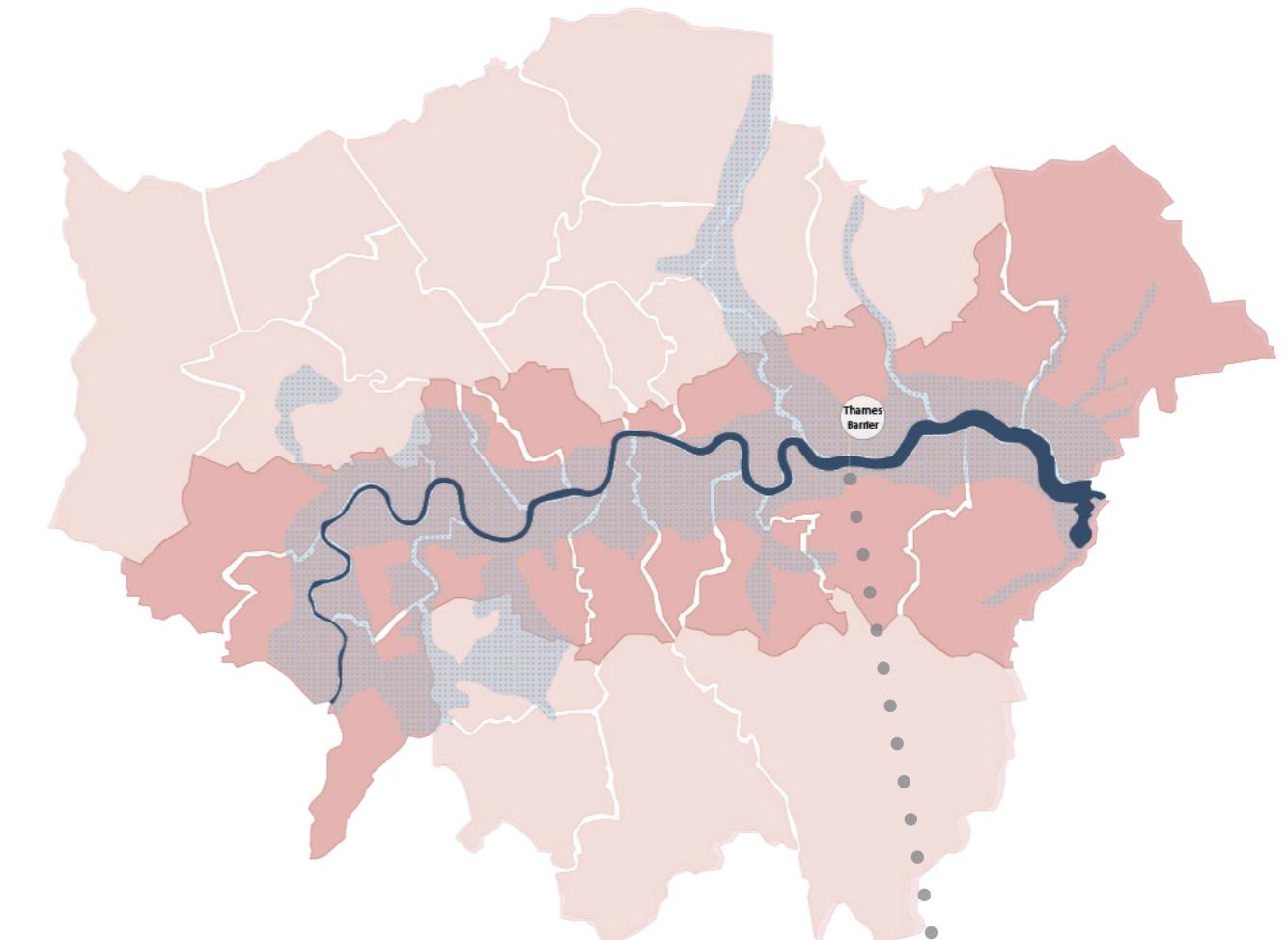
Analyse city approach on water management

3

Identify types of interventions applicable

2

The city's approach to water management and climate change



<https://www.thamesriversightseeing.com/attractions/thames-barrier>

# STEP 1

## THE LANDSCAPE SCALE

### Understanding natural water cycles

From sea to land to rivers

1

Identifying water problem areas

2

Analyse city approach on water management

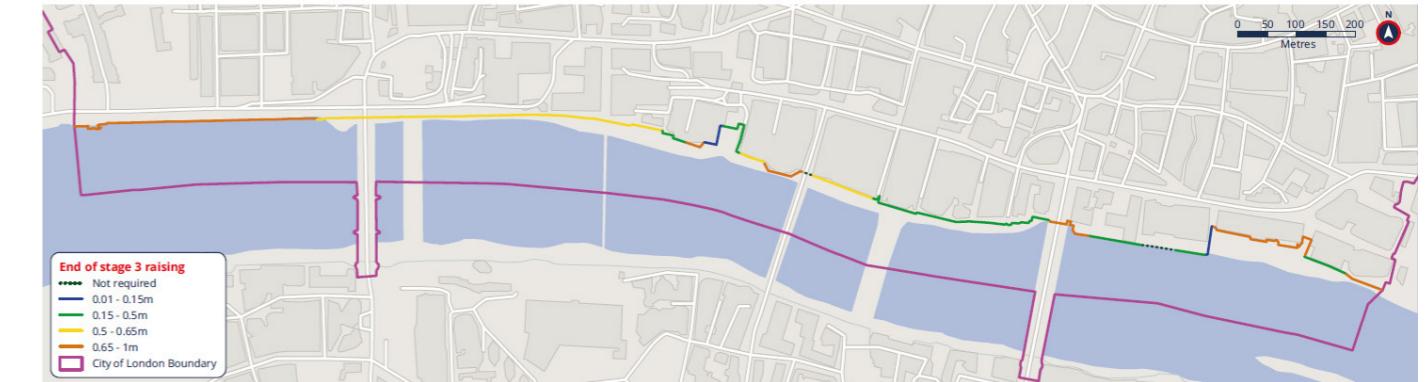
3

Identify types of interventions applicable  
fit within municipality plan...

3

Identify types of interventions applicable

Raising Requirements – **End of Stage 3 (2100)**



Pressure on surface water run-off



(long-term approach needed)

Thames Estuary riverside approach

- engage with local community
- provide space for habitat
- enable people to have access to the riverside with views of the river

*'The selected end-of-century option needs to be in place and operational by 2070 based on current projections. We have changed the deadline for deciding on the final option from 2050 to 2040. This allows enough time for planning and approval before construction begins'*

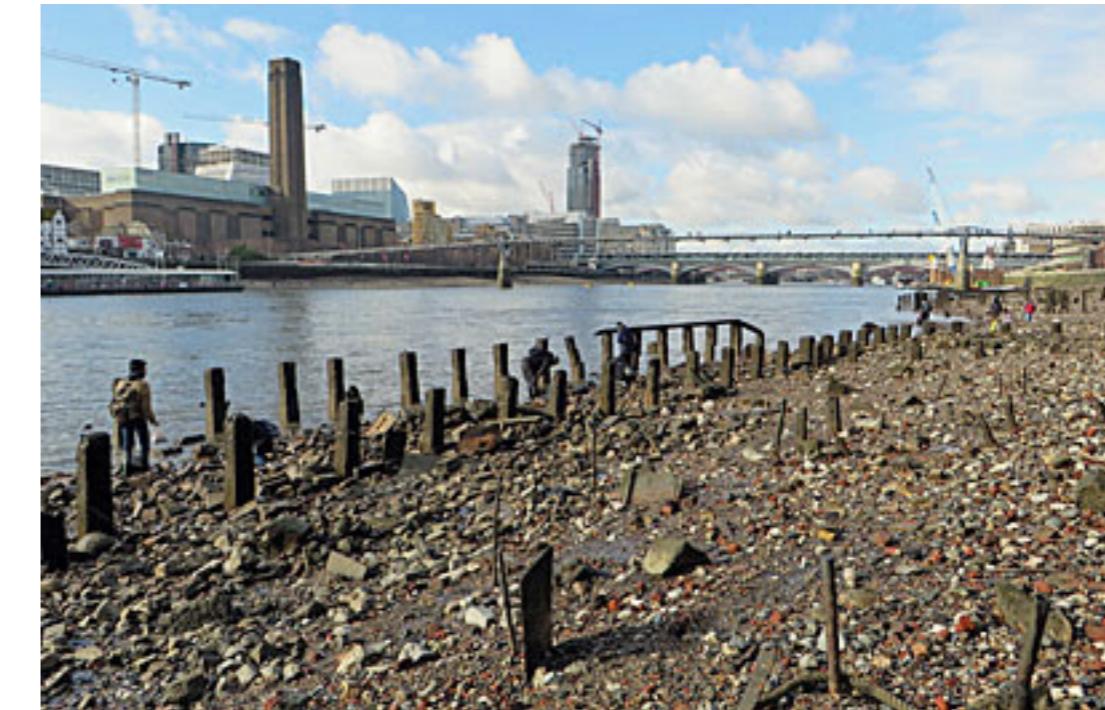
[https://www.gov.uk/  
guidance/major-updates-  
to-thames-estuary-2100-  
from-2012-to-2023](https://www.gov.uk/guidance/major-updates-to-thames-estuary-2100-from-2012-to-2023)

[https://www.gov.uk/  
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fits-and-riverside-strate-  
gies-thames-estuary-2100](https://www.gov.uk/guidance/creating-benefits-and-riverside-strategies-thames-estuary-2100)

# Everyday tidal change



HIGH TIDE



LOW TIDE

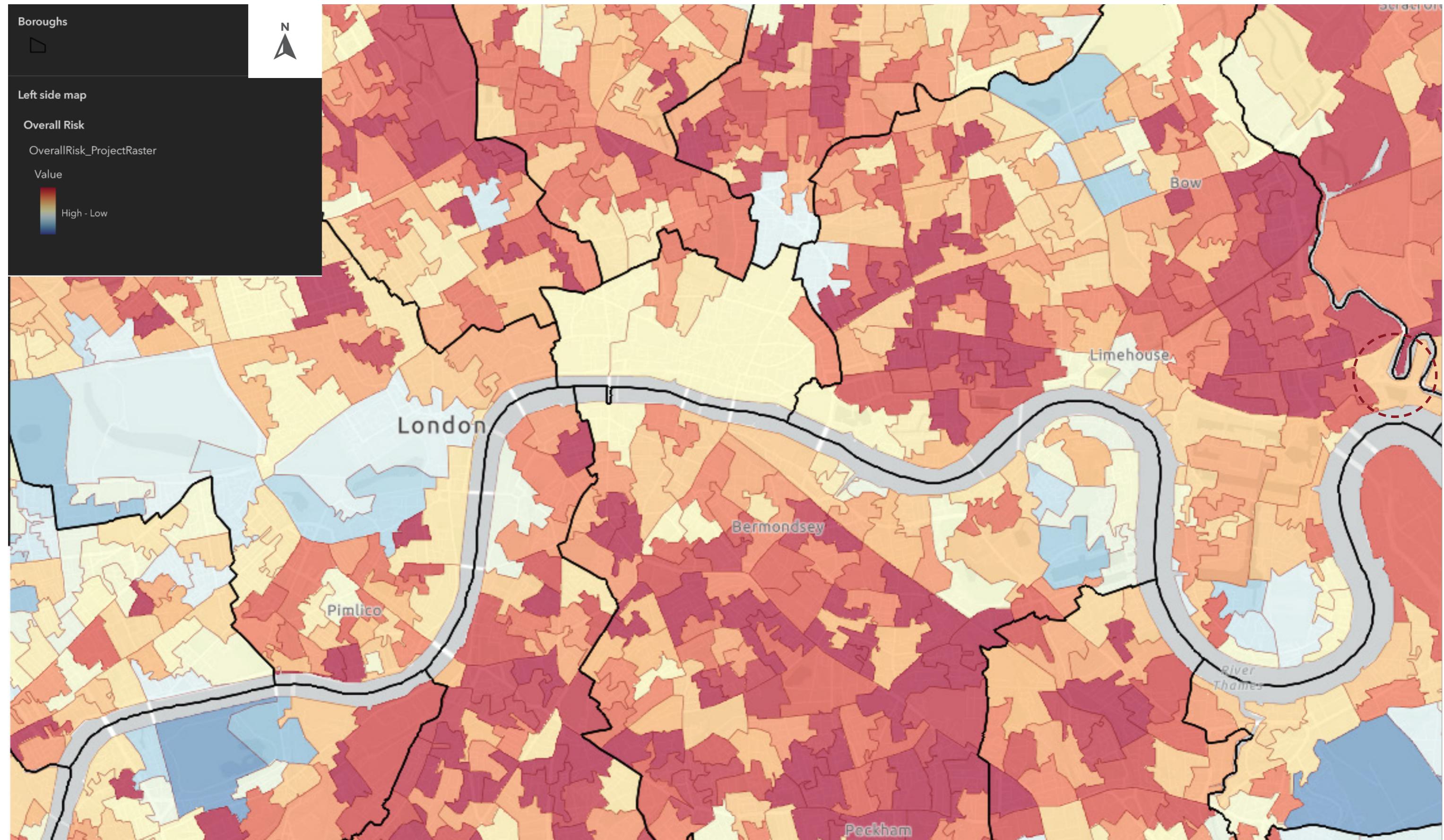
## HOW TO STILL BUILD CLOSE TO THE WATERFRONT?

MAINAINING WATER CONNECTION

<https://diamondgeezer.blogspot.com/2015/02/spring-tide.html>

# Analysing water problems in London

## OVERALL RISK



# Analysing water problems in London

## SURFACE WATER FLOOD RISK



# Social housing shortage

Environmental, economic and social problems



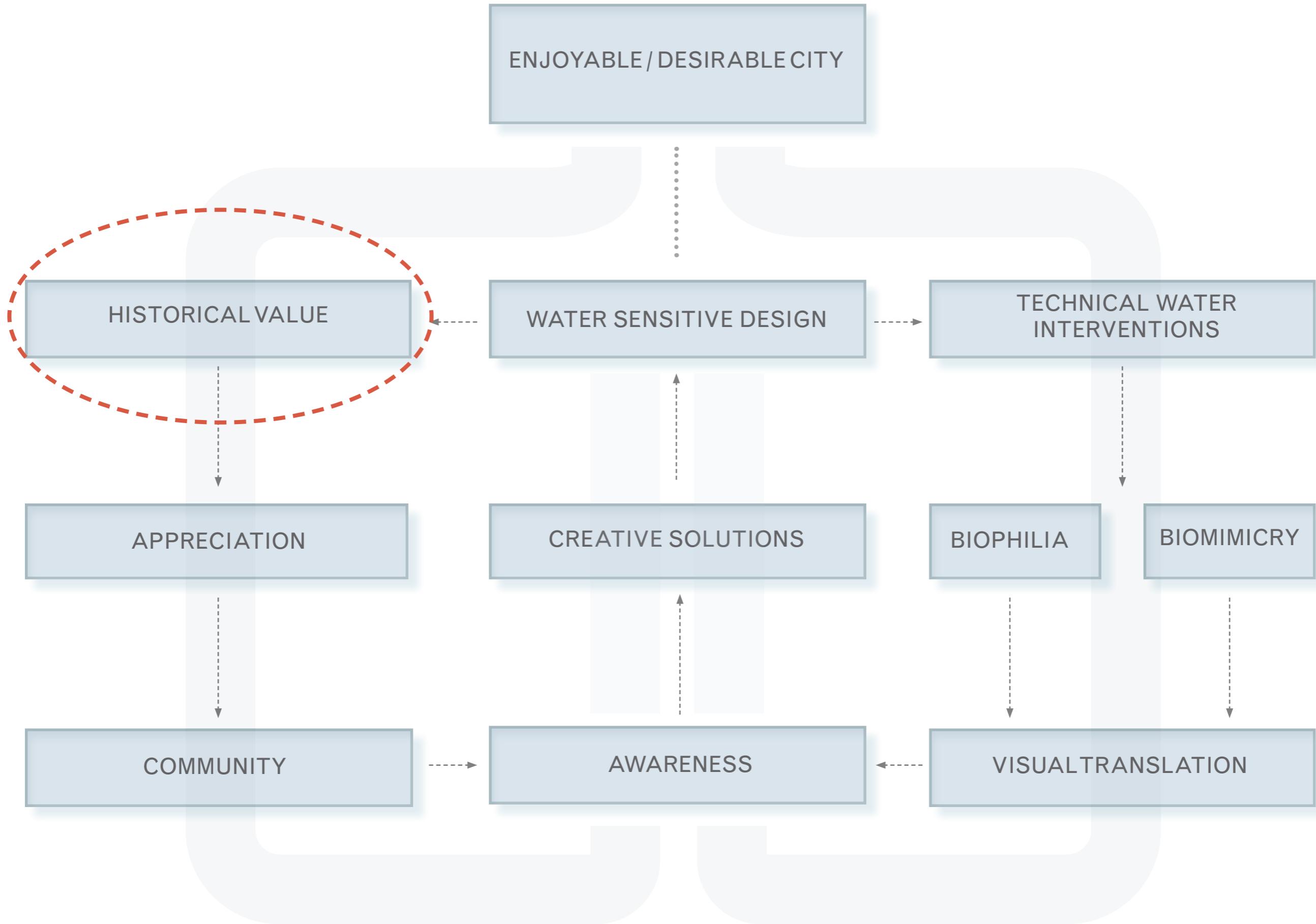
*Why not use vacant industrial building sites?*



Gould, M. (2015). Local residents angry at lack of social housing at West Ham's ground. The Guardian. Retrieved from <https://www.theguardian.com/society/2015/feb/24/newham-residents-social-housing-west-ham>. Accessed on October 19th, 2023.

# Choosing a vulnerable site asking for change

## The prescence of water in architecture...



# Location analysis

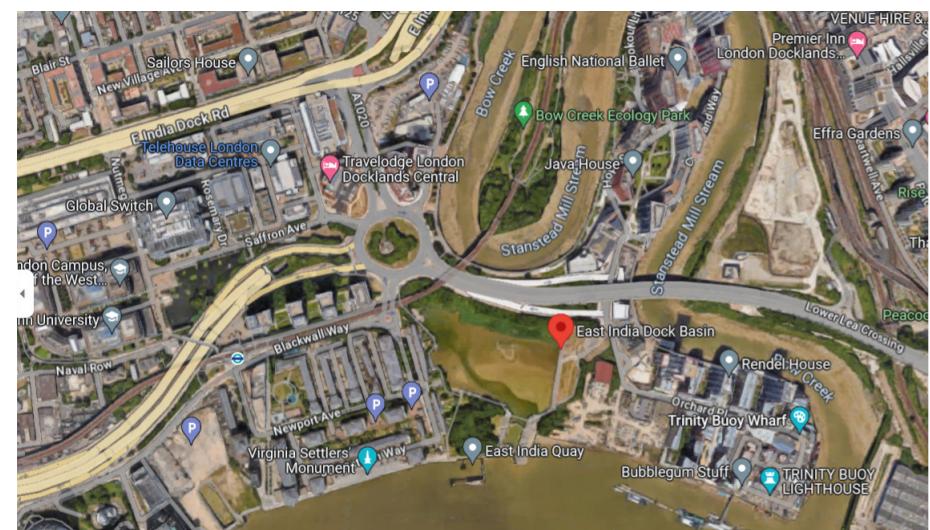
Location 1. The Thames Ironworks and Shipbuilding Company, Leamouth Warf



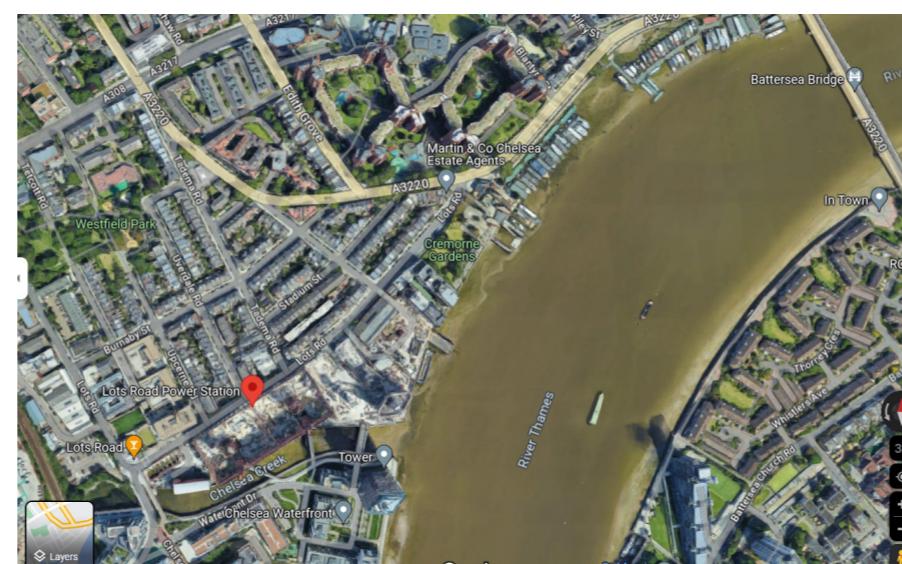
Location 2. Lots Road Power Station, Chelsea



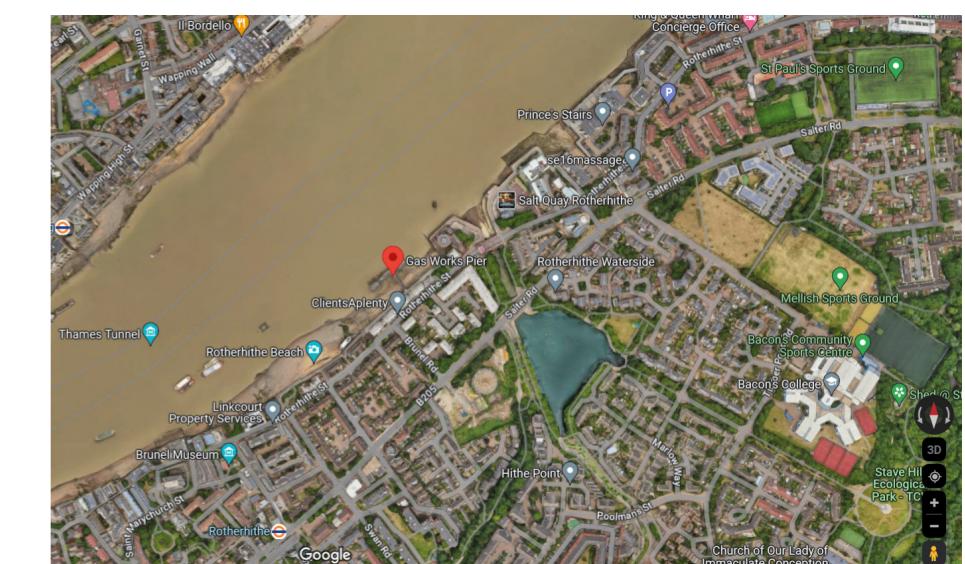
Location 3. Rotherhithe Gas Works, Rotherhithe



Location map - Leamouth Borough Site



Location map - Chelsea Borough Site



Location map - Rotherhithe Site

# Historical vacant buildings and sites in London

How historical value can contribute to creating appreciation for sustainable interventions...



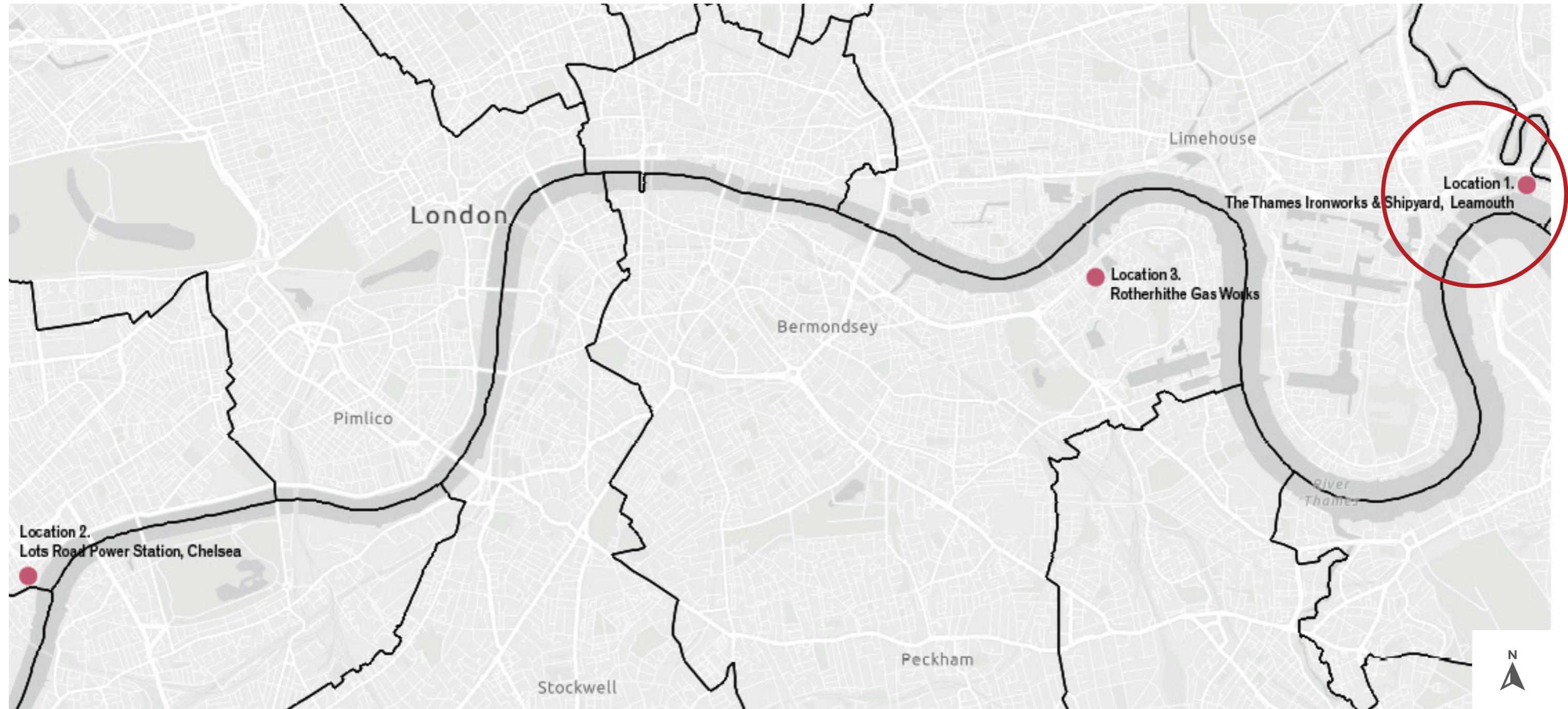
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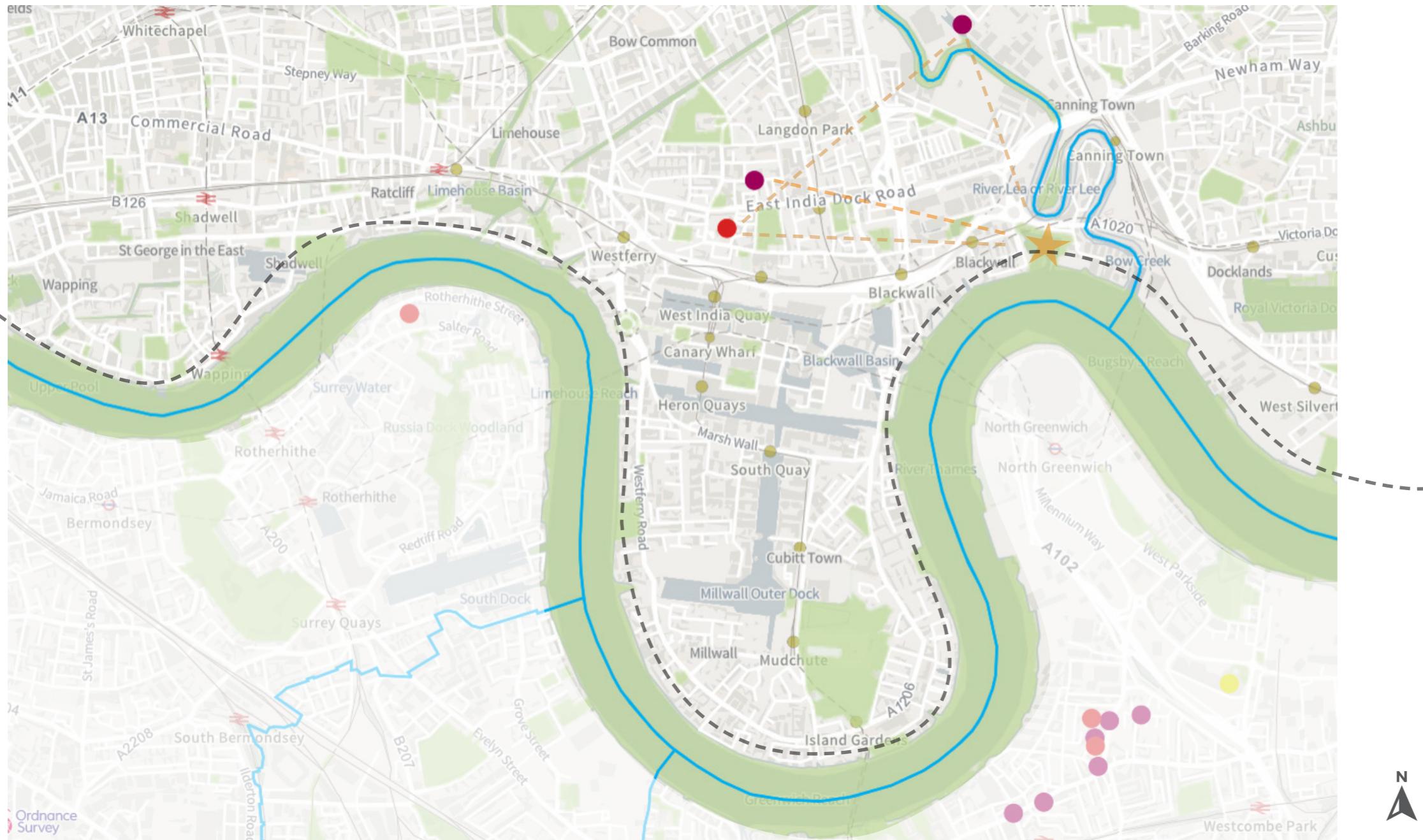
Location 1. The Thames Ironworks and Shipbuilding Company, Leamouth



# Using technical research interventions as a base

Landscape scale: what research has already been done?

Contribute to sustainable drainage interventions  
(colored dots)

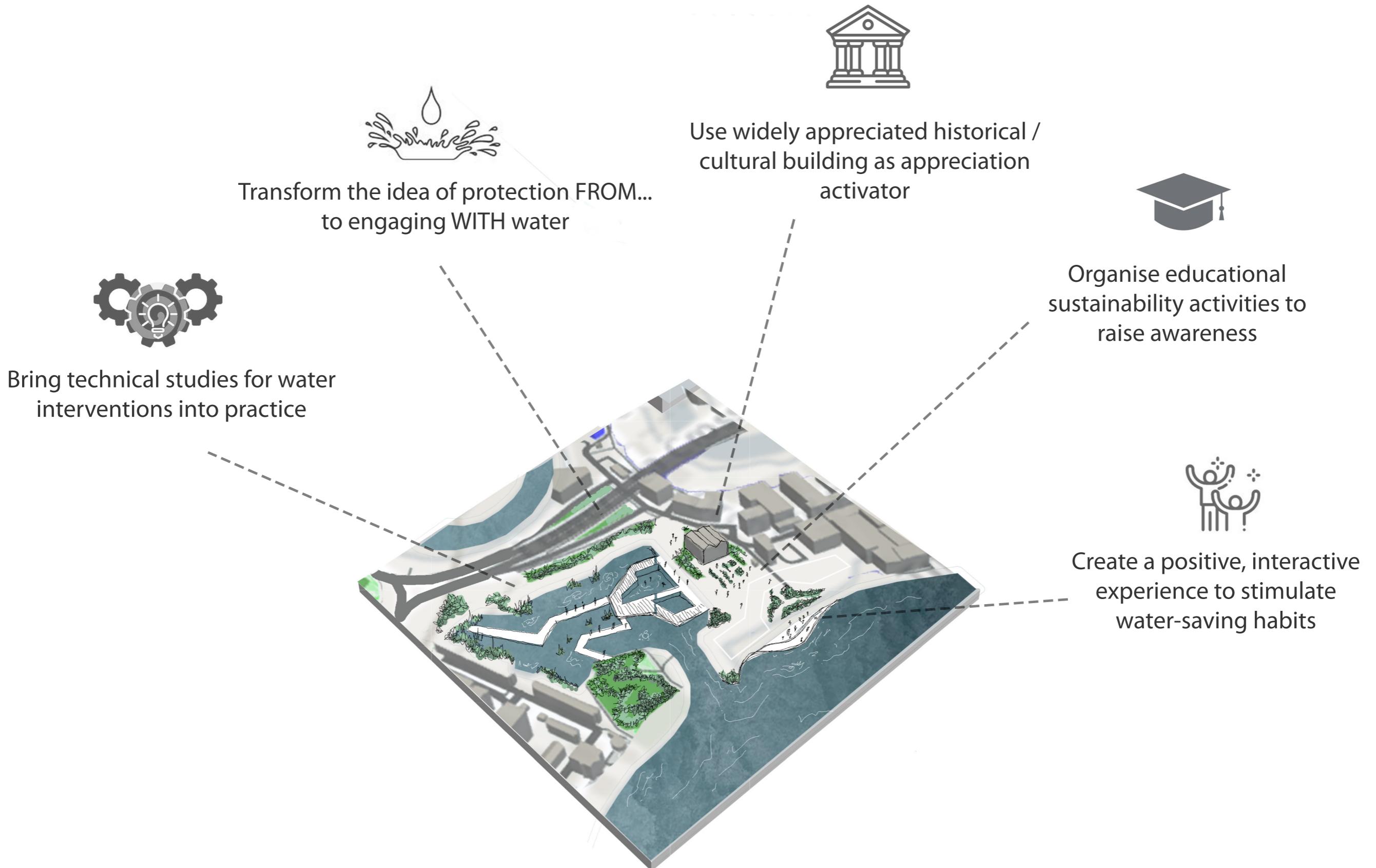


Potential open undeveloped open spaces with amenity value: historical or cultural interest.  
(green spots)

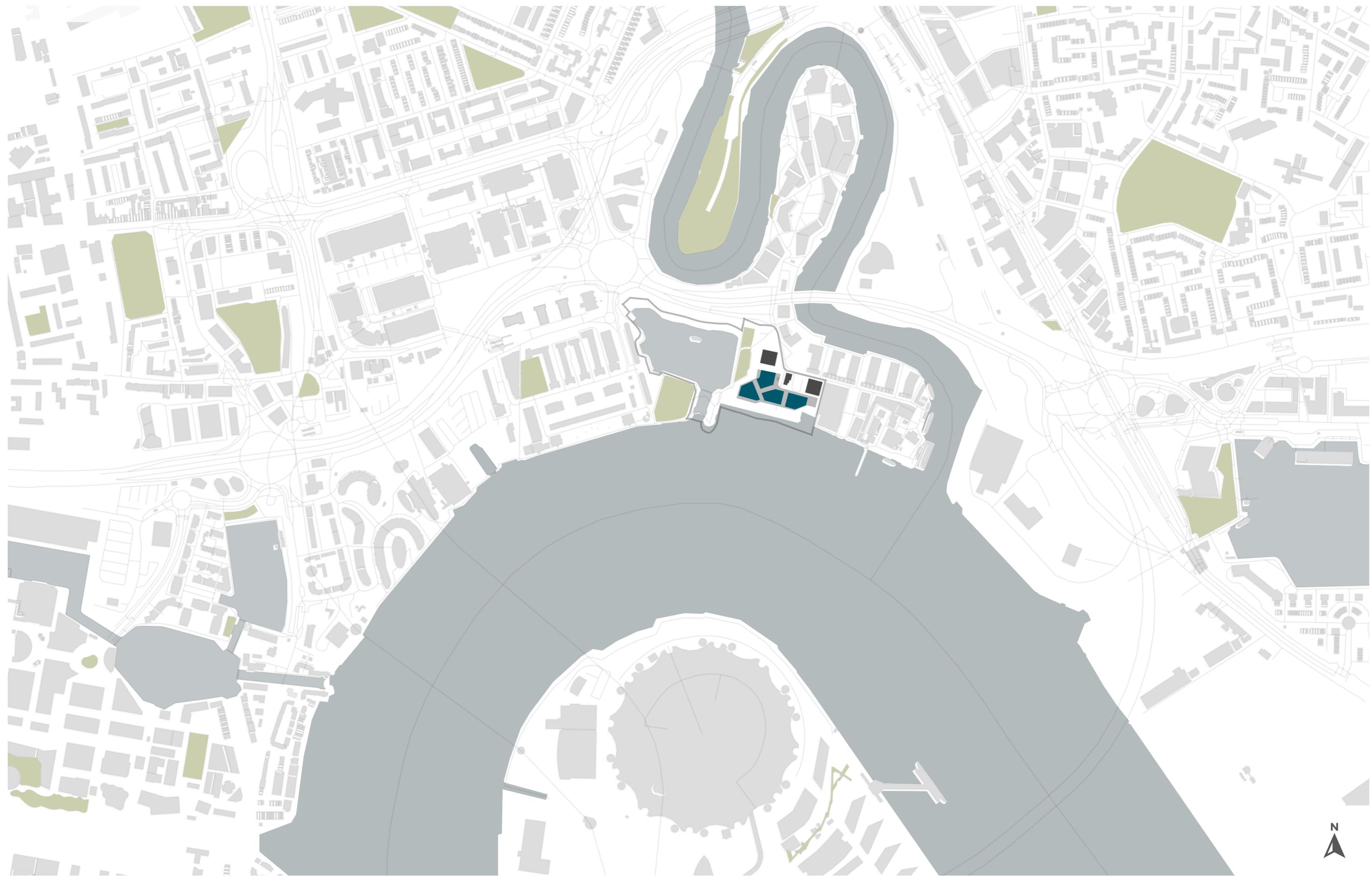
Sewage water and rainwater share the same sewer system

Great Authority of London (Government: Mayor of London)  
<https://apps.london.gov.uk/suds/#12.91/51.50257/-0.00495>

# Design principles

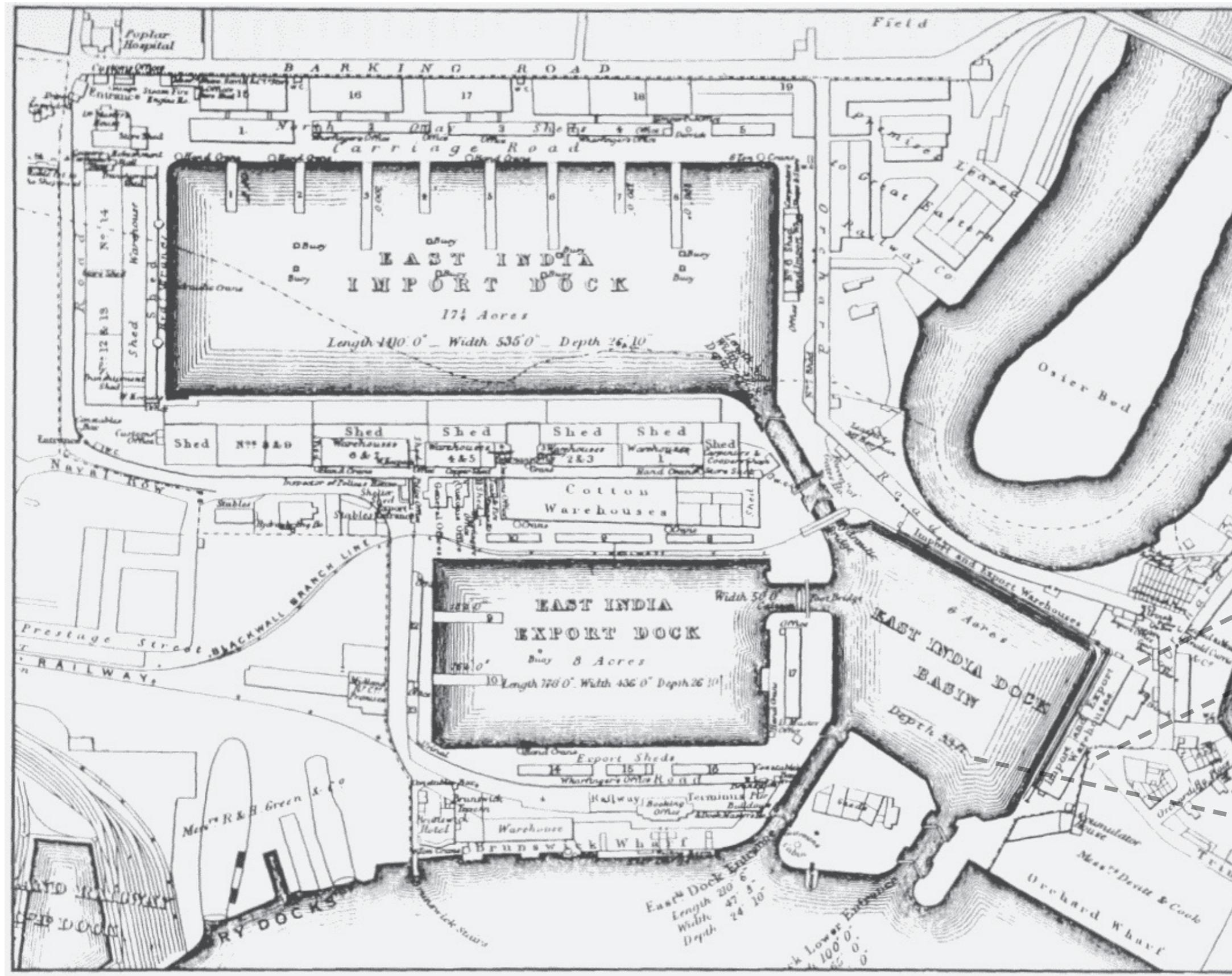


# Site



# Historic development

Prominent existence of East India Docks in 1806 on old maps

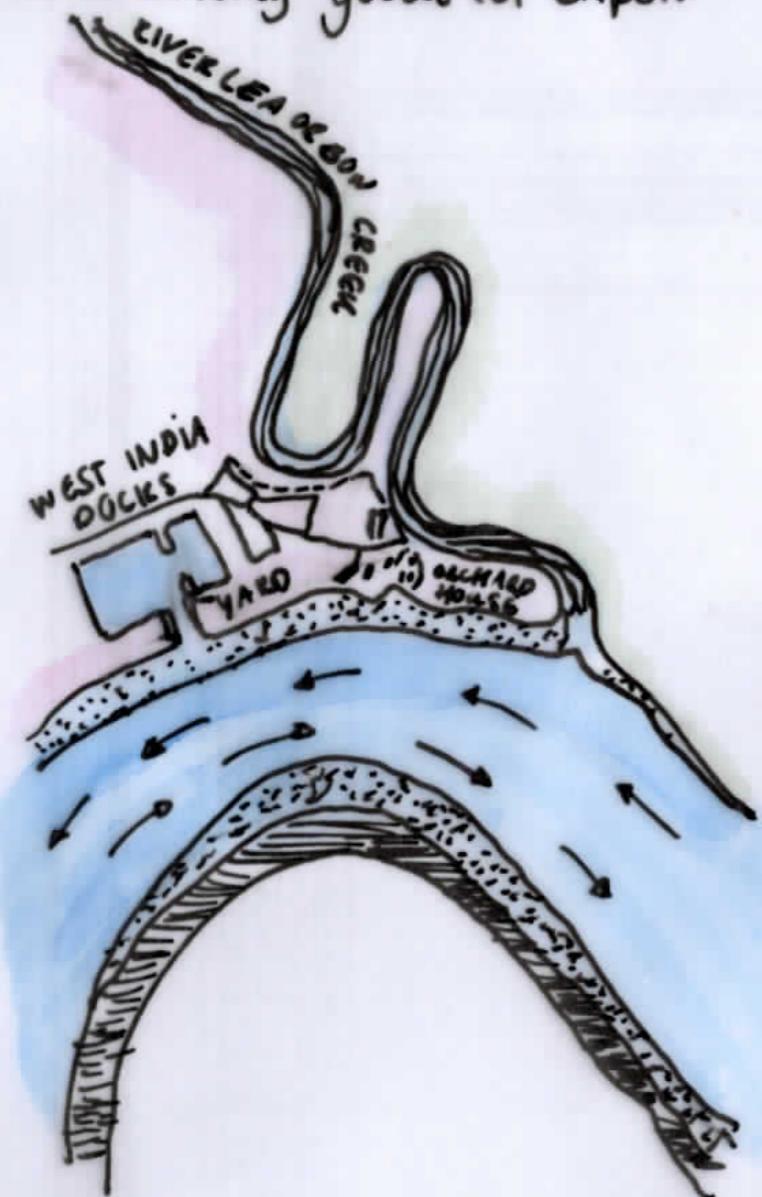


# Historic development: Characteristic warehouses

Visible wooden structures with repetitive, functional facade design

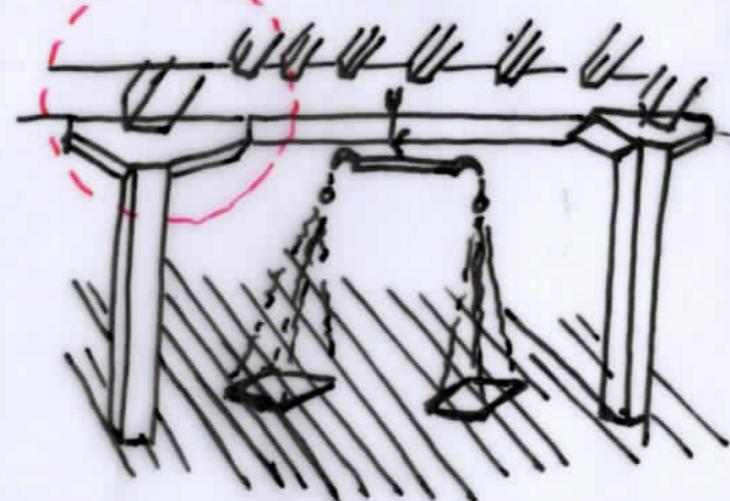
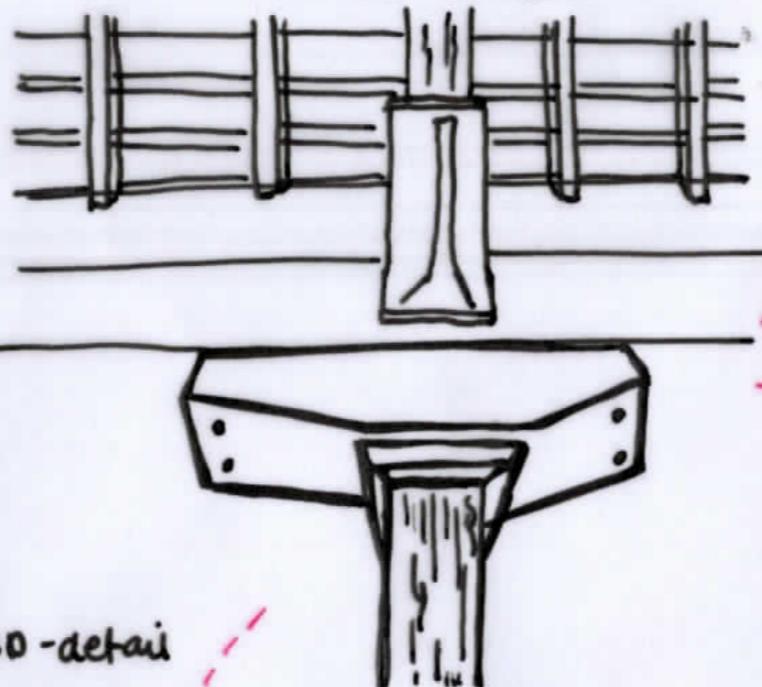
## HISTORIC DEVELOPMENT

- map drawing 1802 displaying West India docks for unloading goods & loading goods for export

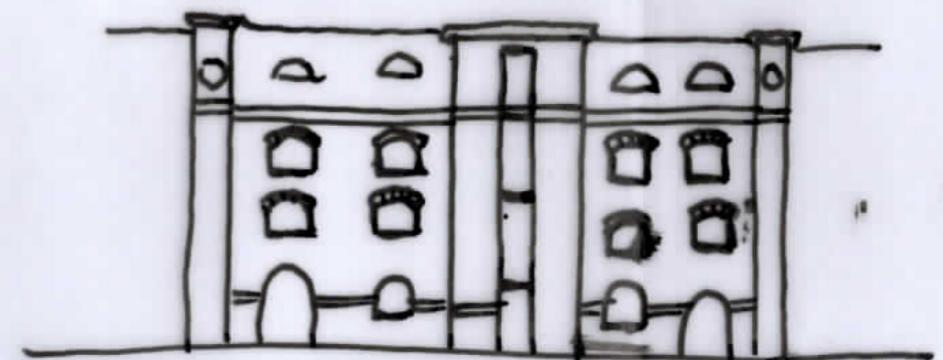


## WAREHOUSE CHARACTERISTICS

- build-up structure of warehouses



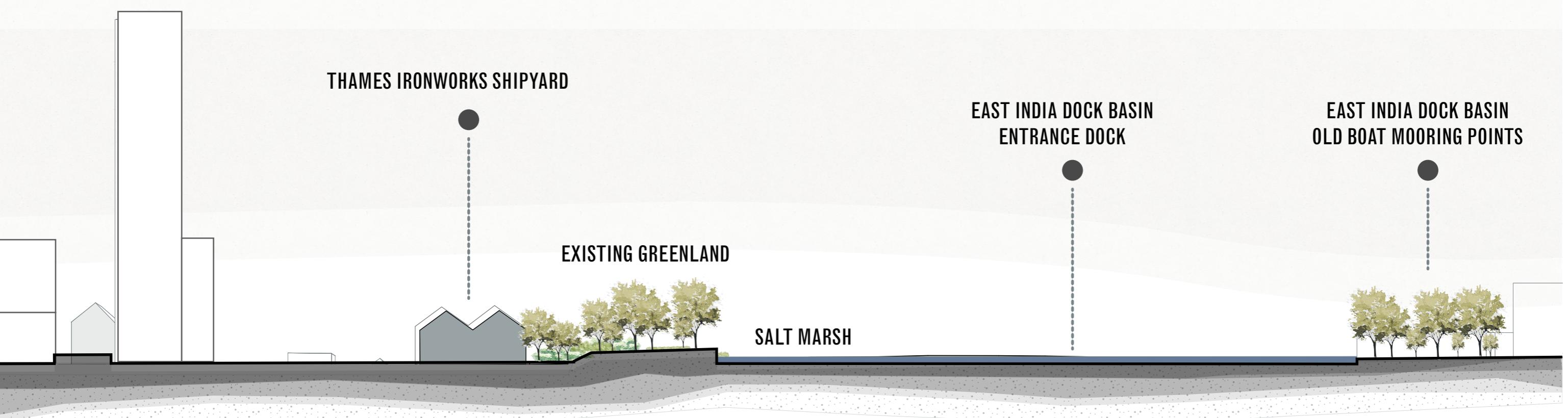
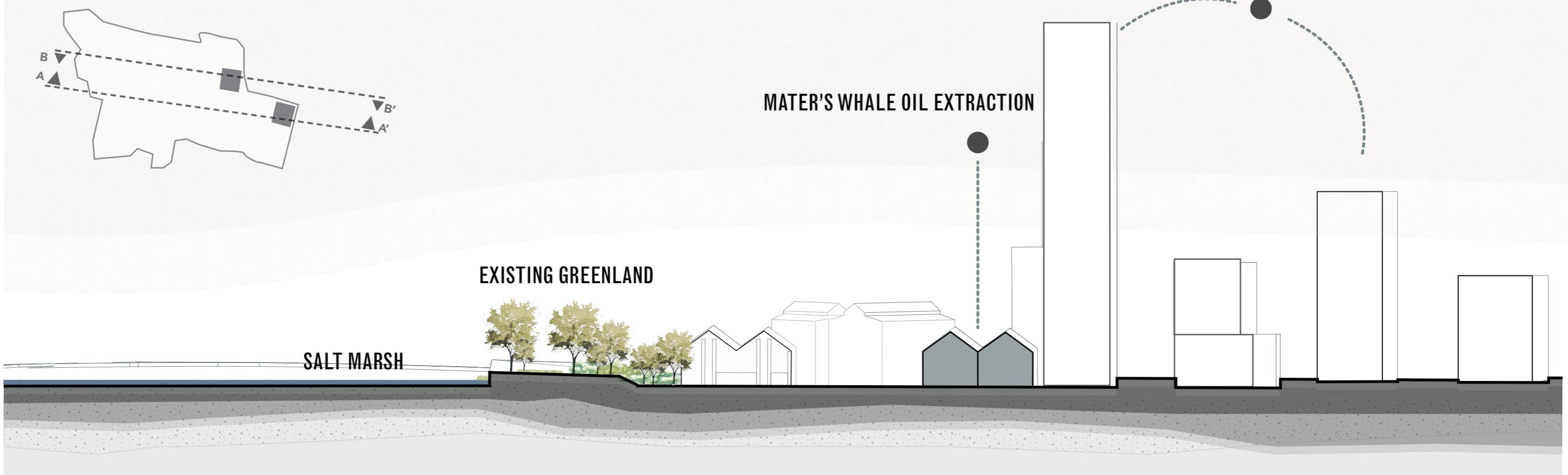
SECTION



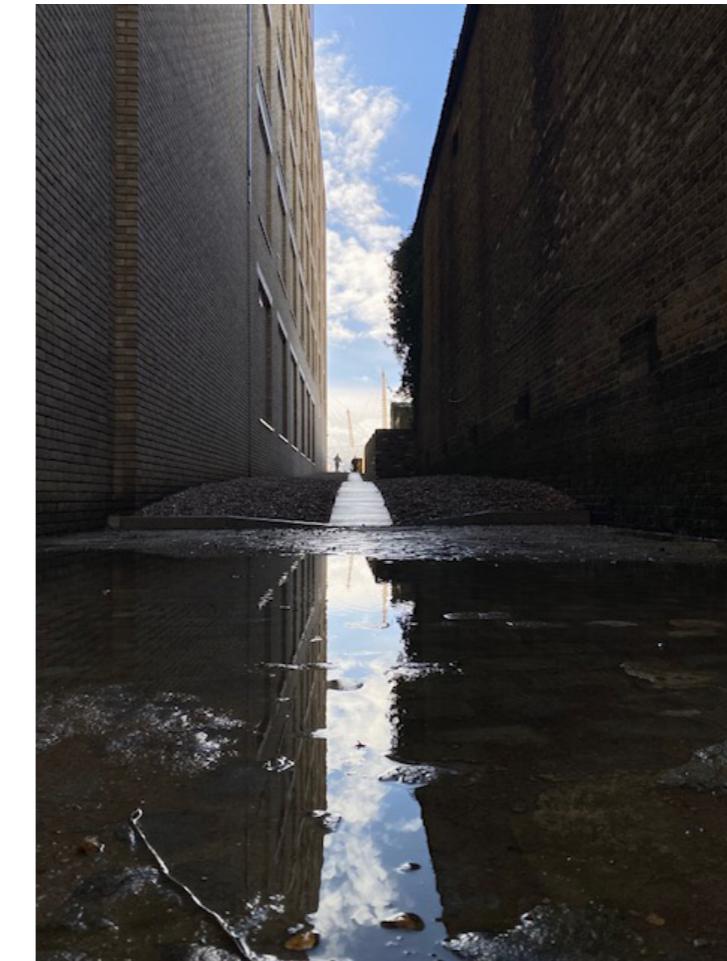
# Existing situation - sections

Re-strengthening the historic characteristics of the old docks

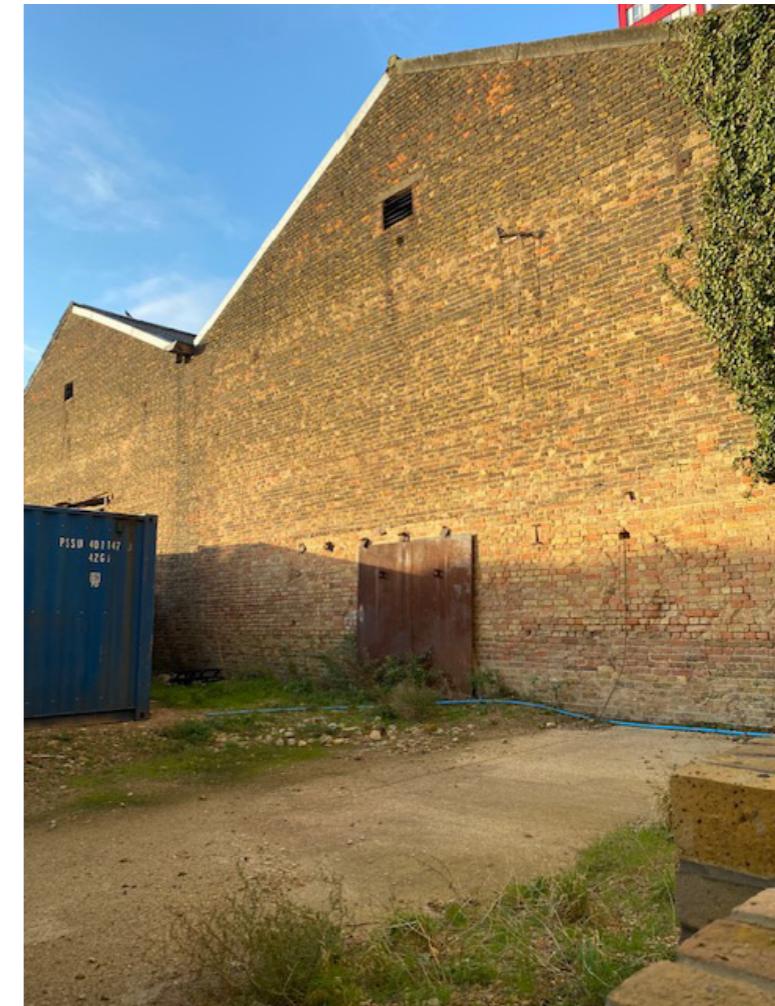
Scale 1000



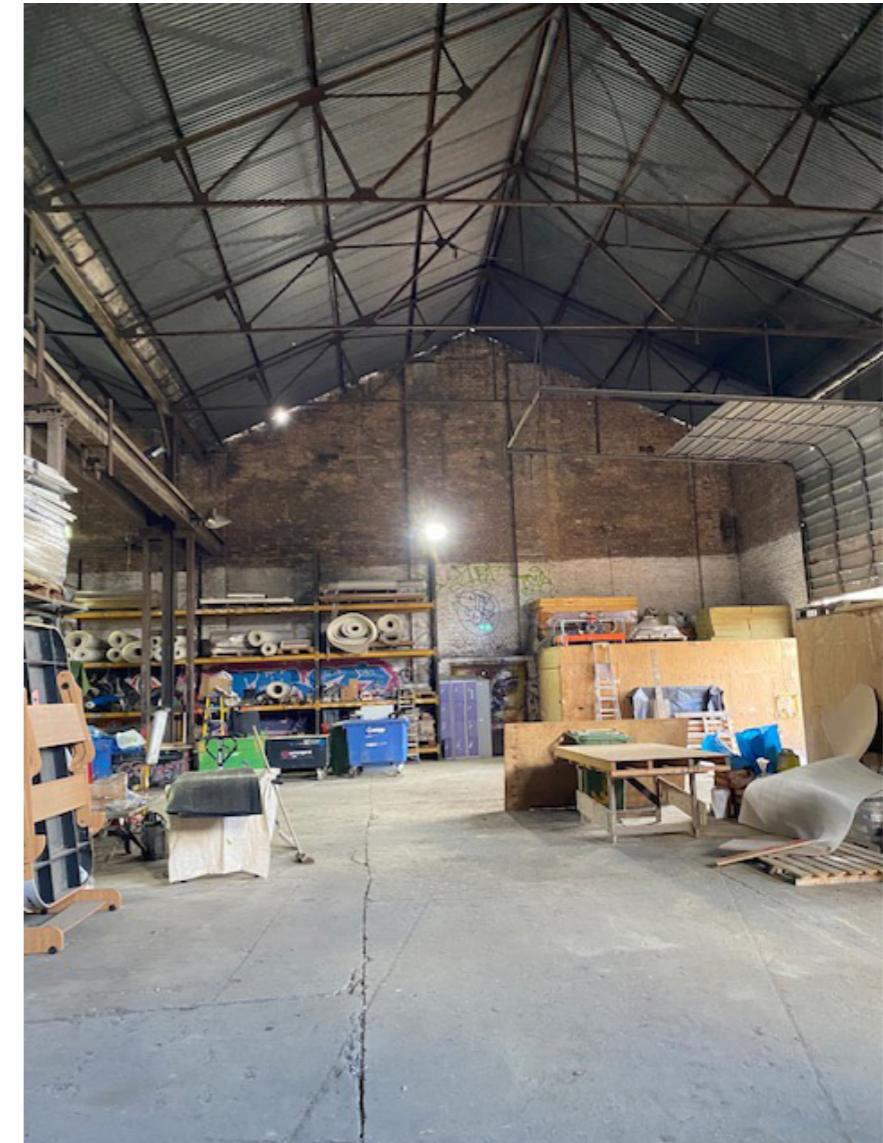
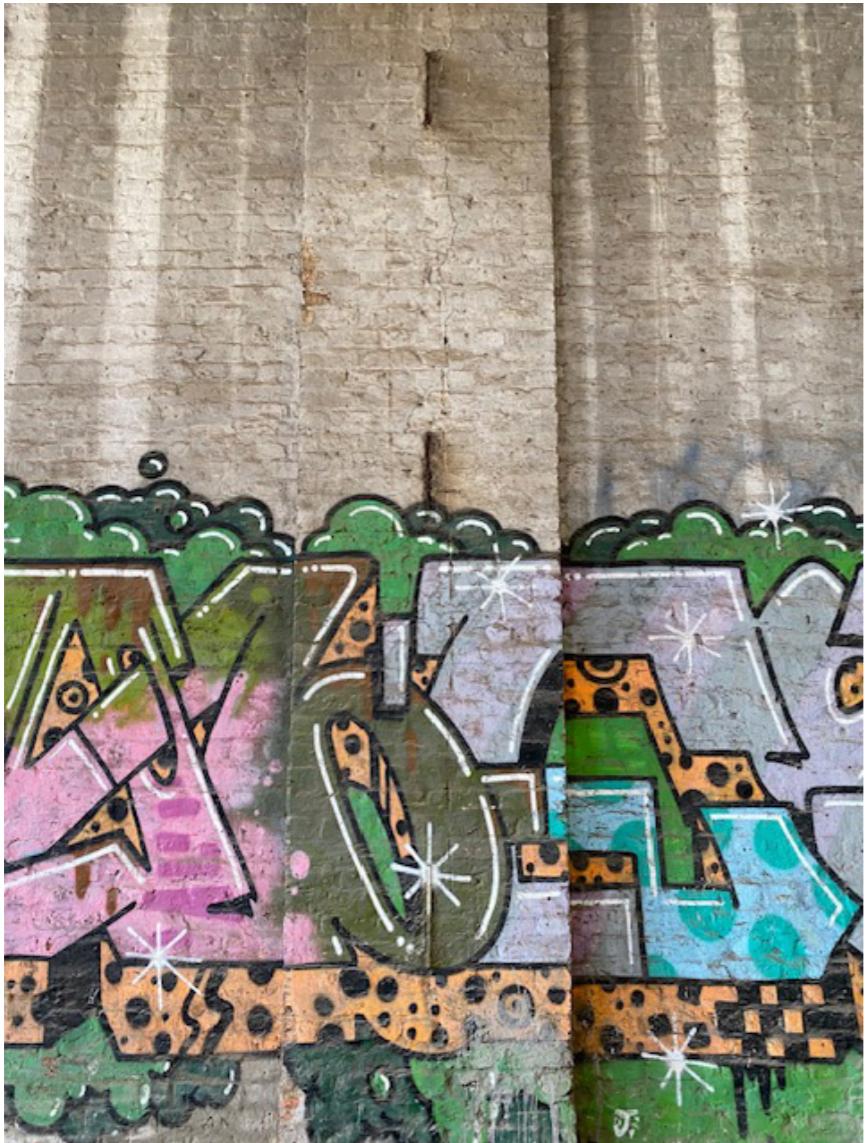
# Site visit



# Site visit



# Site visit



# Design proposals

Already developed plans



View from the basin.



Entrance into Orchard Place.

<https://orchardwharfproposals.co.uk/our-proposals/>

# Alternative approach: Lee Valley Park

Educational centre - close to primary school



<https://laurabarnard.co.uk/lee-valley-country-park>  
<https://tfi.gov.uk/modes/walking/lea-valley>

# Lee Valley Park

Adding an end / starting point to the route



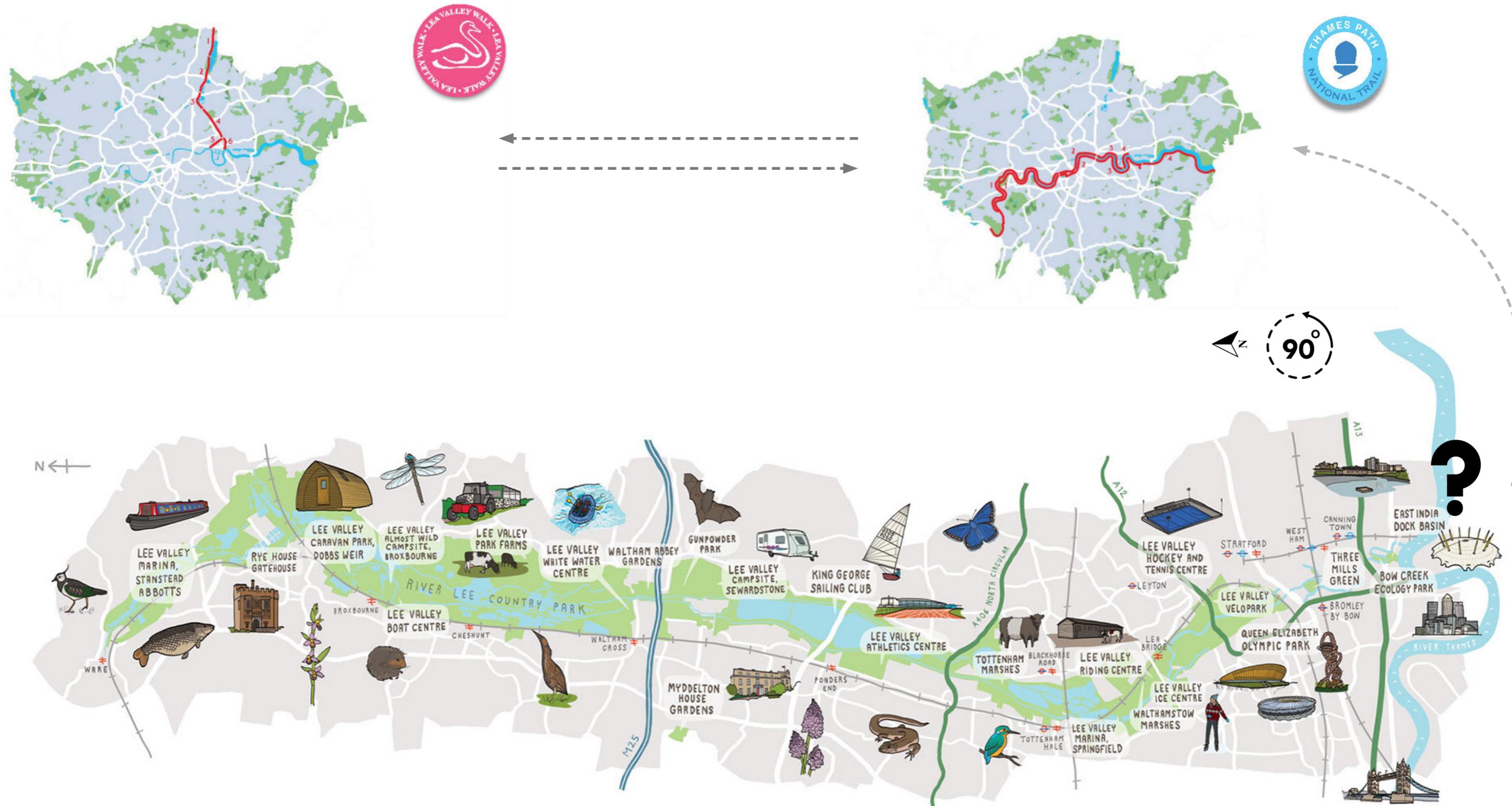
Connecting social housing with a visitor's centre that hosts nature walks and educational activities about water saving habits and the importance of becoming more sustainable.



<https://aurabarnard.co.uk/lee-valley-country-park>  
<https://tfl.gov.uk/modes/walking/lea-valley>

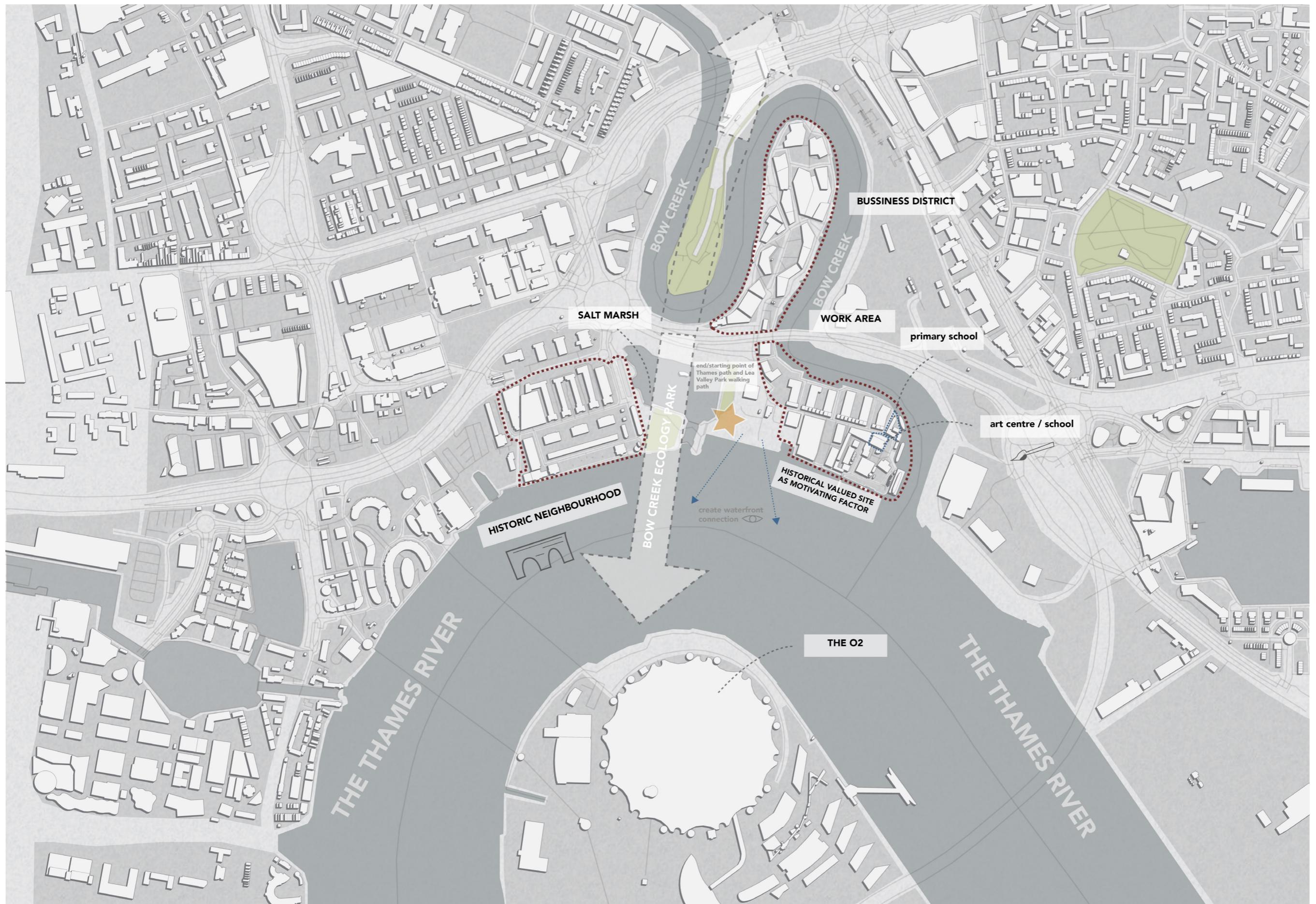
# Thames Path

## Educational visitor's centre - close to primary school combined with social housing



<https://laurabarnard.co.uk/lee-valley-country-park>  
<https://tfi.gov.uk/modes/walking/lea-valley>

# Masterplan



Re-strengthening the historic characteristics of the old docks  
Scale 1:20.000 (re-scaled -300%)

## The 02



[https://www.eastlondonhistory.co.uk/thames-ironworks-a-history-of-shipbuilding-and-engineering-in-london/#google\\_vignette](https://www.eastlondonhistory.co.uk/thames-ironworks-a-history-of-shipbuilding-and-engineering-in-london/#google_vignette)

# Connecting neighbourhoods

Educational visitor's centre - close to primary school combined with social housing

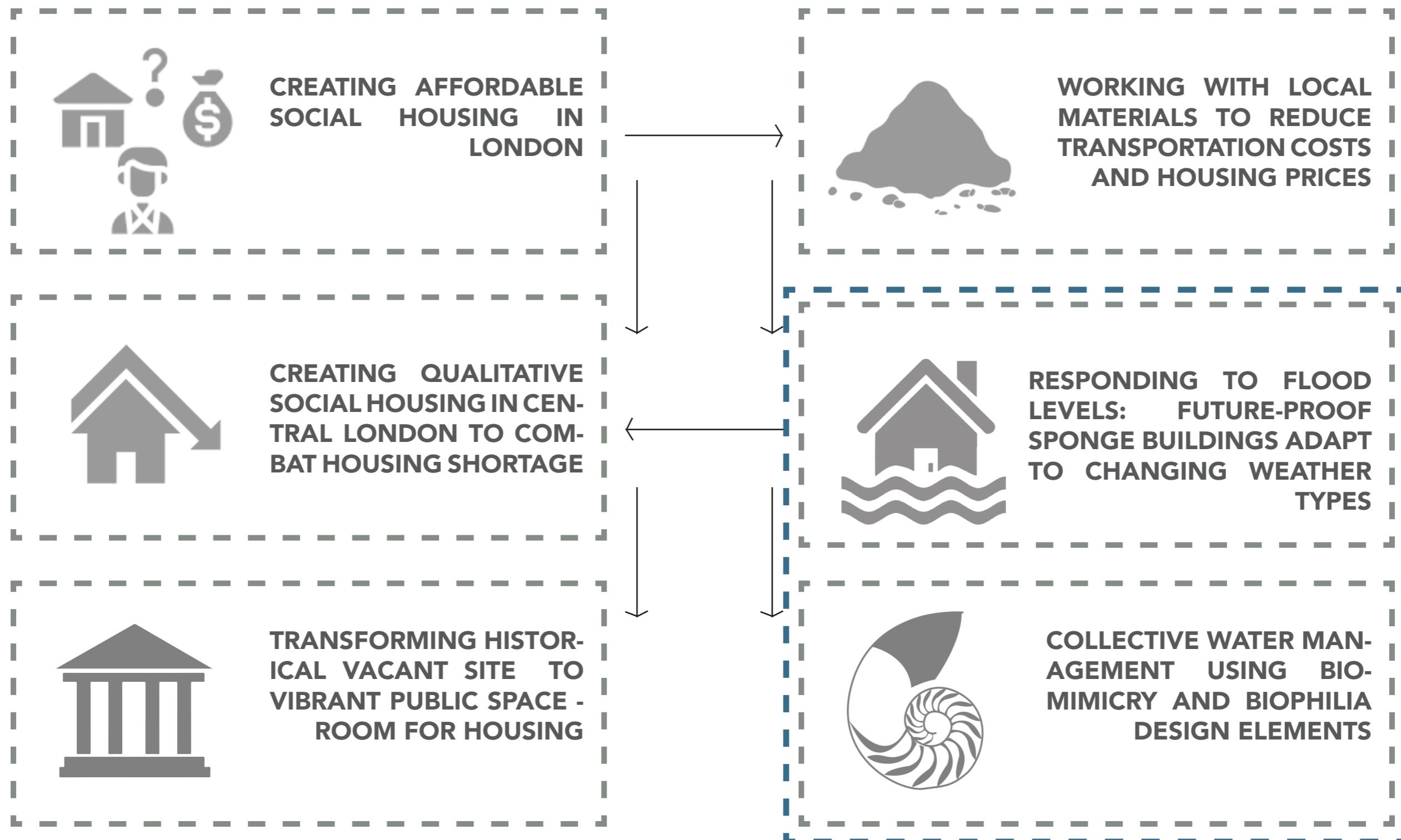


# Mobility: public transport connection nearby supports residents of social housing



# Overall design goal

How to create affordable water resilient social housing?



# STEP 2

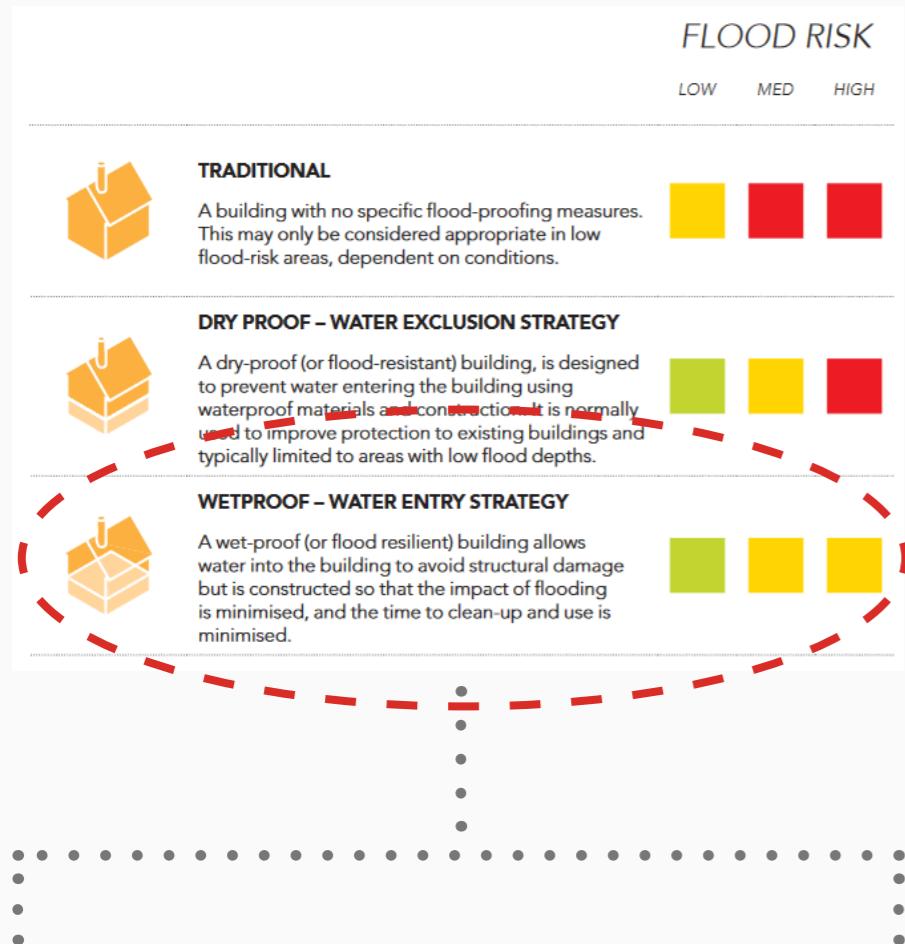
## THE URBAN SQUARE SCALE

### Translating technical interventions into practice

From sea to land to rivers

What design interventions can be taken to restore grey infrastructure to a more connected natural environment to stimulate people to participate in water management design as a community?

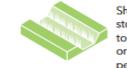
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### Sustainable urban Drainage System

They can function as aesthetic-functional element to offer recreational areas, while also purifying the air and water to improve the microclimate (Parancola, 2019).

### Green Infrastructure

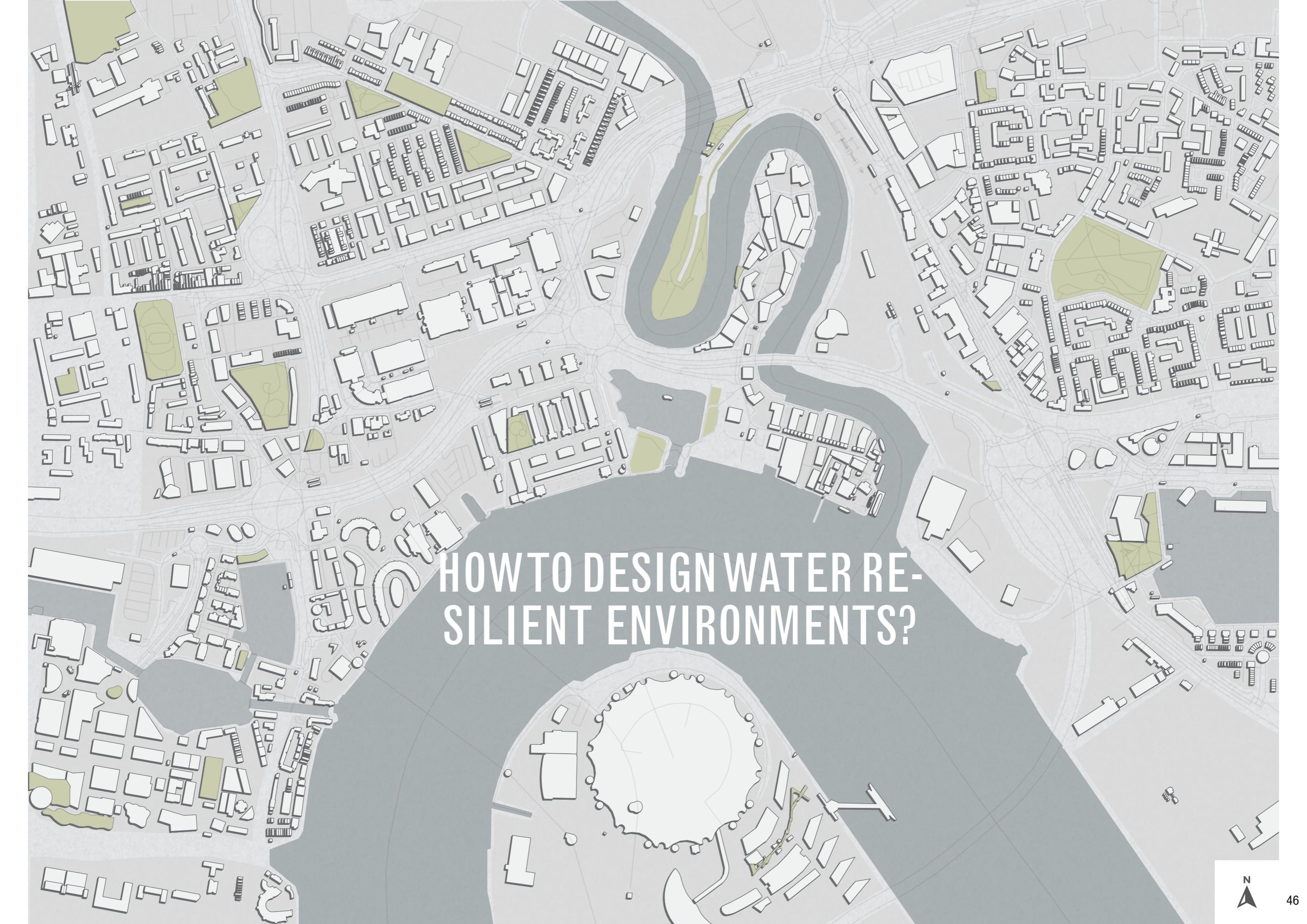
Water Resilient Testing Framework				
PROJECT	WATERFRONT TYPE	INTERVENTIONS APPLIED	LIFE TOOLKIT INTERVENTION TYPES	SOCIAL SUCCESS
<b>HARBOUR BATHS</b>  Location: Aarhus & Copenhagen, Denmark Mission of municipality involving all types of age groups	Harbour	Floating harbour bath with retaining-wall with biofilter	 <b>FLOATING</b> A floating home is a building that rests on a buoyant base or foundation, designed to rise and fall with the level of the water. It can cope with large flood level variations.	Lessons learned: social interaction, health and well-being - Clean harbour water leads to new initiatives by locals including moving activities as sports like kayaking - Biomimicry: using natural processes that show how nature's qualities can be used in our advantage
<b>COMMUNITY CENTRE</b>  Location: Suzhou, China Mission of municipality involving all types of age groups	River	Rainwater harvesting for water basin	 <b>RAIN GARDEN</b> A shallow, planted depression used to store excessive rainwater before it soaks away. Plants and soil layers filter water before entering groundwater system. Ideal in 'ultra urban' areas of limited space.	Lessons learned: social interaction, health and well-being - Still water causes reflection and promotes peace and relaxation - Water basin gets multifunctional purpose as water source for plants and psychological relaxation element - Biophilic elements: water to enhance well-being
<b>WATER SQUARE</b>  Location: Copenhagen, Denmark Mission was to remove the parking lot and replace it with multi-functional square	Public Realm	Artificial creek to enrich square	 <b>FOUNTAINS AND WATER SQUARES</b> Rainwater can be collected at source for use and storage in public focal points.	Lessons learned: social interaction, health and well-being - Rainfall has a positive influence as it enriches the quite grey square during drier periods - Children actively use the creek to play (water visual pleasing element) - Biomimicry: Using the qualities of an artificial creek to guide water
<b>EDUCATIVE SQUARE</b>  Location: Copenhagen, Denmark Investment area to revitalise urban development	Public Realm	Educative water activities with SuDS	 <b>RAIN GARDEN</b> A shallow, planted depression used to store excessive rainwater before it soaks away. Plants and soil layers filter water before entering groundwater system. Ideal in 'ultra urban' areas of limited space.	Lessons learned: social interaction, health and well-being - Visitors are educated by combining water activities with SuDS, also through showing how the system works on information boards - Water can be pumped from reservoir to create water interaction while also storing water
<b>GREEN STREETS</b>  Location: Rotterdam, The Netherlands Transforming flooded streets to a new street profile that includes wadi's and buffers	Residential & infrastructure	Rainwater basin for GI	 <b>GREEN ROOF / WALL</b> A planted roof or wall to a building that helps to control runoff slowing the flow down to the ground, store rainwater and filter out pollutants.	Lessons learned: social interaction, health and well-being - GI combined with SuDS leads to environment pleasant to the eye - Communal garden watered through collection of rainwater stimulates mutual contact among age groups (Water is not physically used as biophilic element to stimulate this, but GI)
<b>LANDSCAPE RETROFIT</b>  Location: Llanelli, United Kingdom Transforming existing playground area of primary school to solve water problems using SuDS and GI	Residential & infrastructure	Educating about combining SuDS	 <b>DRY PROOF - WATER EXCLUSION STRATEGY</b> A dry-proof (or flood-resistant) building, is designed to prevent water entering the building using waterproof materials and construction. It is normally used to improve protection to existing buildings and typically limited to areas with low flood depths.	Lessons learned: social interaction, health and well-being - Also children can be involved during the design process, as they come up with natural ideas how to interact better with nature: outdoor classroom, bug hotel - Educating through information boards and visual divert water
<b>LANDSCAPE DESIGN INTEGRATION</b>  Location: IJburg, Amsterdam Enhancing social interaction by integrating inviting landscape to the building	Docks, wharfs & shipyards	Rainwater as cooling water stream	 <b>GREEN ROOF / WALL</b> A planted roof or wall to a building that helps to control runoff slowing the flow down to the ground, store rainwater and filter out pollutants.	Lessons learned: social interaction, health and well-being - Bringing people closer to the water by integrating water streams in the building - Biophilic: Water experience on the roof as physical cooling element, combined with water reflection visible on the inside triggering the visual experience
<b>GREEN HERITAGE REDEVELOPMENT</b>  Location: Copenhagen, Denmark Transforming existing industrial area, making the harbour accessible for visitors and locals	Harbour	Better accessible waterfronts	 <b>RAIN GARDEN</b> A shallow, planted depression used to store excessive rainwater before it soaks away. Plants and soil layers filter water before entering groundwater system. Ideal 'ultra urban' areas of limited space.	Lessons learned: social interaction, health and well-being - Involving locals in the design process leads to a building being more appreciated - People can use the waterfront to swim, now that it is made accessible again and is still actively in use

PLACE & COMMUNITY

PARKS & SQUARES

BUILDINGS & STREETS

HOUSING



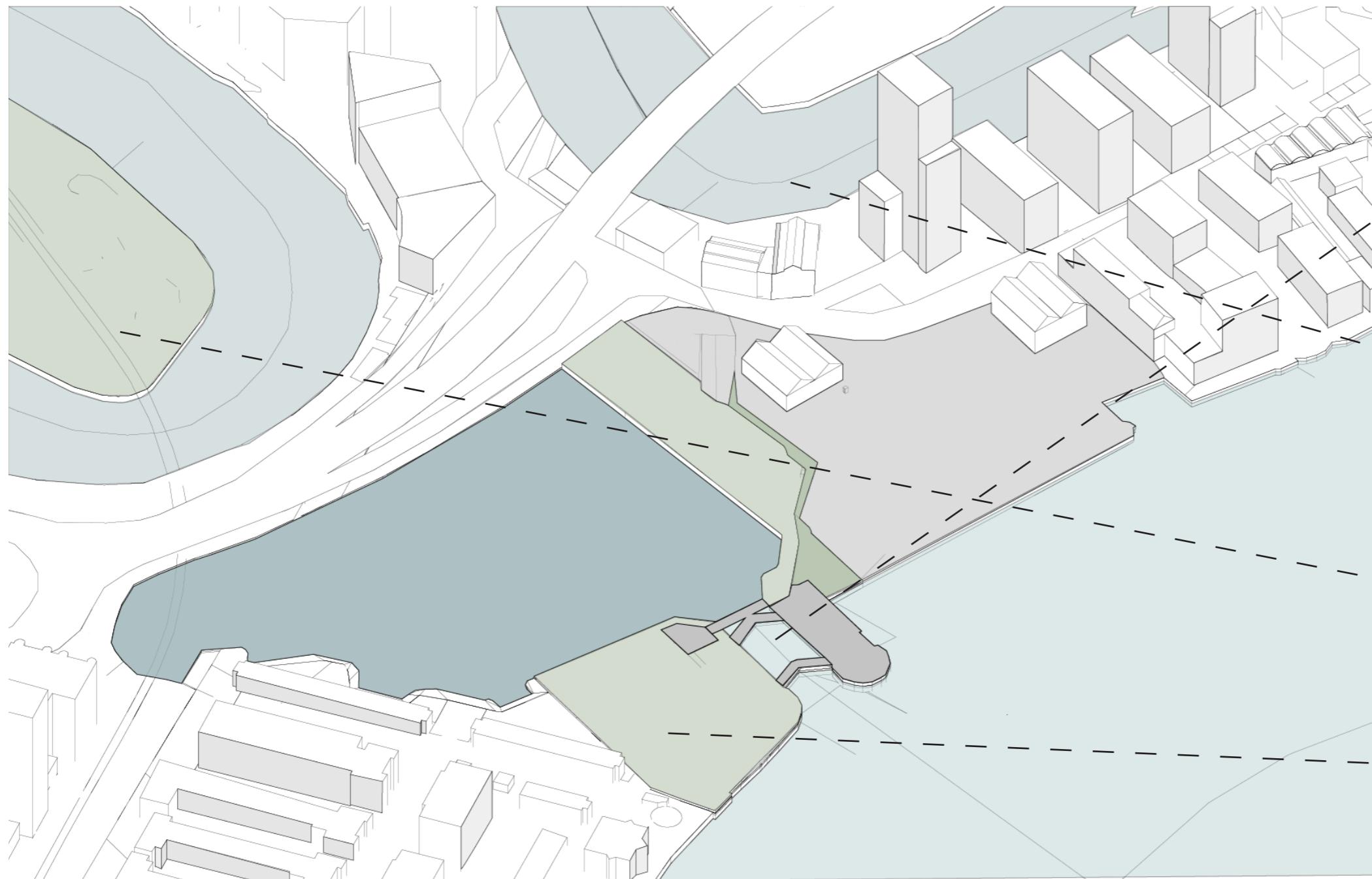
# HOW TO DESIGN WATER RESILIENT ENVIRONMENTS?

# The urban square scale

## Reducing transportation costs for affordable housing



WORKING WITH LOCAL MATERIALS TO REDUCE TRANSPORTATION COSTS AND HOUSING PRICES



use water stream as energy source from high and low tides

local dredge from river to higher up soil and make more room for water

cross laminated bamboo (CLB instead of CLT) as building material - bamboo grows faster and absorbs more CO2, but also 4x stronger

hemp insulation can be grown locally and fast, but also a better water resistance



## Legenda

The whole area is at risk of tidal flooding if the sea level starts to rise and no action is taken. Different flood types can be divided:

- **Fluvial or river flooding**

takes place when the water flow becomes higher than the volume capacity of the canals, river, and other channels

- **Pluvial or overland**

happens when the drainage system cannot withdraw, and the ground surface cannot absorb the large amount of rainwater

- **Coastal floods**

because of storms

- **Groundwater floods**

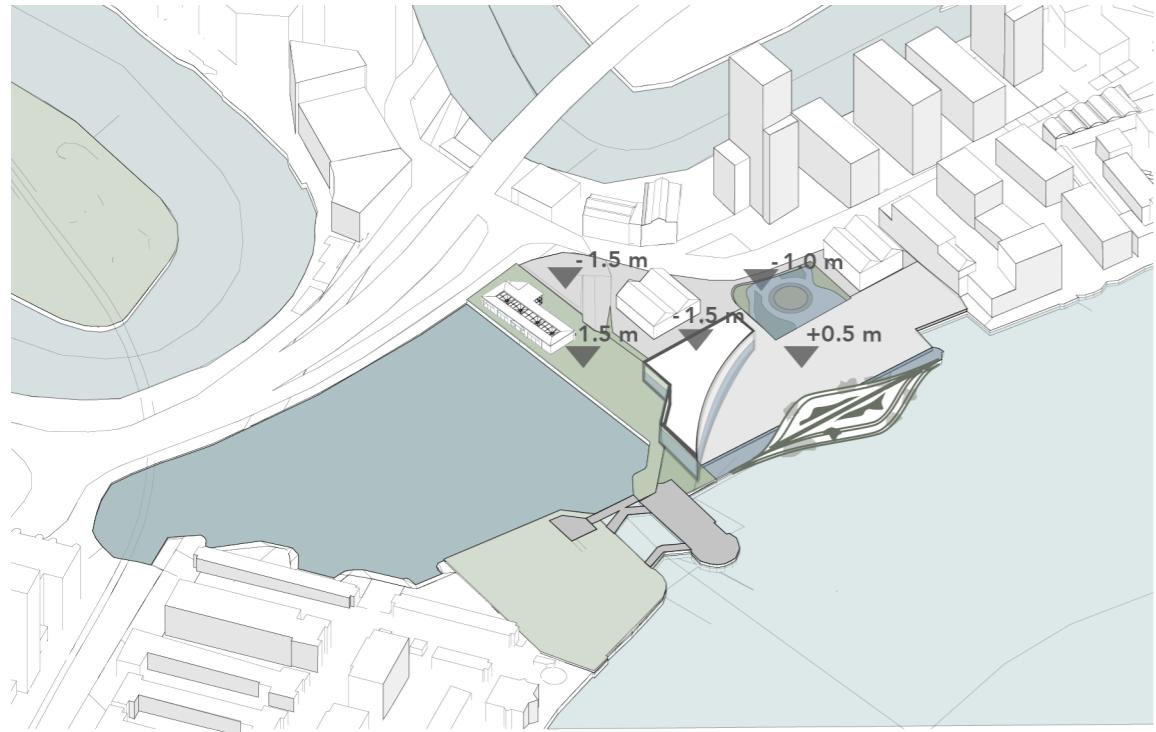
happens when the water table is exceeded due to an increase in rainfall

Soiltype and green land-use also determine how much water can be absorbed

This side of the river only has combined sewage systems, whereby rainwater is mixed with grey water, resulting in loss of 'clean rainwater' that can be used for other purposes. In times of heavy rainfall this can lead to the overflow of the sewage systems too.

# Design principle: designing with different flood levels

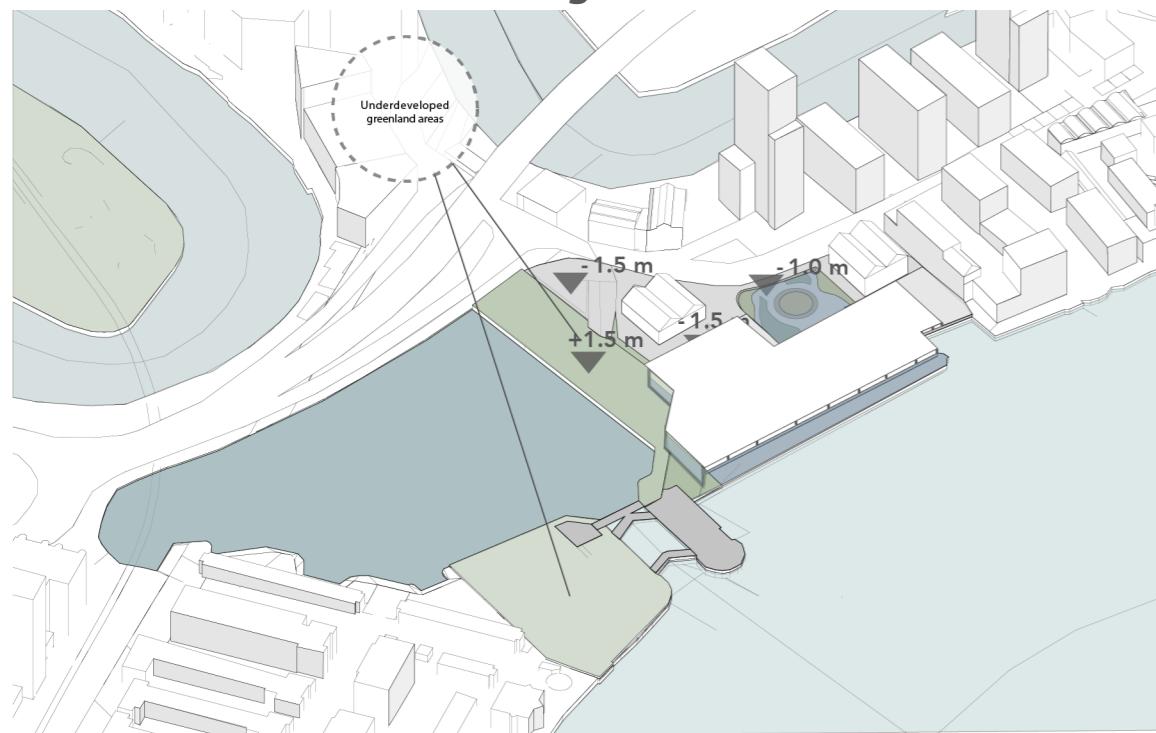
## LEVEL 0.5 - higher-up soil with 0.5 m



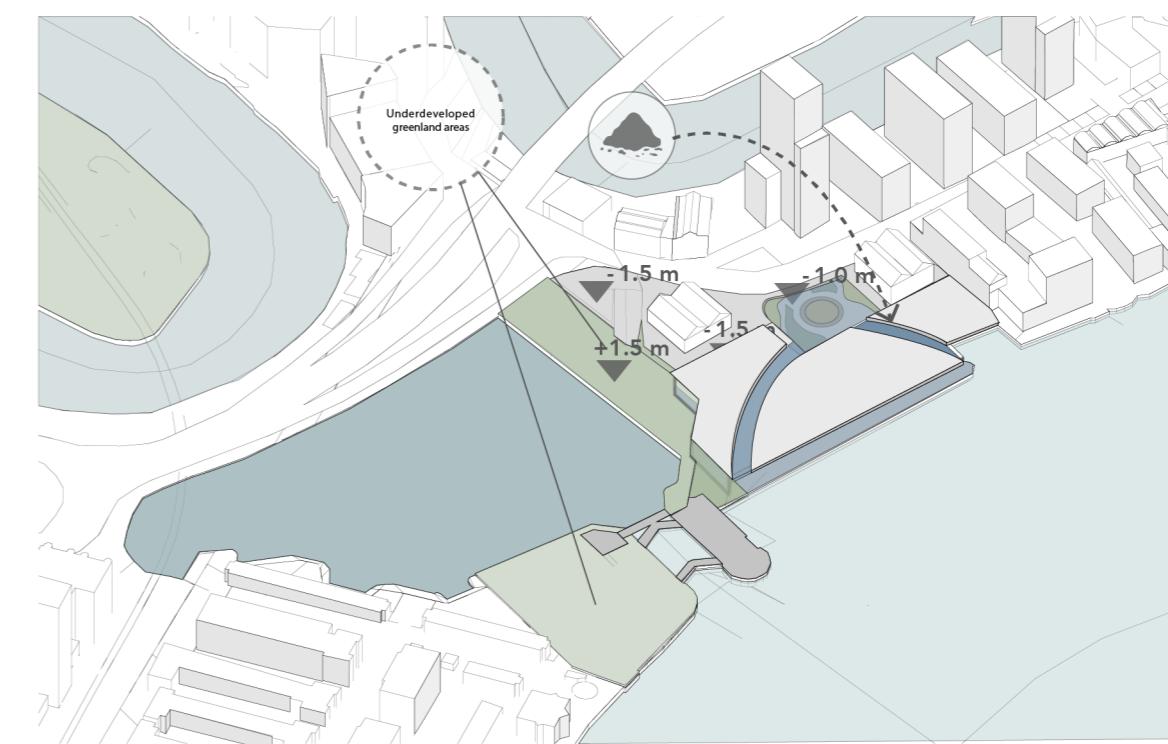
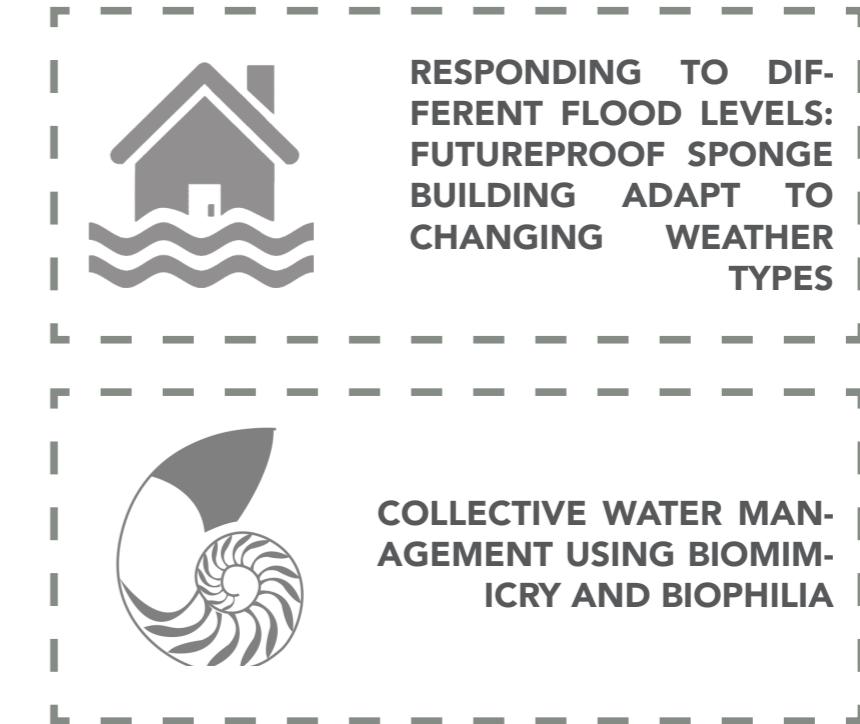
1. acceptable high flood risk: underground parking

2. suspended floor to prevent ground floor from getting wet - reduce rotting process while making open space multifunctional for air labyrinth

## LEVEL 1.0 - air labyrinth 0.5 m

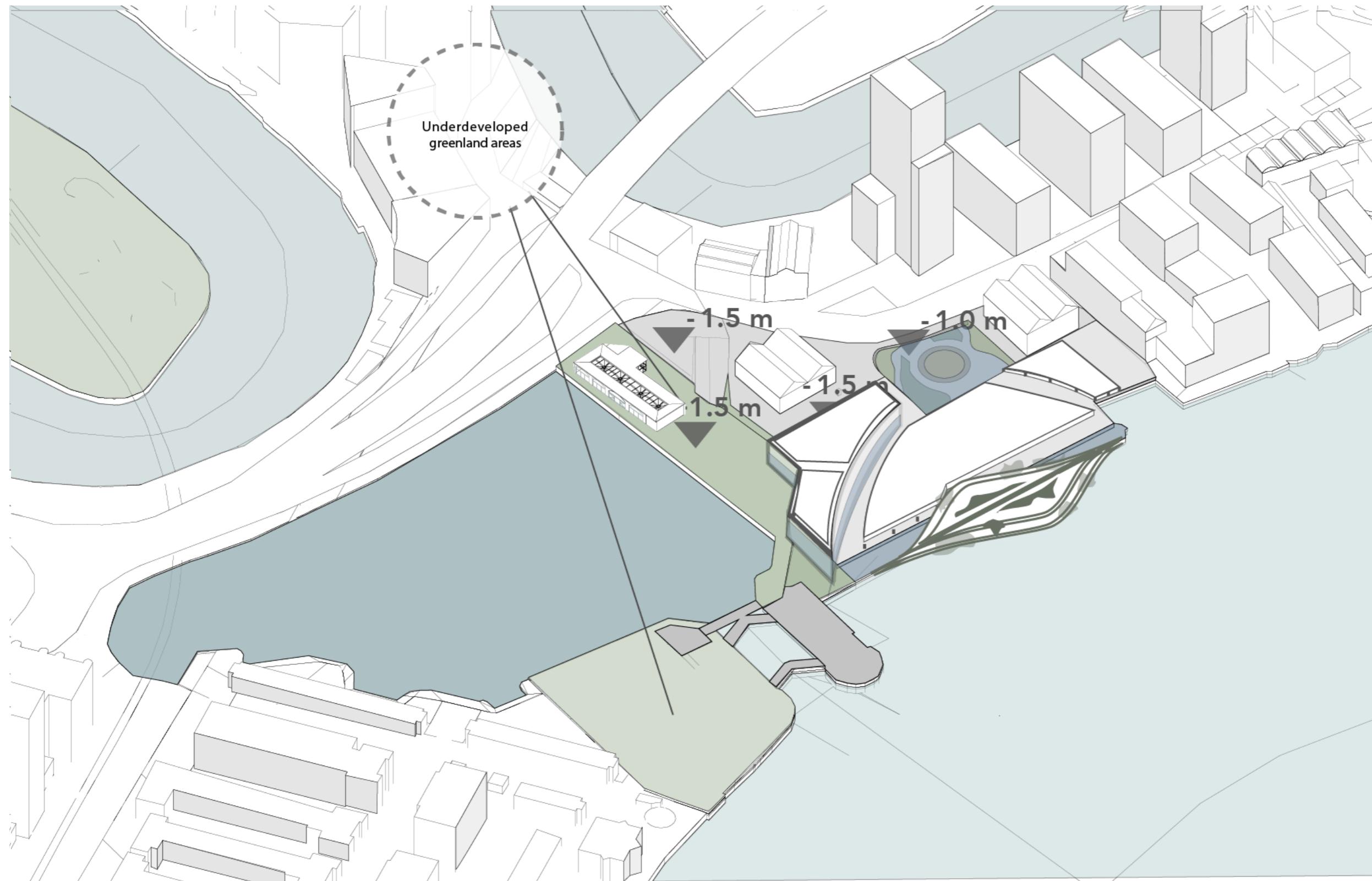


3. on top of soil lowered waterways are created to guide water to designated low risk areas



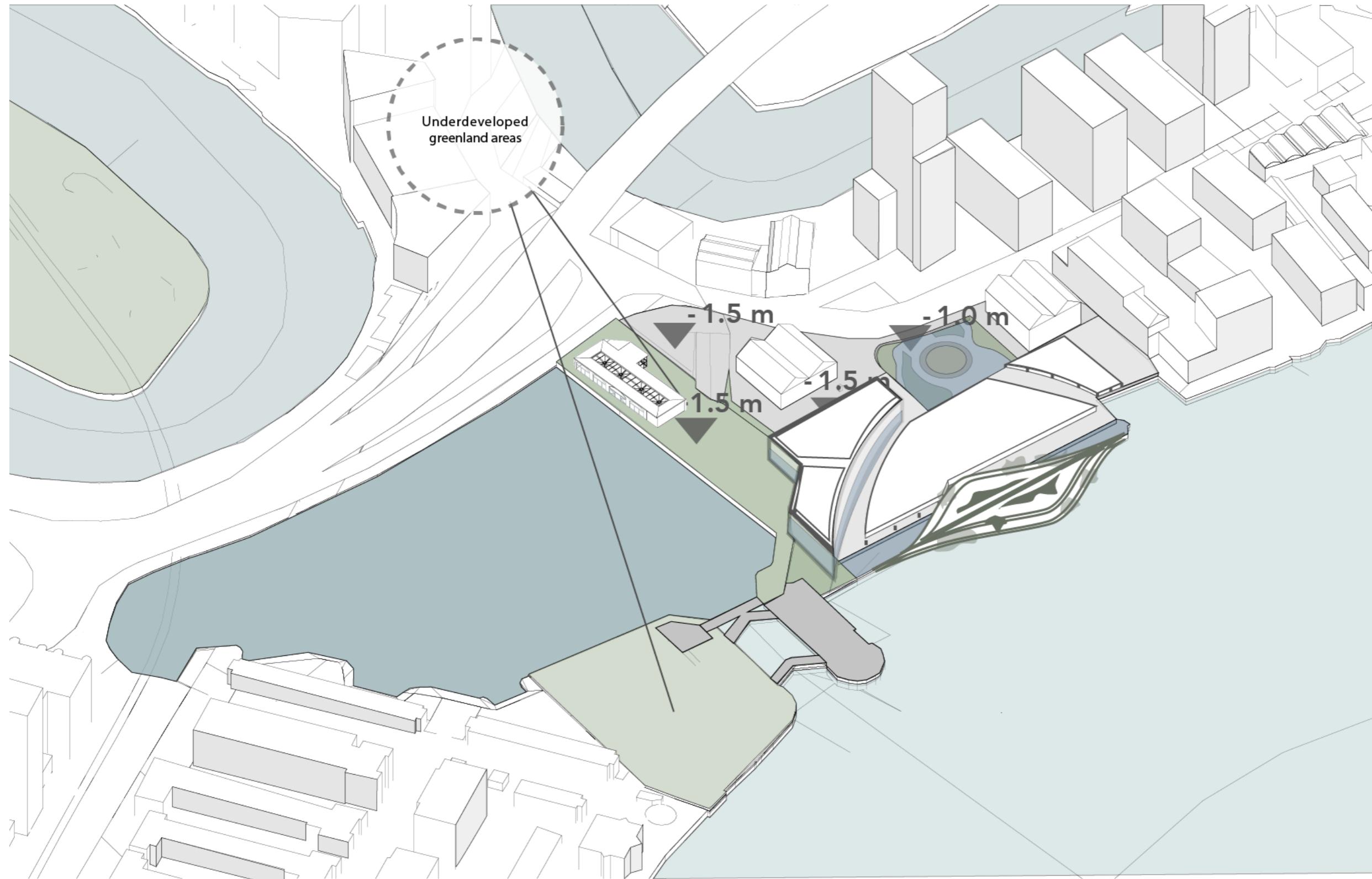
# Design principle: designing with different flood levels

## LEVEL 1.5 - waterways and lowered watergarden determine building formation



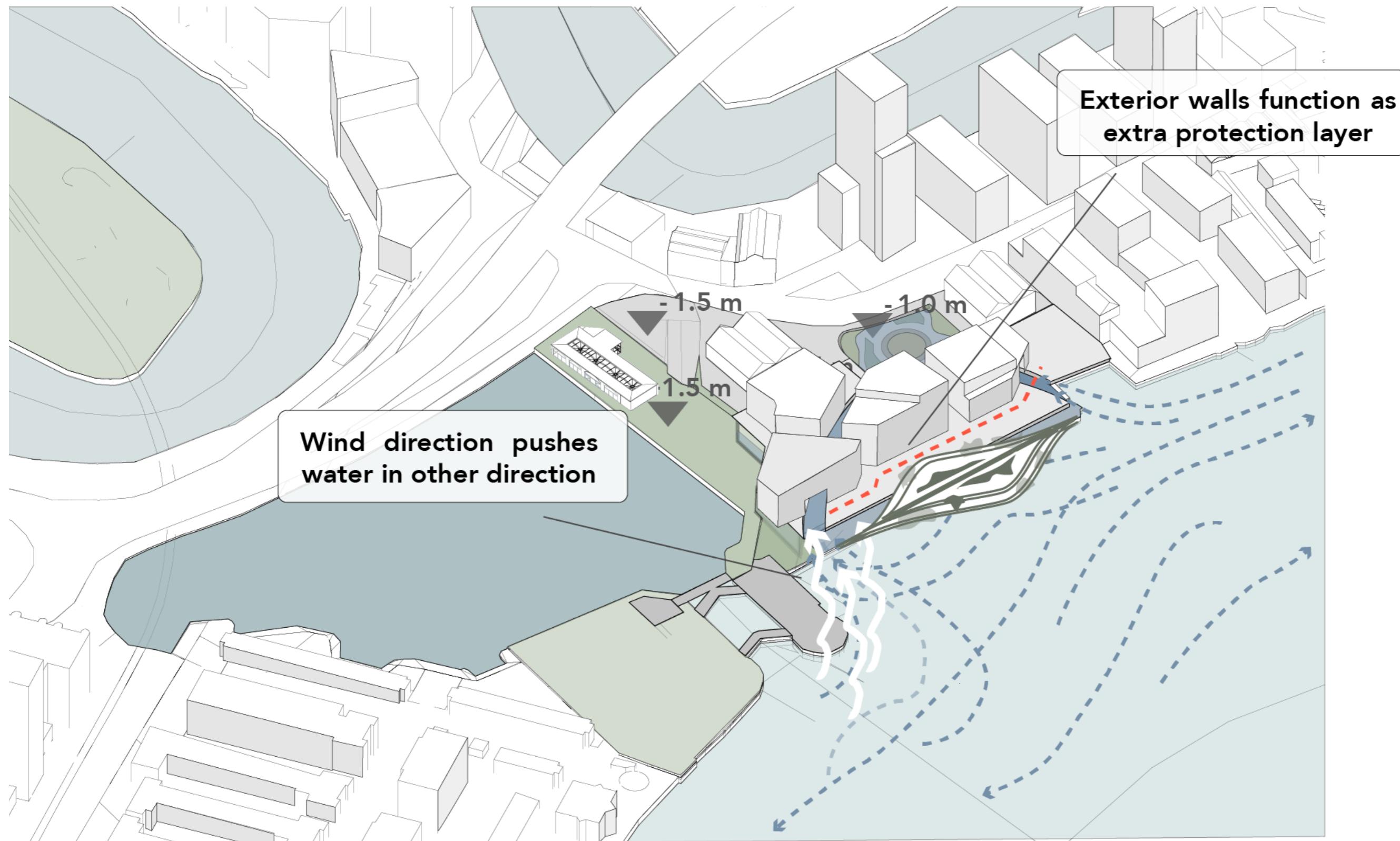
# Design principle: designing with different flood levels

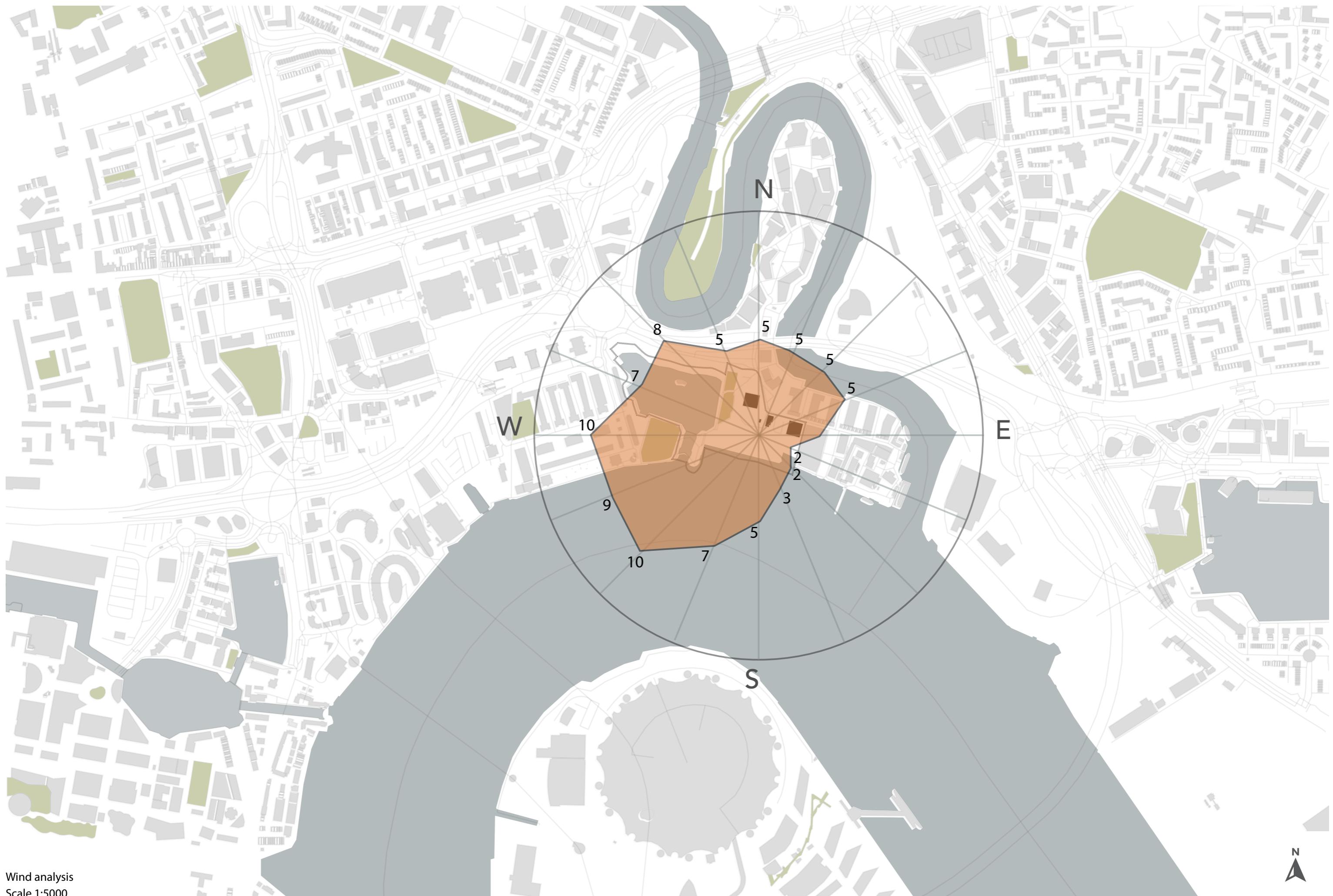
## LEVEL 1.5 - terrased waterfront forms extra water stream protection



# Design principle: designing with different flood levels

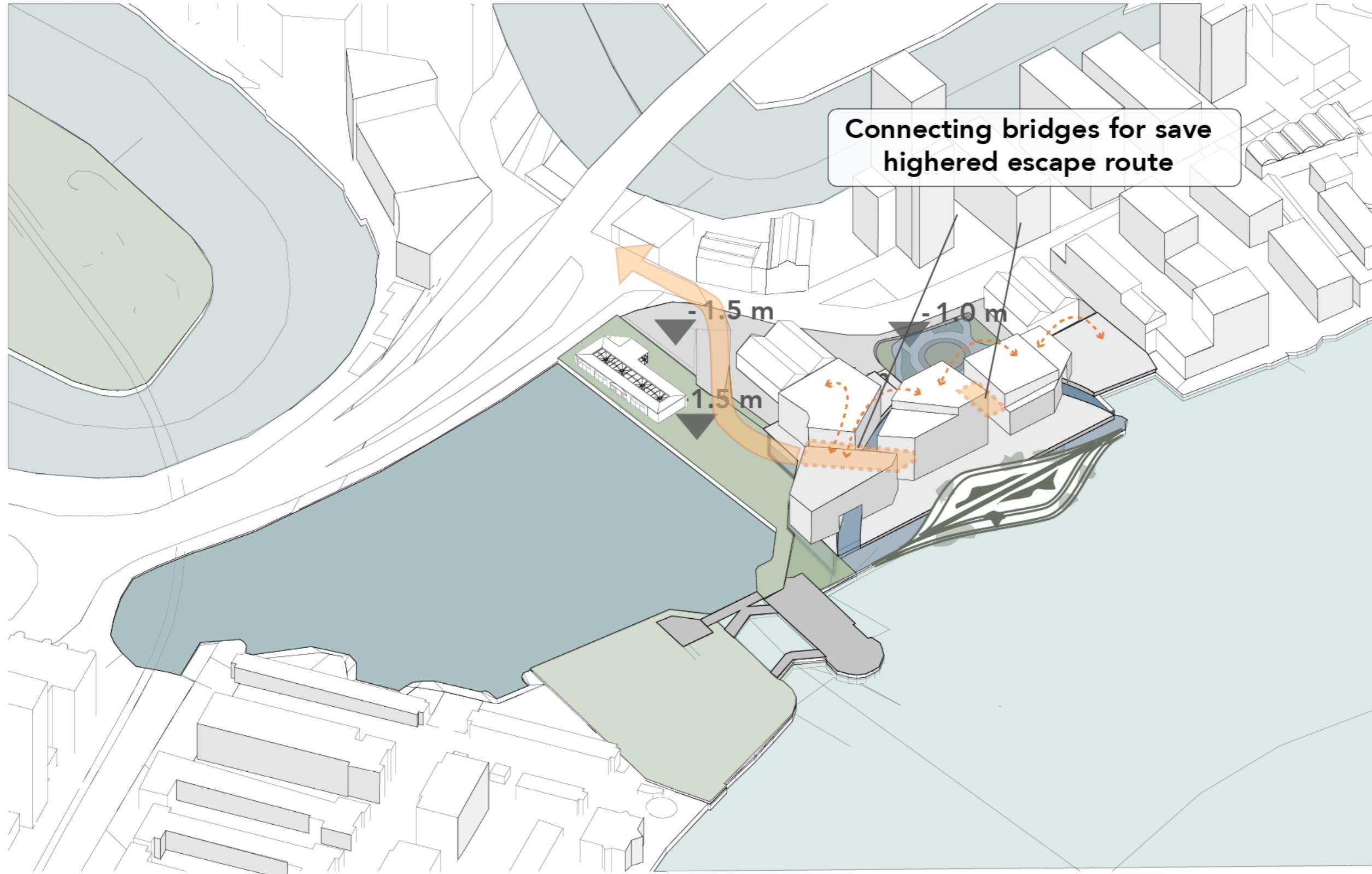
## LEVEL 1.5 - wind and natural waterflow of Thames river influence waterway formation





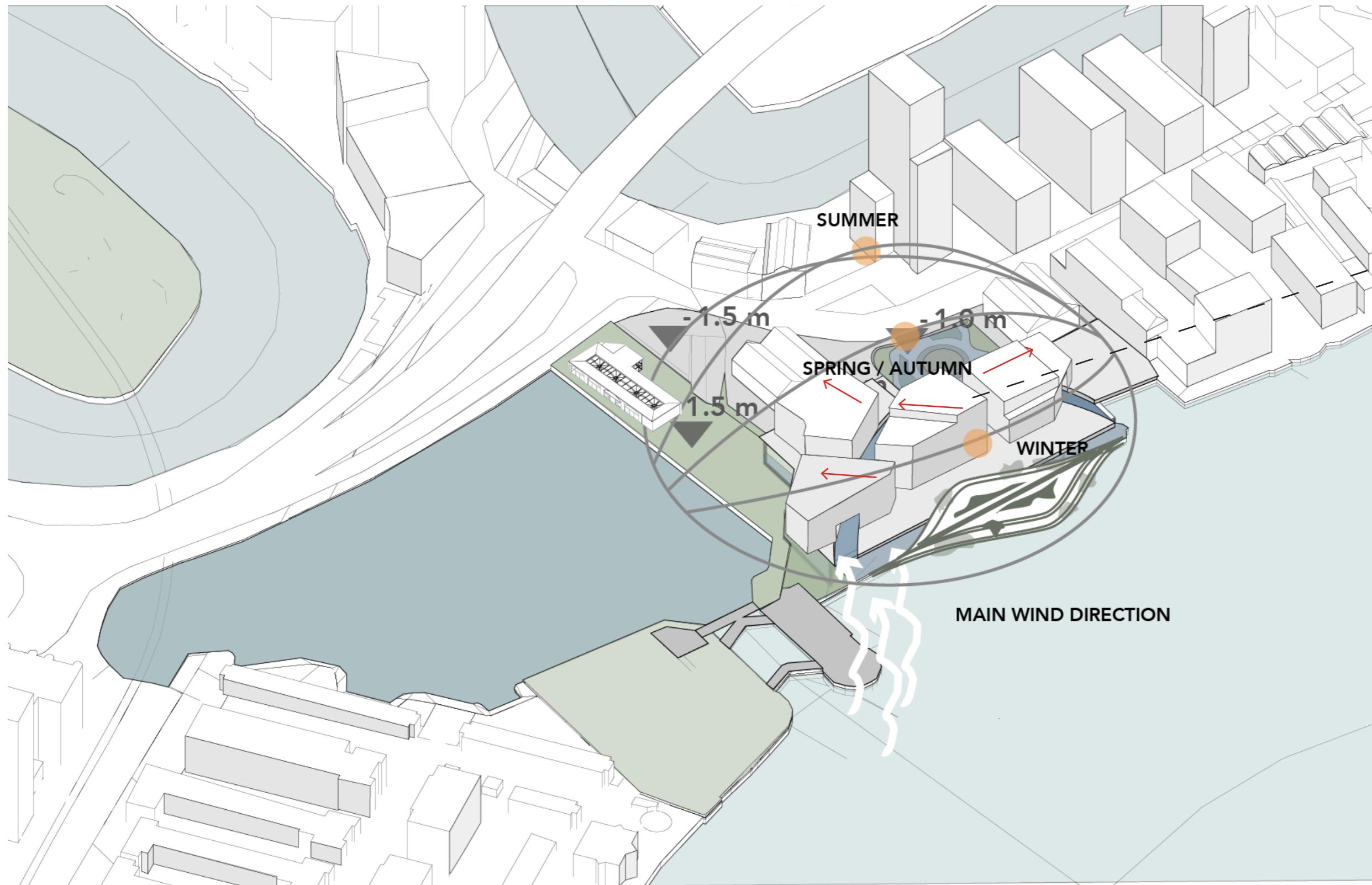
# Design principle: designing with different flood levels

## LEVEL 1.5 - create save escape routes connecting are bridges are formed

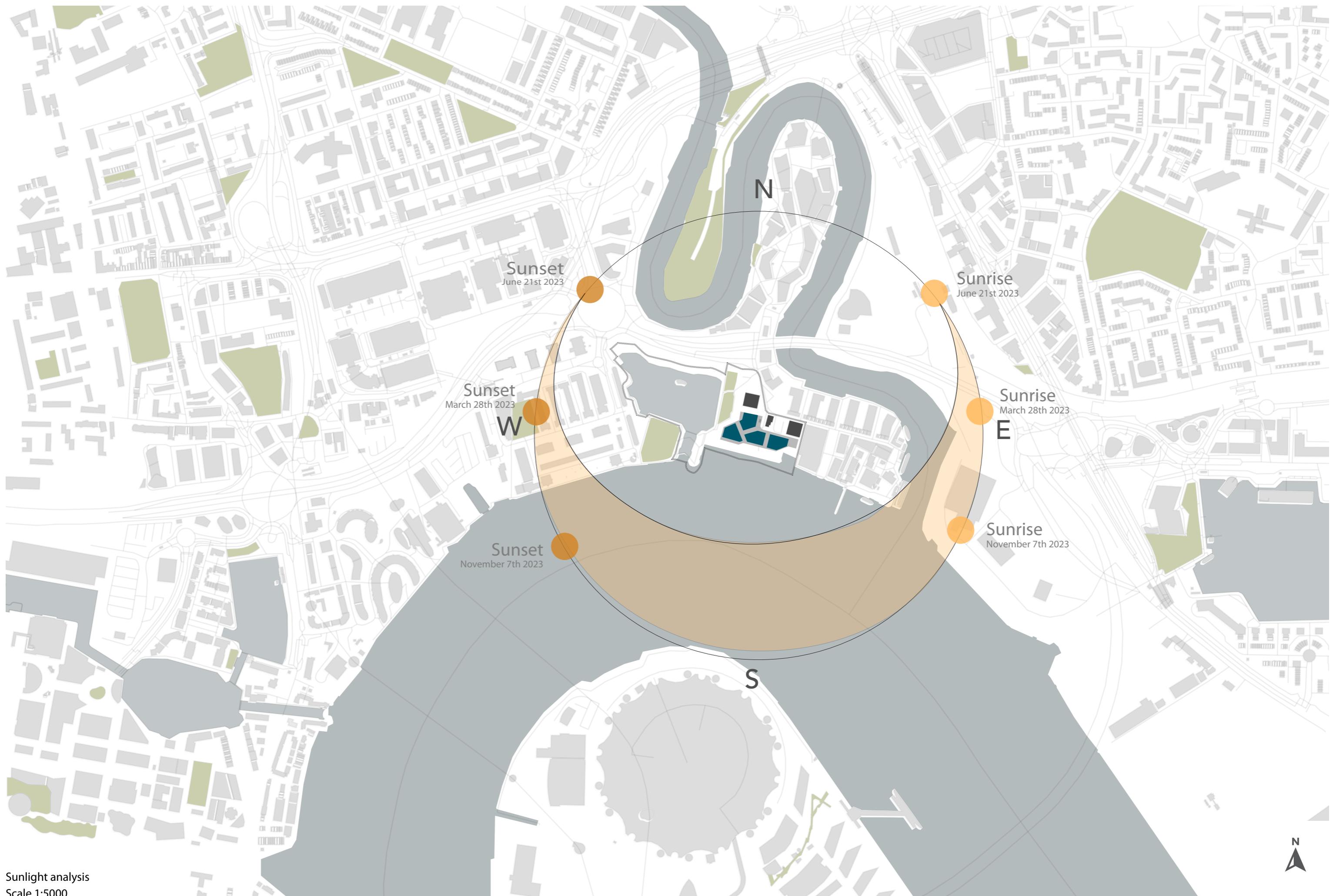


# Design principle: designing with different flood levels

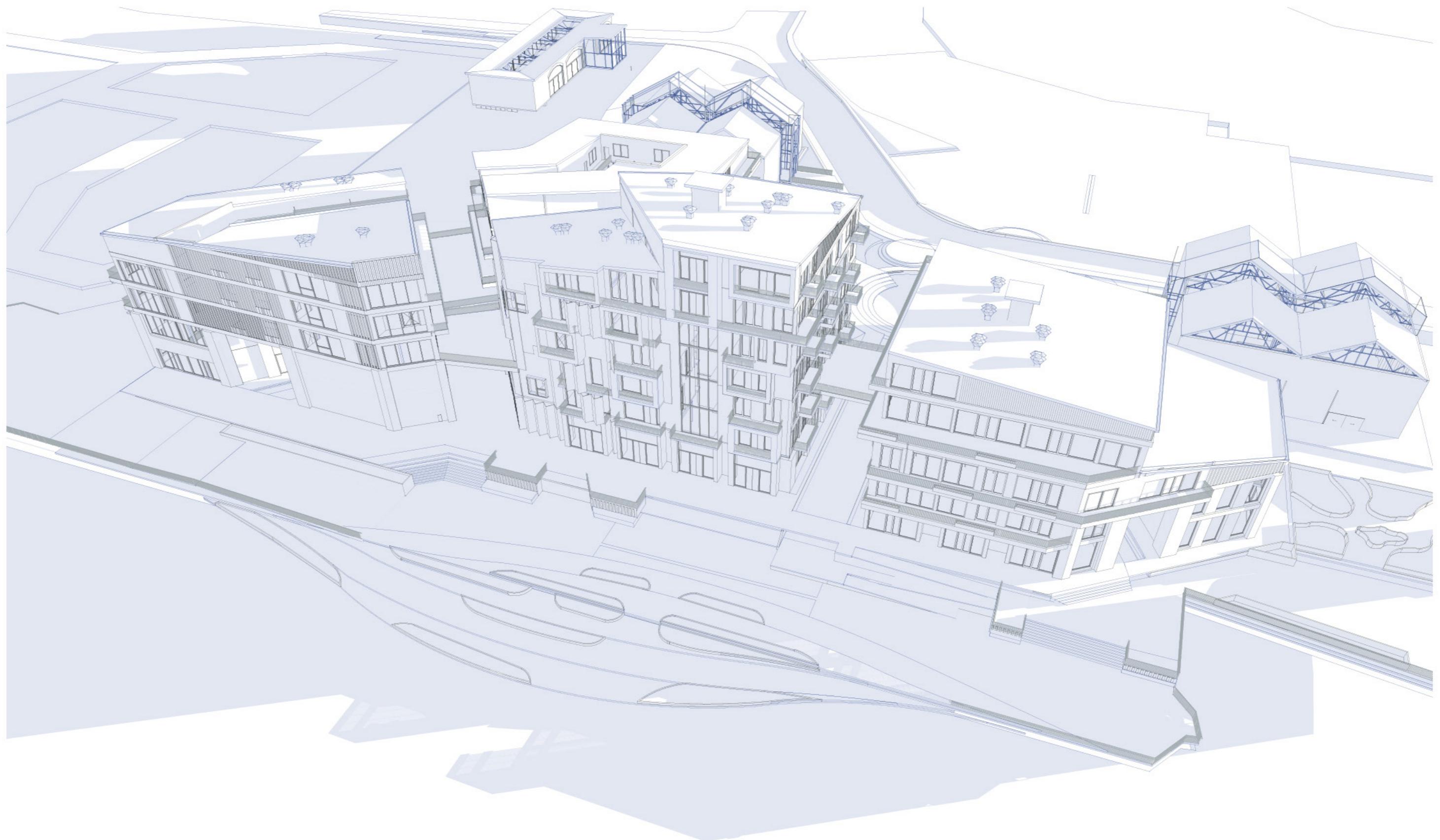
## LEVEL 1.5 - biomimicry: using nature's characteristics optimally



sloping roofs for mitigating surface water from roofs, but also for natural daylight north facade

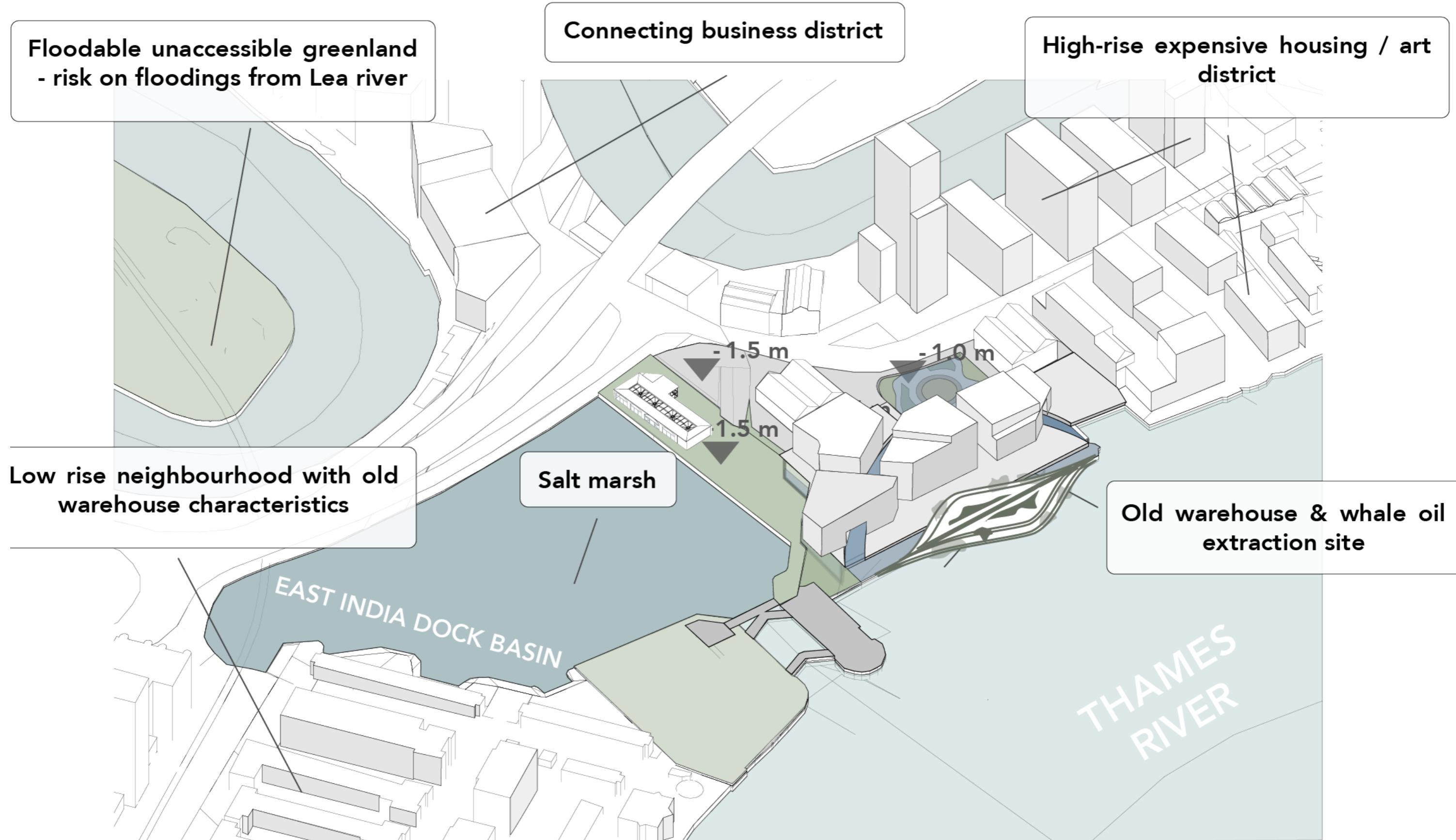


# 3D perspective view of building blocks



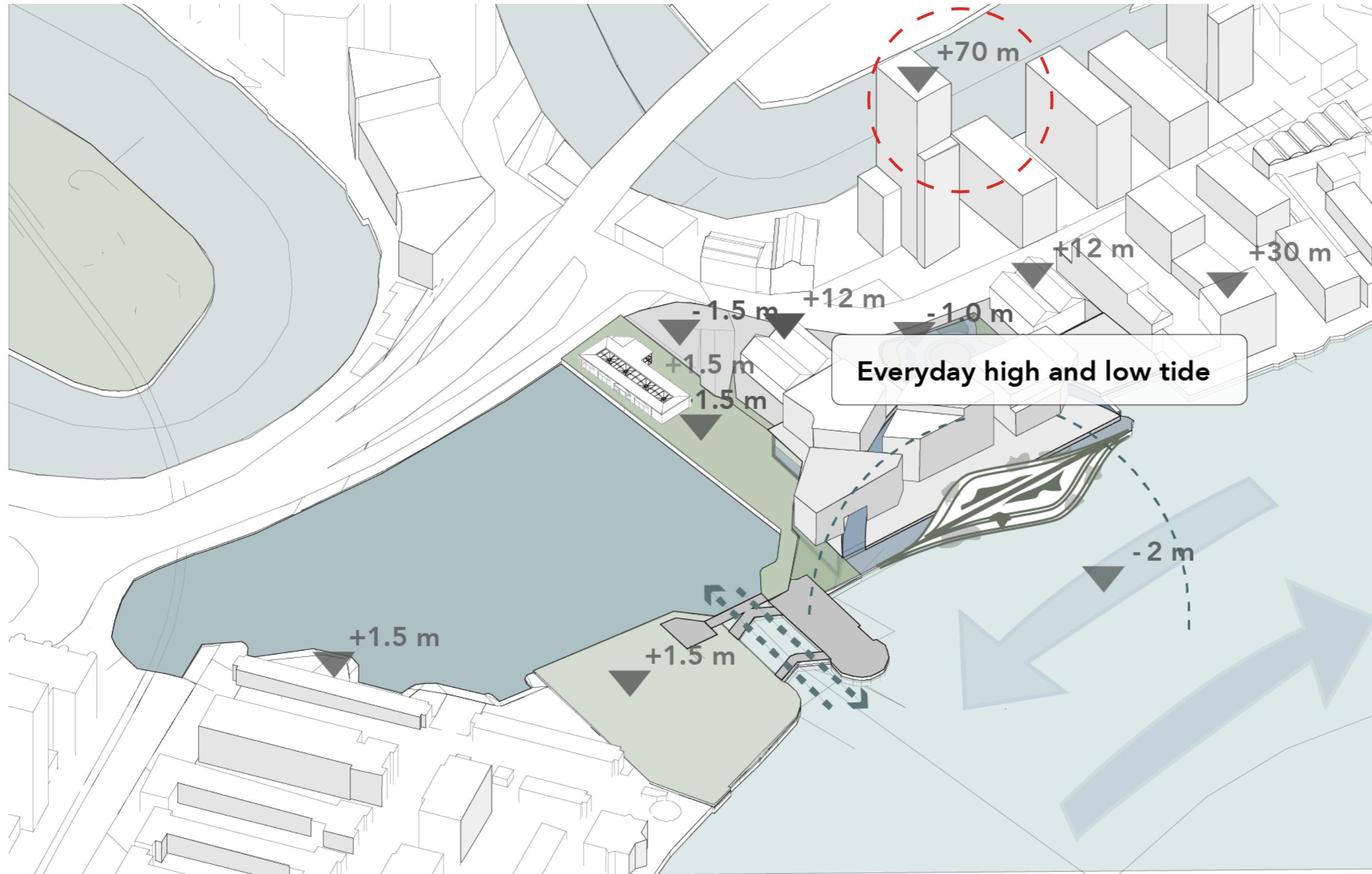
# Design principle: designing with different flood levels

## LEVEL 1.5 - sloping roof design and building heights also respond to surroundings



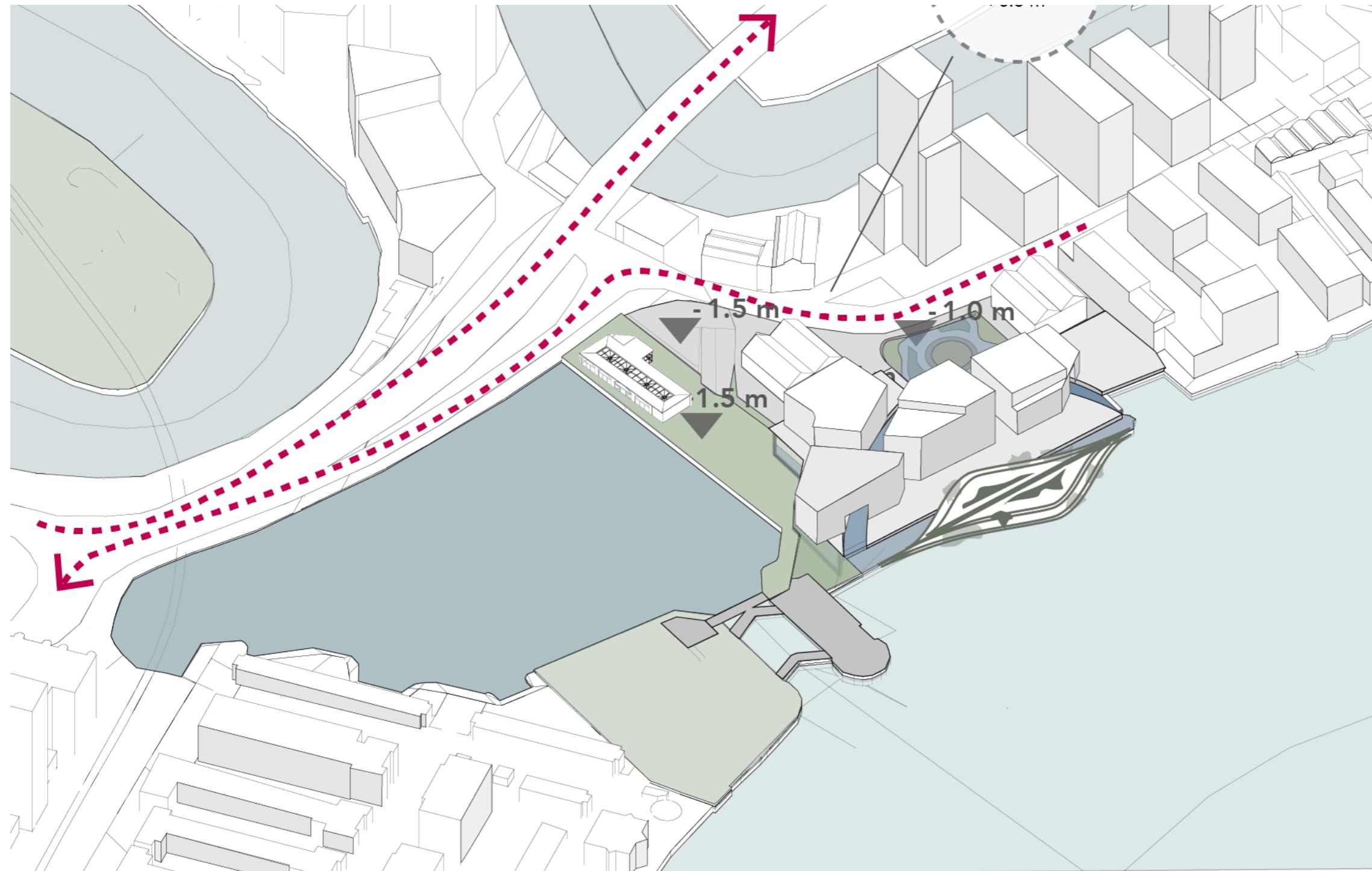
# Design principle: designing with different flood levels

## LEVEL 1.5 - final everyday functioning



# Design principle: designing with different flood levels

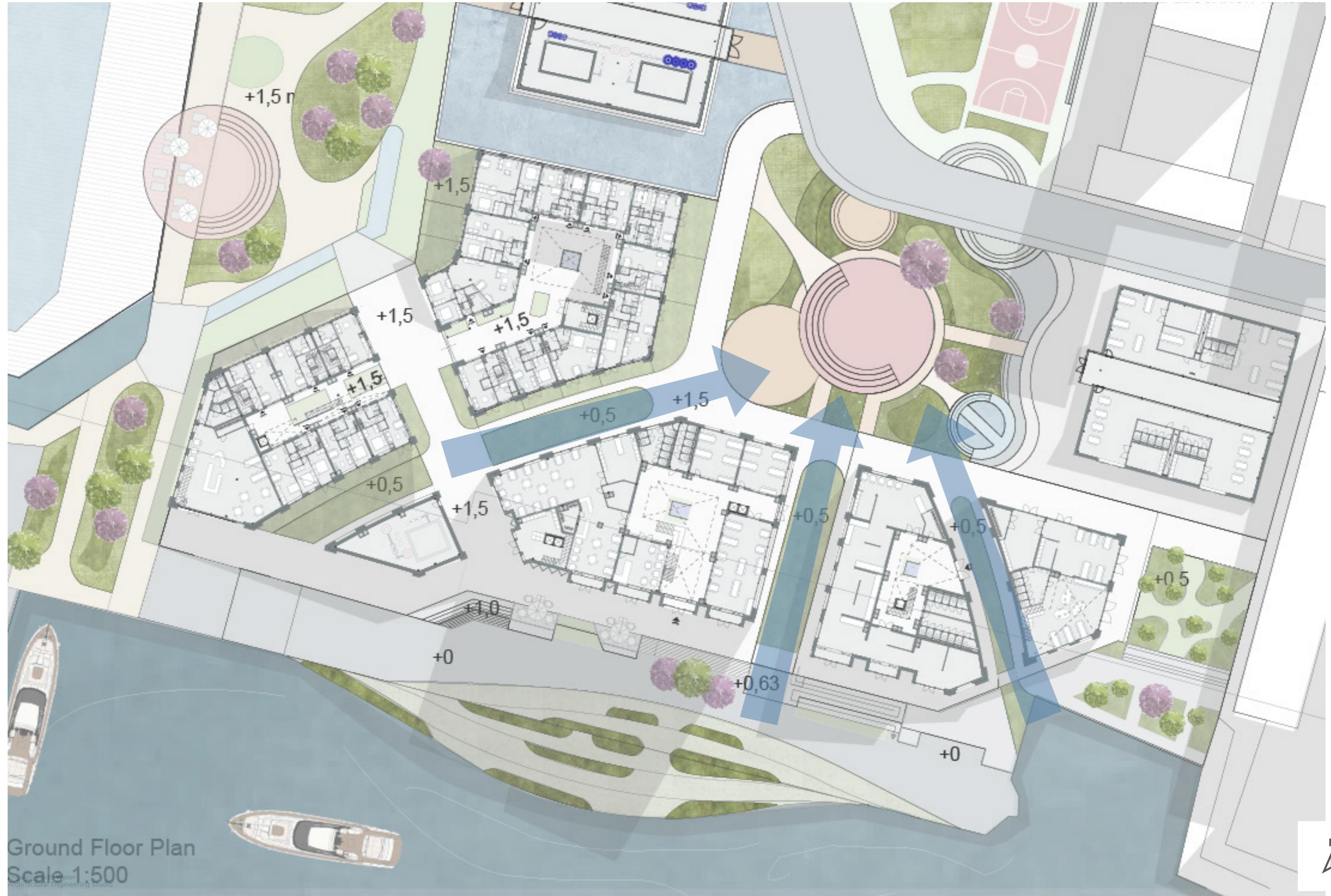
## LEVEL 1.5 FLOOD - main escape routes for neighborhood - highered roads



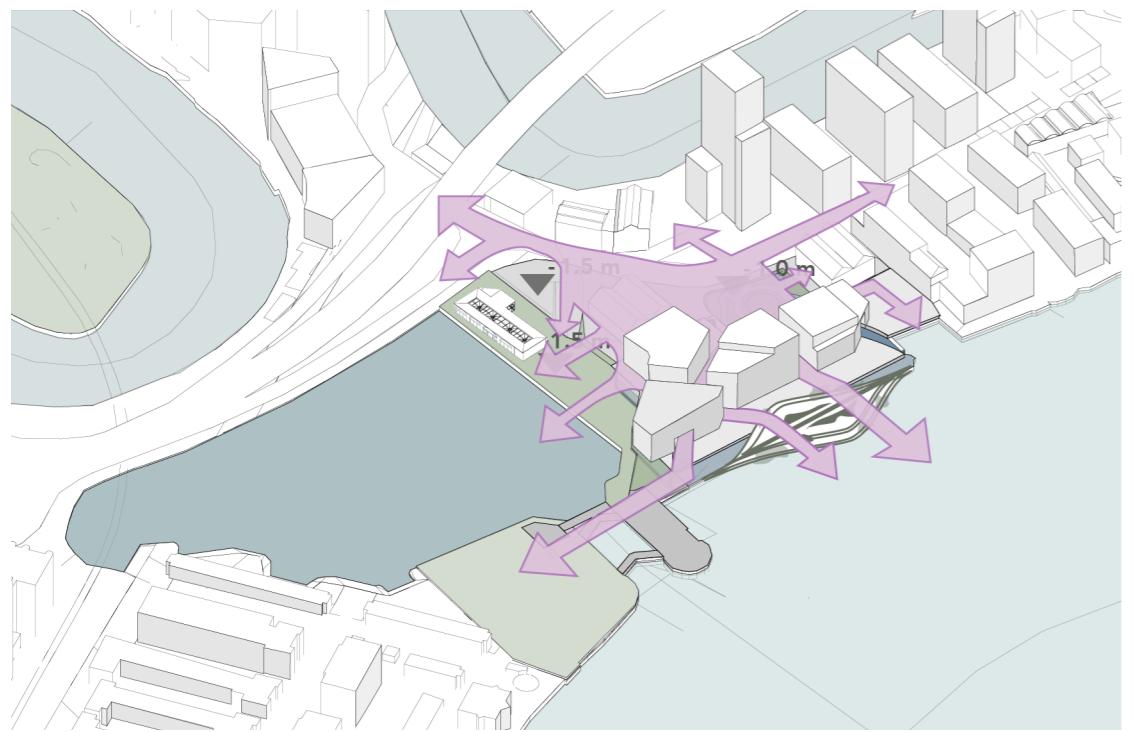
from highered escape bridges existing highered ground of 1.5 m can be reached to later access the main road

main road highered with 0.5 m

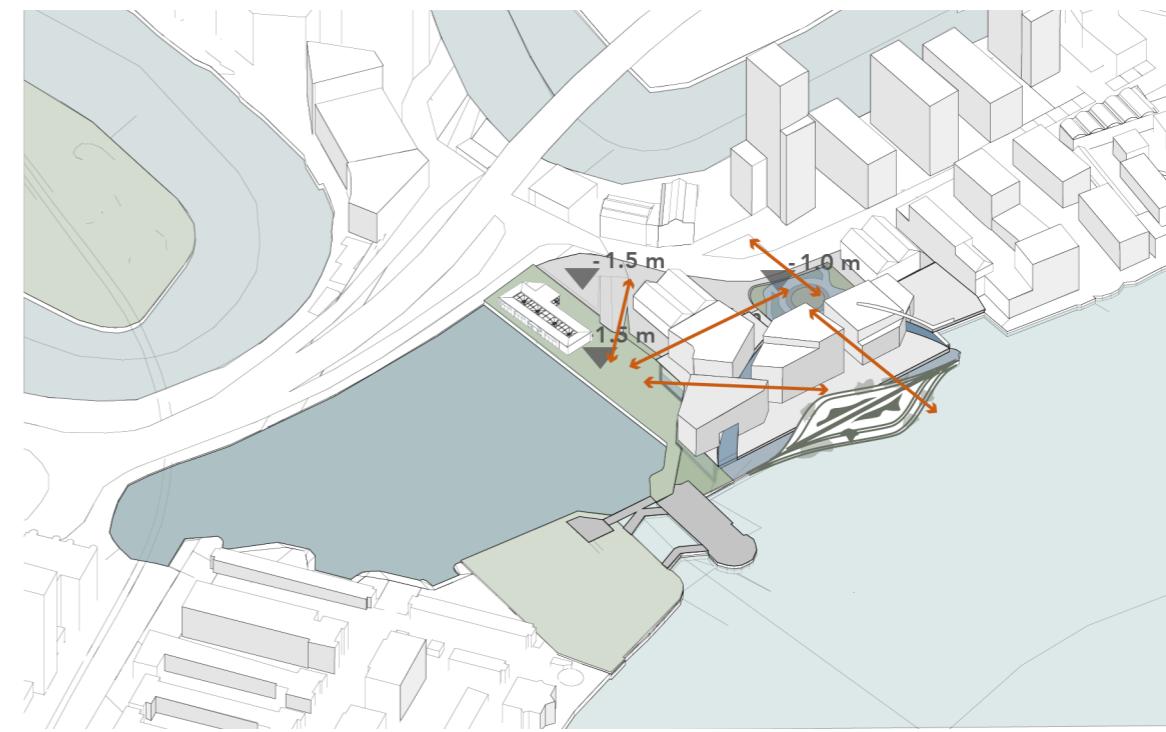
# Urban plan: riverfront building blocks with public functions prone to floodings



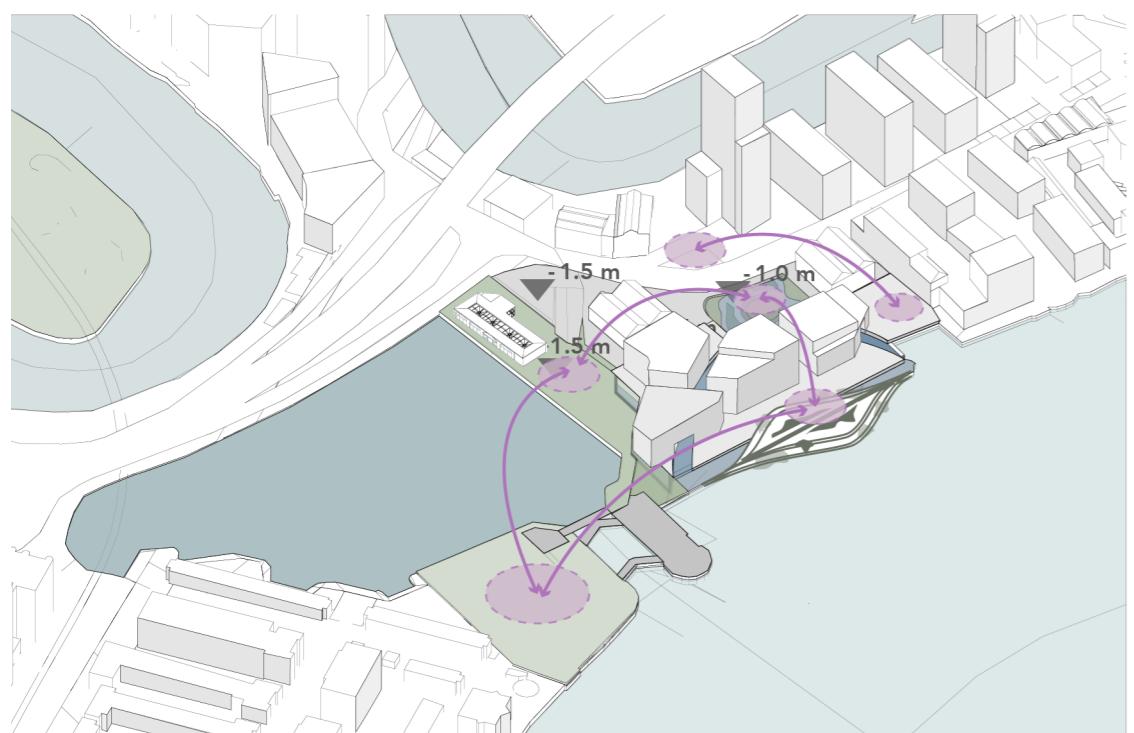
# Urban plan - flow through areas



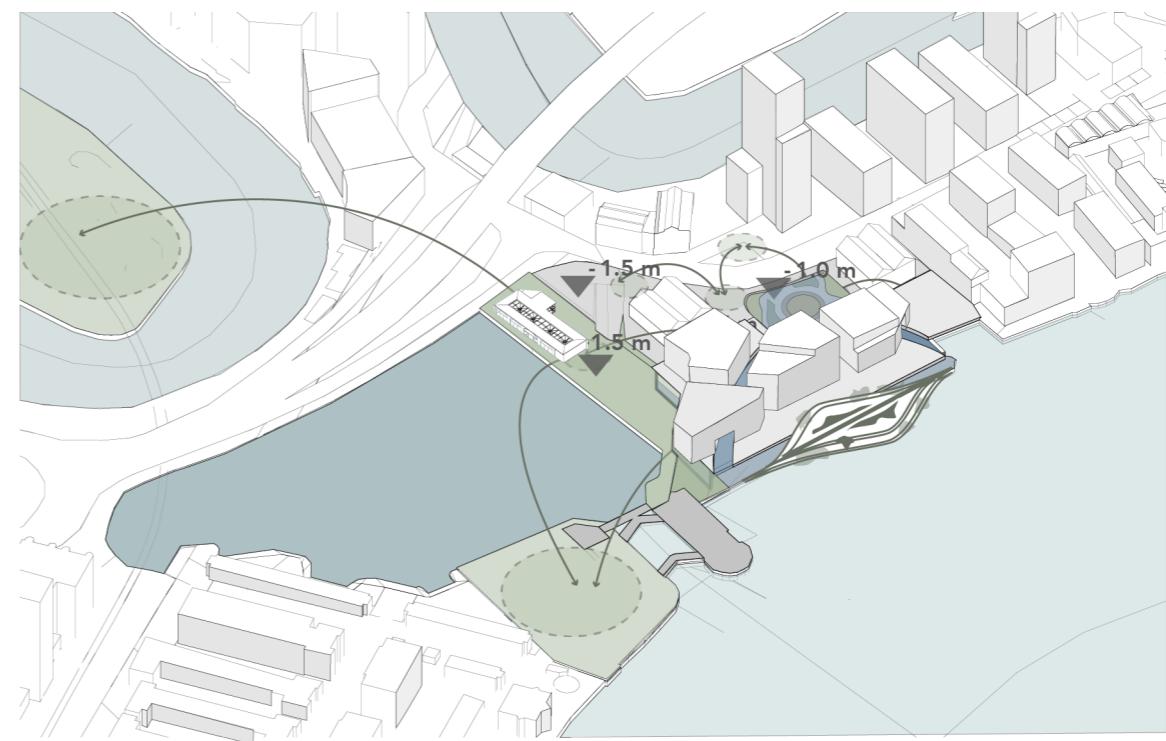
**ROUTING - CONNECTING NEIGHBORHOODS WITH THE WATERFRONT OF THE THAMES**



**ROUTING - CREATING SIGHTLINES FOR CONNECTION**



**ROUTING - CONNECTING GREEN URBAN SPACES**



**ROUTING - STRENGTHEN EXISTING GREEN AREAS TO STIMULATE BIODIVERSITY**

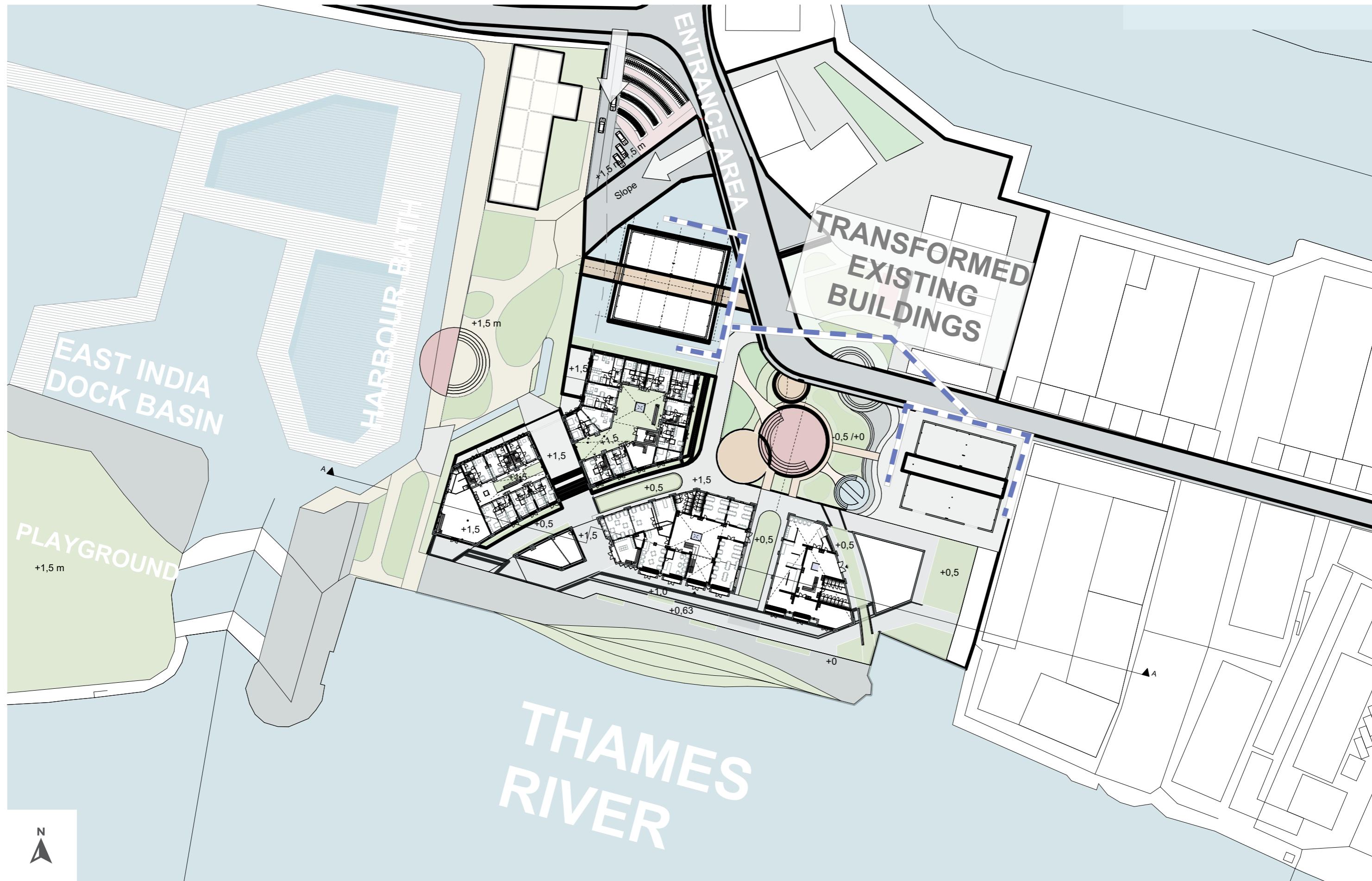
# Urban plan

Scale 1:1000

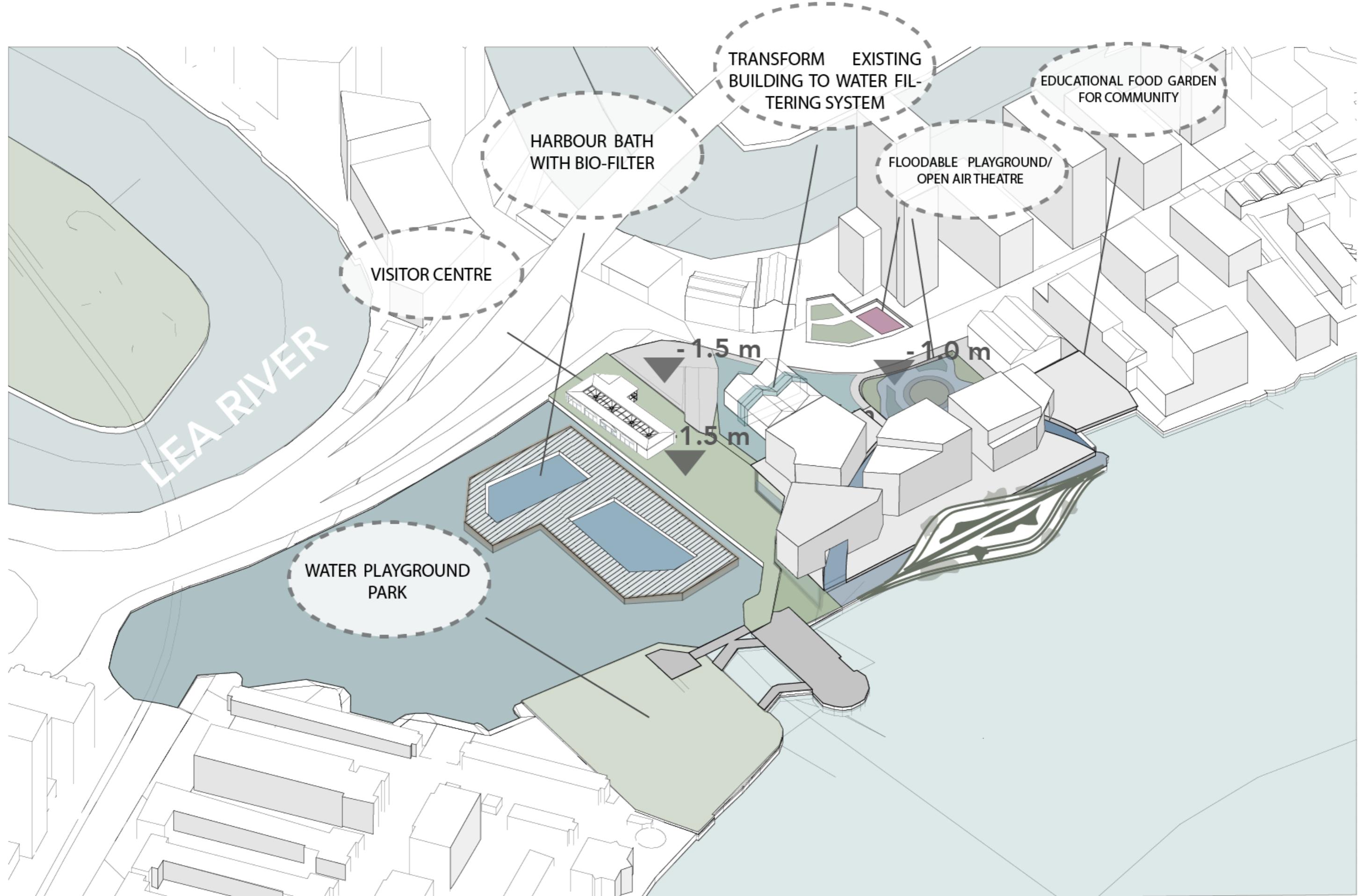


# Urban plan

Scale 1:1000



# Integrating Sustainable Urban Drainage Systems (SUDS) and Green Infrastructure (GI)



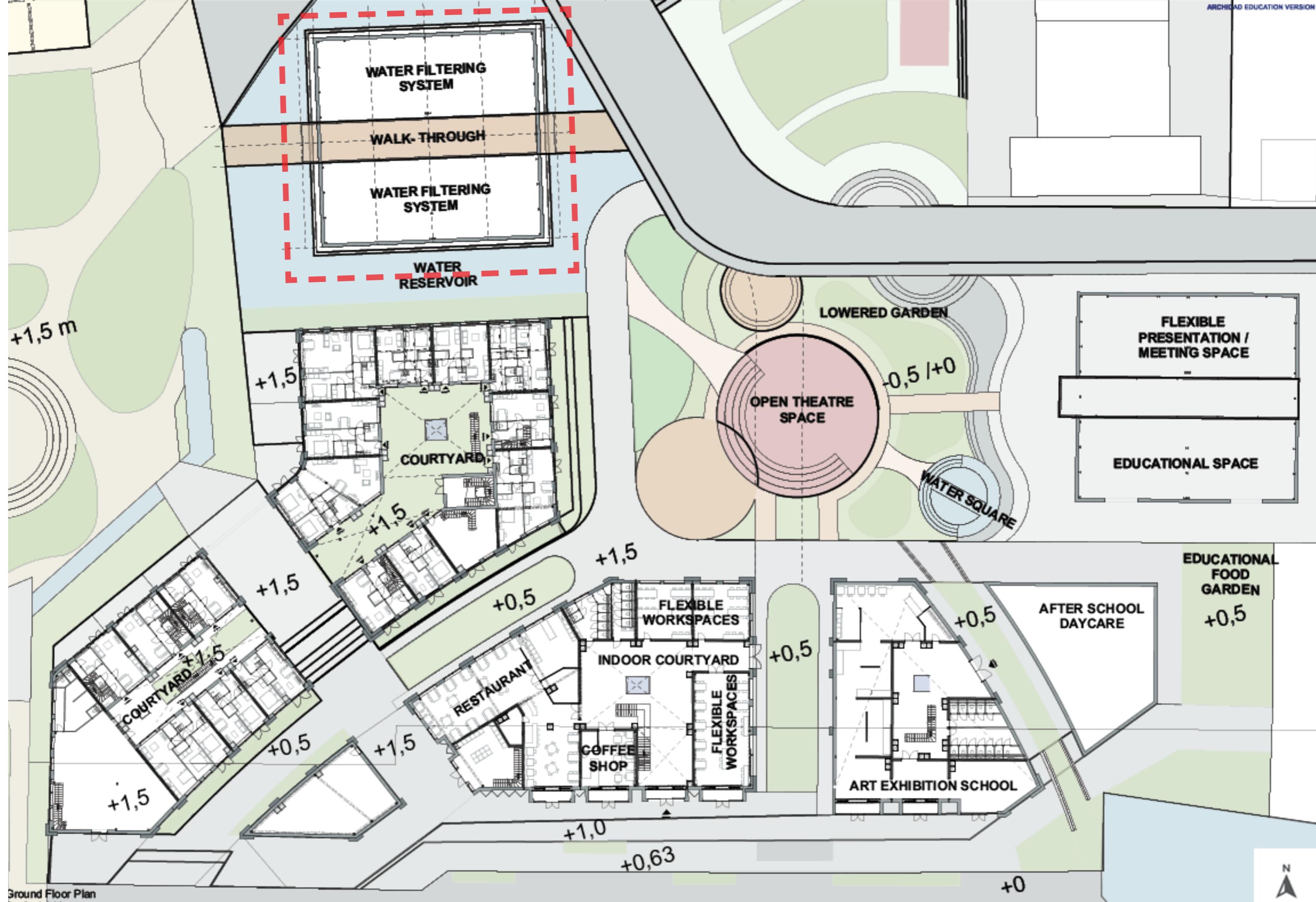
# Terraced waterfront



Lowered watergarden



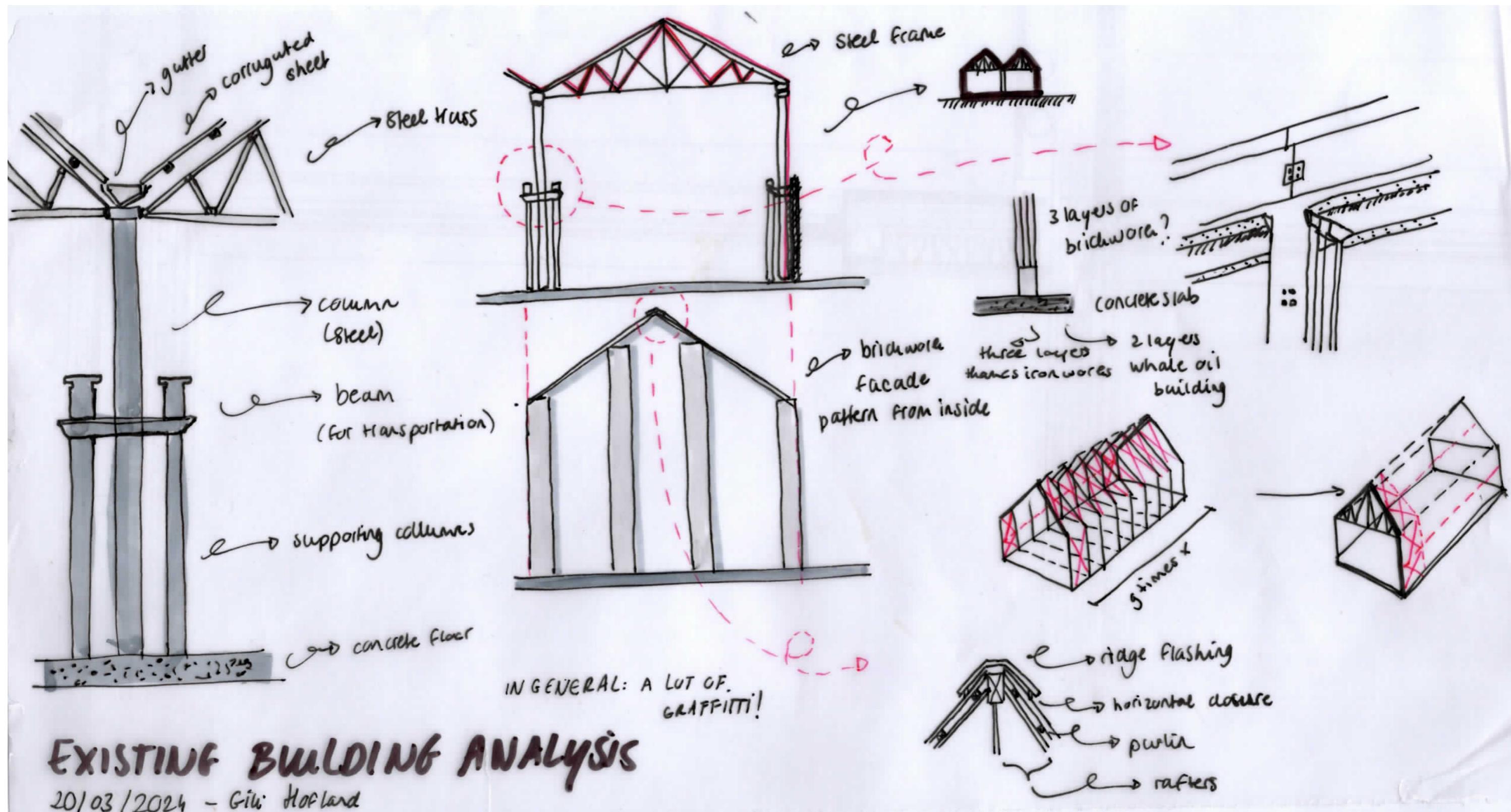




SuDS example: Thames ironworks historic building as water reservoir

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Re-using the existing structure as historic recognition points for water re-use



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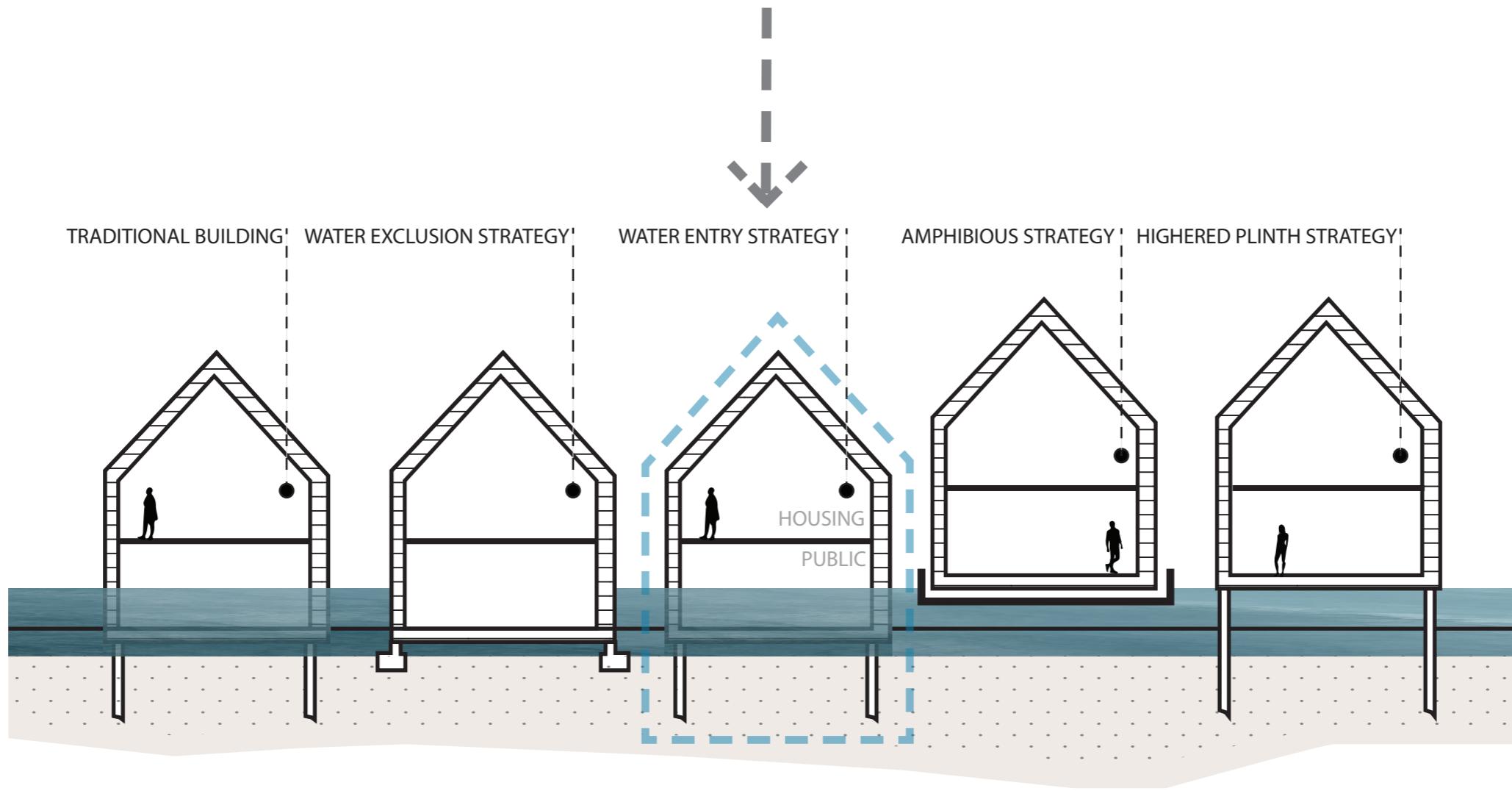
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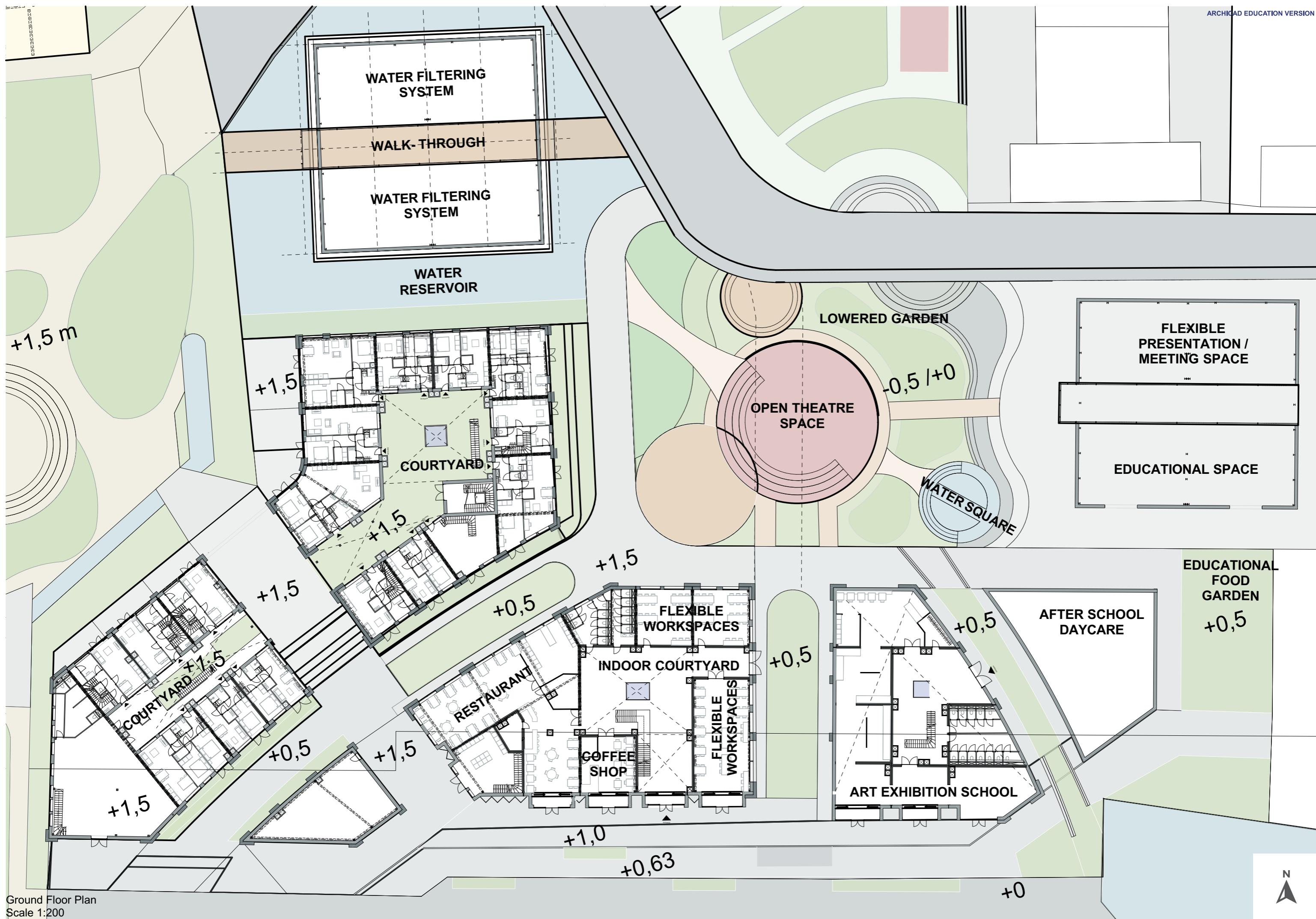


# HOW TO DESIGN WATER RESILIENT BUILDINGS?

# Water exclusion versus water entry strategies



**GROUND FLOOR: MOSTLY PUBLIC  
UPPER FLOORS: HOUSING**

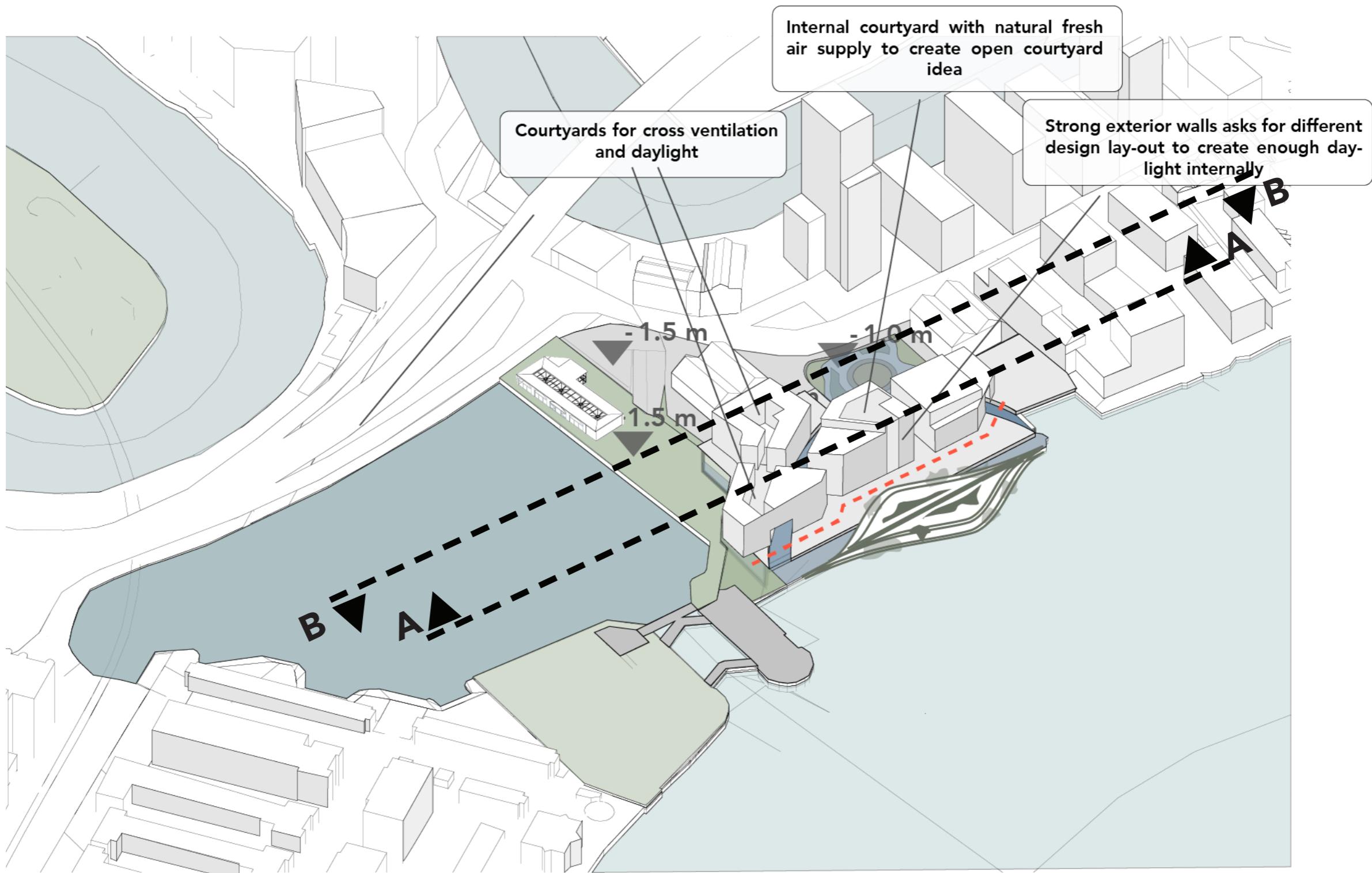


# Legenda

- dwelling type 1: 75 m<sup>2</sup>
- dwelling type 2: 45 m<sup>2</sup>
- dwelling type 3: 90 m<sup>2</sup>
- study area
- restaurant
- after school care
- flexible workspaces
- after school care
- restrooms
- water core
- access areas

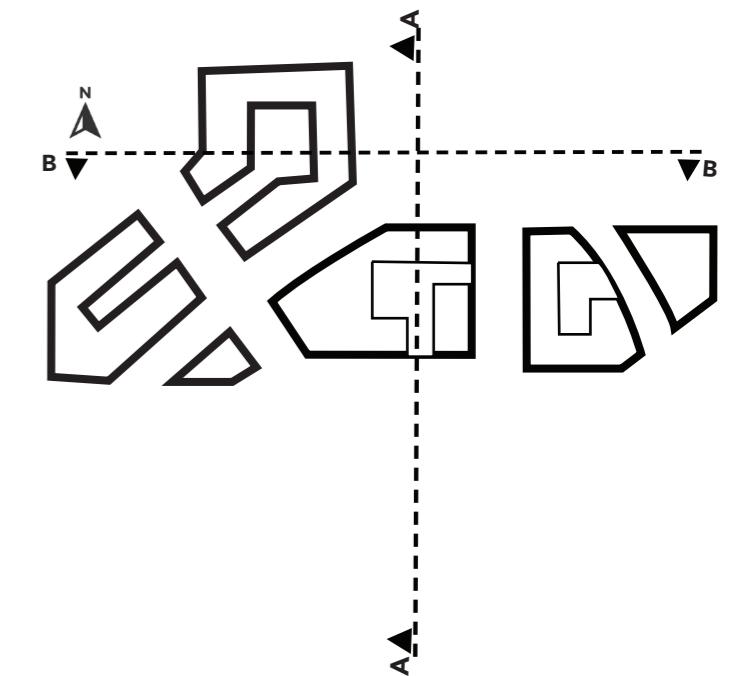


# Protective waterfront layer



# Courtyard watercore: everyday

Scale 1:200



# Courtyard watercore: everyday functioning

Scale 1:200



**SECTION AA'**



**SECTION BB'**

# Courtyard watercore: 0.5 m flood level

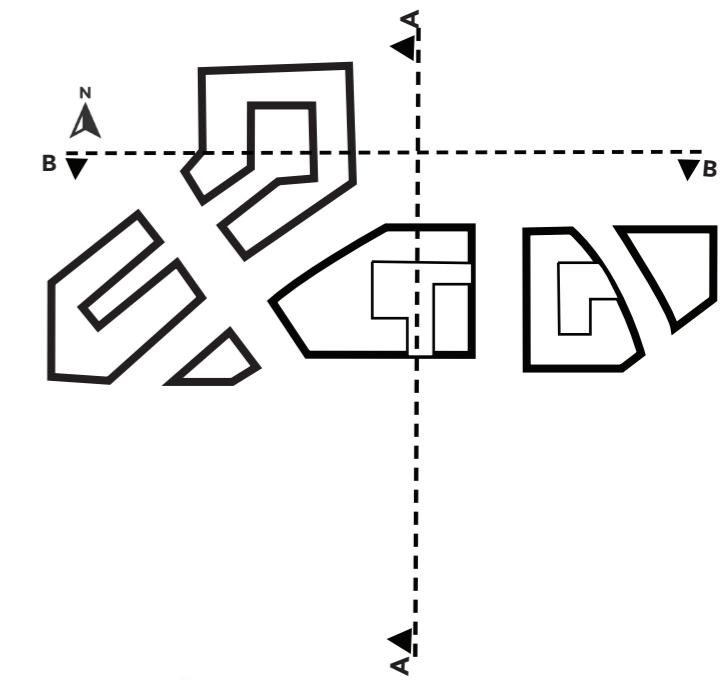
Scale 1:200



**SECTION AA'**

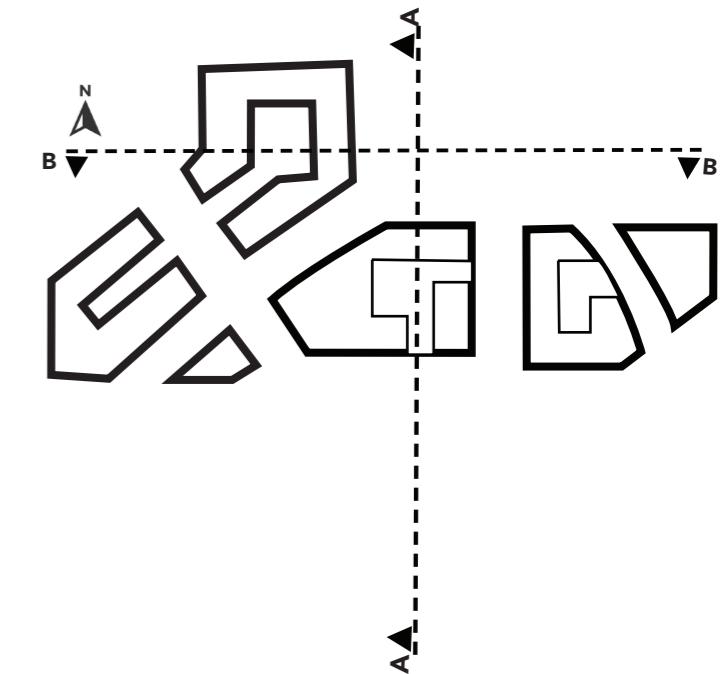


**SECTION BB'**



# Courtyard watercore: 1 m flood level

Scale 1:200

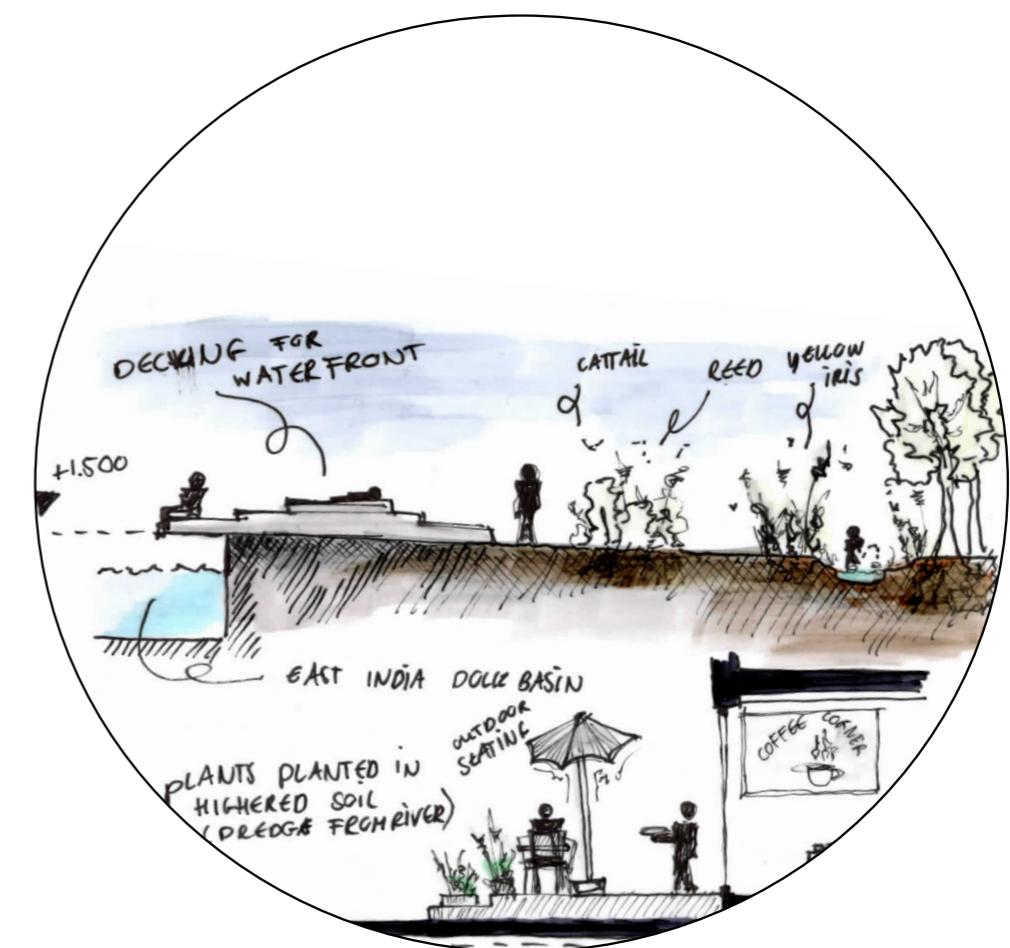
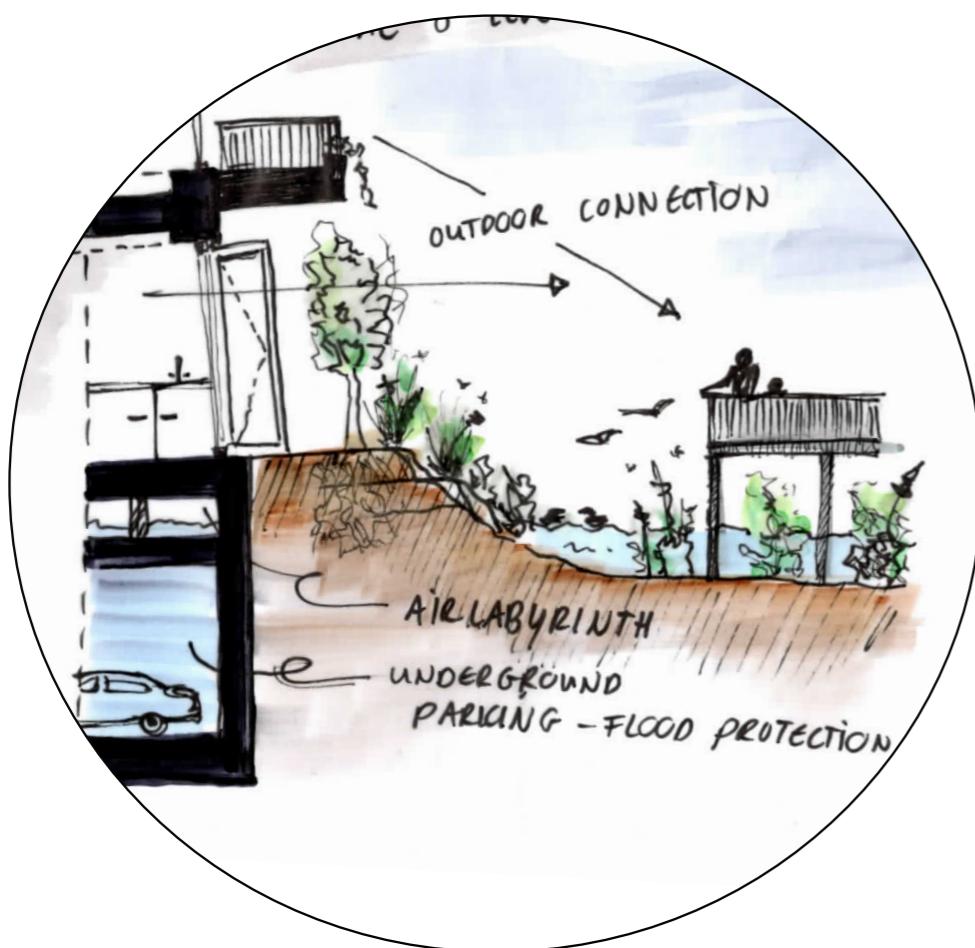


# Street profile - water entry connection

Scale 1:200



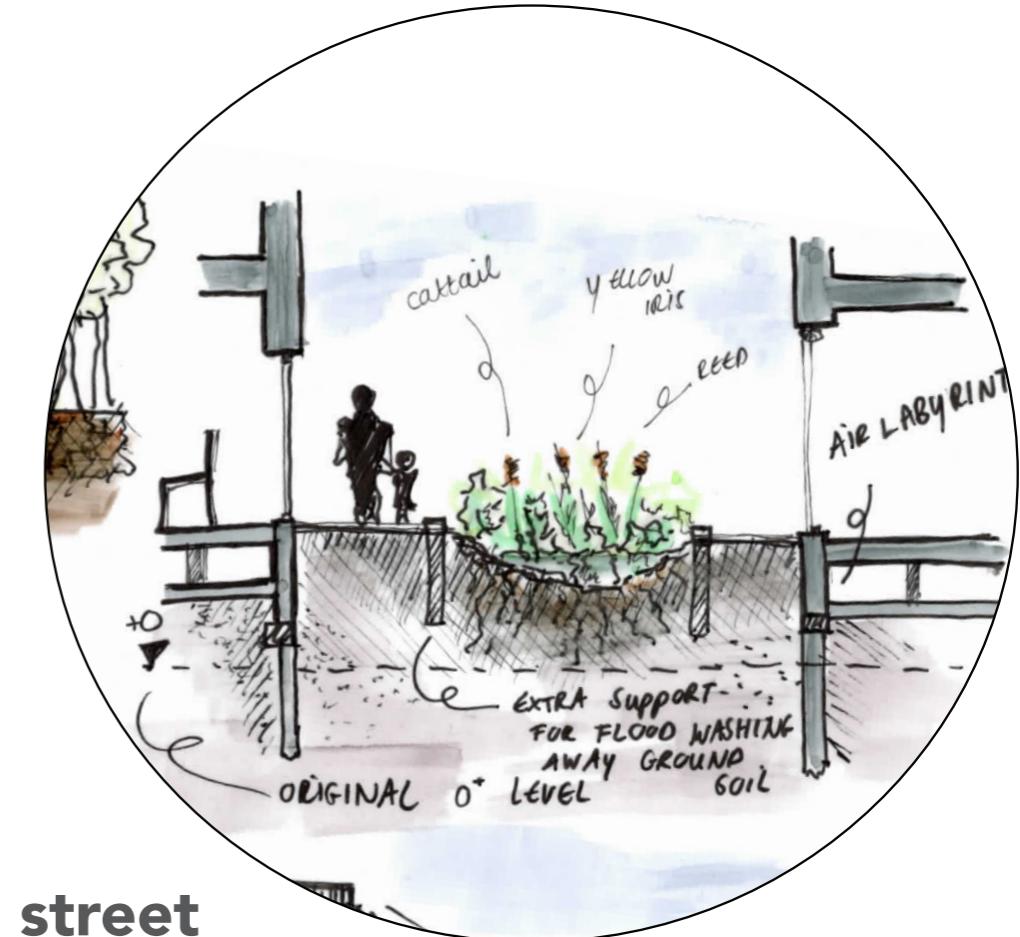
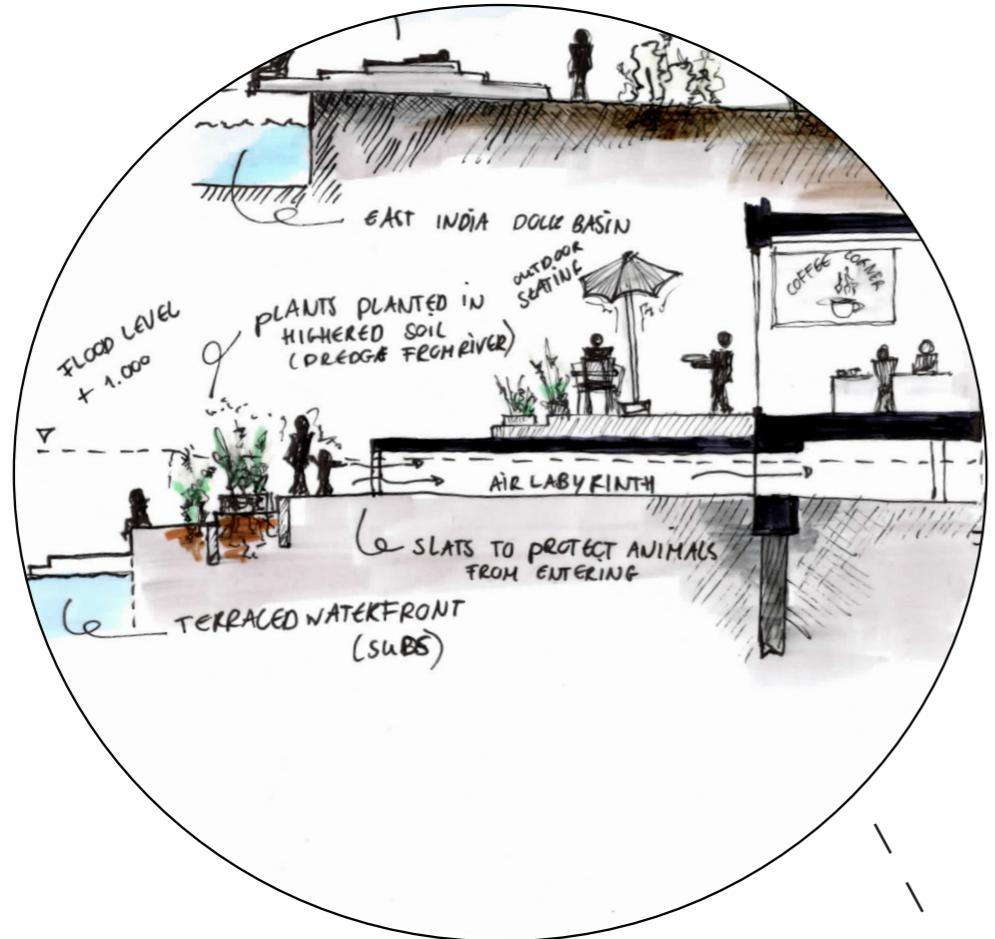
SECTION AA'



# Waterfront and street profile

Scale 1:200

## waterfront connection

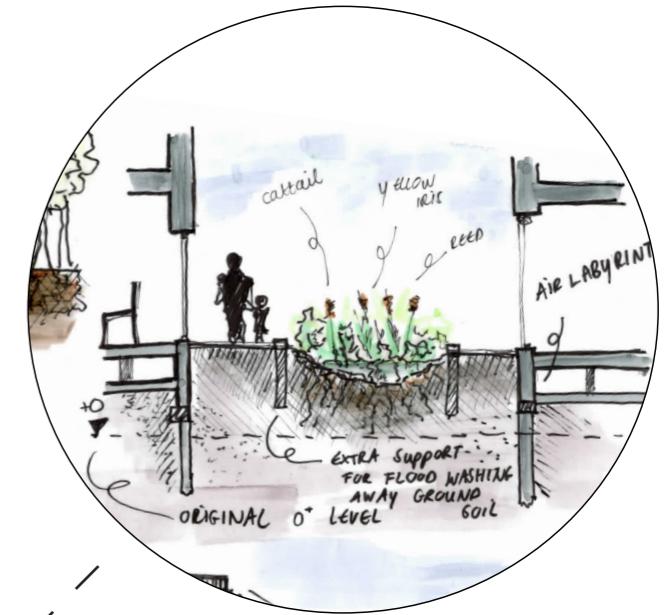
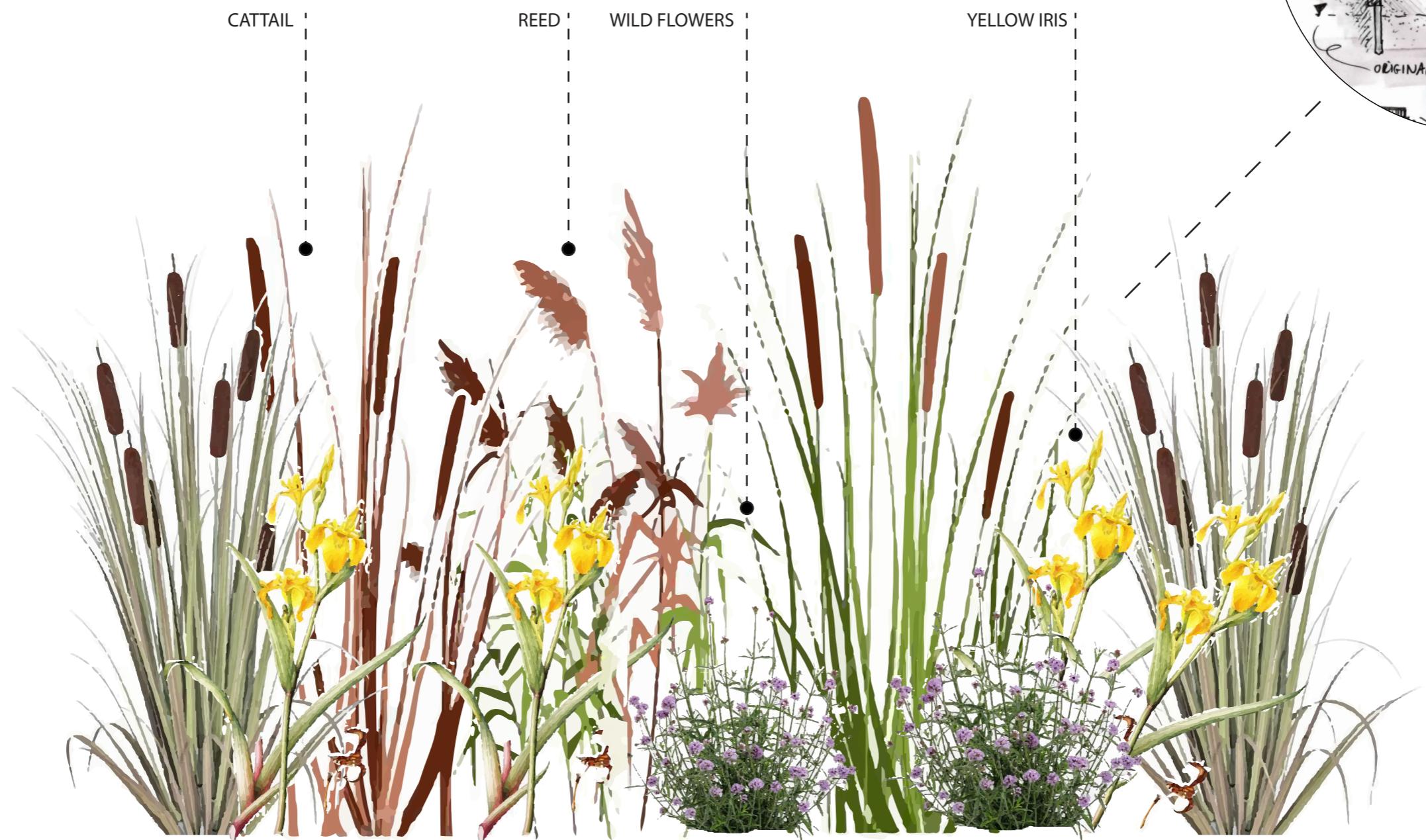


## water guiding street



## SECTION BB'

# Plant selection street profile

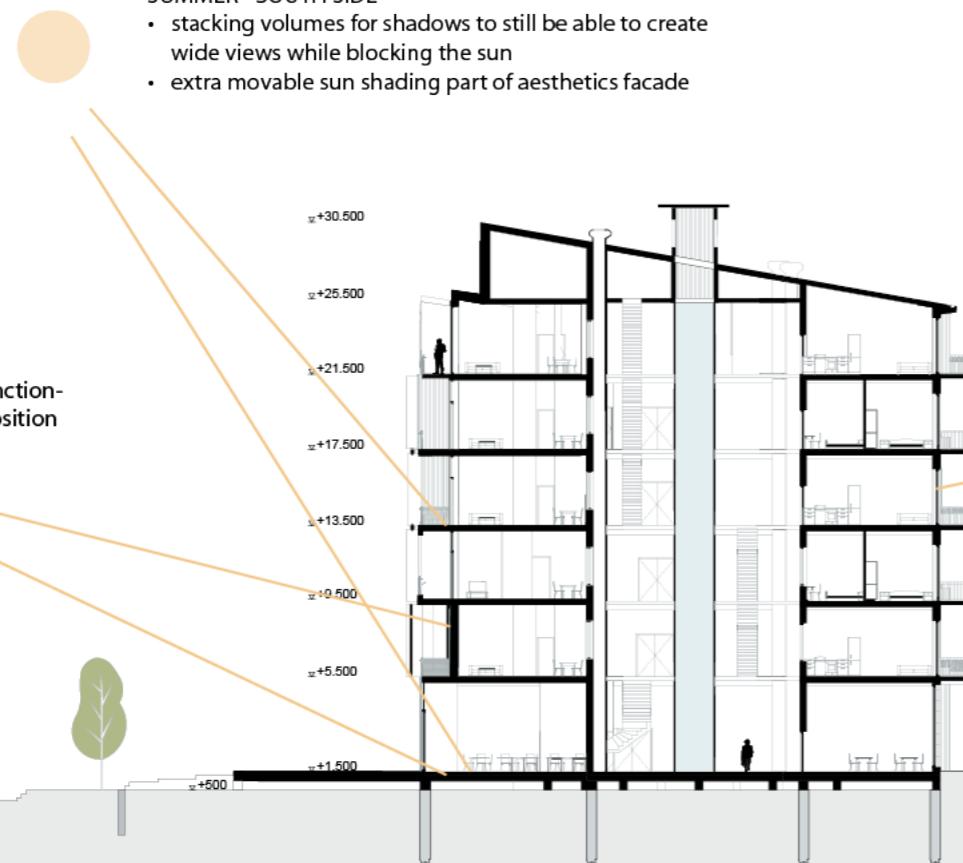


# Sunlight - metal sheeting and gutter with vertical slats as sun shading

Scale 1:200

**SUMMER - SOUTH SIDE**

- stacking volumes for shadows to still be able to create wide views while blocking the sun
- extra movable sun shading part of aesthetics facade

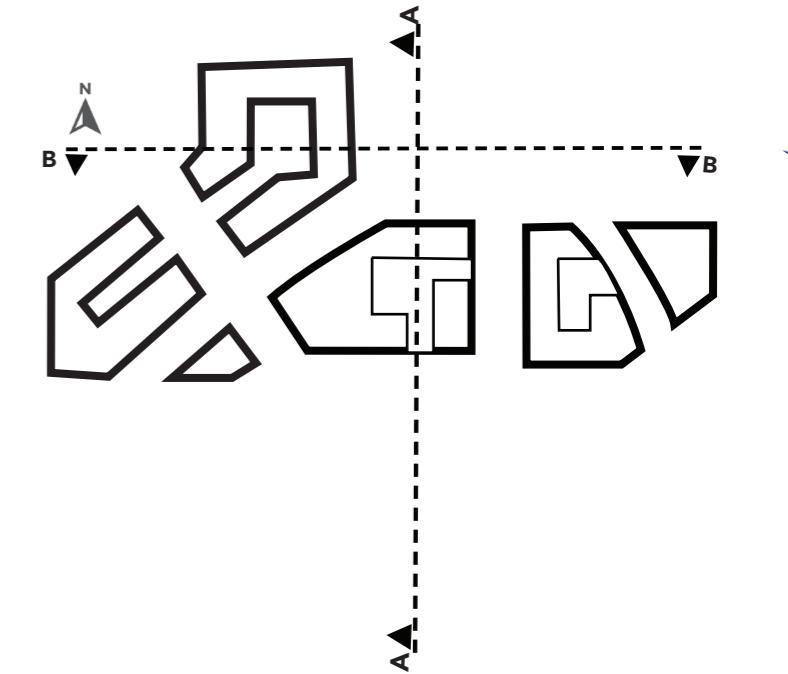


**WINTER - SOUTH SIDE**

- metal sheeting is more functional because of lower sun position

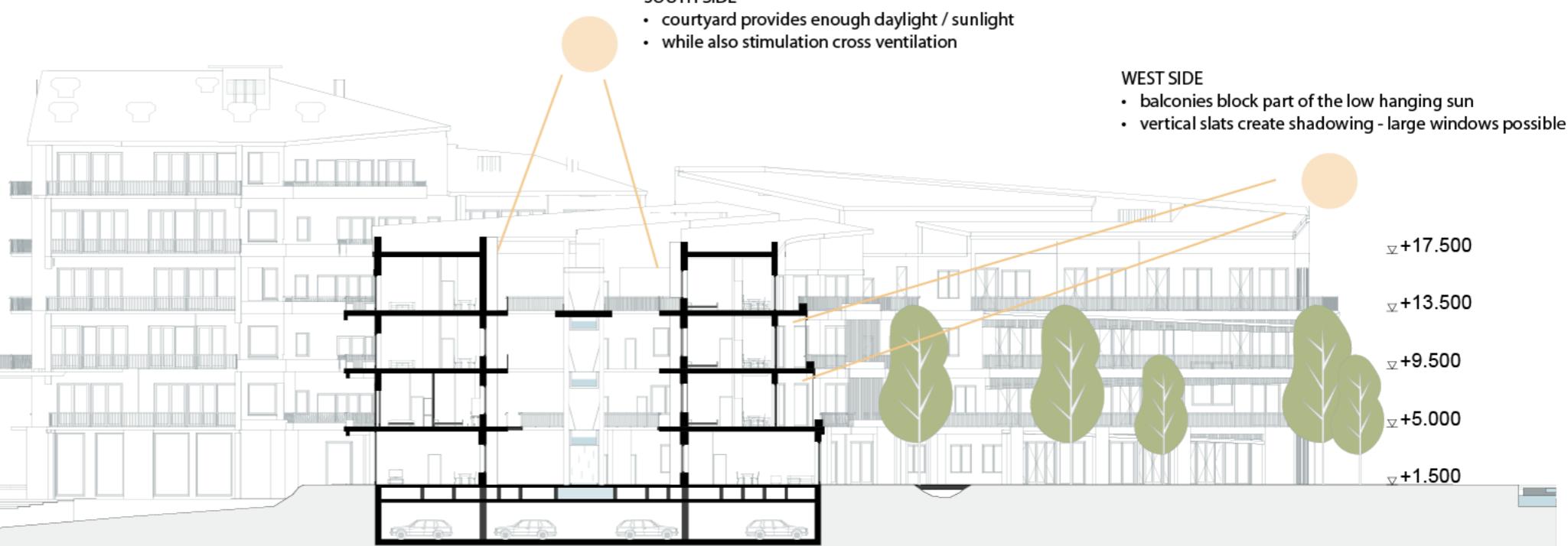
**SUMMER - WEST SIDE**

- balconies block part of the low hanging sun
- gutter design partly blocks sunlight



**SOUTH SIDE**

- courtyard provides enough daylight / sunlight
- while also stimulation cross ventilation



# 3D section - streetprofile and garden connection to buildings





An aerial map of a city showing a dense grid of buildings and a large river flowing through the center. Several green shaded areas represent parks and green spaces. The map is oriented with the top left corner pointing towards the center of the river.

## HOW TO BUILD WATER RESILIENT WATER SYSTEMS?

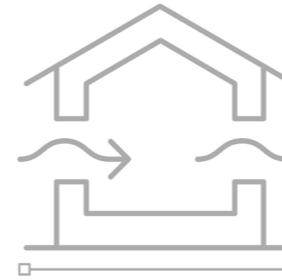
# Water-resiliency design steps



WATER RESISTANT BUILDING MATERIALS



RECOVERY MAINTENANCE

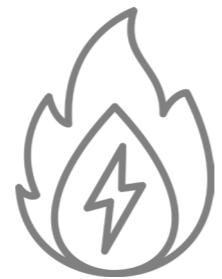


VENTILATION & COOLING SYSTEMS



(BIOPHILIA / BIOMIMICRY)

HEALTHY, INTERACTIVE WATER EXPERIENCE



ENERGY / HEATING SYSTEM



WATER RUN-OFF FACADE & ROOF DESIGN

# STEP 3

## THE SOCIAL BUILDING SCALE

Using biomimicry and biophilia to help raise sustainable awareness

Different water patterns as aesthetic and physically pleasing element

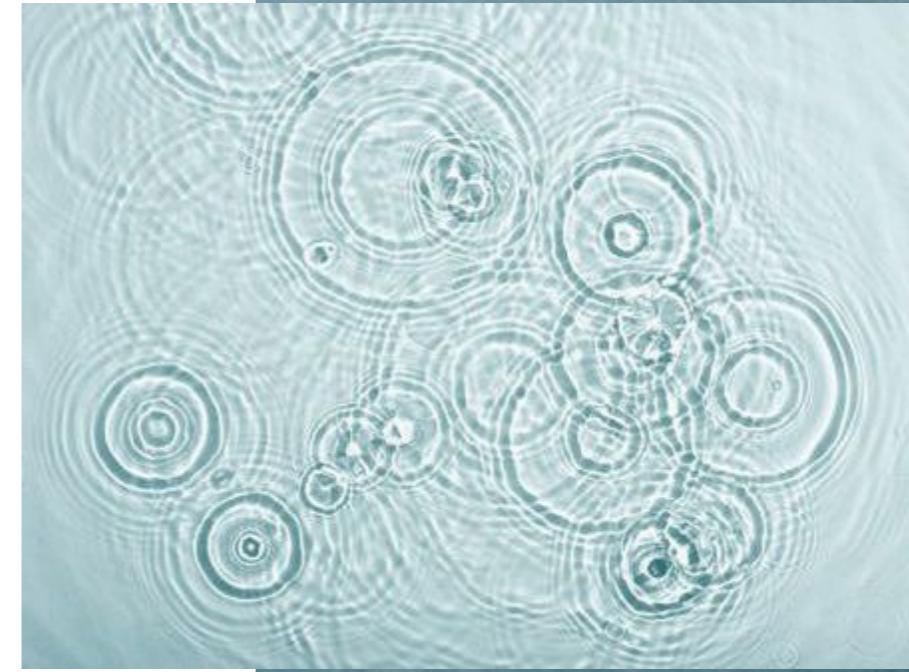
*How can the usage of biomimicry and biophilia in a building design enhance our living environment?*

*How do you teach people about sustainable solutions?*

**Symbol of the flow of life** and contemplation that promotes prosperity, progress, and technical power (Mikhailova, 2018).



Historic use of water



art & design



architectural-artistic solutions like fountains

# STEP 3

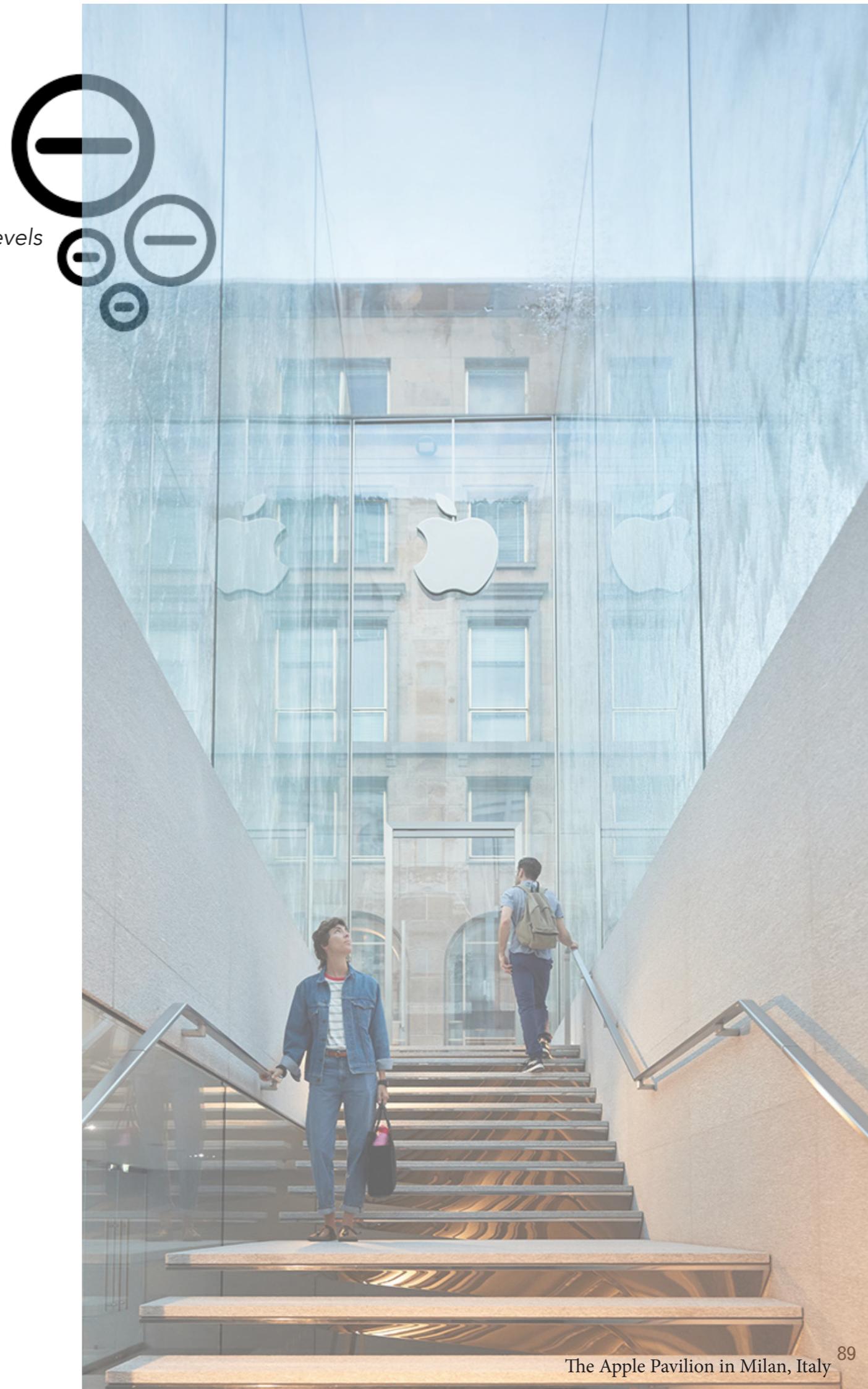
## THE SOCIAL BUILDING SCALE

Using biomimicry and biophilia as emotional influencing aesthetic

Different water patterns as aesthetic and physically pleasing element

biomimicry: "using the movement of water that evokes relaxing sounds, visual satisfaction, and physical influence such as cooling air and purification to create interaction".

negative ions  
high serotonin levels  
& relaxation



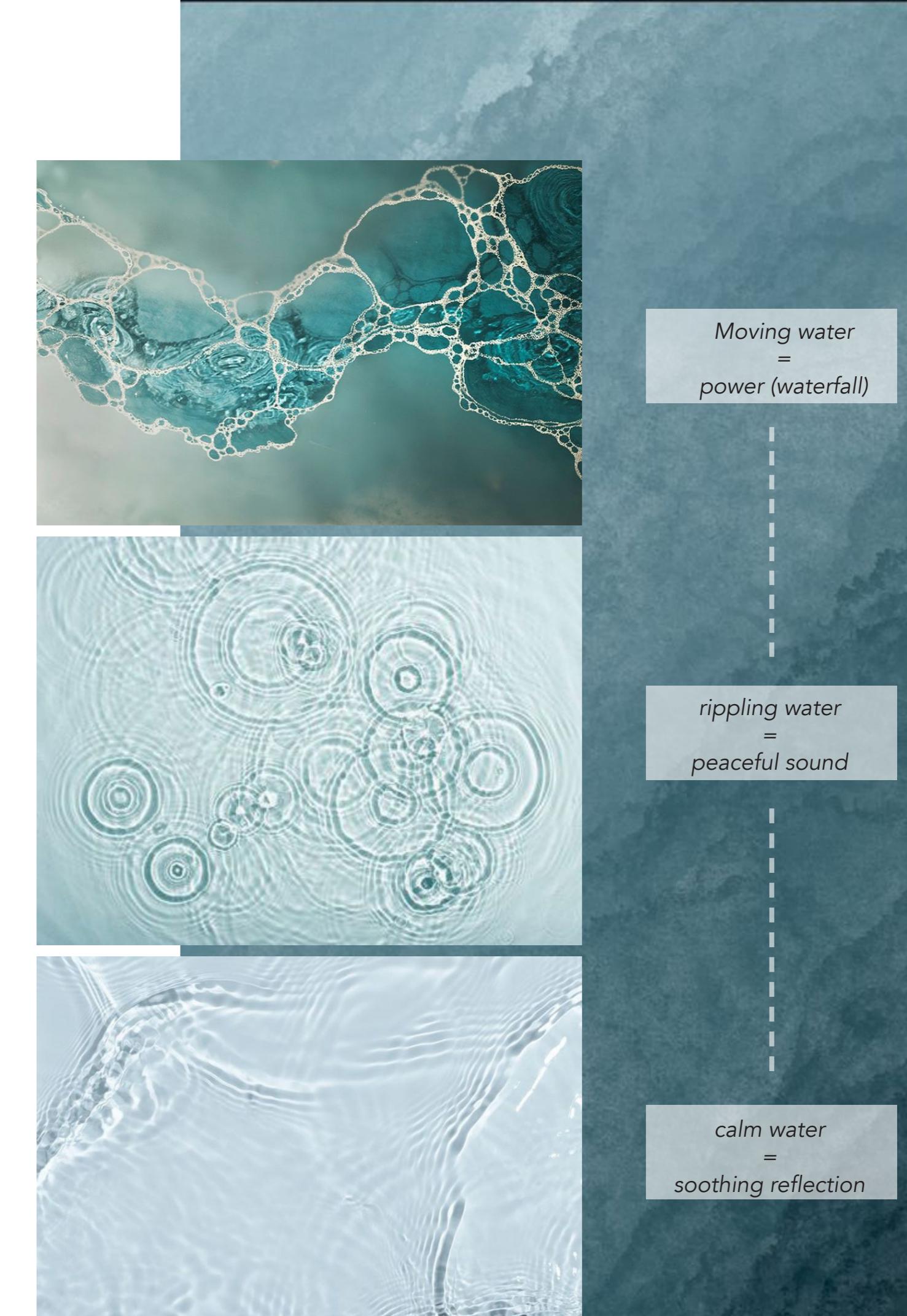
# STEP 3

## THE SOCIAL BUILDING SCALE

Using biomimicry and biophilia to help raise sustainable awareness

Different water patterns as aesthetic and physically pleasing element

**Biophilic effect on well-being:** Context, motion, clarity, sound, and colour are part of the experience and perception of water that can be linked to biophilia (Kistemann & Völker, 2011).



# Conclusion

Motivating stakeholders: BREEAM rules and awards

**To activate stakeholders, communicating and showing the way we consume and use water is crucial.**



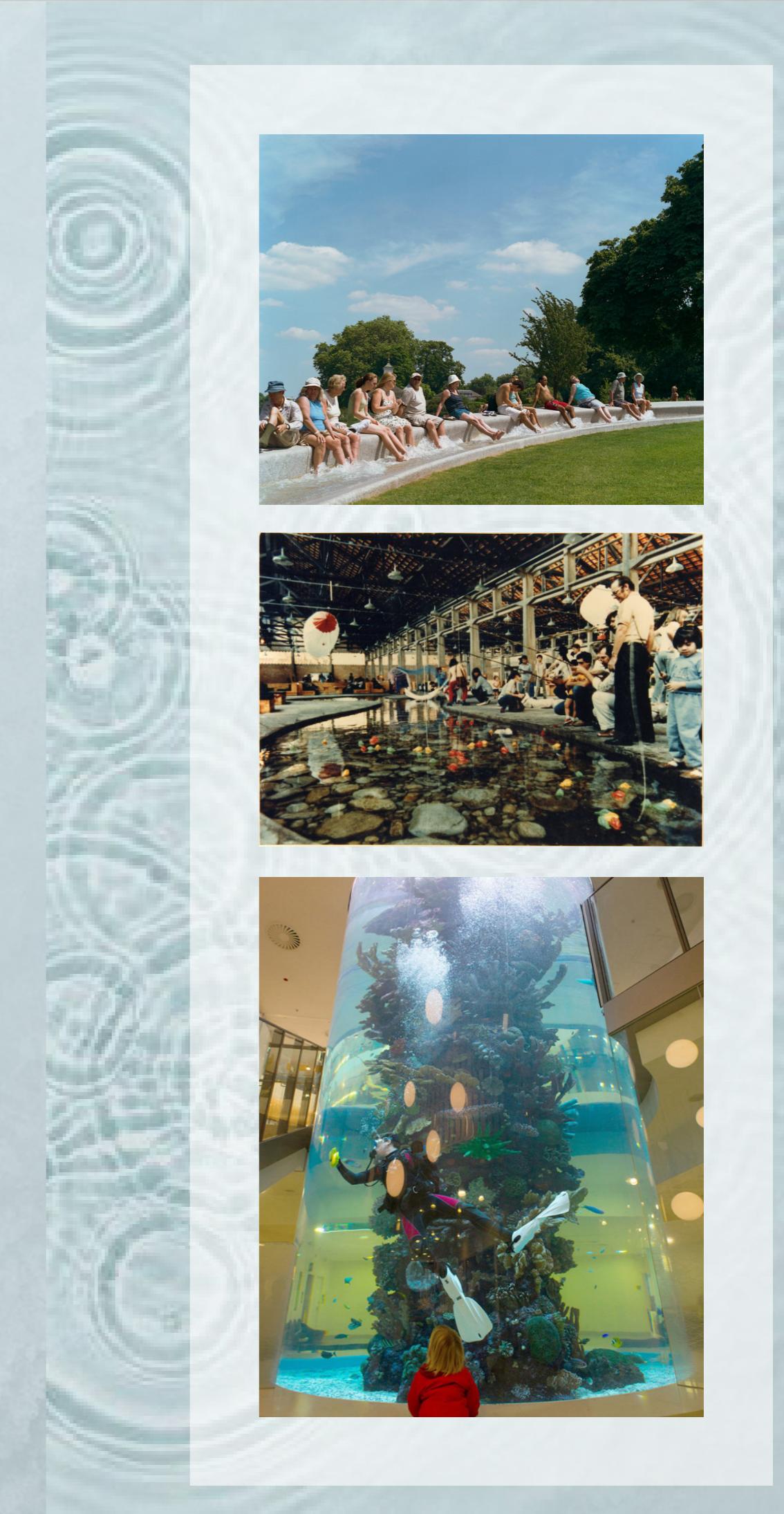
*Involving ALL stakeholders*

hidden sewage systems

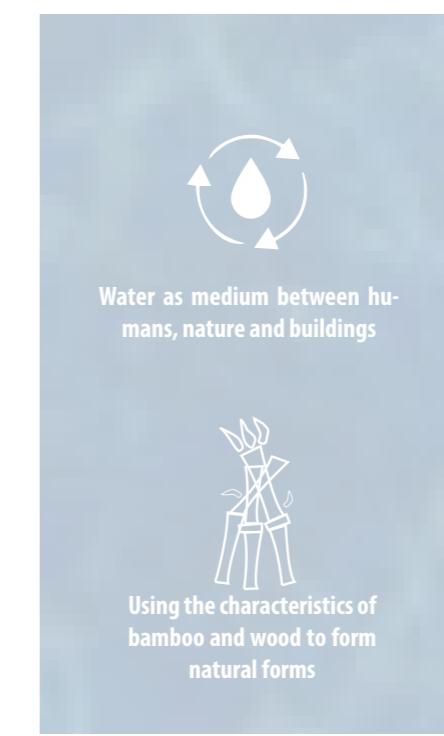
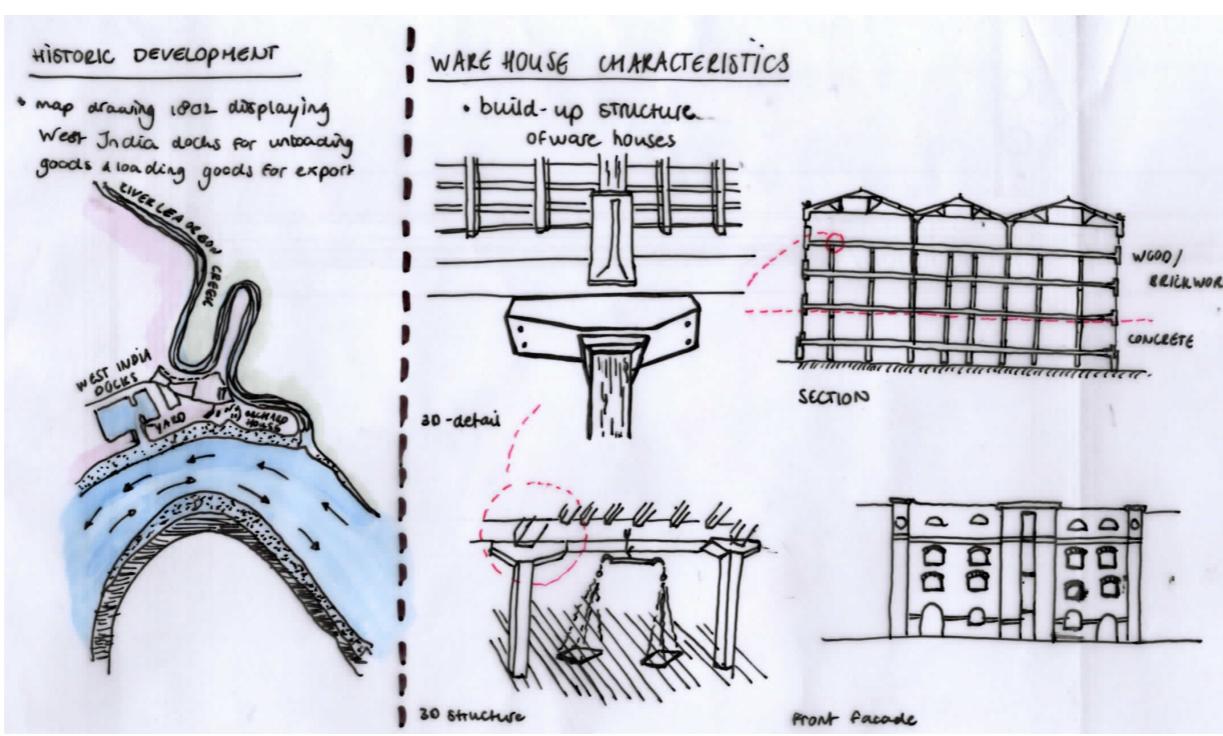
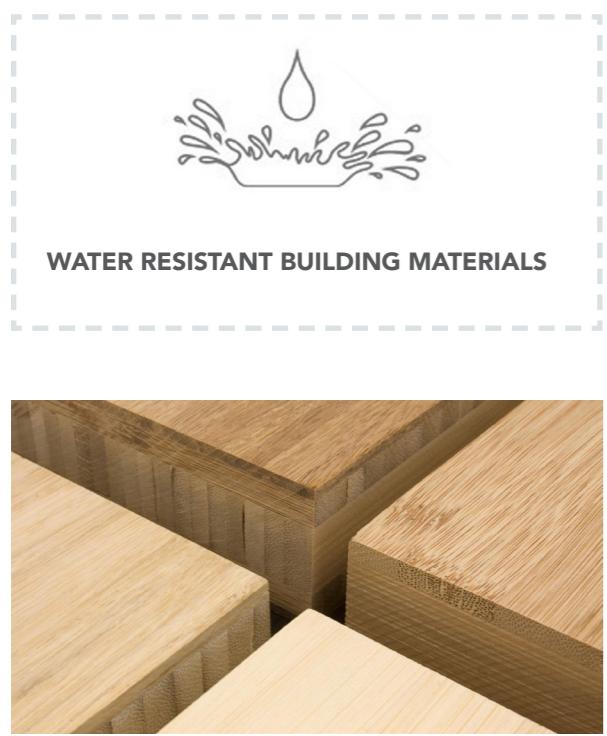


*BREEAM outstanding award  
(example building)*

*A more sensitive attitude of the user can only be reached if users are aware of the sustainable water systems within the building. It activates them to want to participate in realizing sustainable solutions, resulting in communities that exchange ideas and knowledge. The design focus is then related to both indoor and outdoor and tries to create a connection between the two spheres, by means of a multifunctional building that connects private and public spaces through water sensitive projects.*



# Building materials



CLB

CHARACTERISTIC OLD WOODEN STRUCTURE

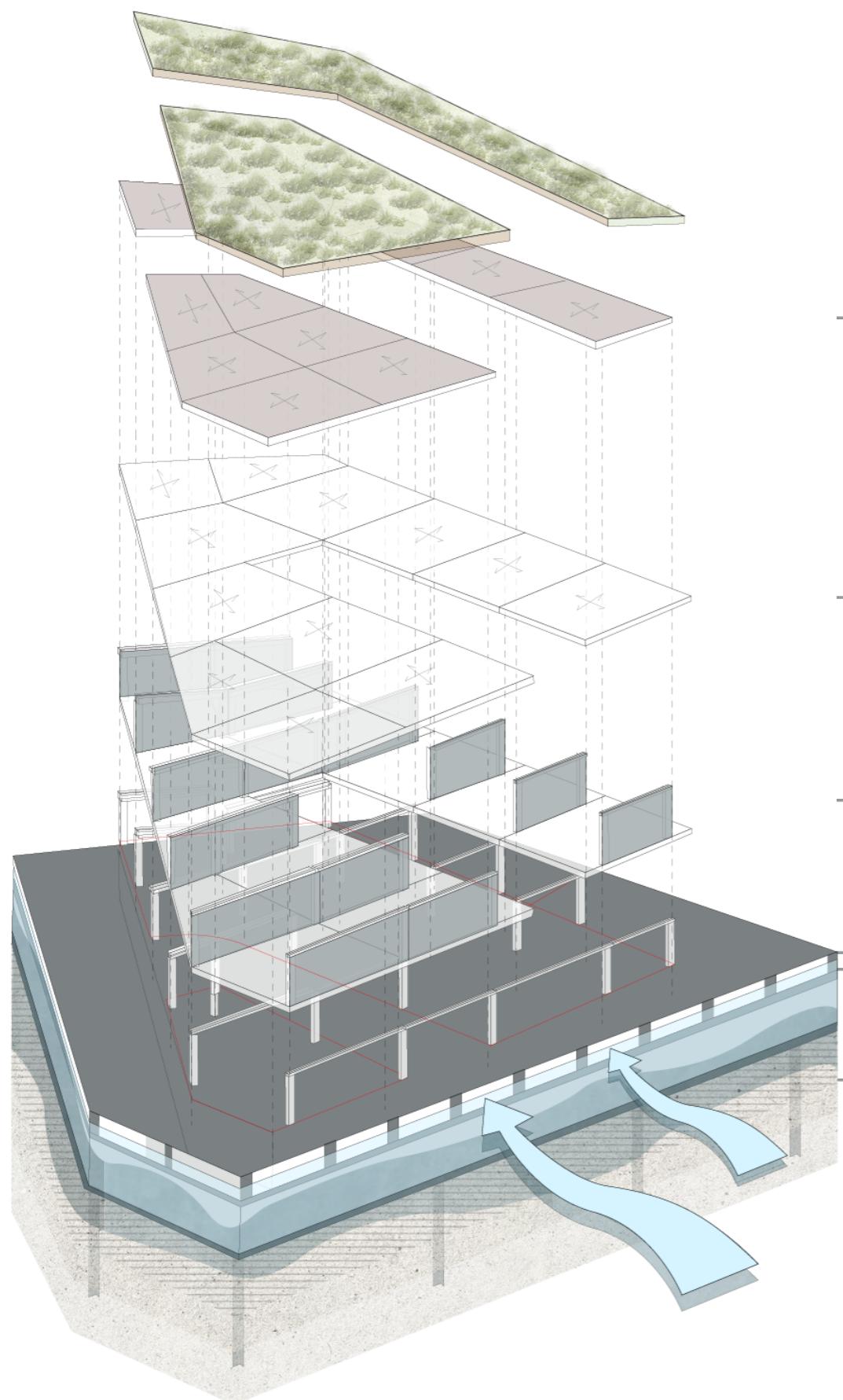
BIOPHILIC EFFECT

## CROSS LAMINATED TIMBER (CLT) VERSUS CROSS LAMINATED BAMBOO (CLB)

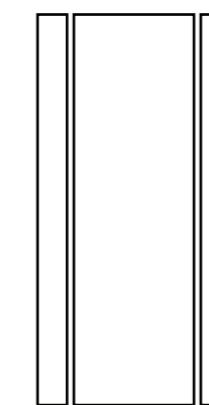
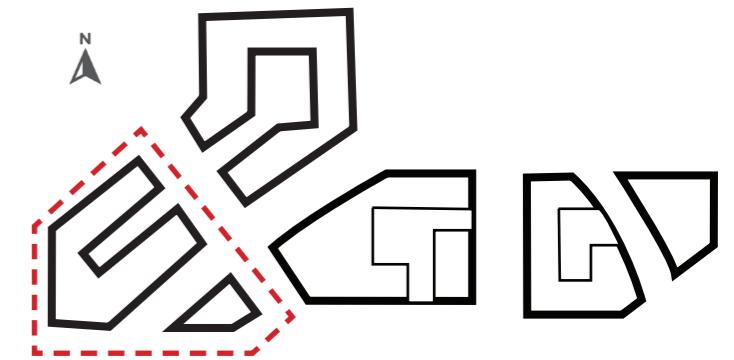
- CLB more water resistant than CLT
- CLB is 4x stronger
- Lighter environmental carbon footprint
- Two-way span direction

# Combining technical interventions with construction principle

Air labyrinth as structural layer



AXONOMETRIC PERSPECTIVE CONSTRUCTION



clamping plate with black alder wood - water resistant



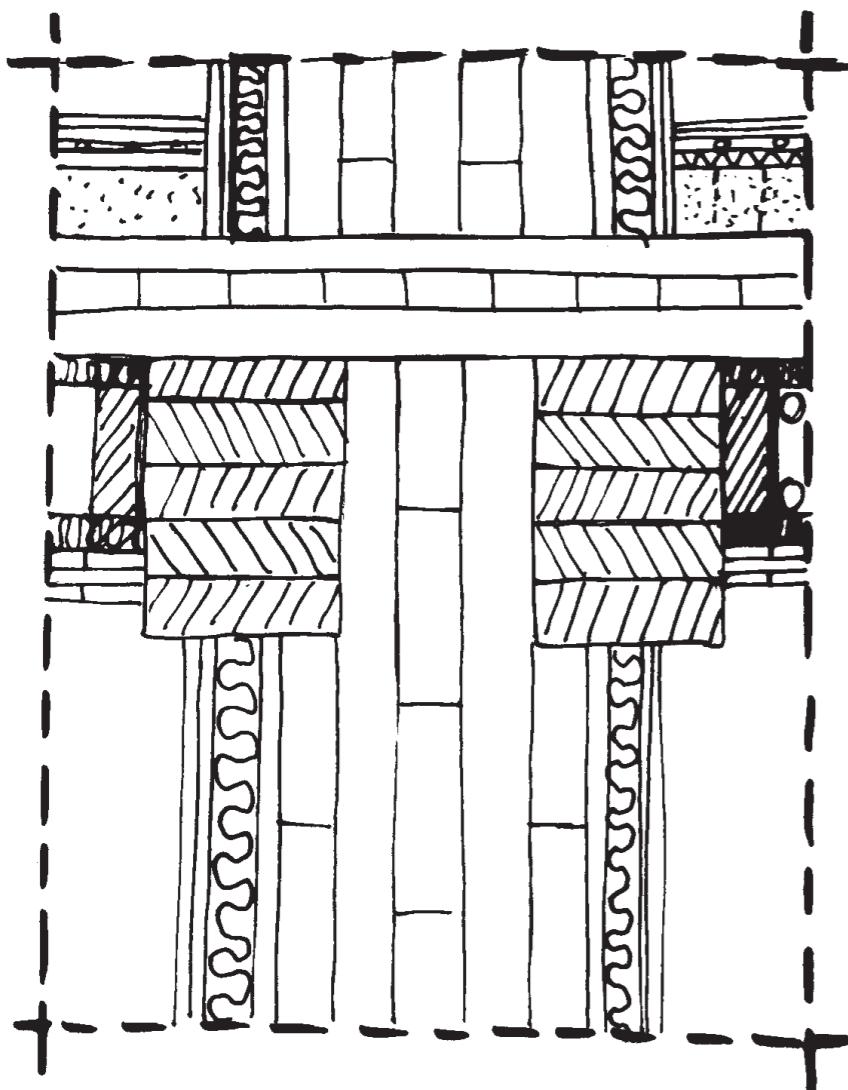
Stelcon slabs

# Combining principle house seperating walls

CLB structural walls and glulam beams



## RECOVERY MAINTENANCE



**LOWERED CEILING WITH 100 mm CLB finish for air supply pipes for central cores**

**SOUND INSULATION above CLB**

**INSULATION** on outsides of CLB wall as protective water layer (hemp insulation partly absorbs water)

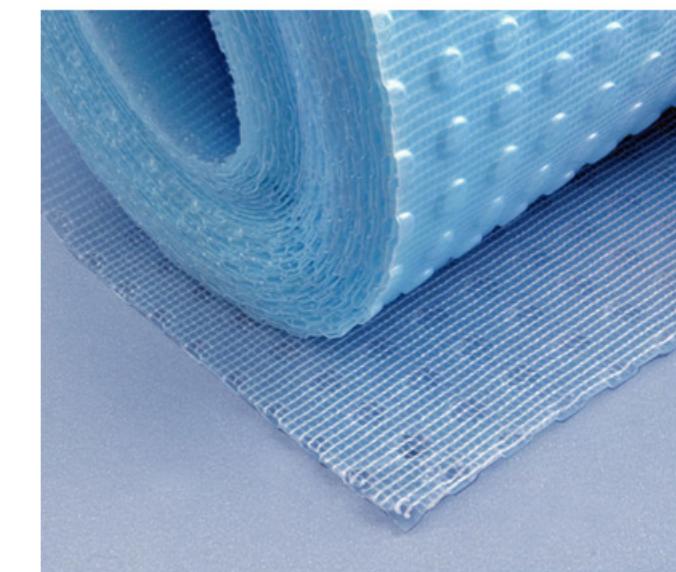
**AIR GAP for CLB to breathe**

**VISIBLE GLULAM BEAMS** - referring to old warehouses of East India Company

**5-layered CLB on ground floor as extra water protection layer because of natural glue**

**TWISTFIX or EPDM-foil: cavity drain membranes to create a waterproof barrier - creating a continuous air-gap that can be ventilated. Plaster can directly be attached to it**

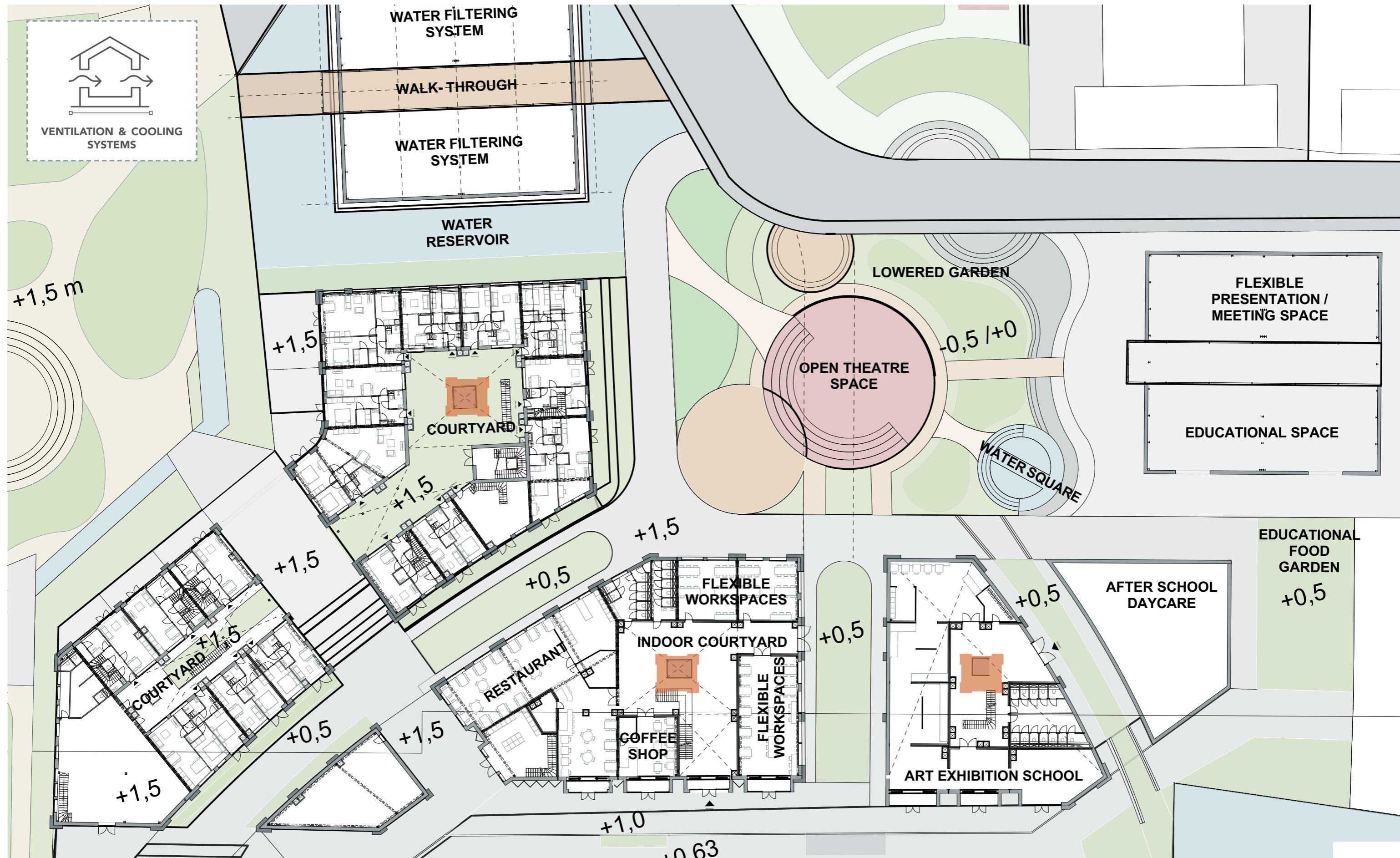
**Behind insulation air gap so construction can dry, while household still can live in their home**





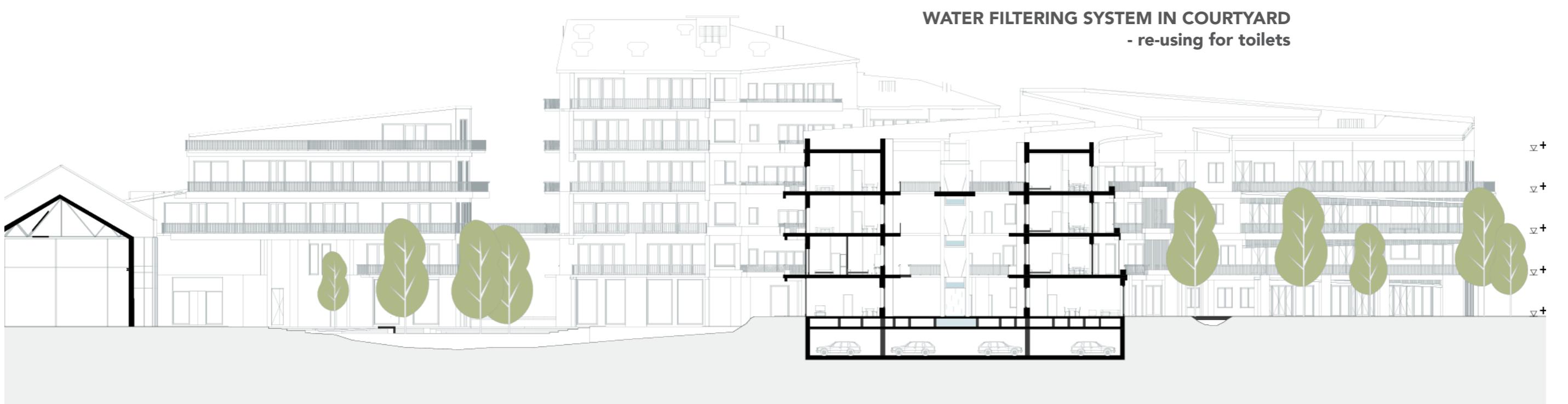
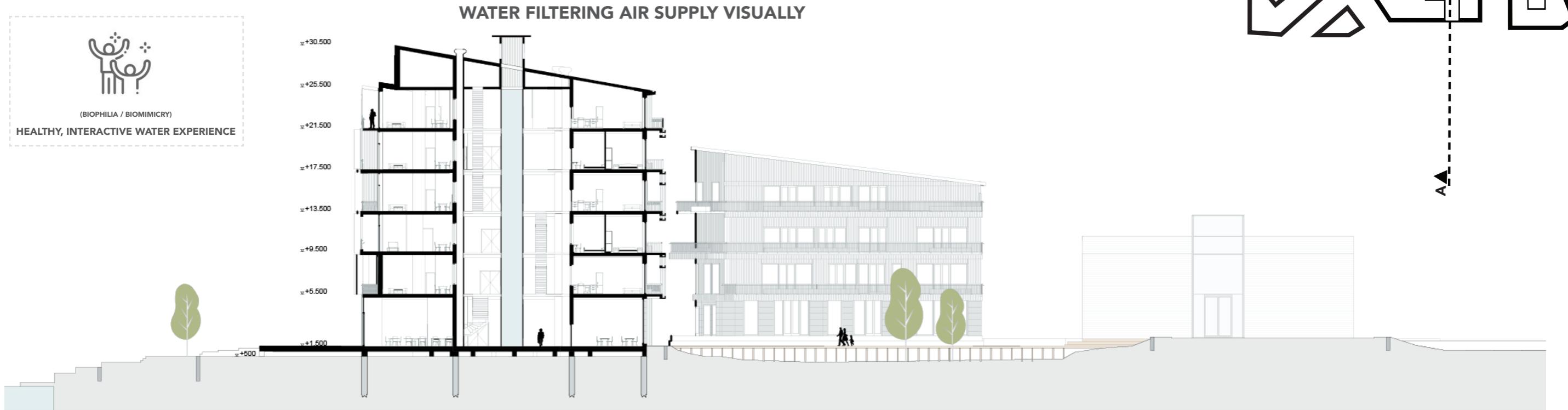
Visible GLUBAM beams & CLB ceiling in interior

# Natural ventilation & cooling system (type c)



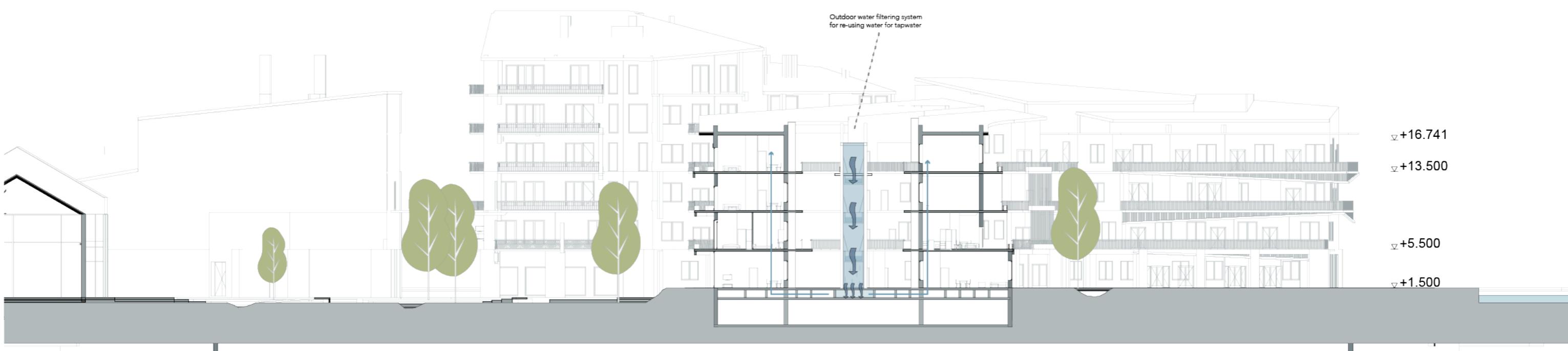
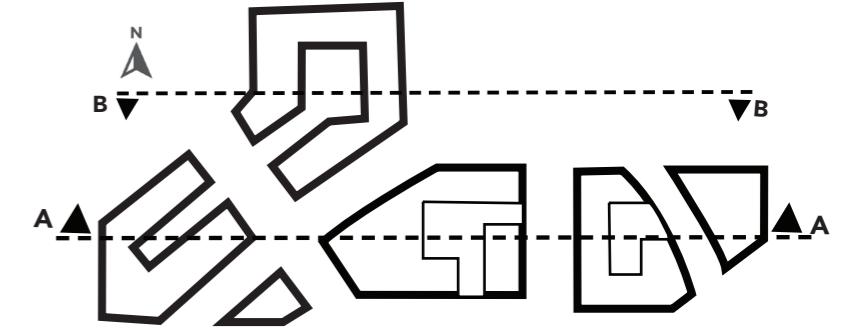
# Healthy indoor climate: re-creating the 'waterfall' effect

Biophilic aspects combined with biomimicry and technical interventions for healthy indoor climate



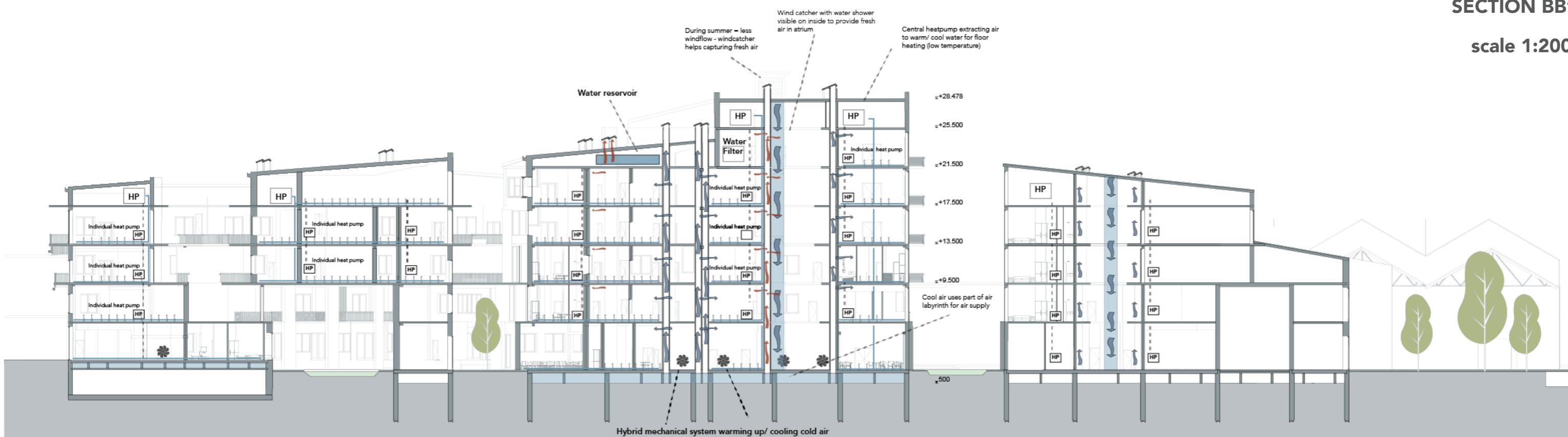
# Healthy indoor climate: using natural wind for air supply

## Climate system during summer



## SECTION BB'

scale 1:200

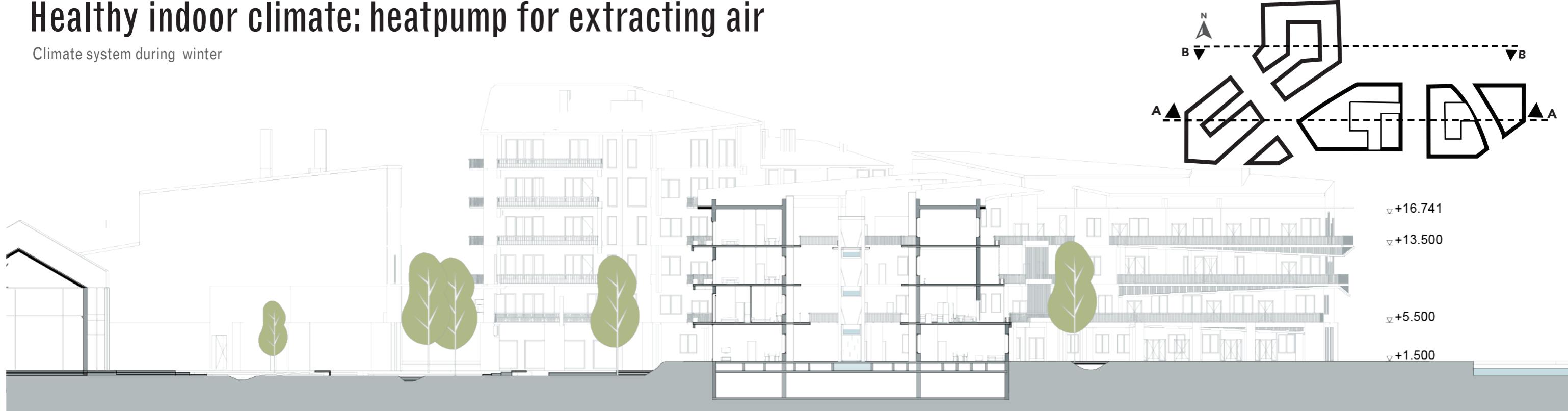


## SECTION AA'

scale 1:200

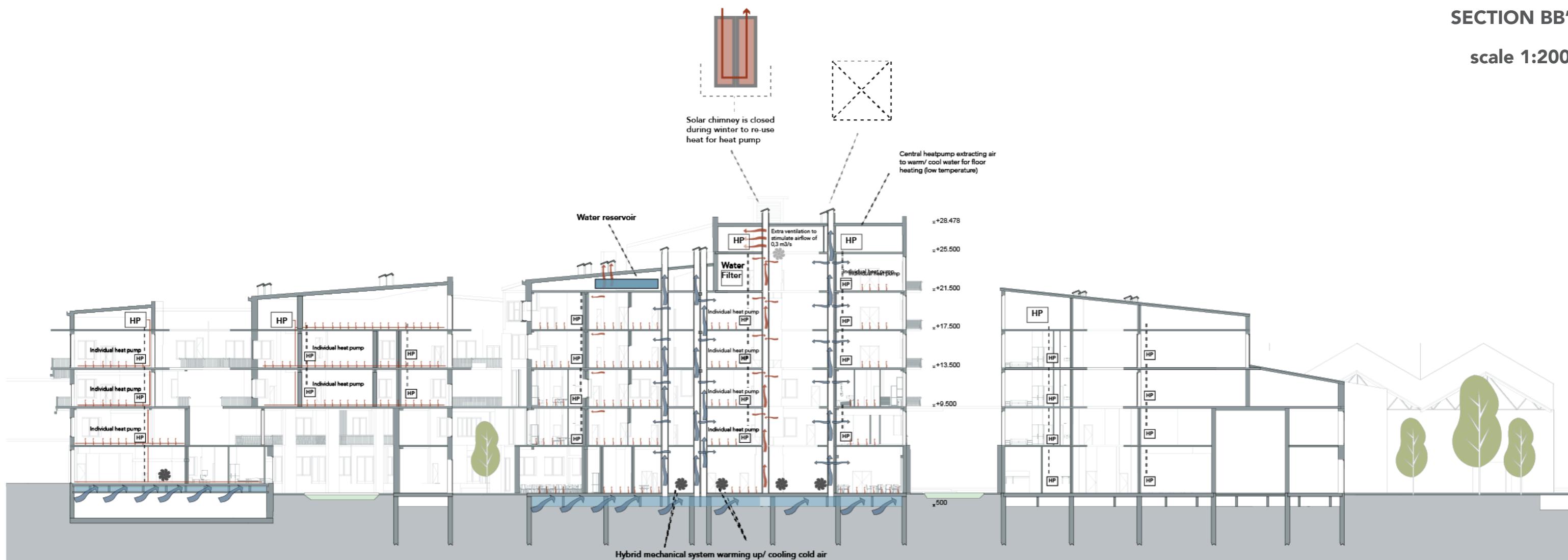
# Healthy indoor climate: heatpump for extracting air

Climate system during winter



SECTION BB'

scale 1:200

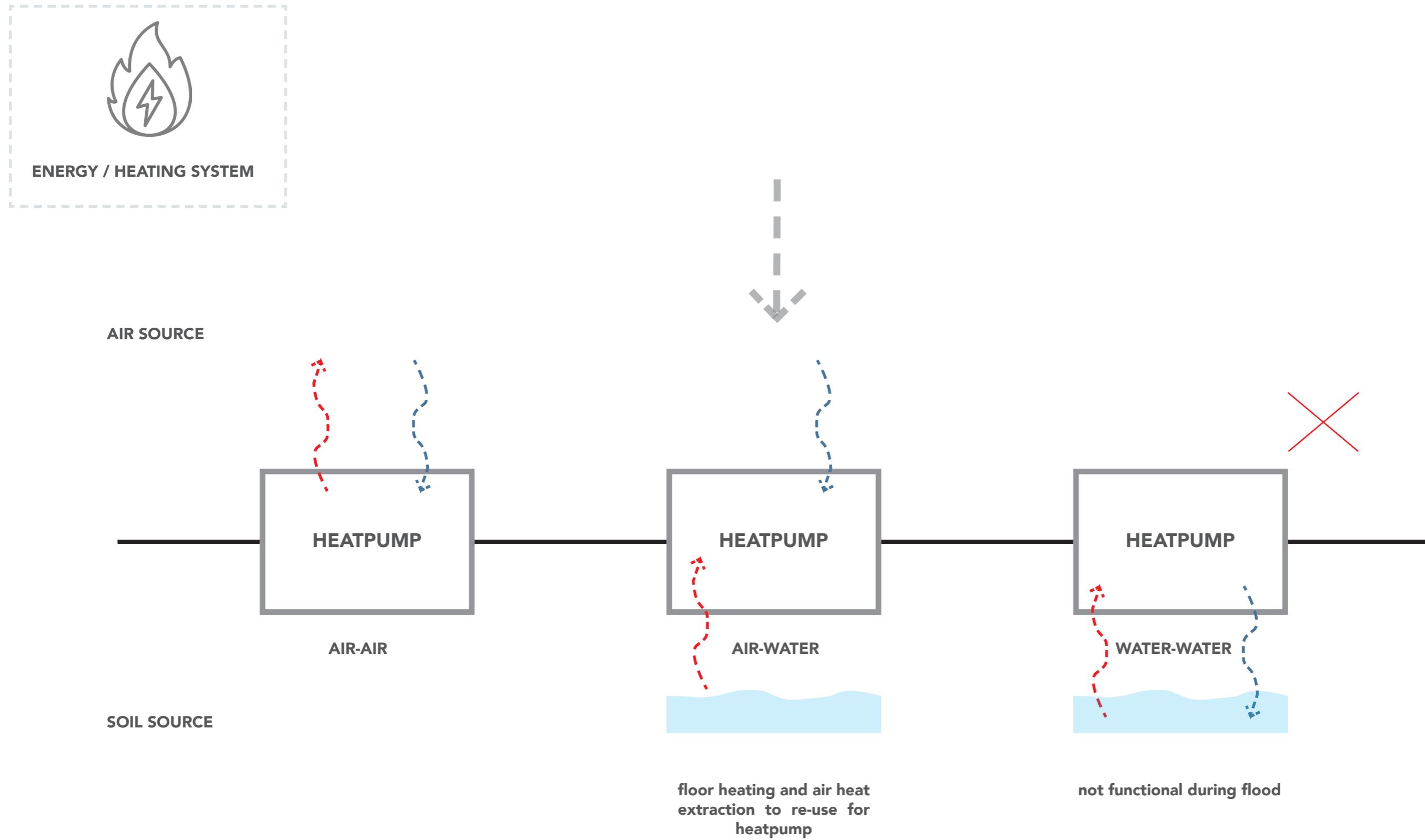


SECTION AA'

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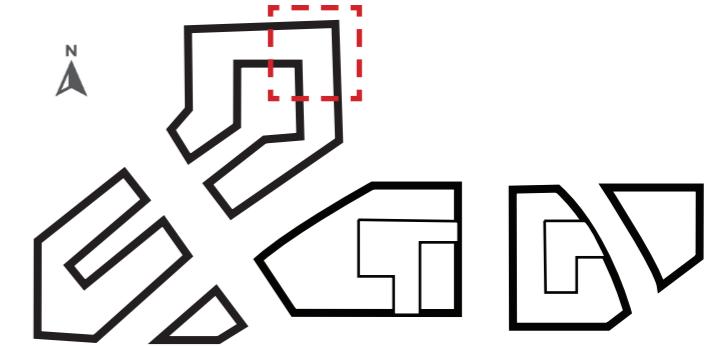
# Heatpump functioning

Dependency on functioning during floods

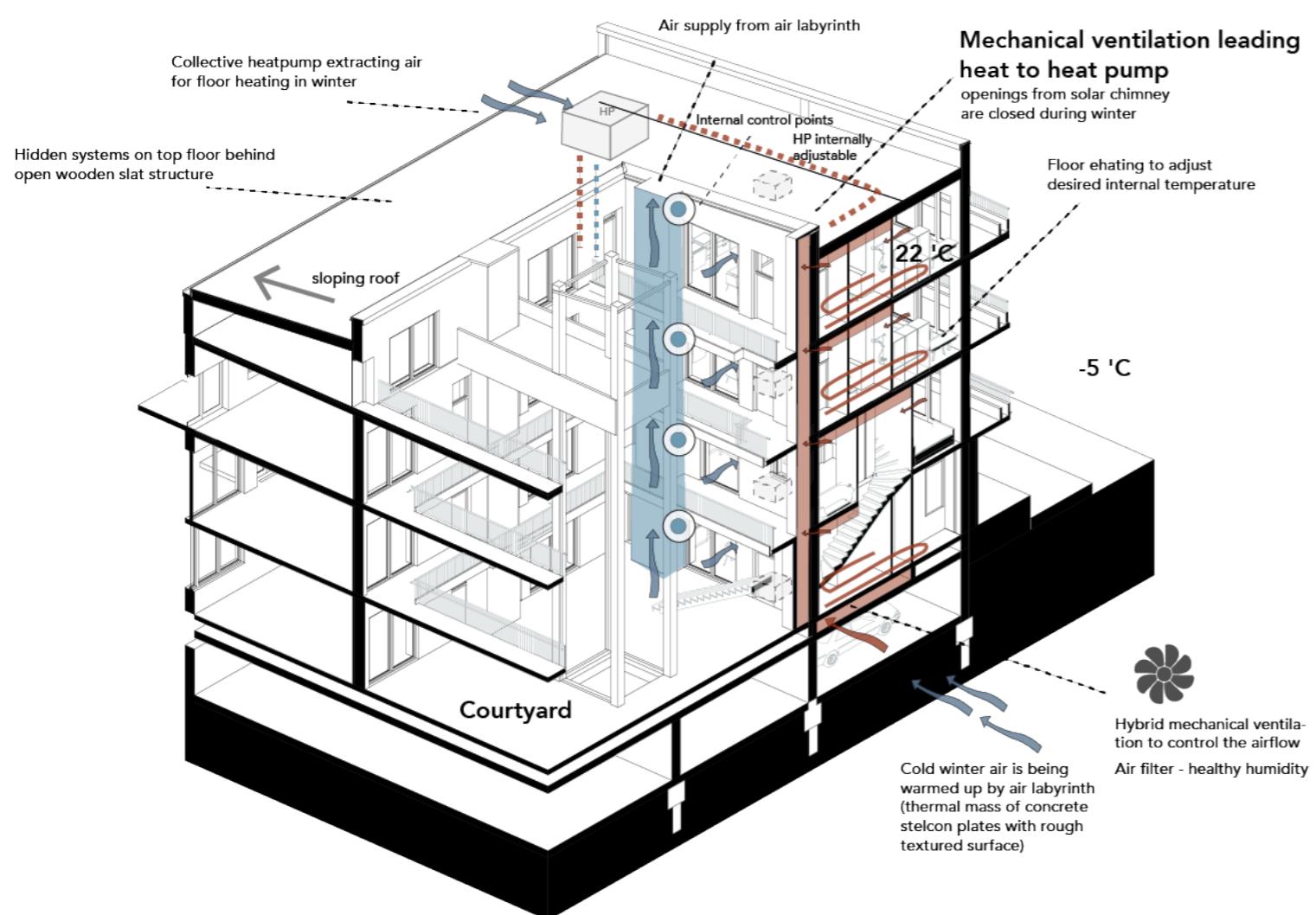


## Other building block: air labyrinth with central waterfilter system

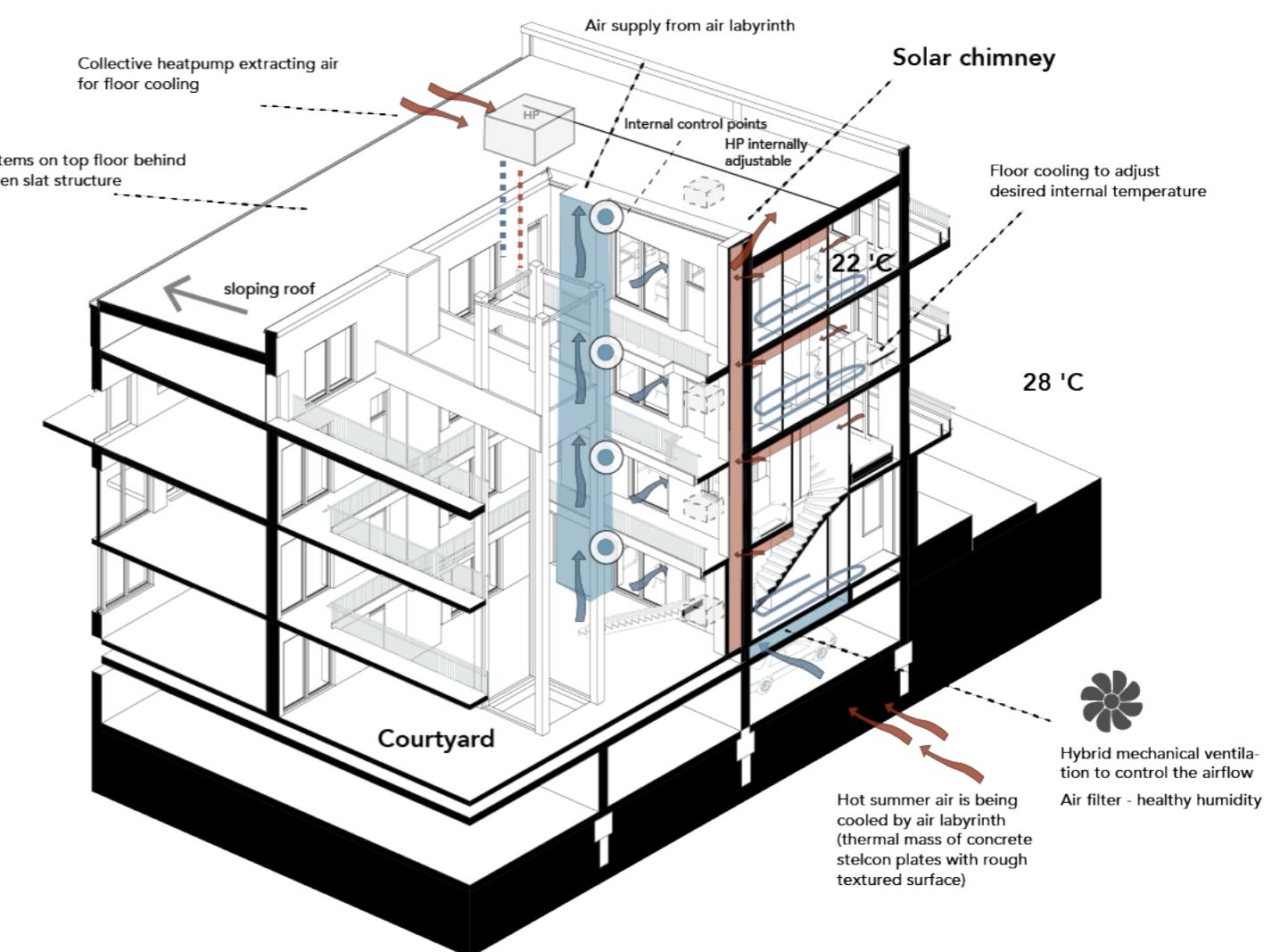
## Climate systems



## HOT AIR SOLAR CHIMNEY IS RE-USED TO WARM UP WATER (ventilation type C)



## AIR - WATER HEATPUMP ON ROOF REDUCES MALFUNCTIONING DURING FLOOD

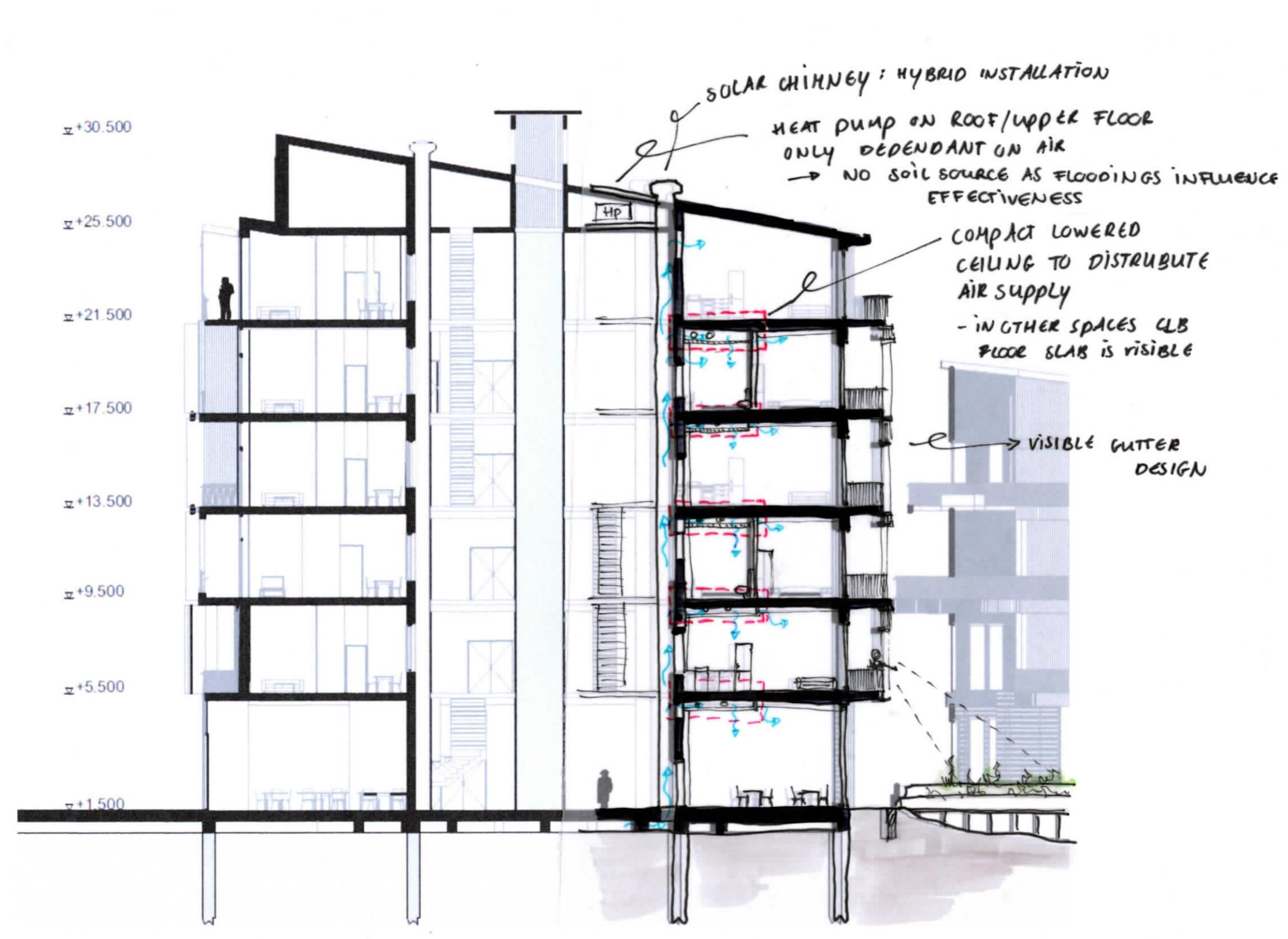


## SECTION OF CLIMATE PRINCIPLE WINTER

Scale 1:200

# Lowered ceiling section for distributing natural air supply from air labyrinth

Section of internal courtyard building



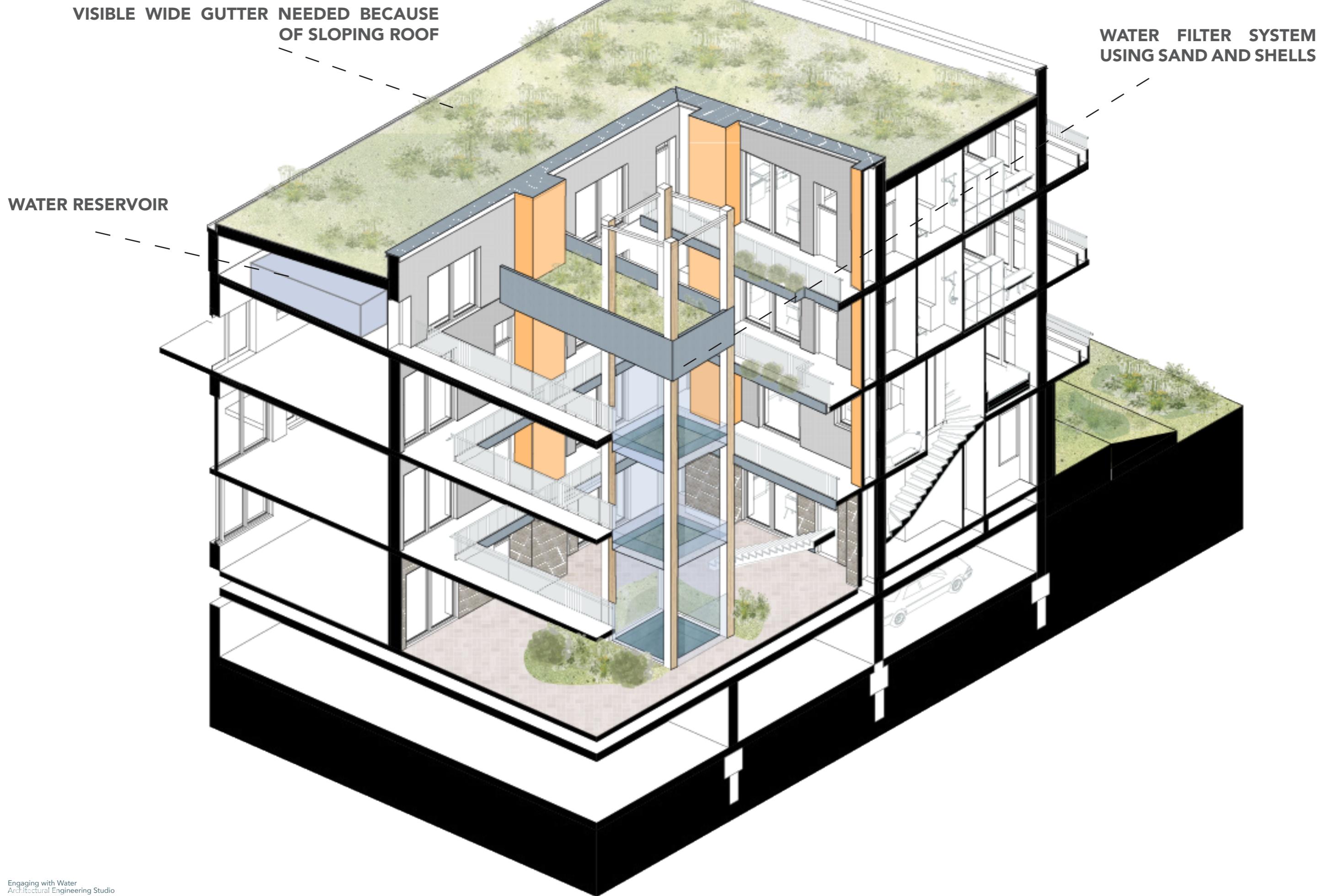
SECTION INTERNAL COURTYARD BUILDING

Scale 1:200

# Air labyrinth with indoor 'waterfall'



# 3D perspective of courtyard with air shafts



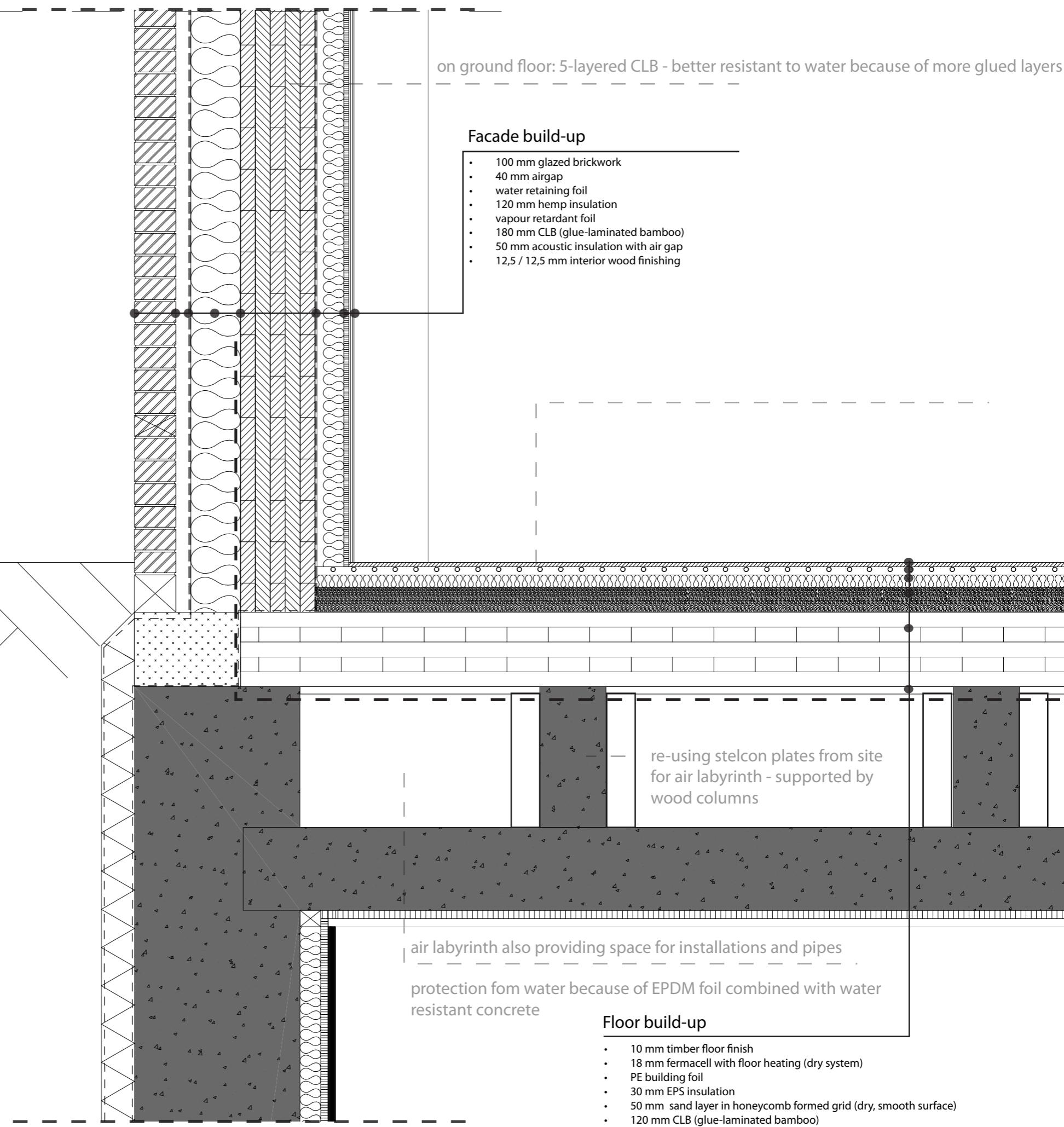
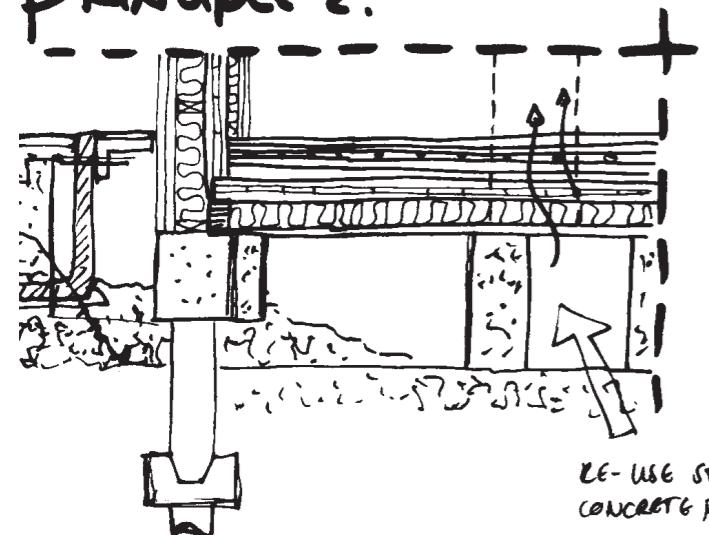


# Ground floor air labyrinth detail

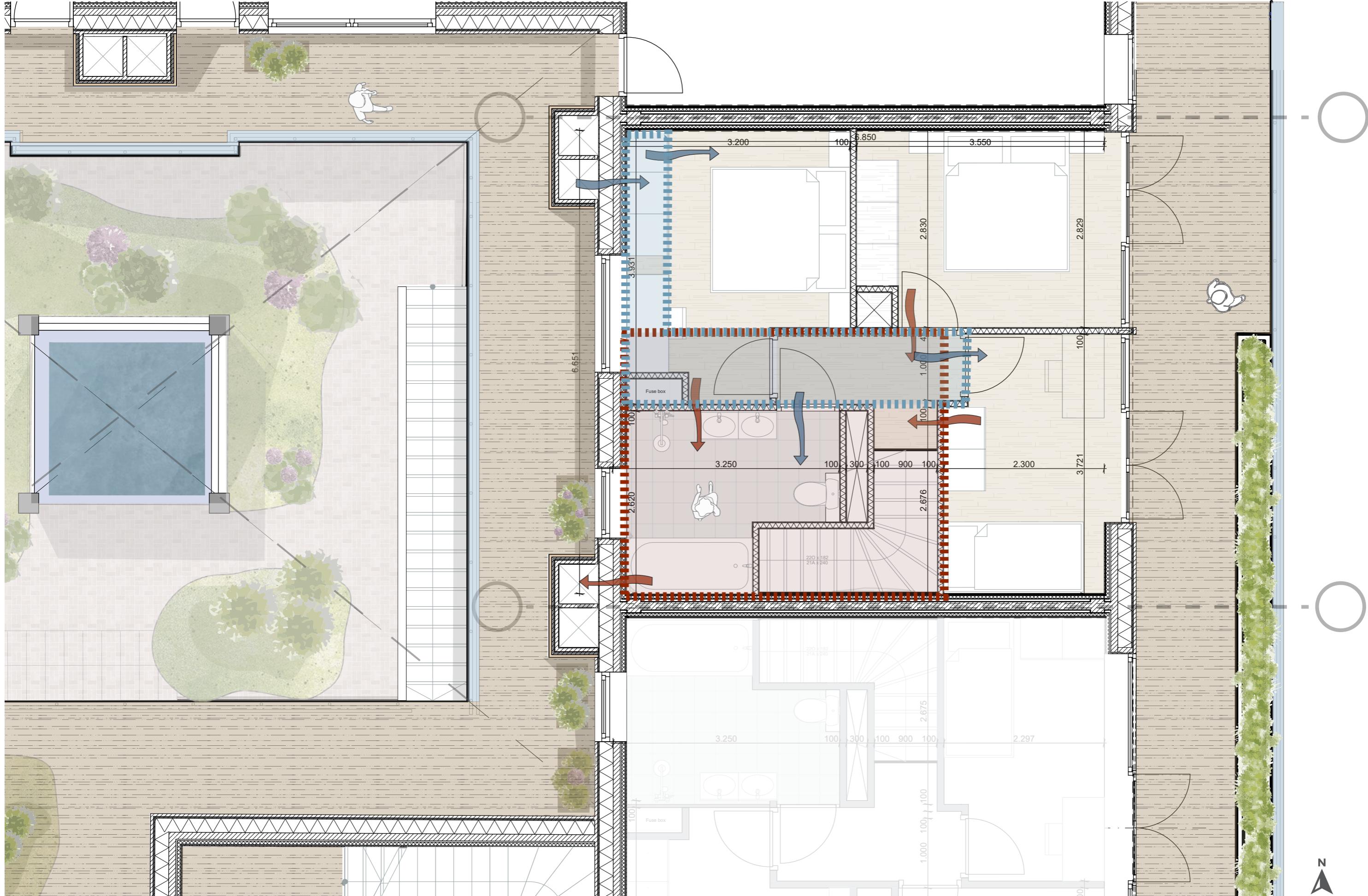
Fire-glazed brick finish and water resistant concrete floor slab air labyrinth



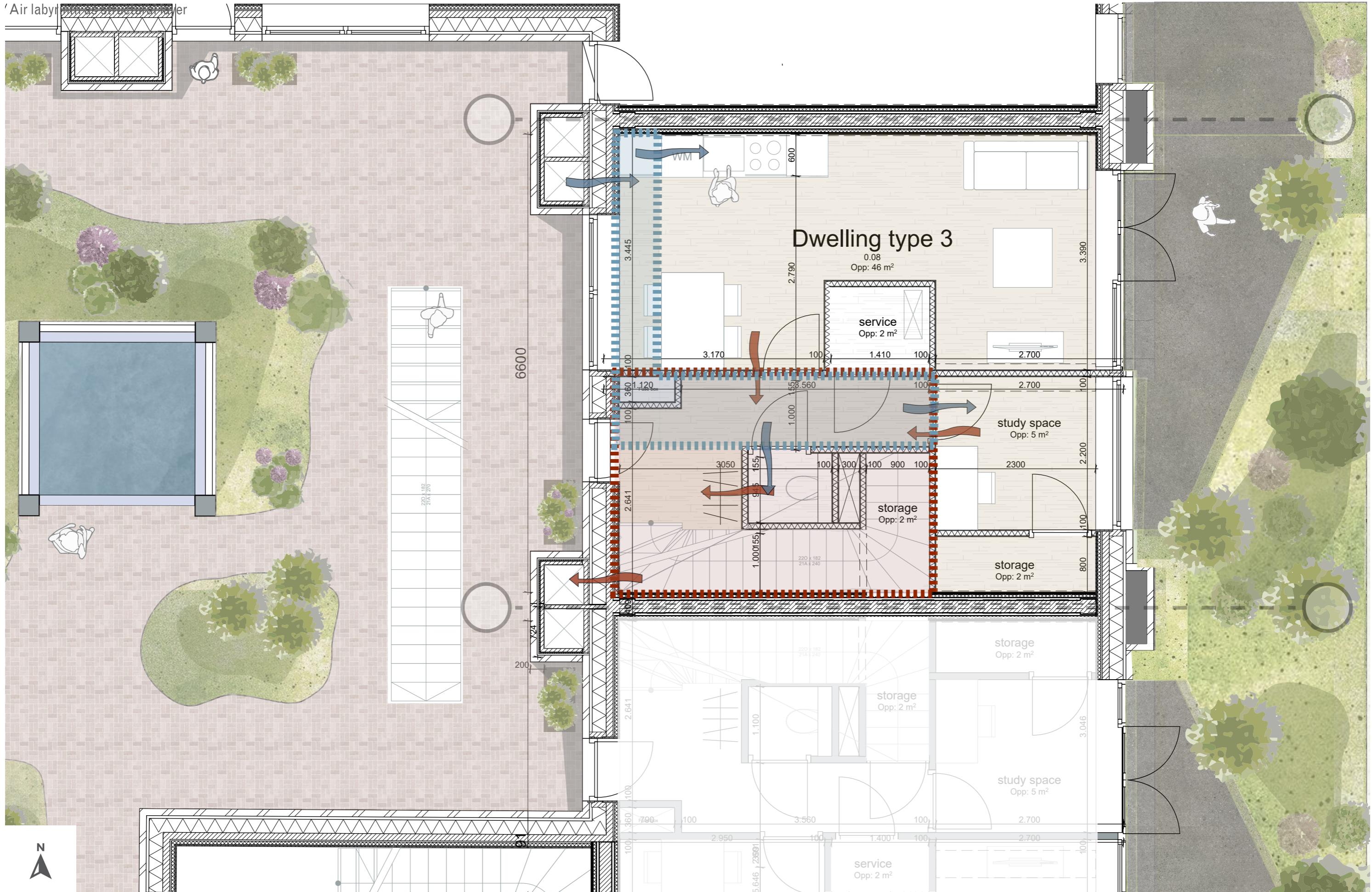
PRINCIPLE 2.



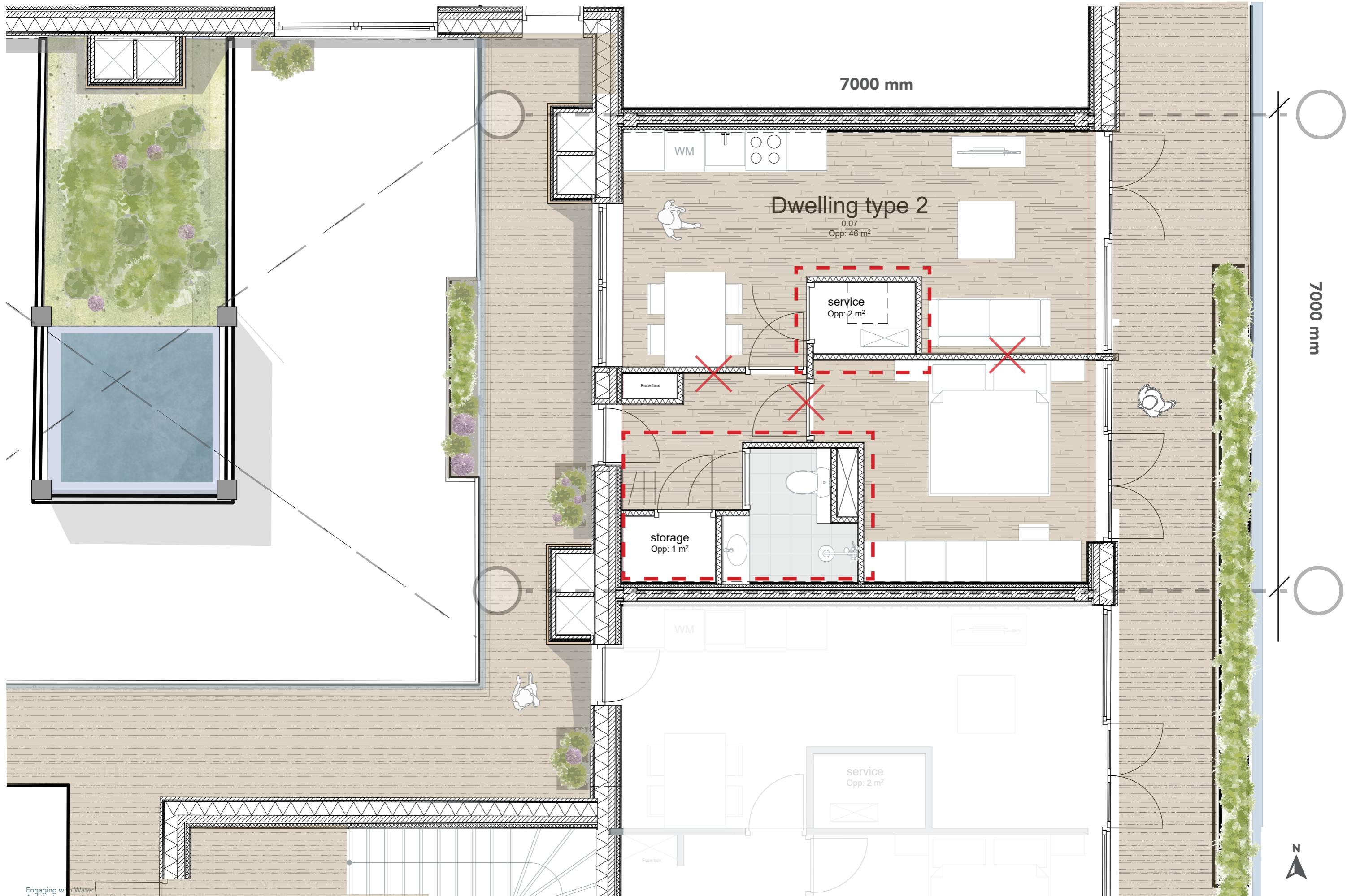
# Bathroom as last passing point for air exhaust



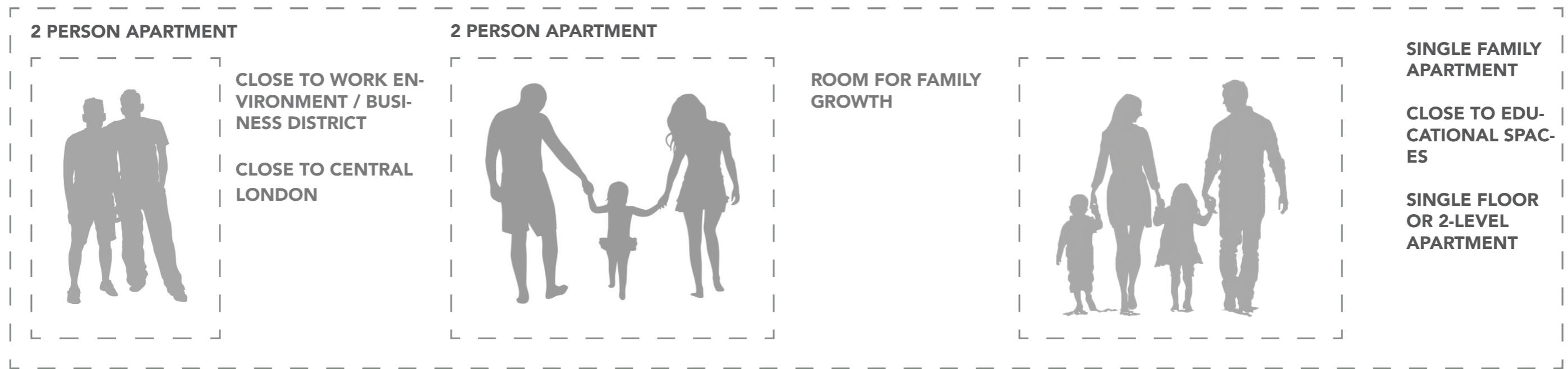
# Climate principle and construction in floorplan: family home type: 90 m<sup>2</sup>



# Central cores allow floor plans to change: 2-person home type: 45 m<sup>2</sup>

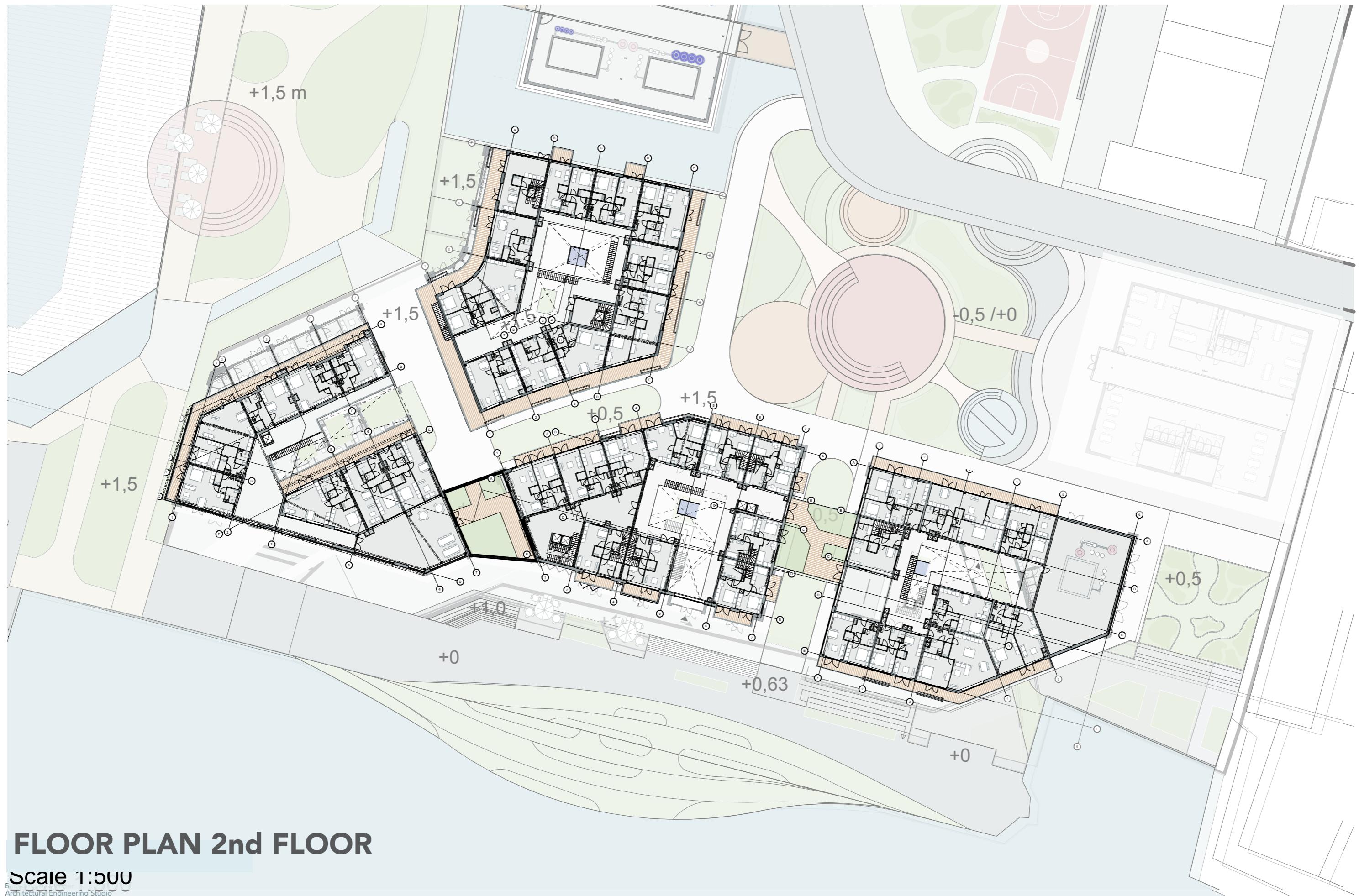


# Allowing more flexibility: changing floor plans



same grid system allows for changing floor plans - according to demand for 3 housing types  
approximately 110 apartments



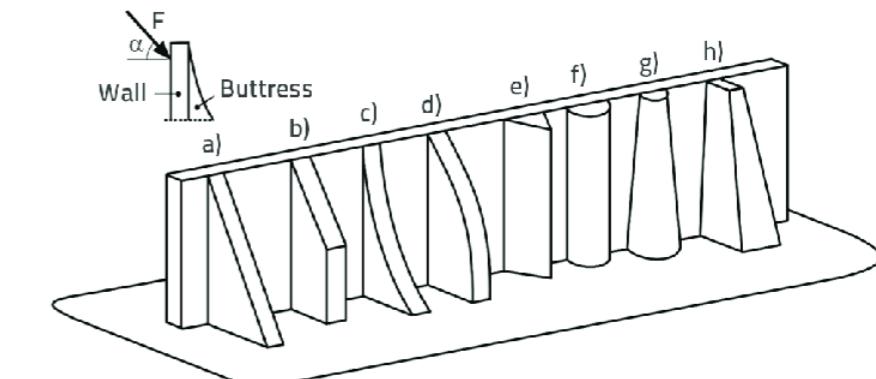
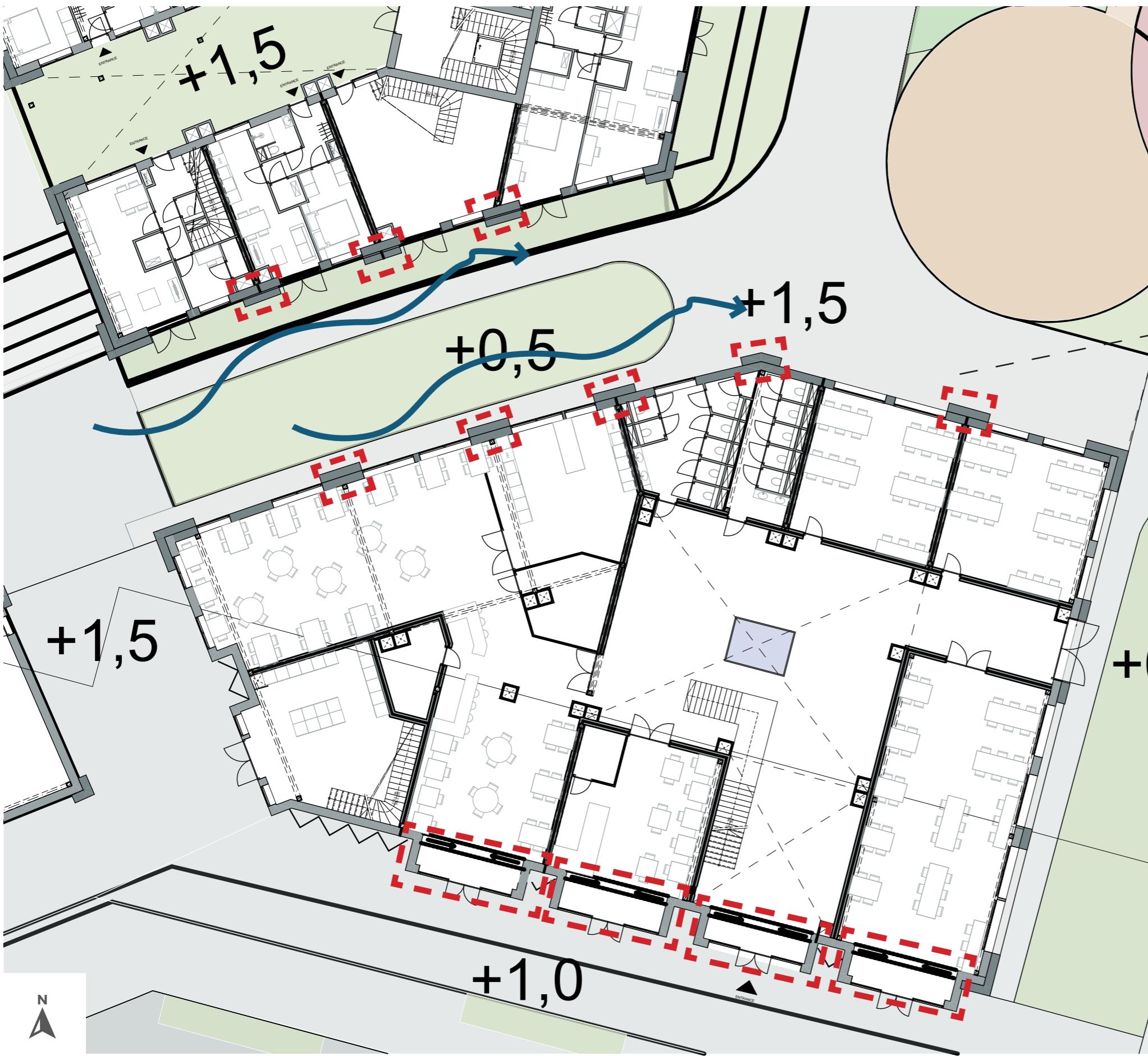


# What materials to use for water resilient buildings?



# Combining construction principle with aesthetics of facade

Loweral horizontal forces water pressure on external walls by using buttresses



Buttresses form vertical aesthetical addition to facade, but also...

- protect the glass facade parts from rubbish being taken by the river when it gets flooded
- slow down the water stream of the guiding-waterways
- fire-glazed bricks combined with water-resistant concrete

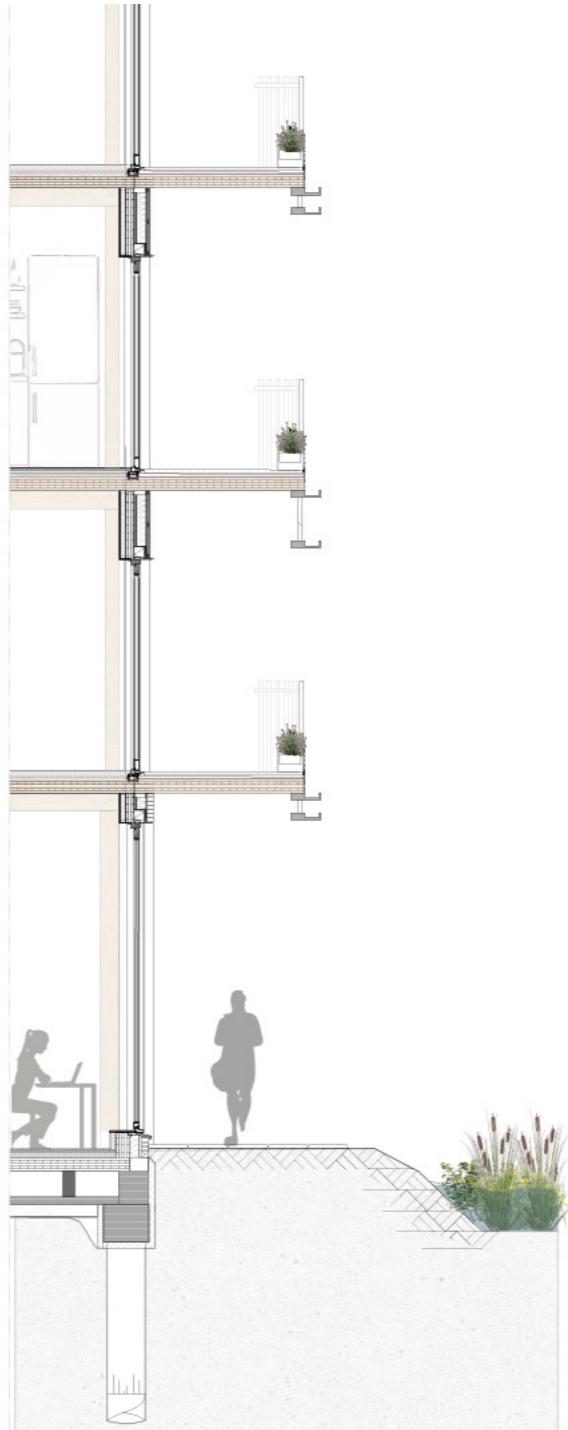


WATER RUN-OFF FACADE & ROOF DESIGN

SCALE 1:200

# Translation of buttress in facade (fire-glazed brick)

Scale 1:50 from 1:20

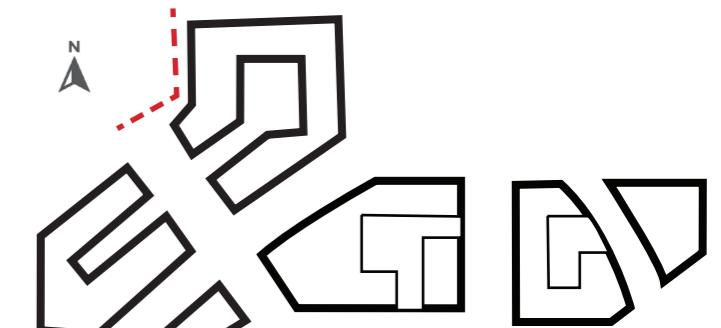
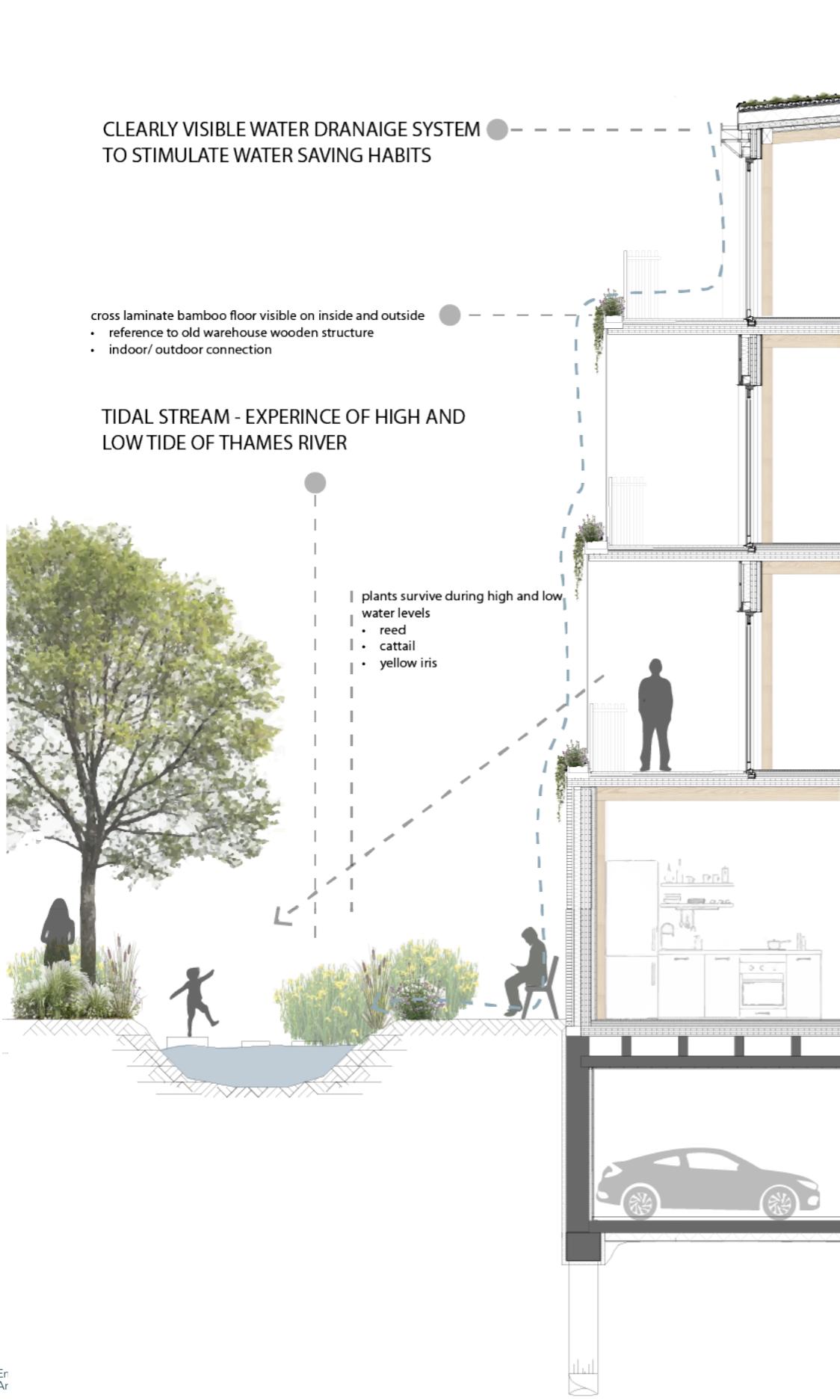


## Visual of buttresses in facade



# Slowing down- water runn-off facade

Loweral horizontal forces water pressure on external walls by using butresses

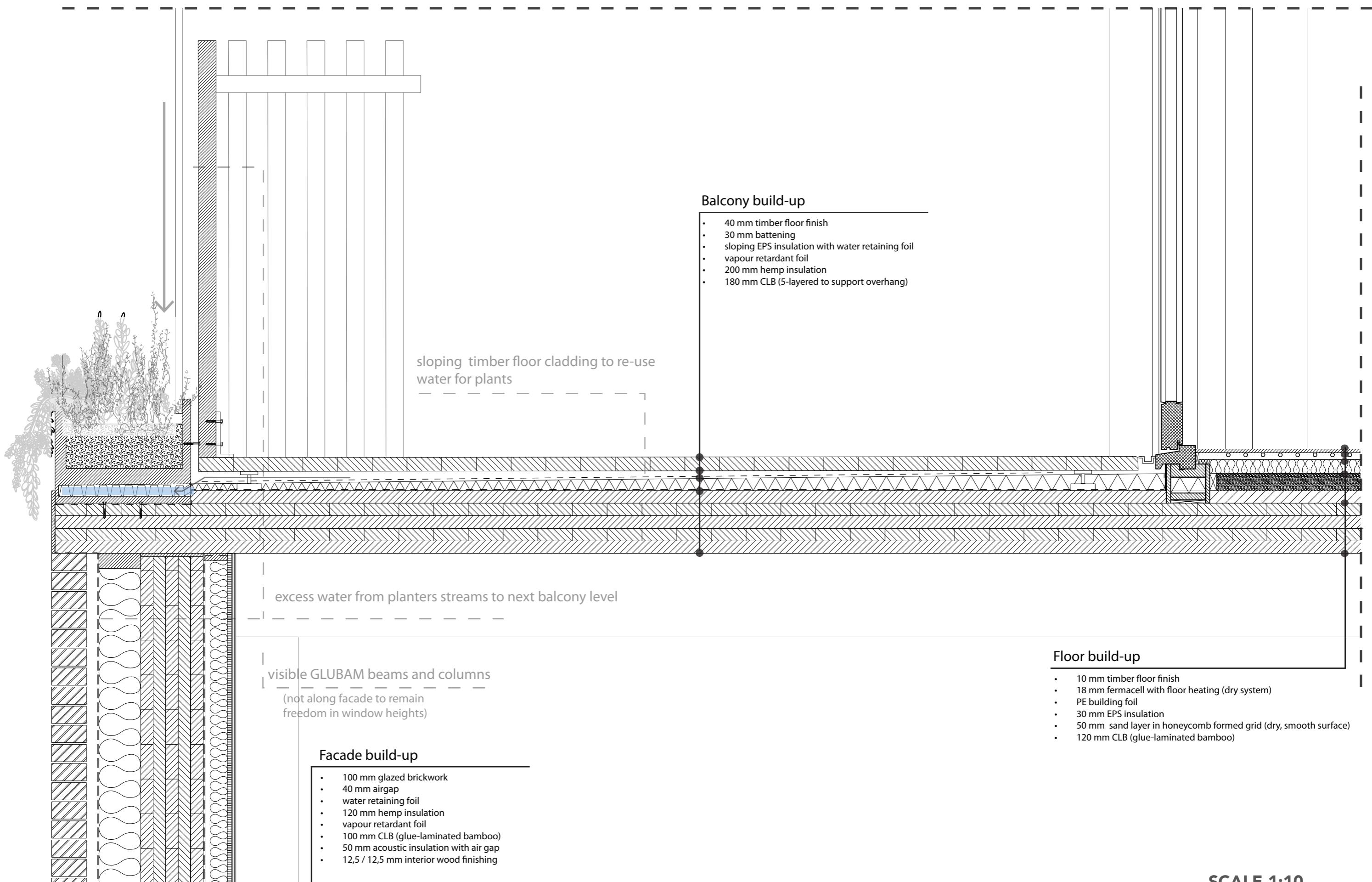


Facade part on park side



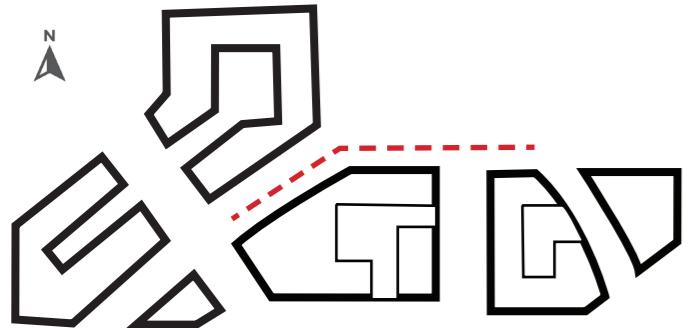
butress in facade

# Balcony detail 1st floor



SCALE 1:10

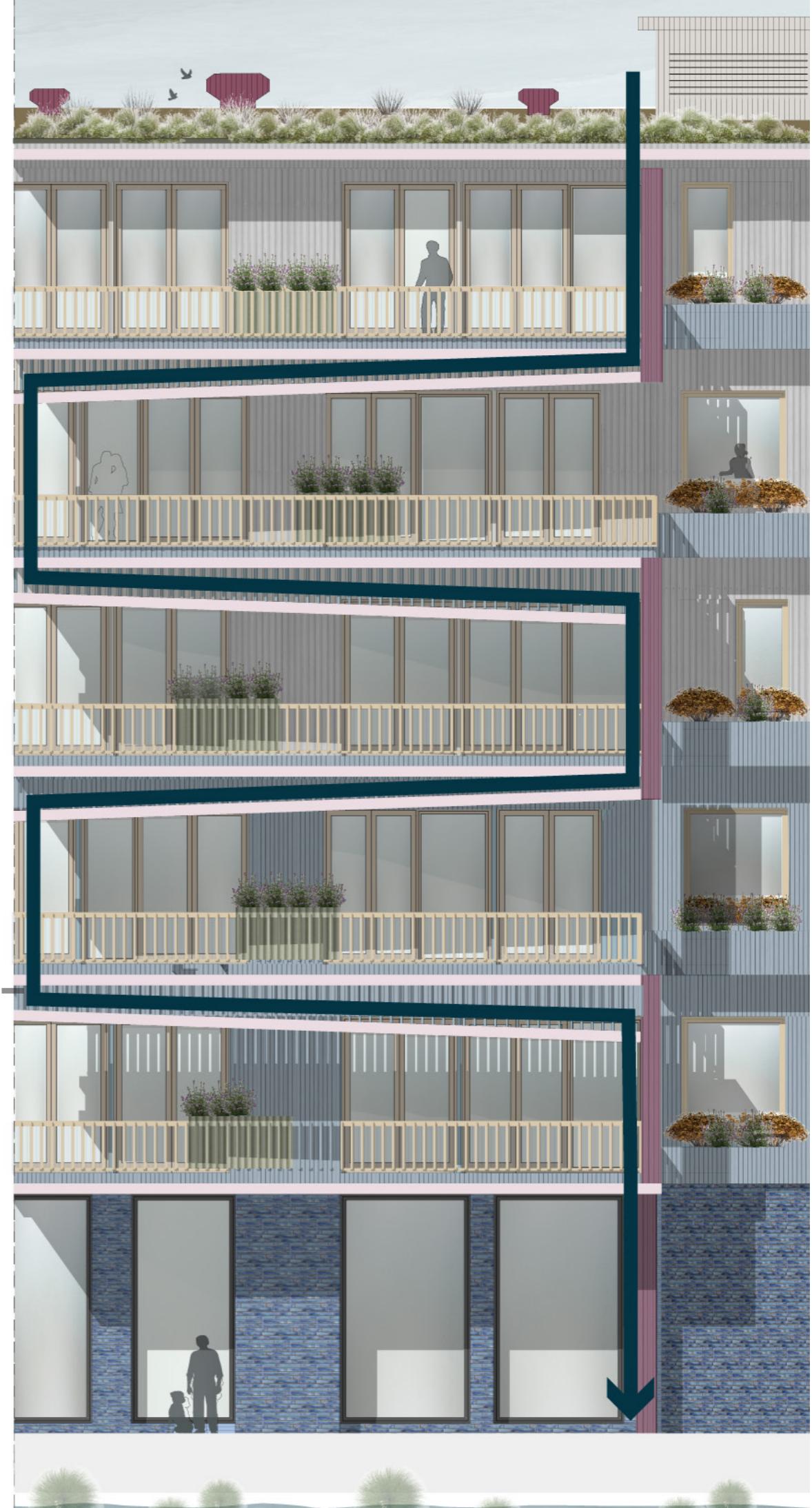
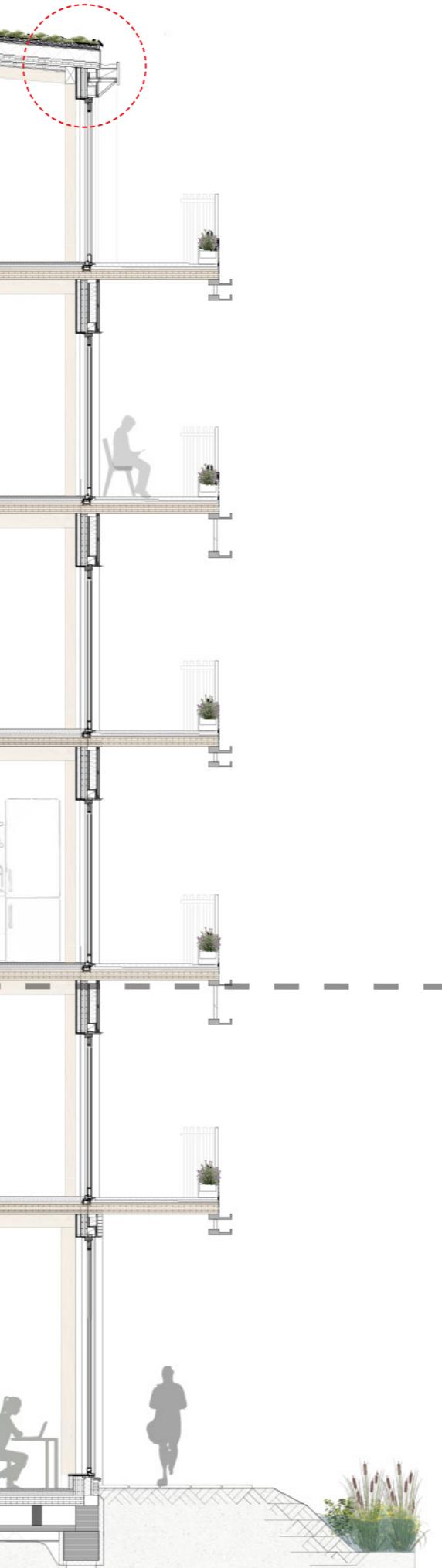
# Visible gutter facade design as part of balcony



Facade part on garden side

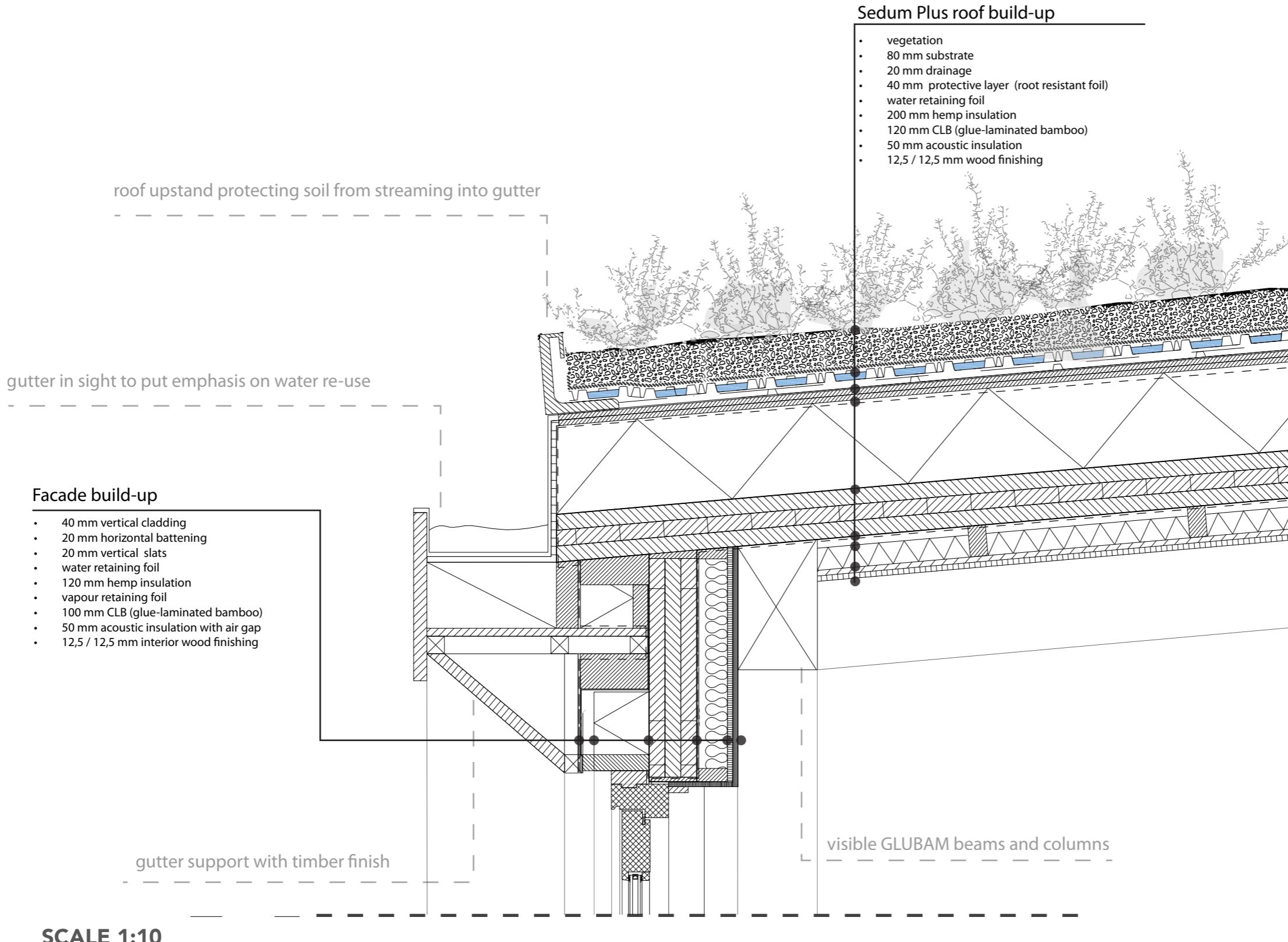
Gutter with wooden slats continuing in balcony to create one facade element

Balcony is not only 'an addition' but a real aesthetic element



# Roof detail - lowest point

Visible gutter to show water re-use aspect



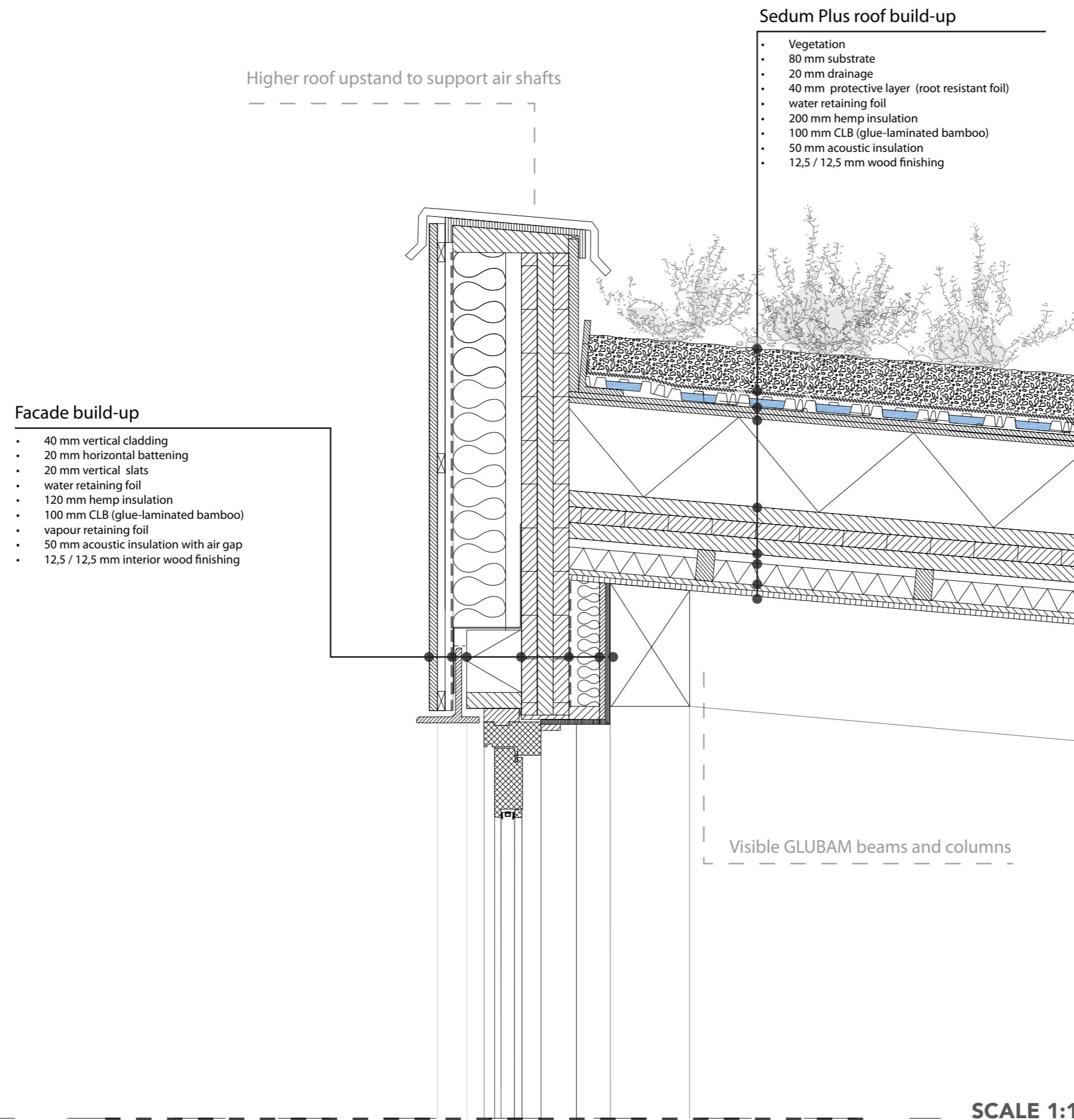
# Visual of gutter facade design as part of balcony



# Free to be designed facade



# Highest point roof detail



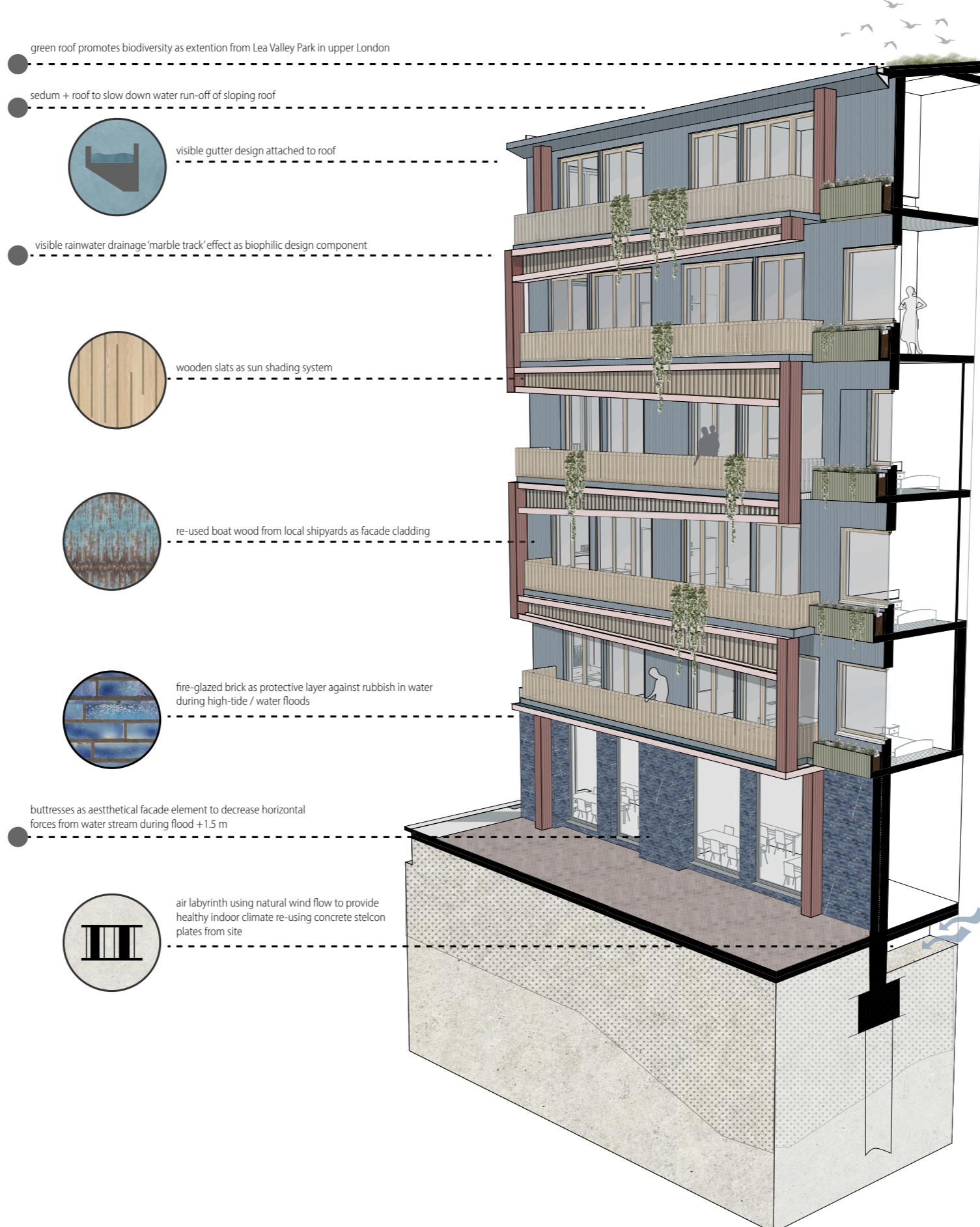
# Visuale waterfront facade





# Overview of interventions translated in facade design

## WATER RESILIENT DESIGN INTERVENTIONS





# Final visual translation of gutter integrating technical interventions in facade design



SCALE 1:200 - rescaled 50%

# Final visual translation of gutter integrating technical interventions in facade design



SCALE 1:200 - rescaled 50%

View from waterfront - normal situation



View from waterfront - 0.5 m flood



View from waterfront - 1.0 m flood



View from waterfront -1.5 m flood



# Connection facade with watergarden



# 3D view - water collecting balcony side



Use of perennials to...

...absorb heat to help cool area  
...attract pollinators  
(stimulating ecosystem)  
... reduce the need for irrigation  
- but also....



....Yellow iris



...Reed



...Cattail

# Final conclusion

## CHALLENGES AND OPPORTUNITIES OF

...integrating biophilic elements and biomimicry systems...

forms a combination of both and makes it possible to show technical water interventions in an aesthetical way

- internal waterfall to stimulate natural airflow
- visual gutter design as part of sun shading system and facade design
- functioning of a buttress to counteract to horizontal forces

...using the landscape and natural characteristics of a site suffering from waterfloods as a base,...

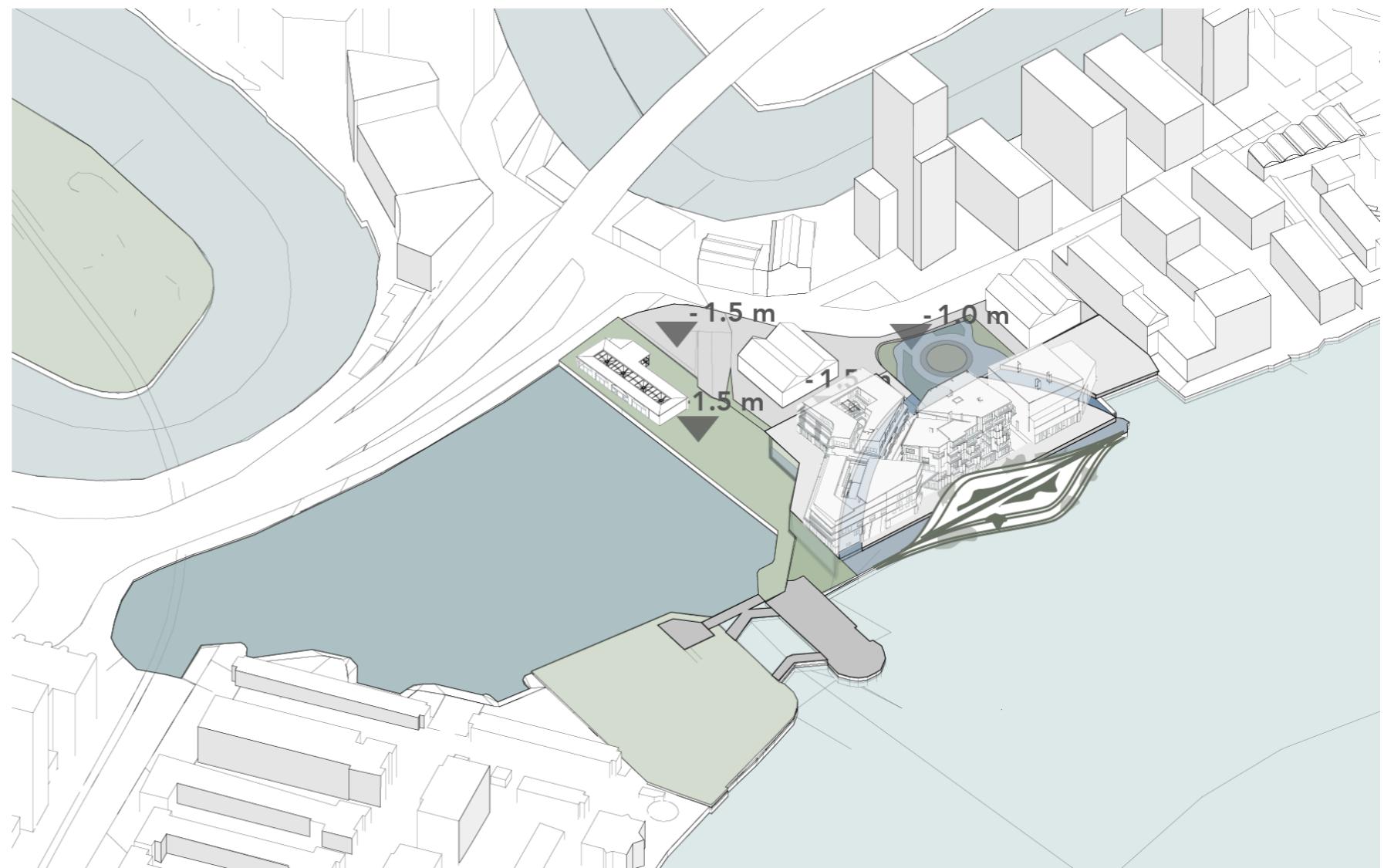
- brings limitations to building block formation because of guiding waterways
- creates a different sponge architecture typology responding to different flood levels and other natural characteristics
- leads to an integration of technical interventions with visual experience

...incorporating visual water systems to enhance well-being and stimulate sustainable awareness / water saving habits

- still raises the question of who will invest, how do you convince other parties
- asks for a lot of research about these systems as not a lot of research about water resilient materials has been conducted yet

...affordability to reduce total project costs

- leads to a creative way of thinking when it comes to technical construction design



# Discussion

Motivating stakeholders: BREEAM rules and awards

**To activate stakeholders, communicating and showing the way we consume and use water is crucial.**



*Involving ALL stakeholders*

No insurances  
Less recovery costs



*BREEAM outstanding award  
(example building)*

*A motivating factor to reach sustainable goals, not the desired way of thinking about sustainability that should be reached.*

*Integration of landscape and architectural designs not researched, but of great importance to propose a well-considered water sensitive design approach that fits within the multiple scales of the landscape scale, urban square scale and social building scale.*



Any questions?

