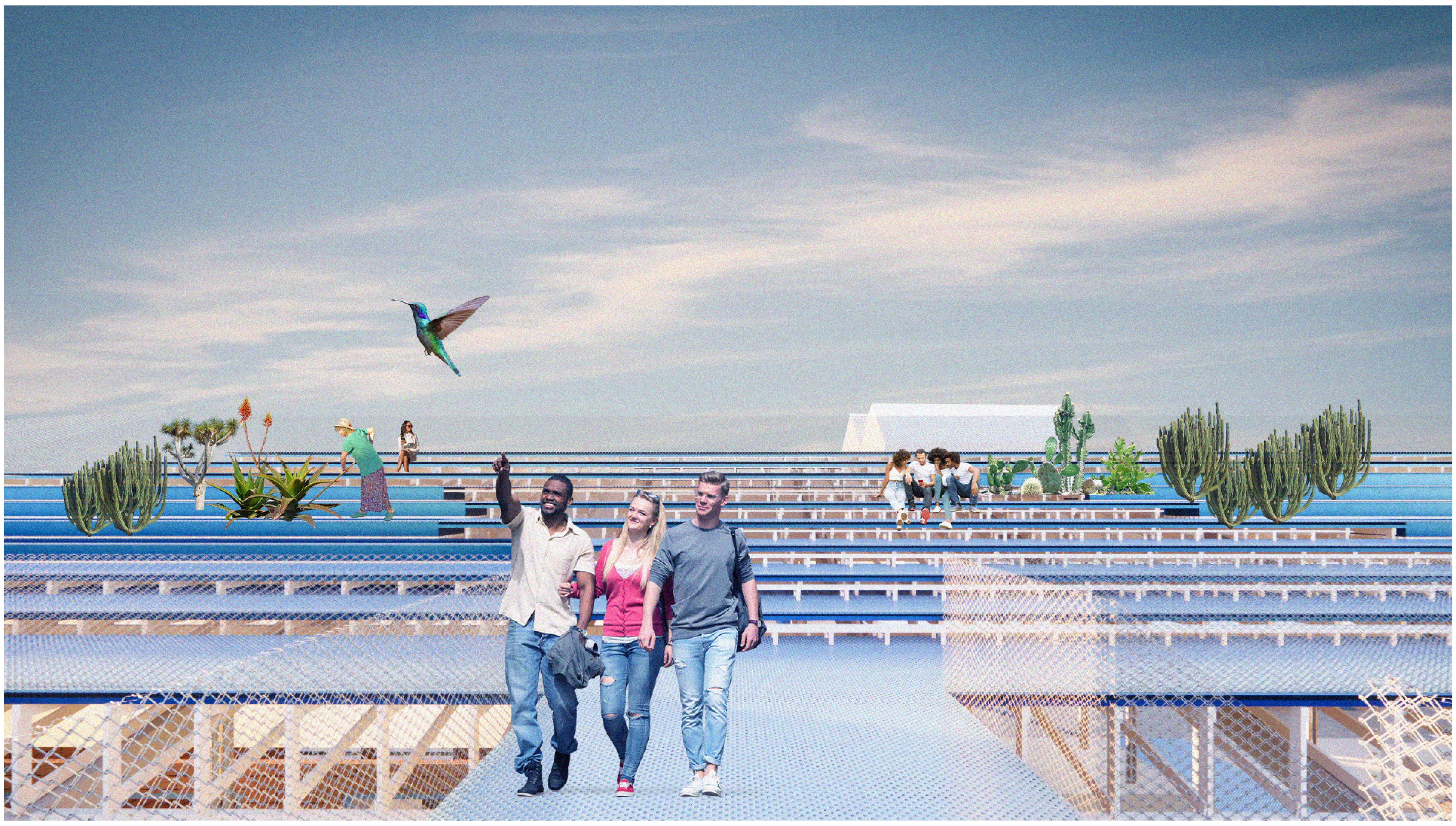
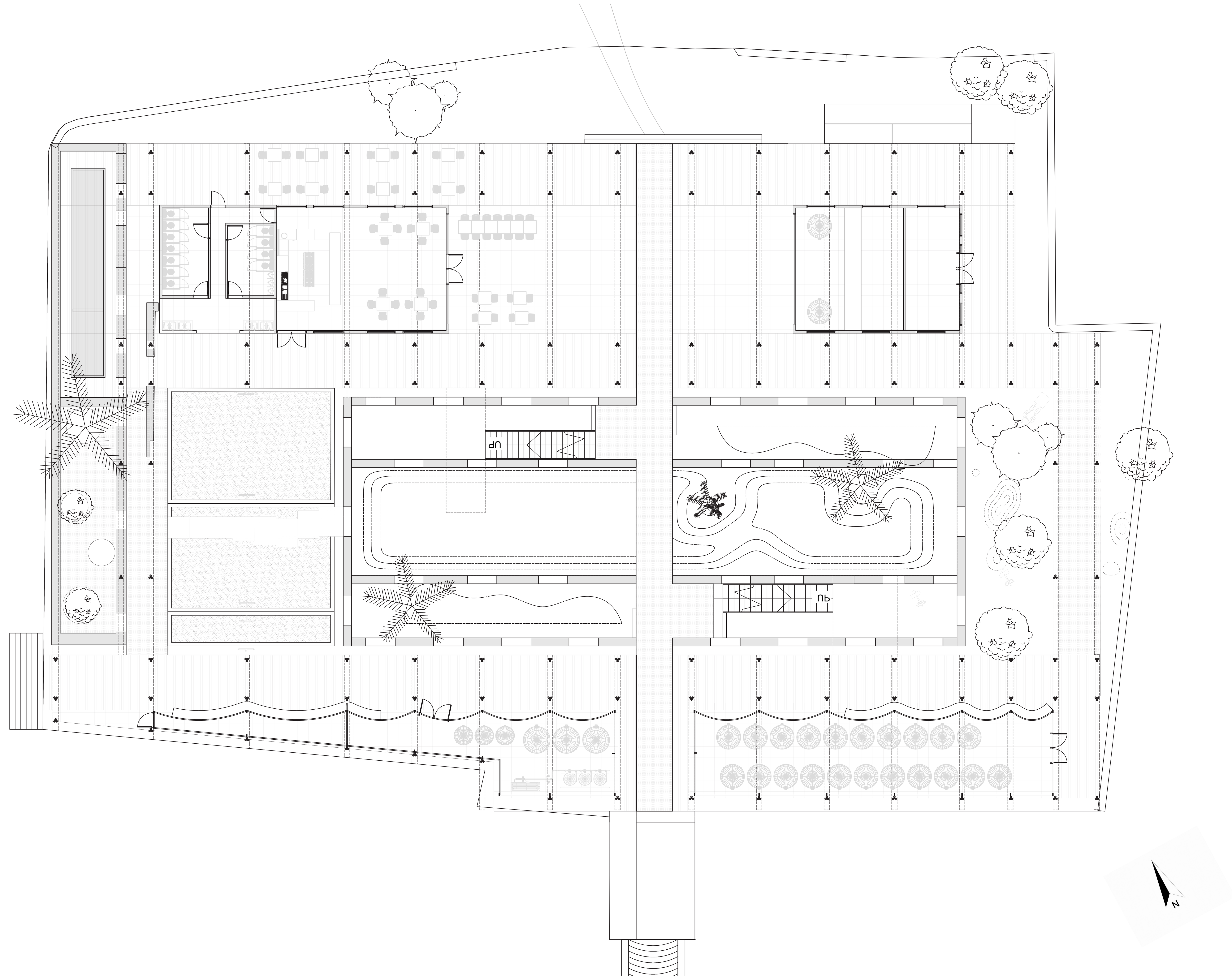
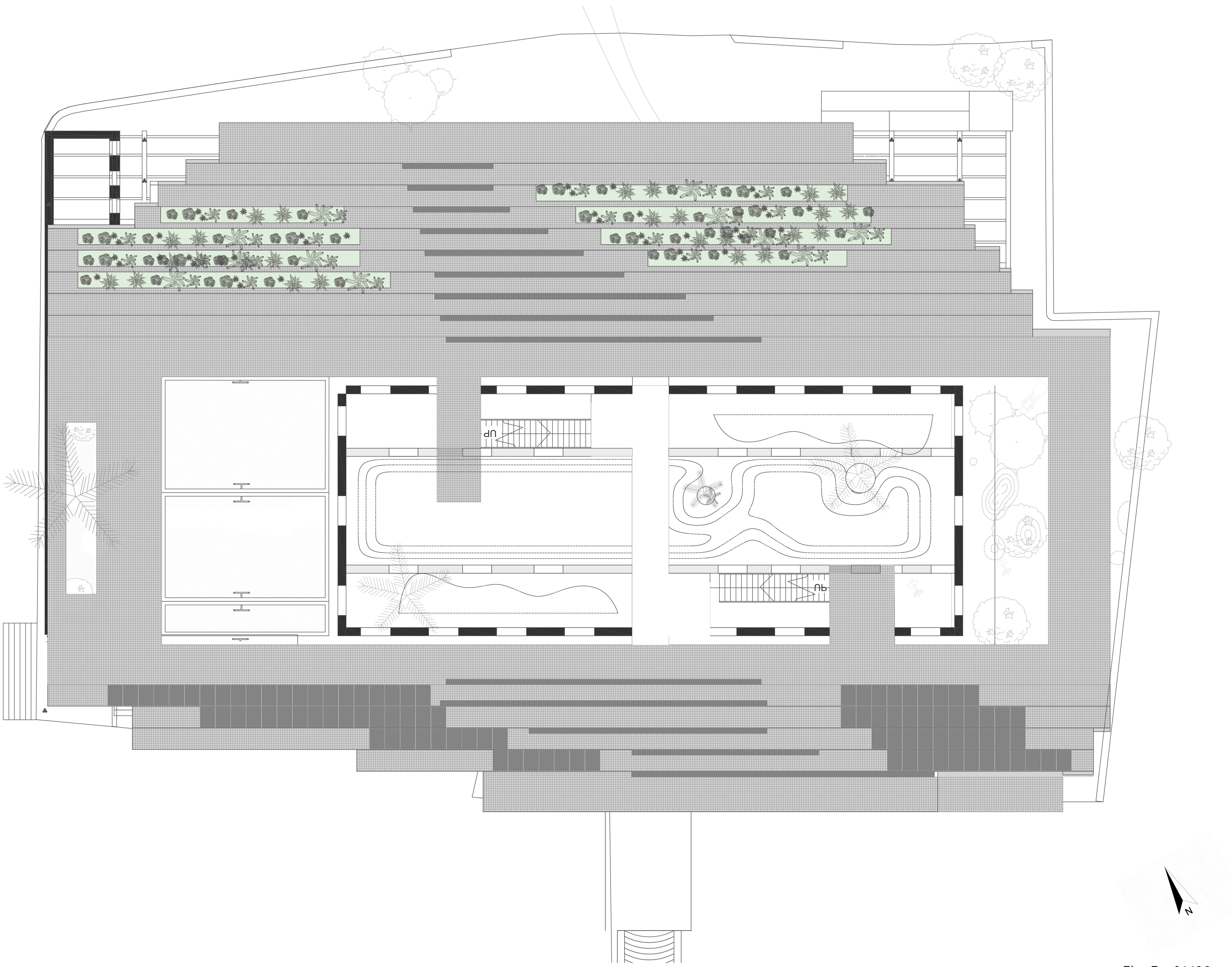
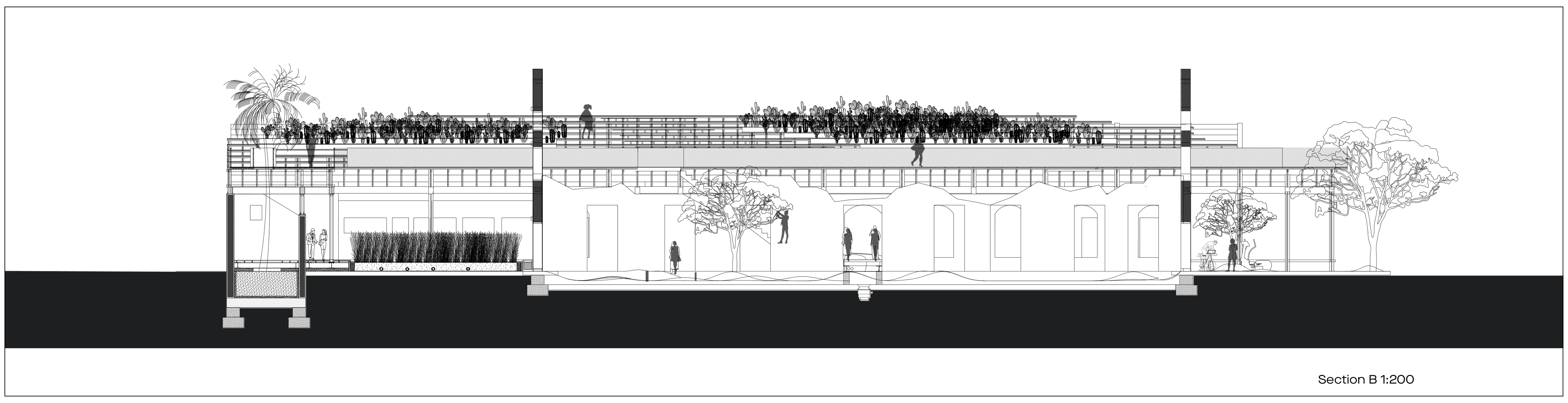




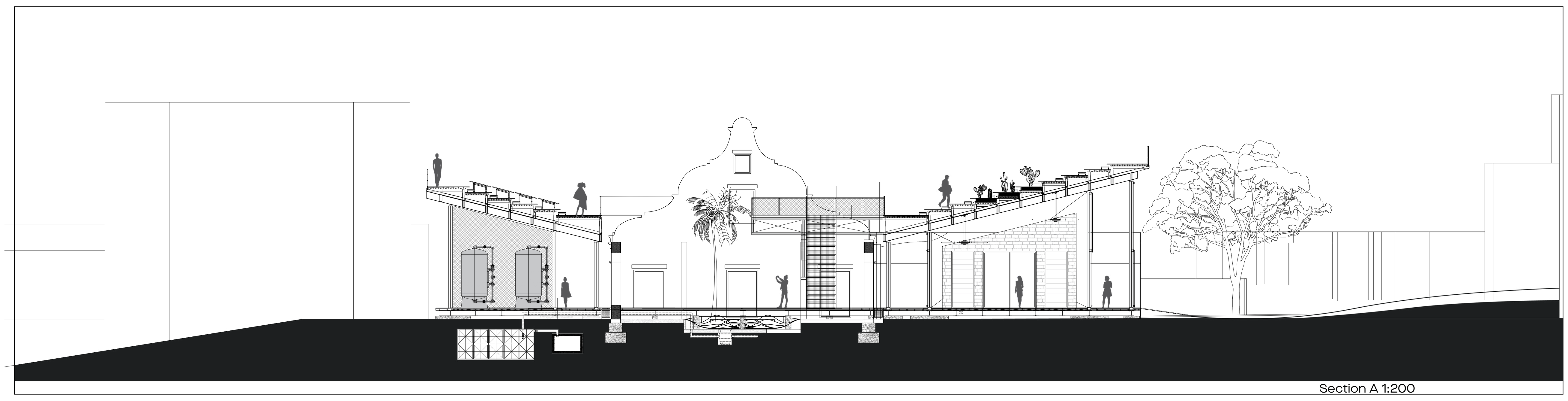
Plan Ground floor 1:100



Plan Roof 1:100



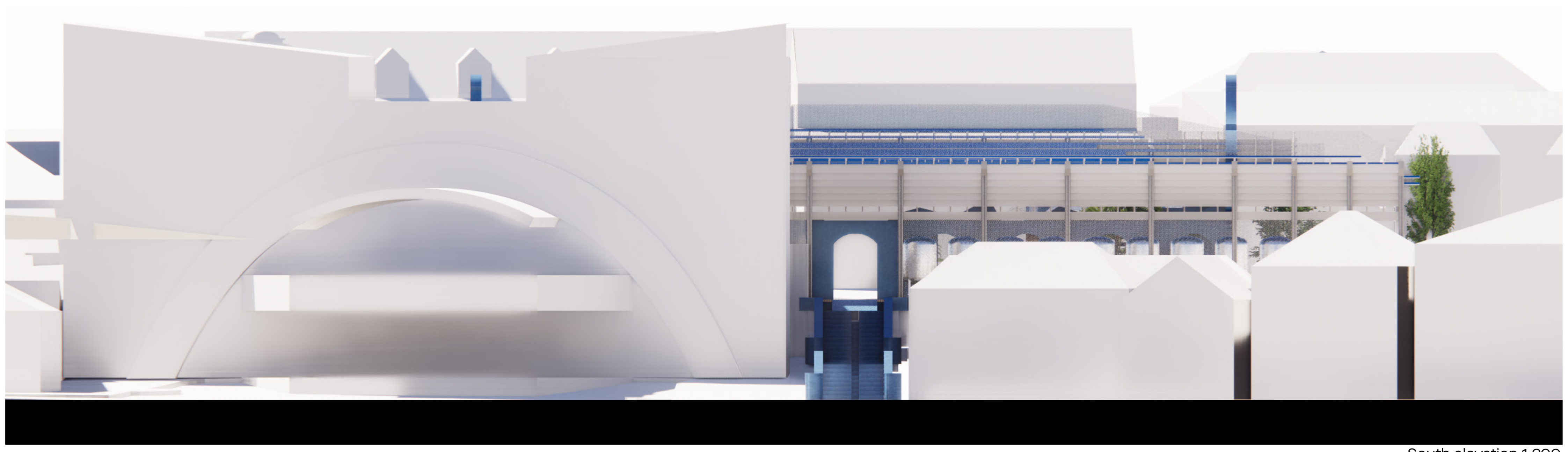
Section B 1:200



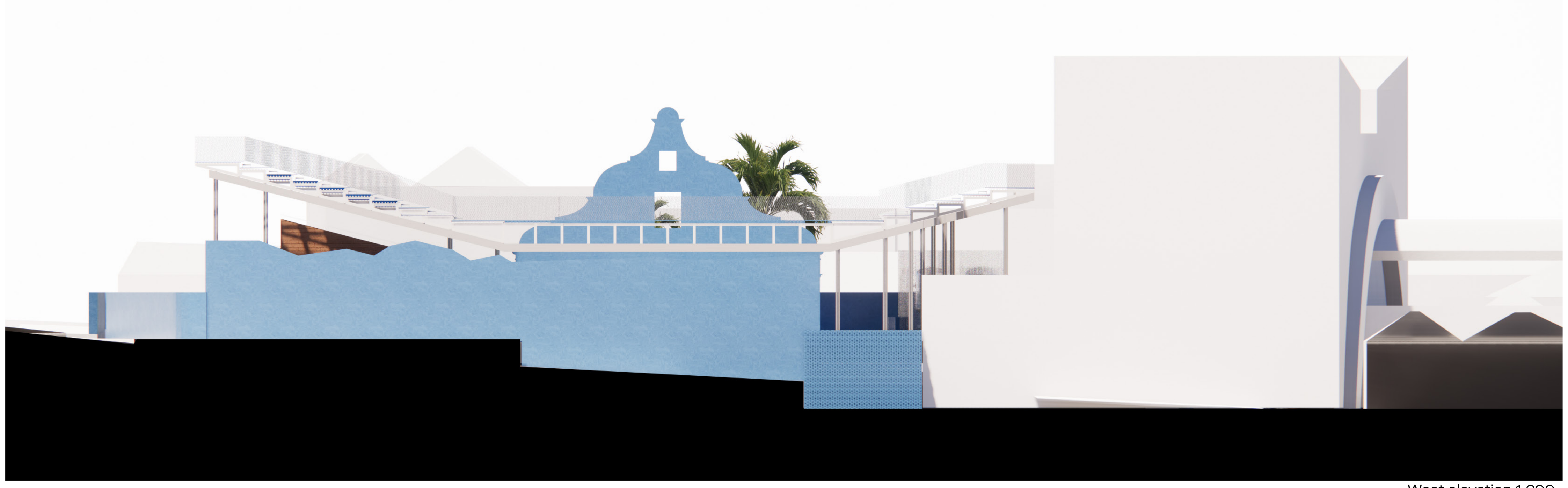
Section A 1:200

North elevation 1:200

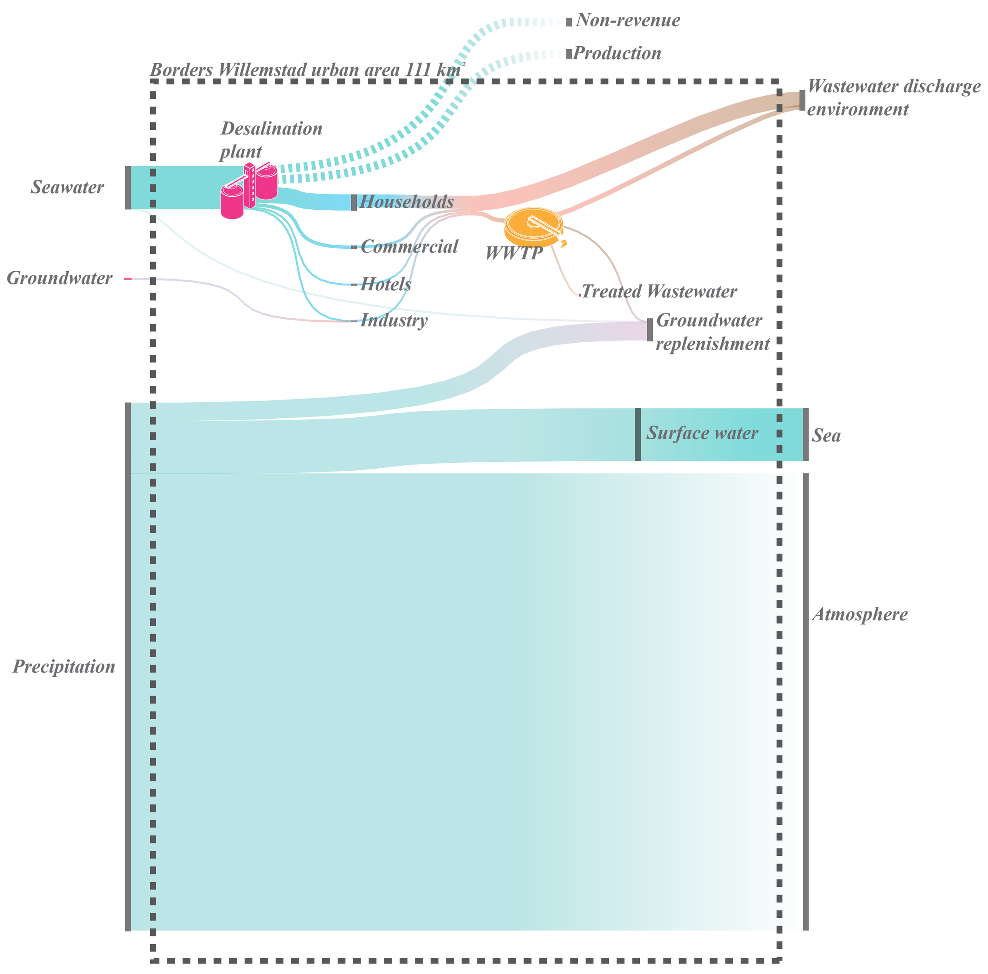
East elevation 1:200

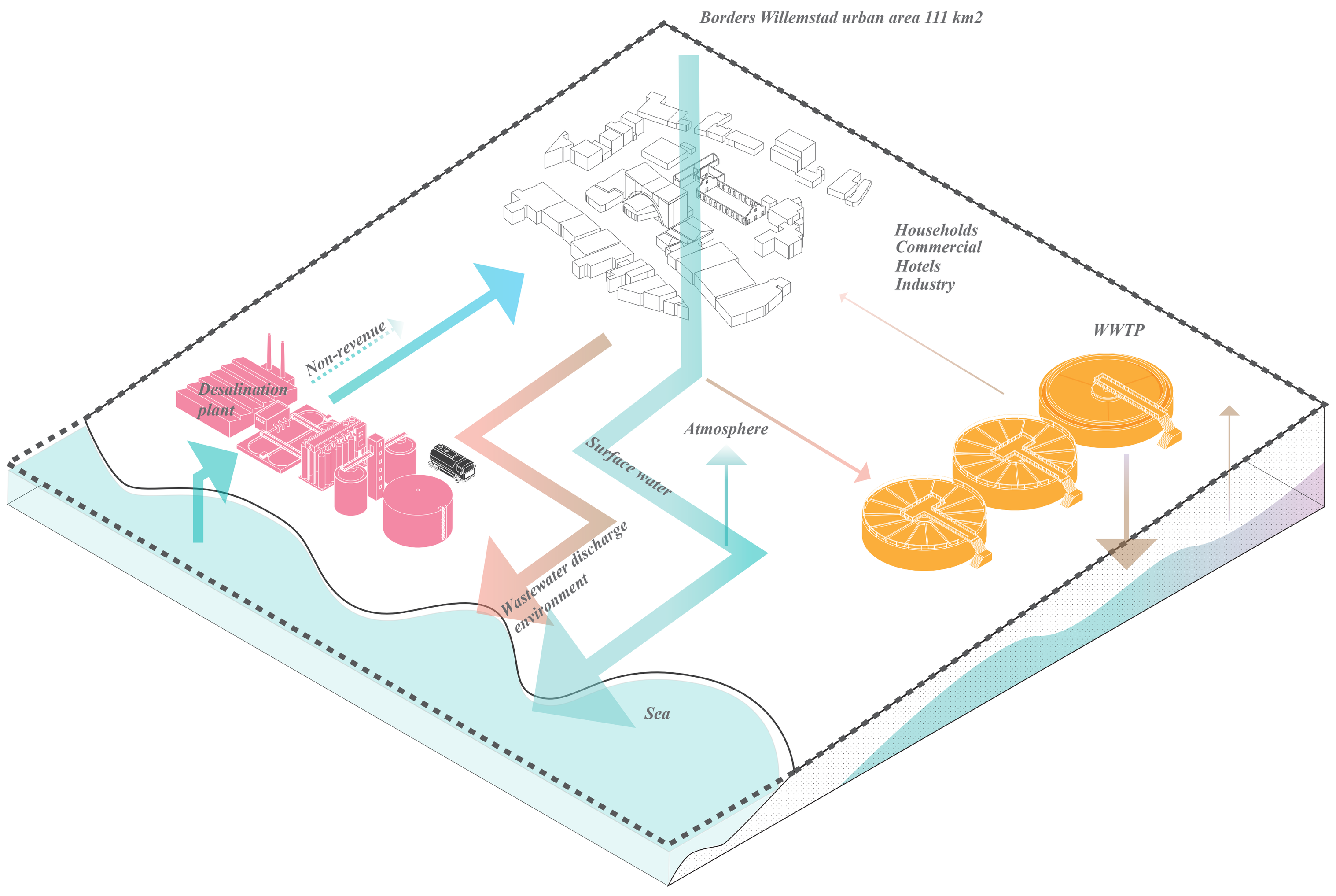


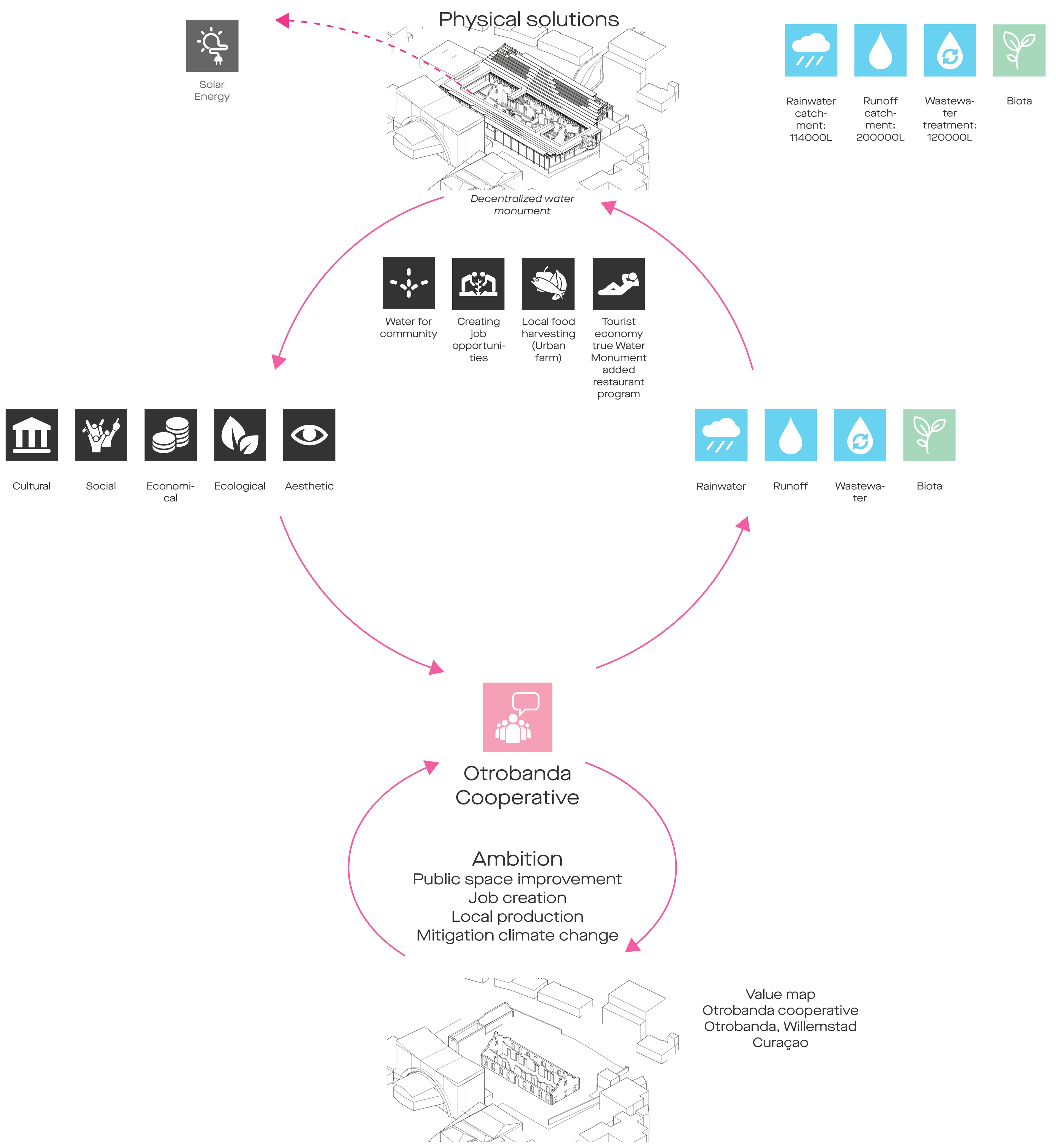
South elevation 1:200



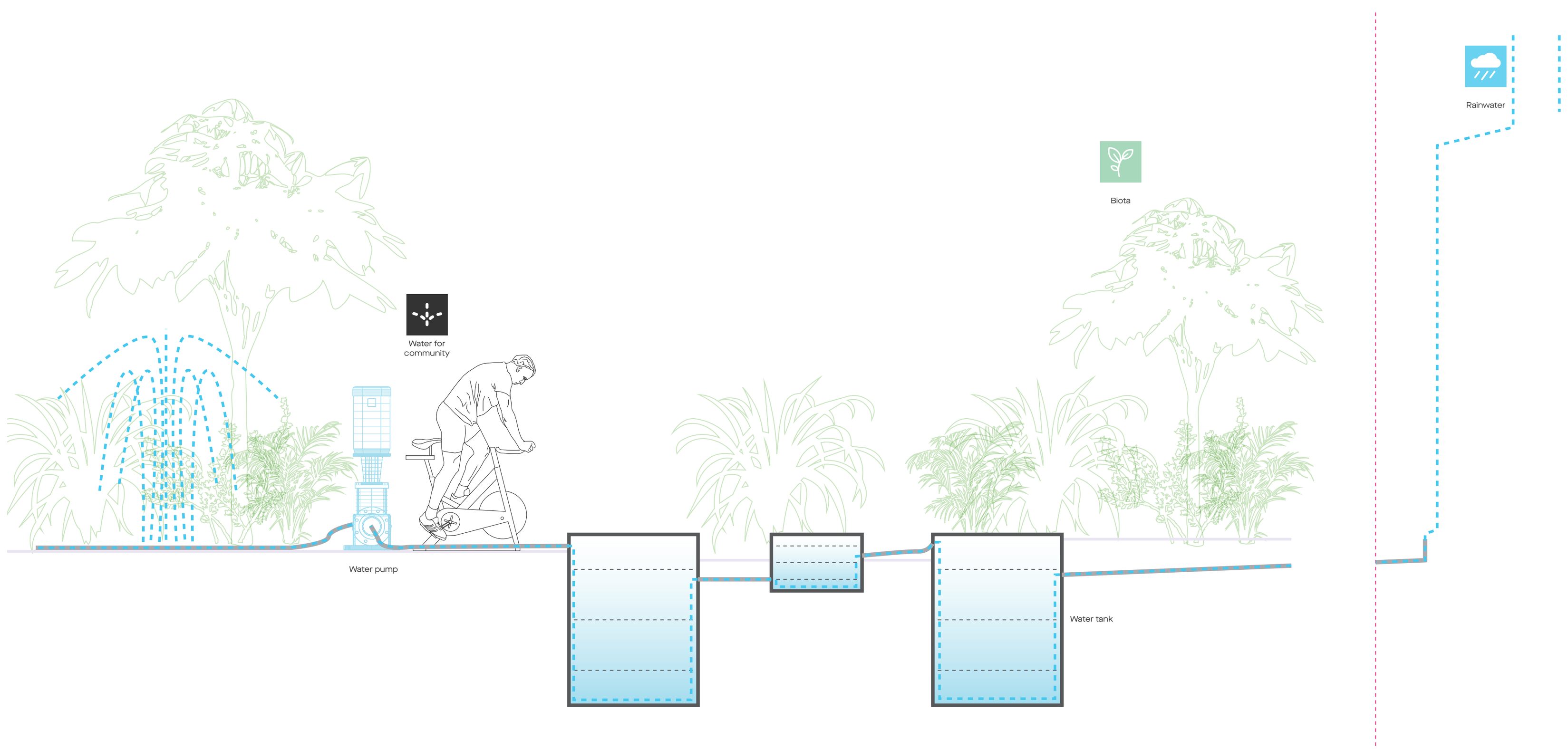
West elevation 1:200

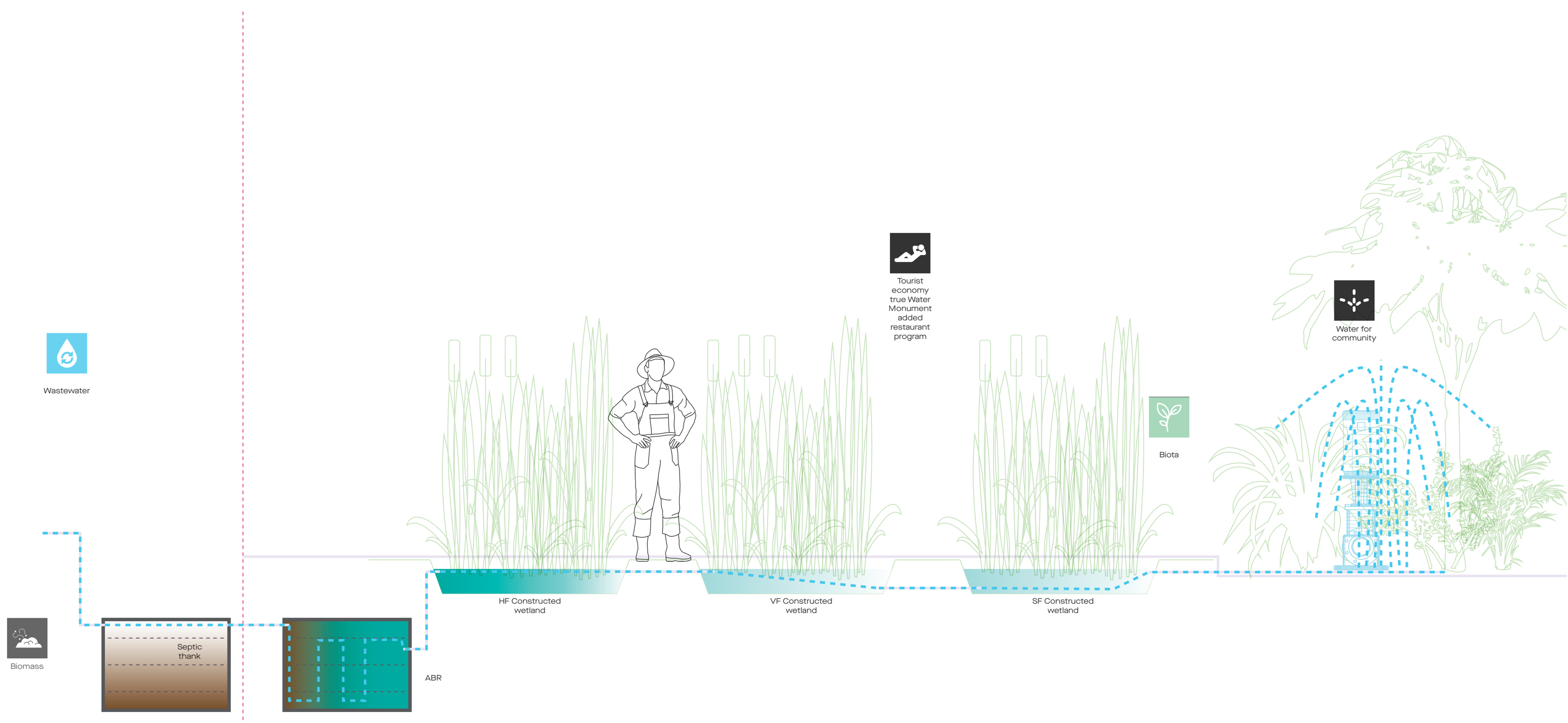

Non-revenue
Production
Borders Willemstad urban area 111 km²
Wastewater discharge environment
Desalination plant
Seawater
Households
Commercial
WWTP
Groundwater
Hotels
Treated Wastewater
Industry
Groundwater replenishment
Surface water
Sea
Atmosphere
Precipitation

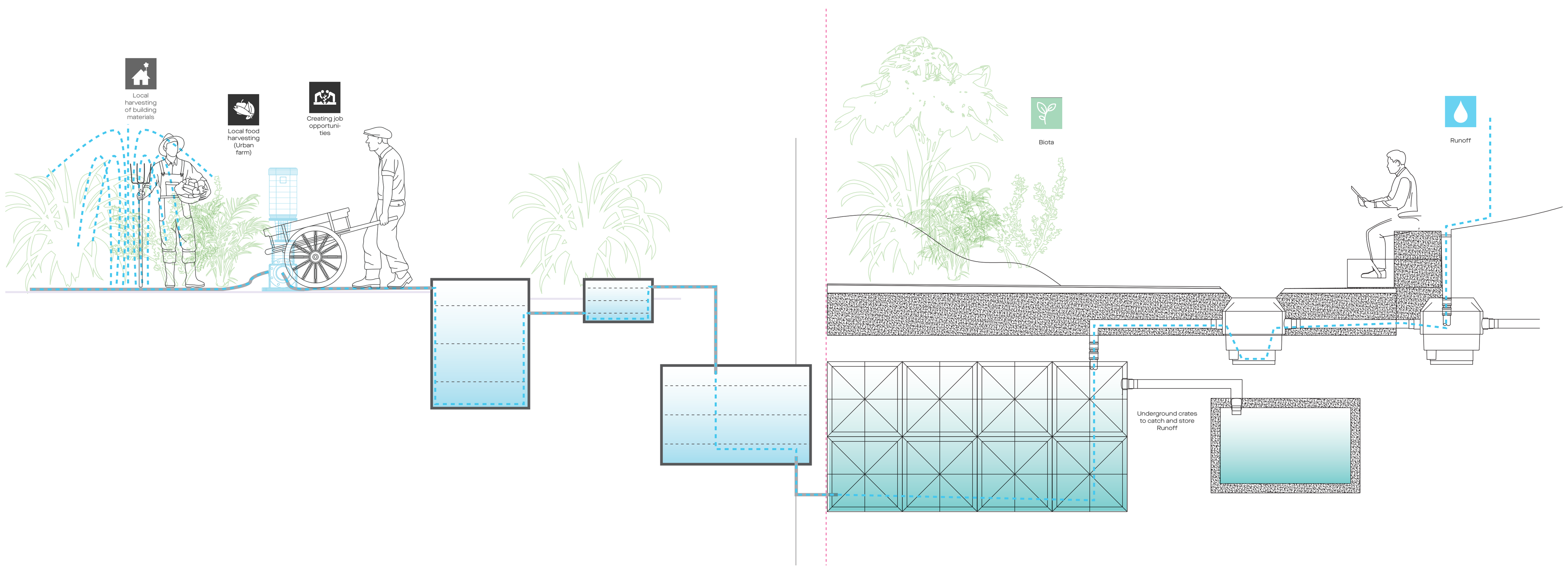

Borders Willemstad urban area 111 km2
Households
Commercial
Hotels
Industry
WWTP
Non-revenue
Desalination plant
Atmosphere
Surface water
Wastewater discharge environment
Sea

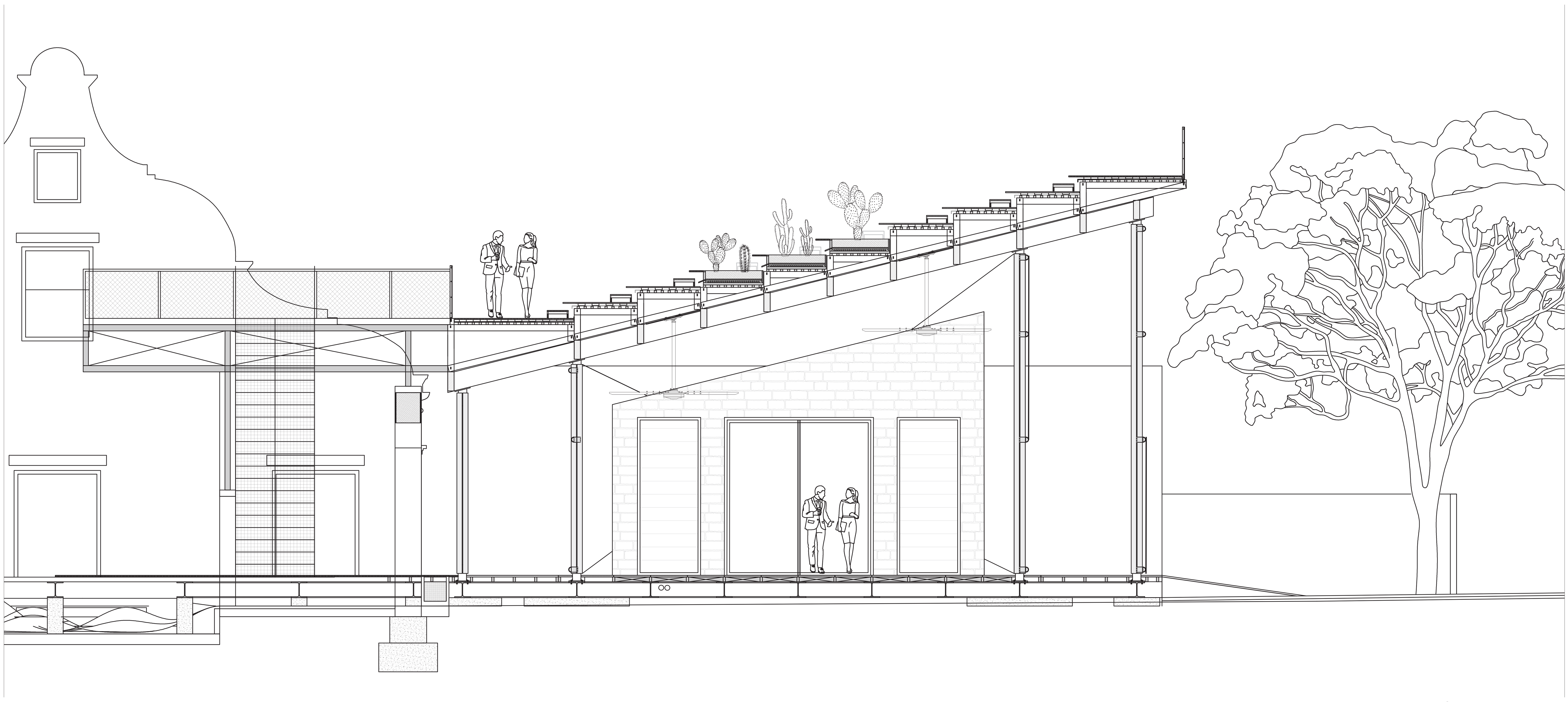


Value map
Otrobanda cooperative
Otrobanda, Willemstad
Curaçao

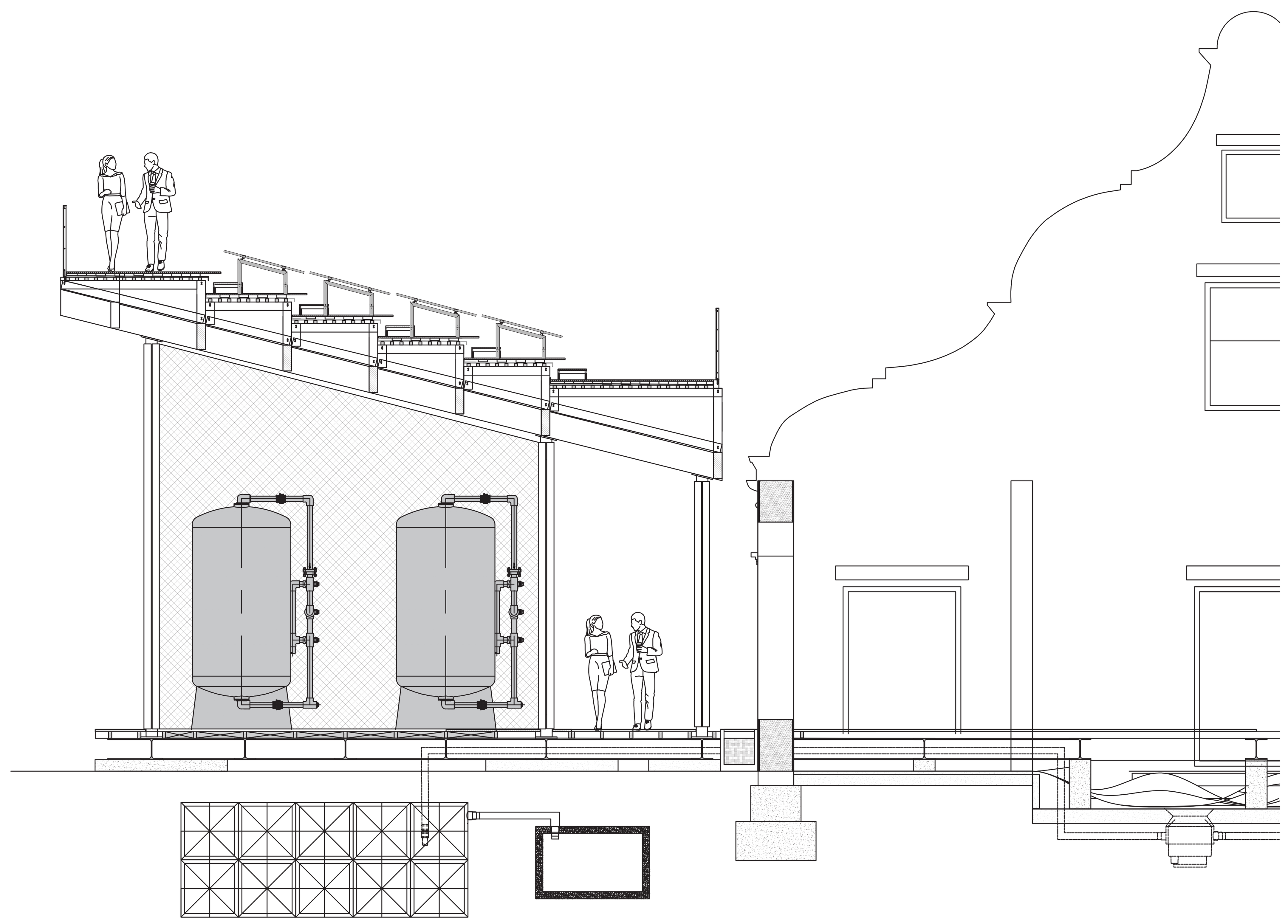




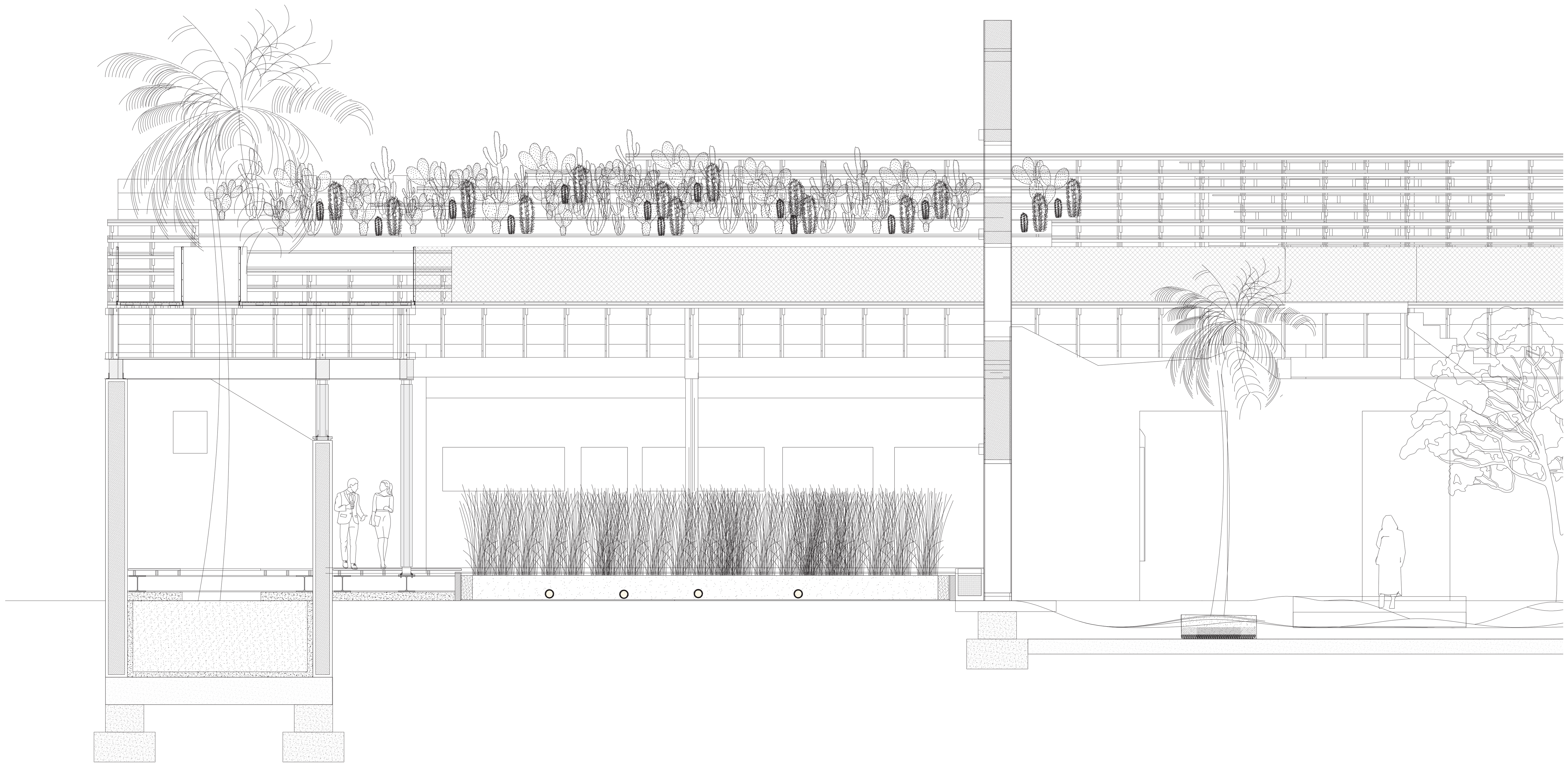




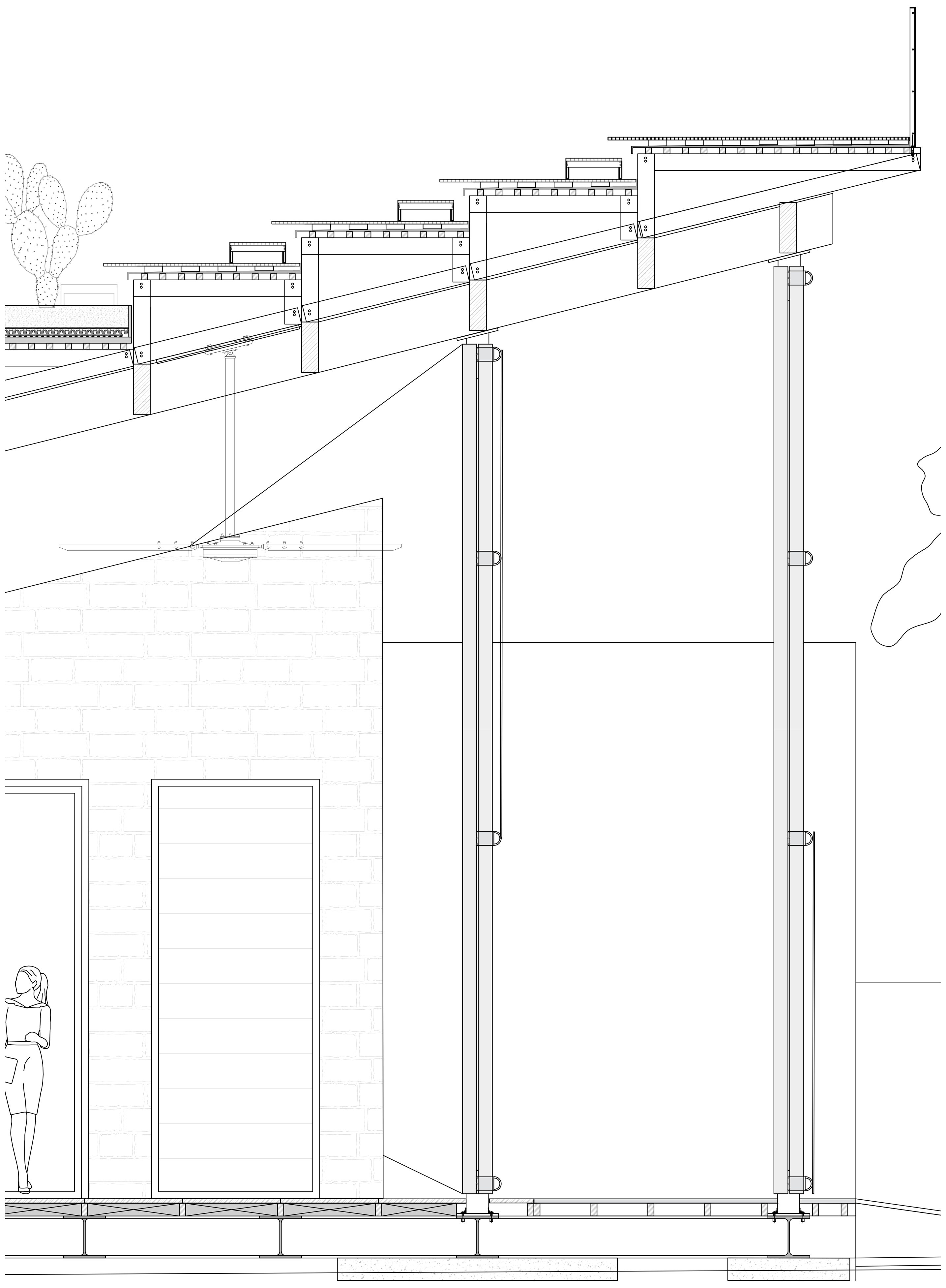
Section new construction north 1:50



Section new construction south 1:50

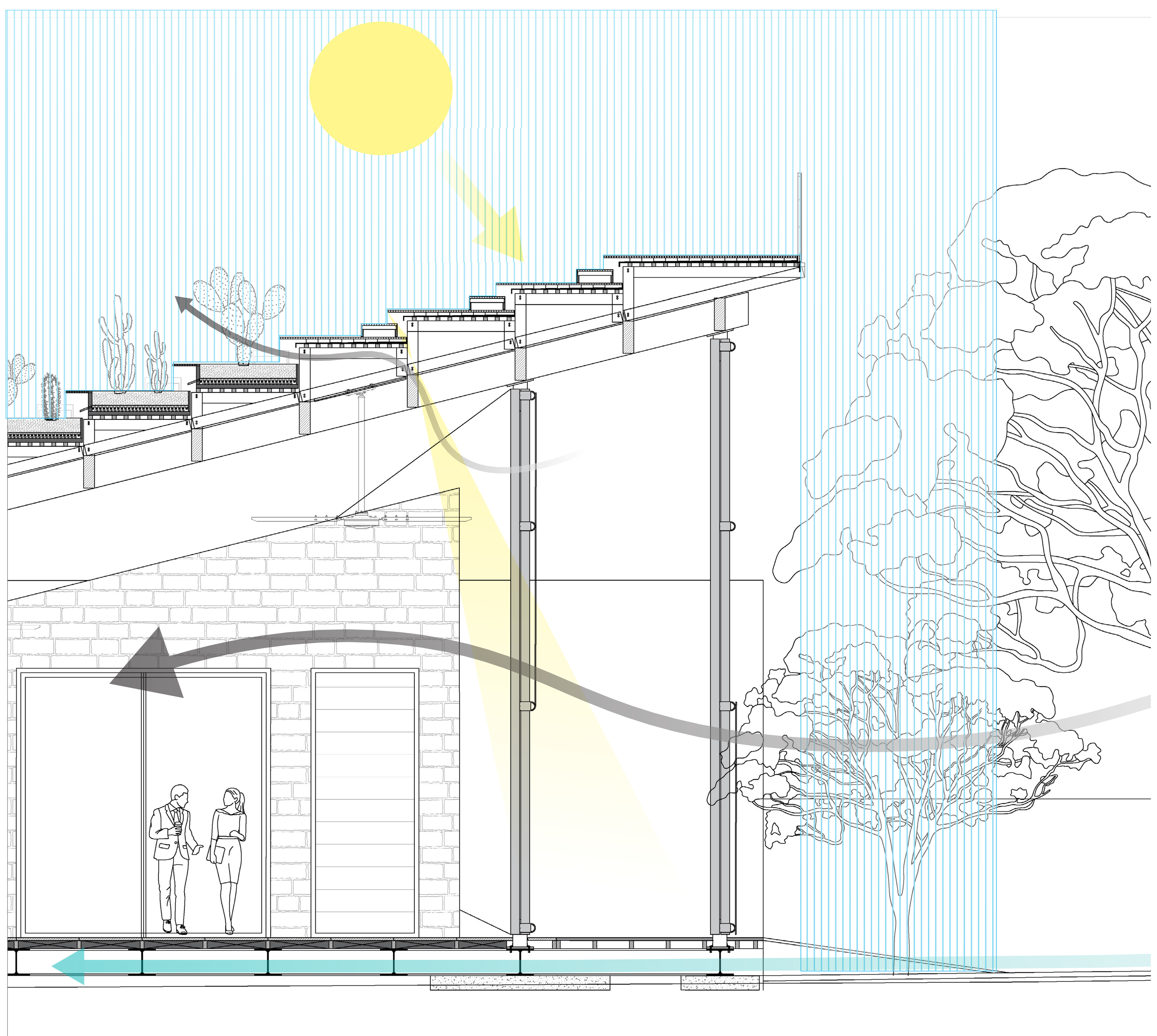


Section new construction wastewater treatment plant 1:50

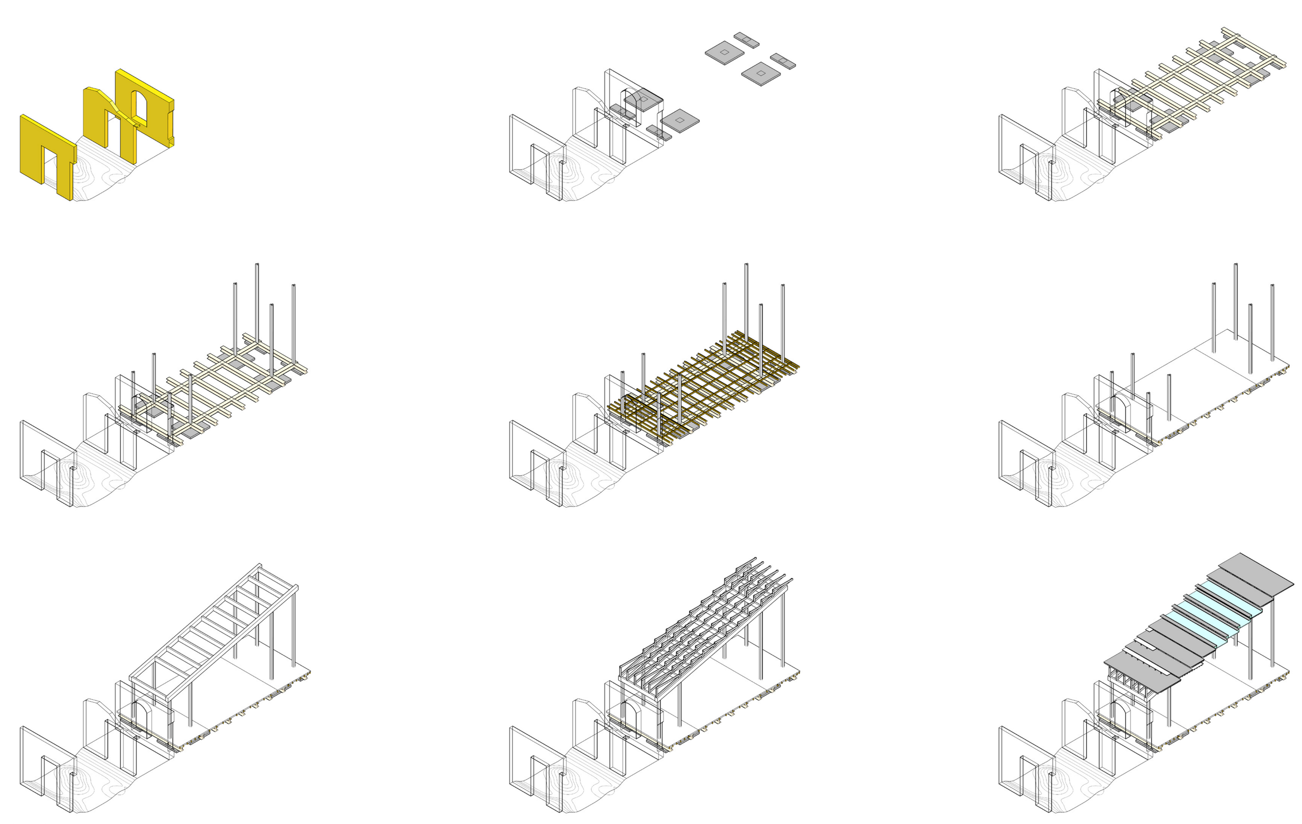


Vertical section 1:20

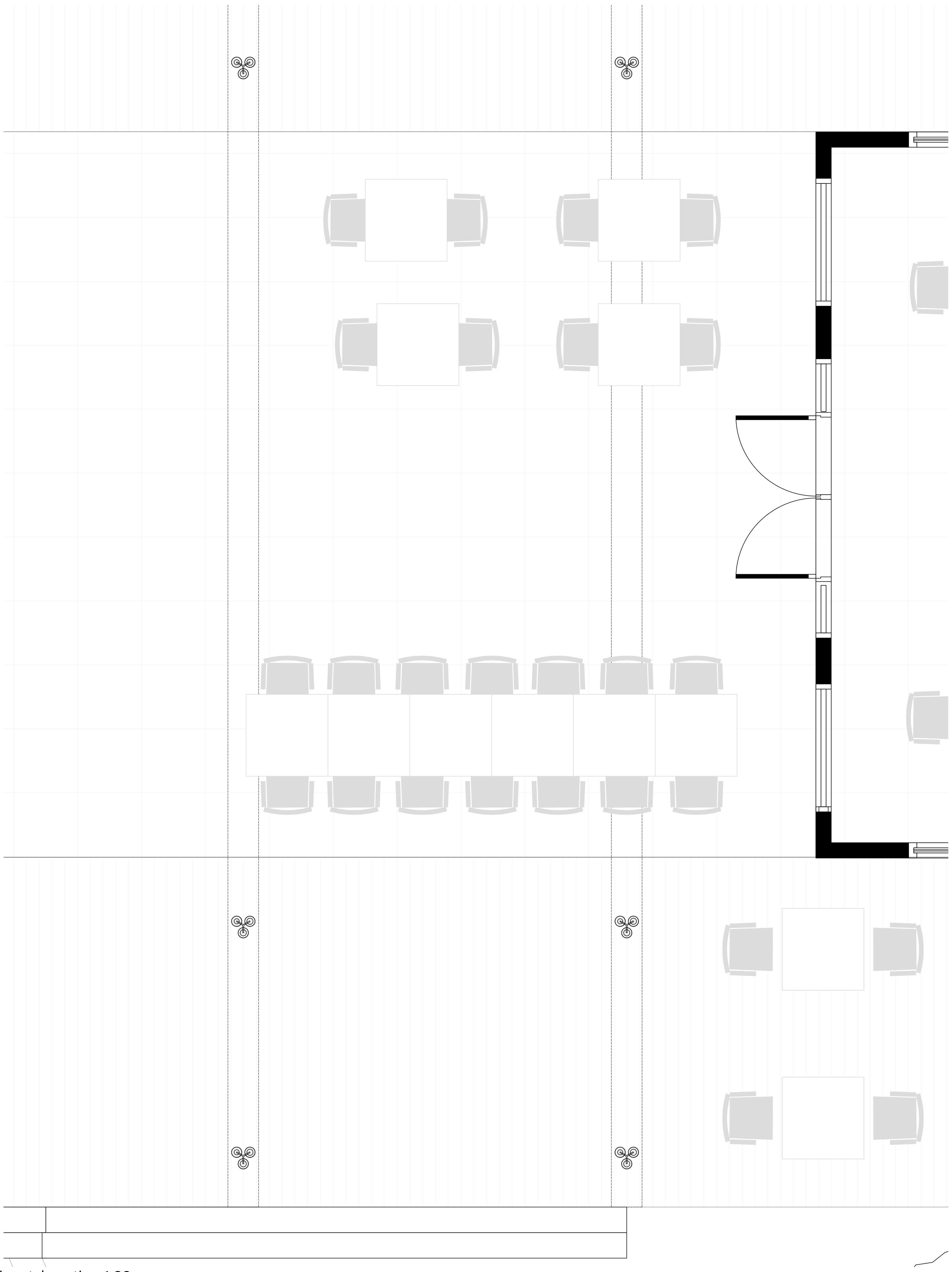
Facade 1:20



Section climate principal



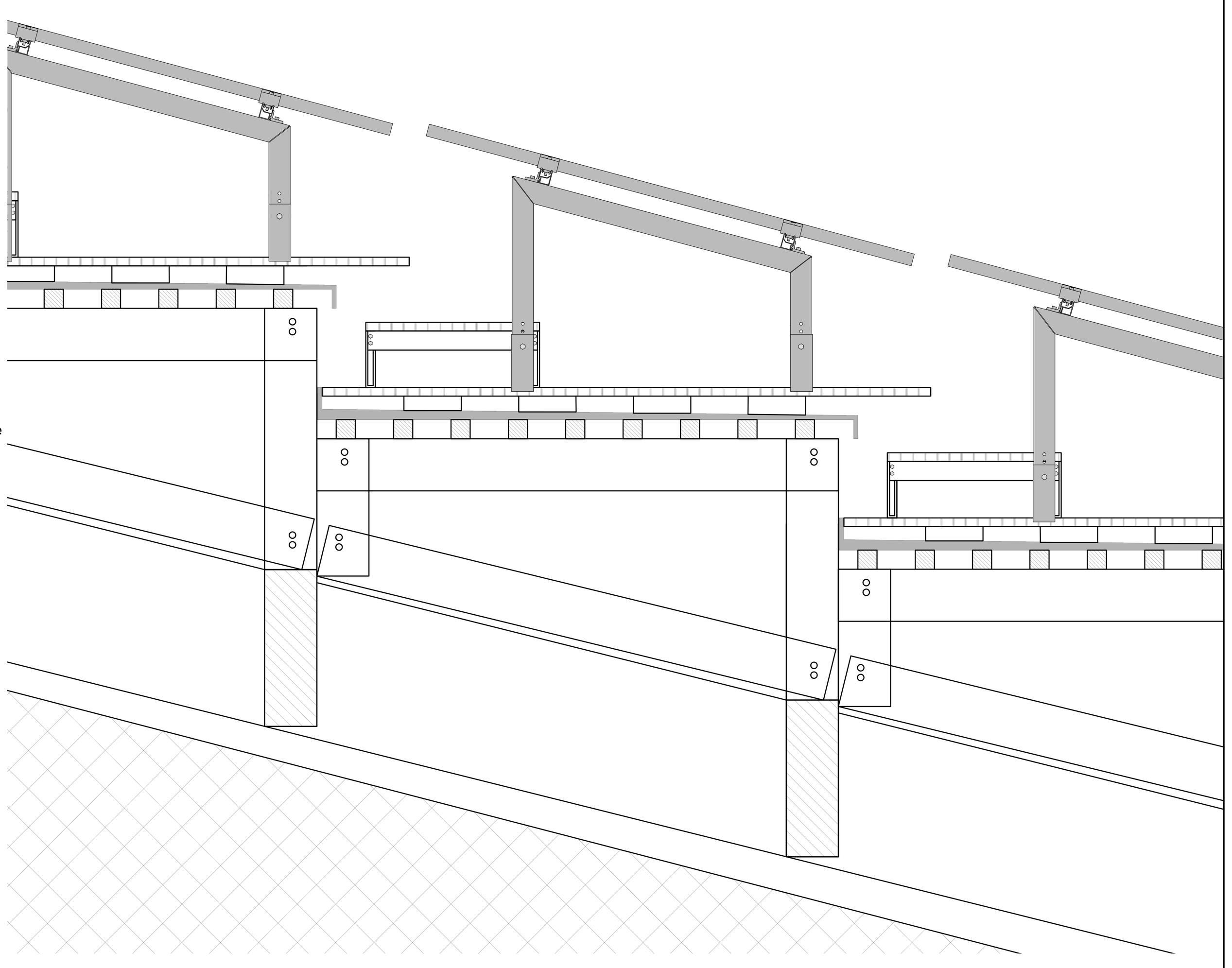
Low tech build up



Horizontal section 1:20

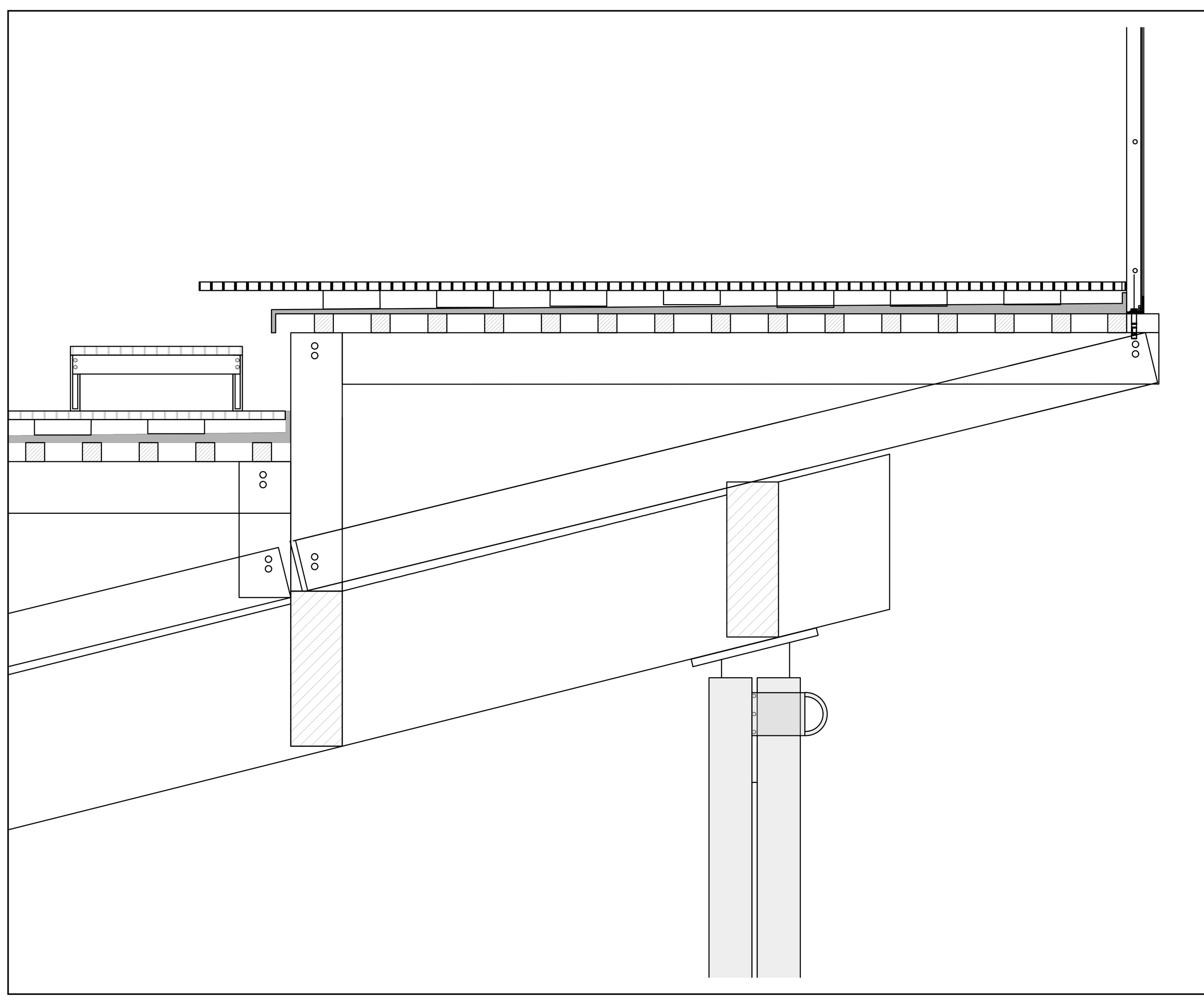
Detail: Roof solar panel 1:10

1. Primary Timber beam structure 350×250x 11000mm
2. Secondary timber beam structure 350×120×3750mm
3. Reclaimed wooden frame made of 44×120mm pallet wood
4. Water drain tray (folded steel) on sub-frame wood structure 44×44×3750 mm
5. Stepped bleachers structure made from perforated aluminum 20mm thick
6. PV solar panel 1200×600×30mm + structure
7. Reclaimed steel pipe (old gas pipes) column's 250×205 mm
8. Herras Fencing Wall



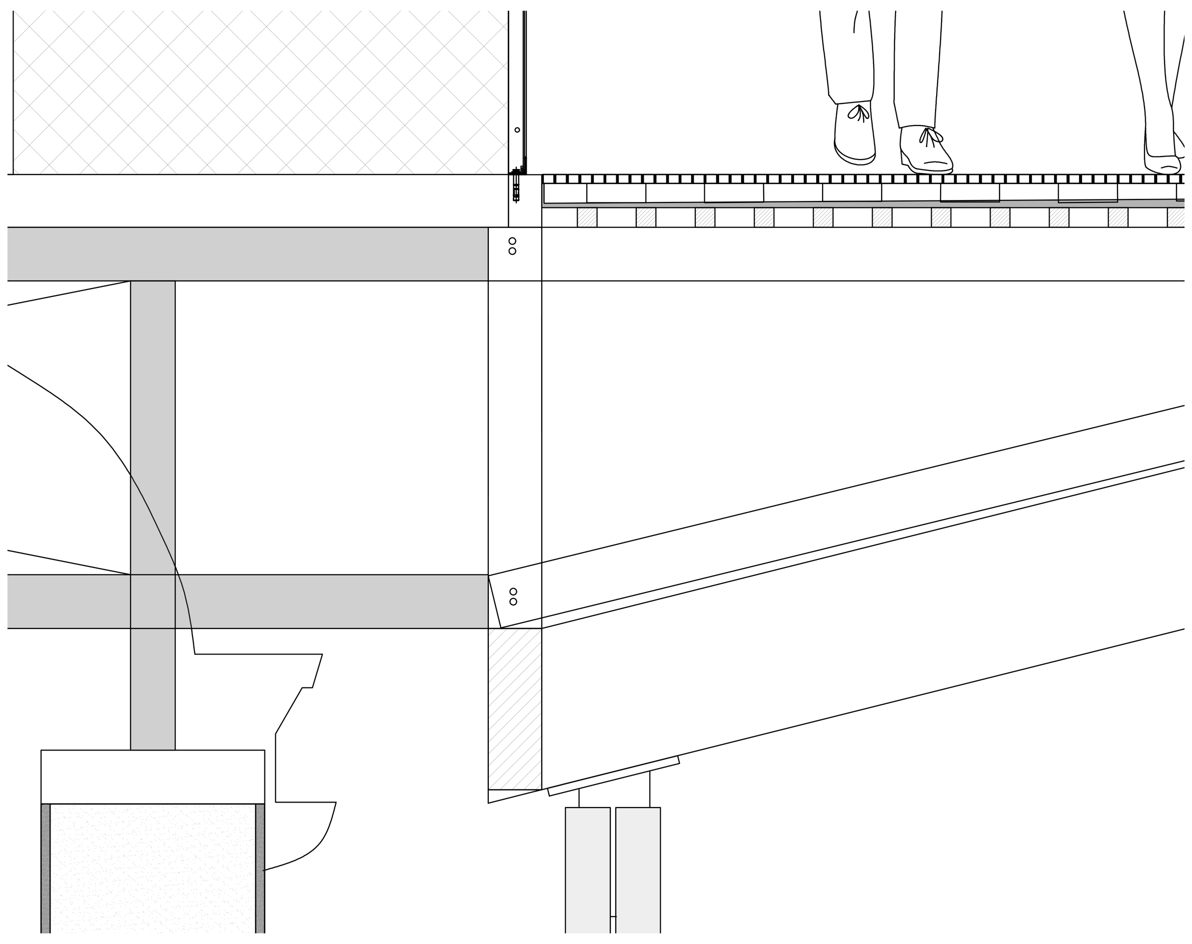
Detail: Roof edge 1:10

1. Primary Timber beam structure 350×250x 11000mm
2. Secondary timber beam structure 350×120×3750mm
3. Narrowed roof edge made of 44×120mm pallet wood frame
4. Water drain tray (folded steel) on sub-frame wood structure 44×44×3750 mm
5. Stepped bleachers structure made from perforated aluminum 20mm thick
6. Reclaimed steel pipe (old gas pipes) column's 250×205 mm
7. Herras Fencing 1000mm height



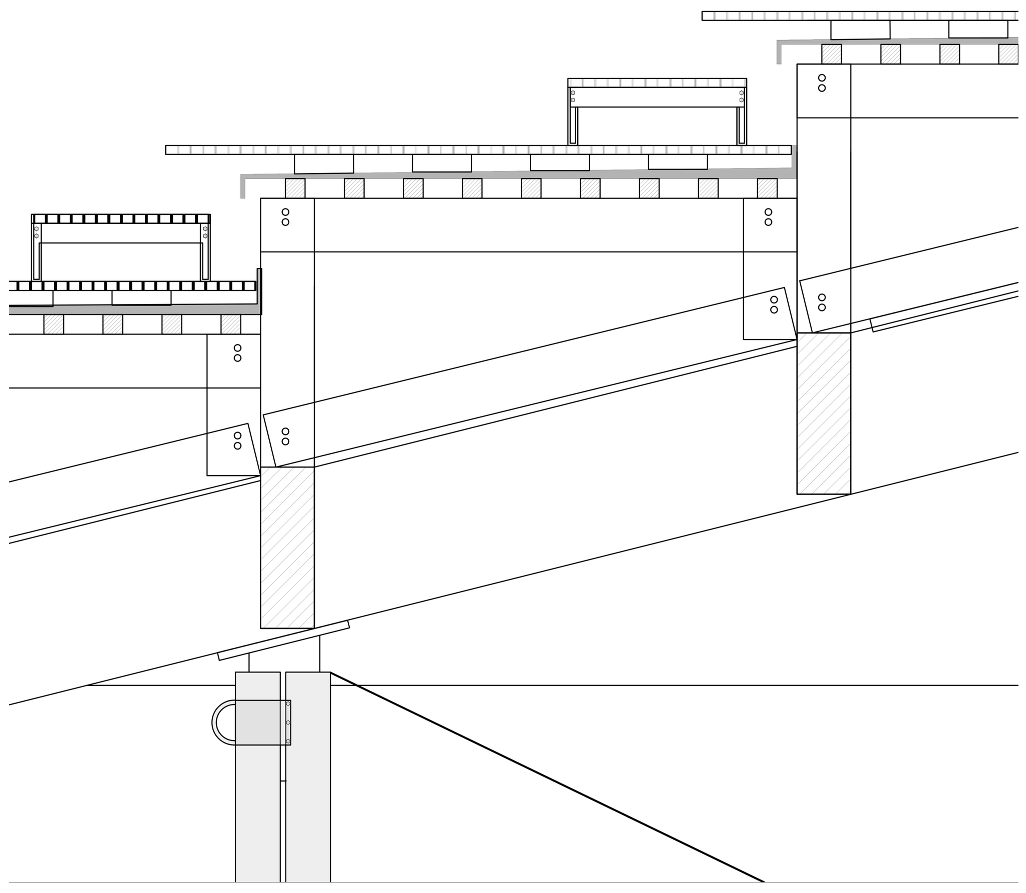
Detail: Connection Gutter new and existing structure 1:10

1. Primary Timber beam structure 350×250x 11000mm
2. Secondary timber beam structure 350×120×3750mm
3. Reclaimed wooden frame made of 44×120mm pallet wood
4. Water drain tray (folded steel) on sub-frame wood structure 44×44×3750 mm
5. Stepped bleachers structure made from perforated aluminum 20mm thick
6. Reclaimed steel pipe (old gas pipes) column's 250×205 mm



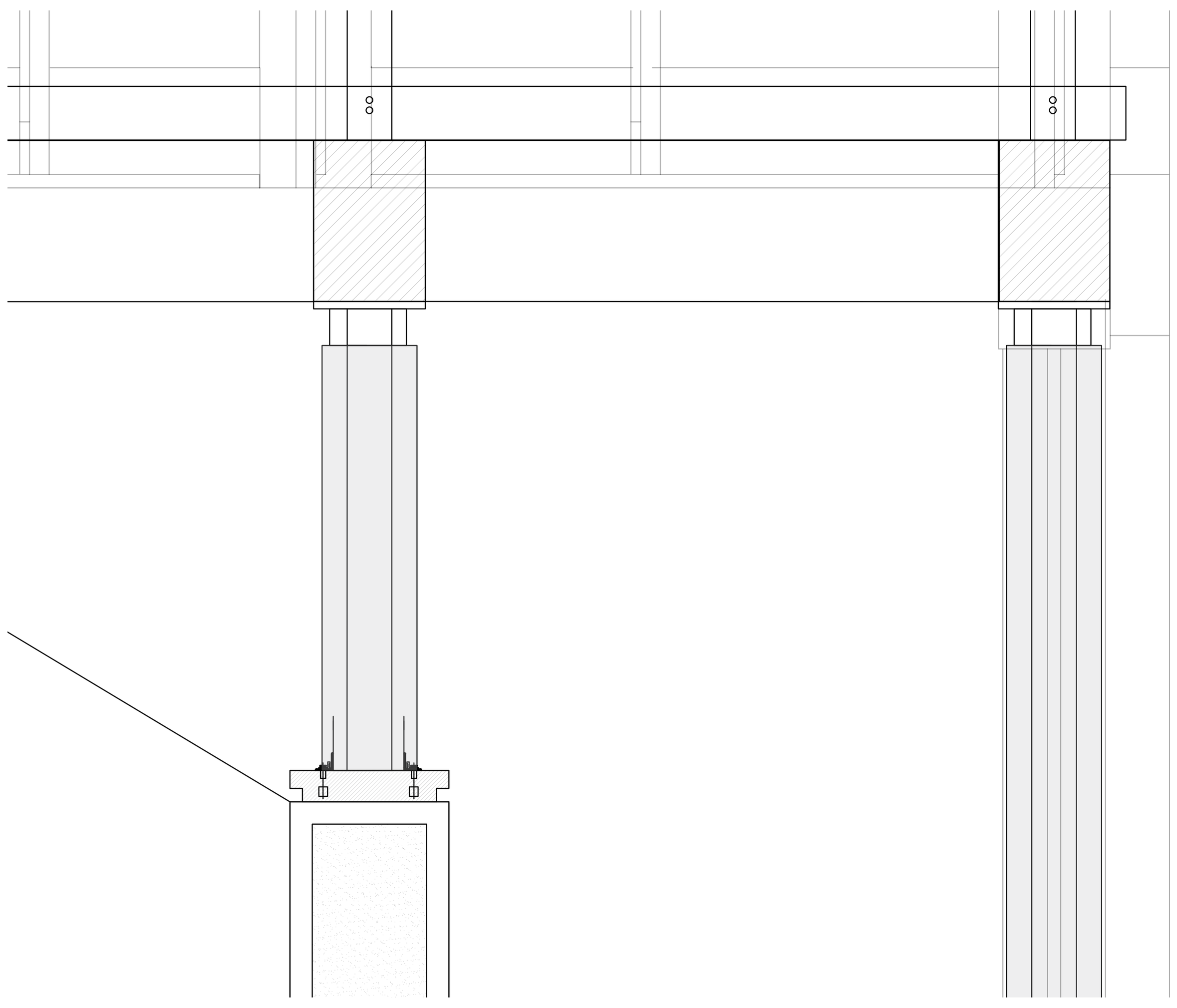
Detail: Rainwater harvesting bleacher steps 1:10

1. Primary Timber beam structure 350×250x 11000mm
2. Secondary timber beam structure 350×120×3750mm
3. Reclaimed wooden frame made of 44×120mm pallet wood
4. Water drain tray (folded steel) on sub-frame wood structure 44×44×3750 mm
5. Stepped bleachers structure made from perforated aluminum 20mm thick
6. Reclaimed steel pipe (old gas pipes) column's 250×205 mm



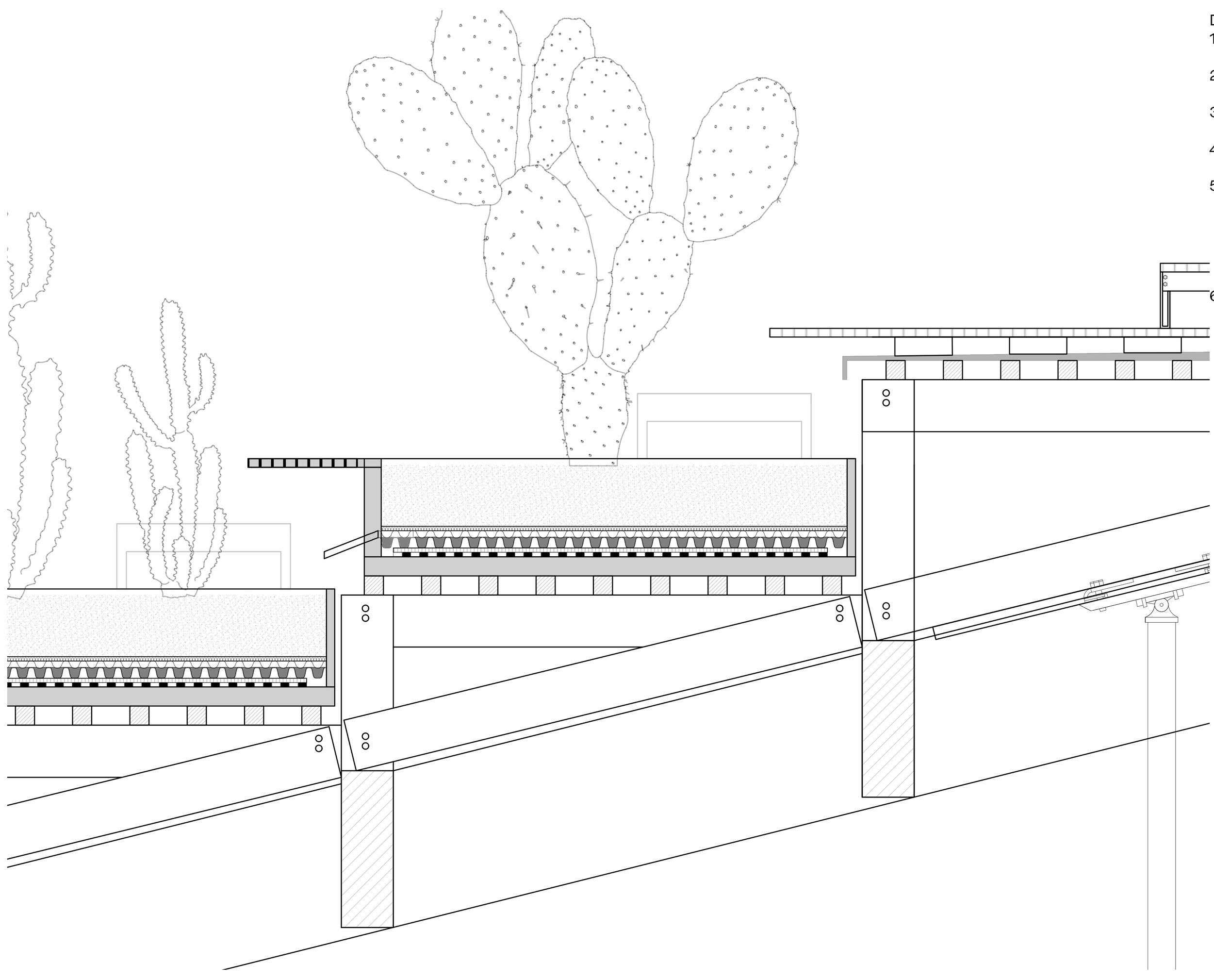
Detail: Connection Gutter new and existing structure 1:10

1. Primary Timber beam structure 350×250x 11000mm
2. Secondary timber beam structure 350×120×3750mm
3. Reclaimed wooden frame made of 44×120mm pallet wood
4. Dry steel column-beam connection (rotting resistant)
5. Reclaimed steel pipe (old gas pipes) column's 250×205 mm
6. Timber beam with coves/verkenning (looks thinner and prevents cracks in the outer layer existing construction)



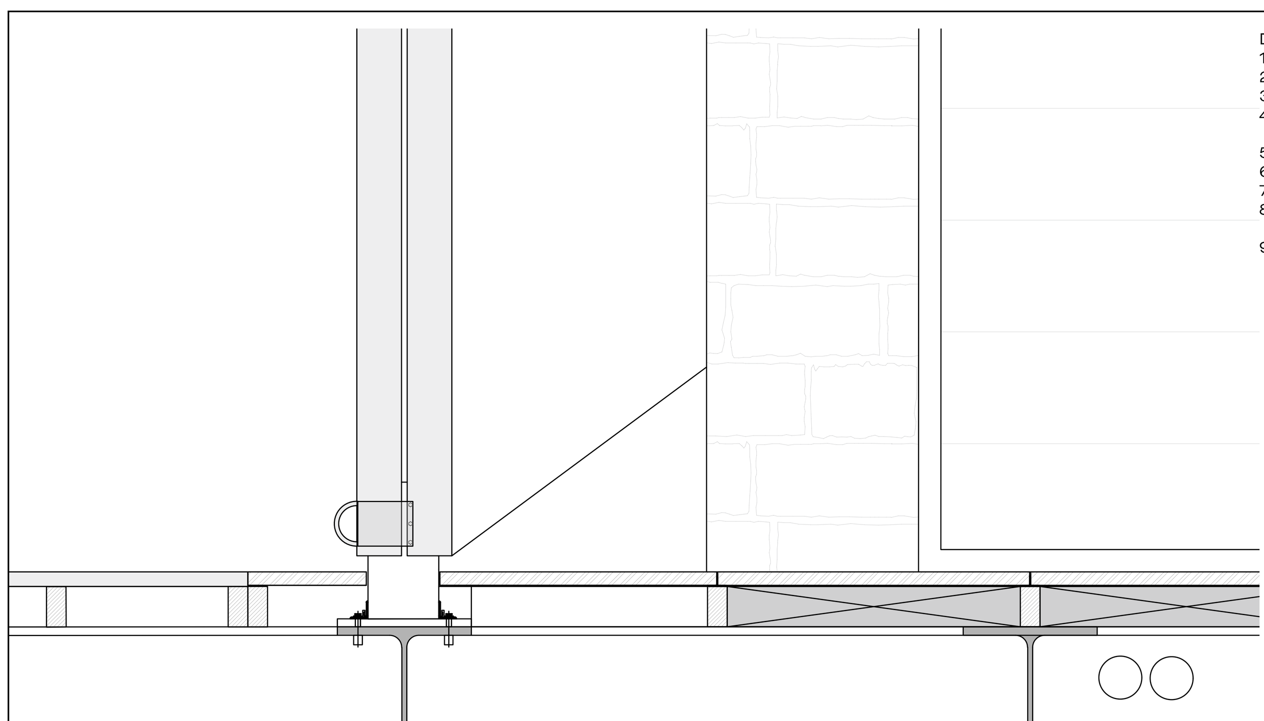
Detail: Rainwater catchment cactus steps 1:10

1. Primary Timber beam structure 350×250x 11000mm
2. Secondary timber beam structure 350×120×3750mm
3. Reclaimed wooden frame B made of 44×120mm pallet wood
4. Water drain tray (folded steel) on sub-frame wood structure 44×44×3750 mm
5. Stepped cactus greenery structure: Cacti layer, intensive substrate layer 200mm, Fil 105 filter layer, drainage layer 40 mm, absorption layer 4 mm root-resistant roofing layer
6. Reclaimed steel pipe (old gas pipes) column's 250×205 mm

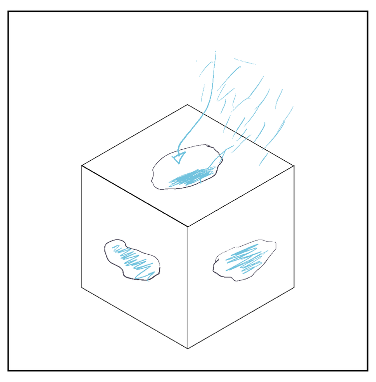


Detail: Lifted floor 1:10

1. Stelcon plaat 2000×2000×140 mm
2. HEB 300 steel I profile
3. Wood frame 90×44 mm
4. Wall-bearing wooden infill bar to prevent sagging
5. Limestone flooring tiles 33×700×700 mm
6. Aluminium T-profile 20×20×2 mm
7. Wooden decking floor mm
8. Dry steel column-beam connection (rotting resistant)
9. Reclaimed steel pipe (old gas pipes) column's 250×205 mm



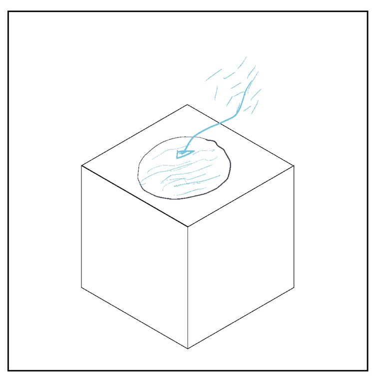
Karstputten



Characteristics

According to Hartog (1968) the use of shallow karstbronnen or karst wells was well developed upon arrival of the Dutch. Debrot (2009) also refers to them as shallow water holes. Water moving through to karst is recharged by surface and point infiltration in the naturally occurring holes, pits and cracks in the surface. During periods with significant rainfall these cracks and pots, the karstputten, would fill up and sometimes even spill over forming water pools. During droughts the pits and pools would run dry quickly. According to Versluys (1934) the quality of karst water on higher altitude at a distance from the coast is less brackish and of better quality. It is highly probable the Caquetio built dams or walls around these pits to prevent water loss from overflowing karstputten (Loen, 2019).

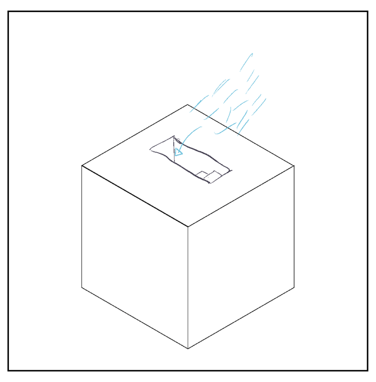
Rooi



Characteristics

According to Werbata's legend (fig. 1 nr. 6). a rooi is a "in the rain season filled dry bed of a brook". During rain runoff water flows downhill through the bed of the rooi. Some rooi are also fed with seepwater that flows out at the foot off porous karst formation hills, cliffs and notches. The rooien played an important part in the islands water catchment system.

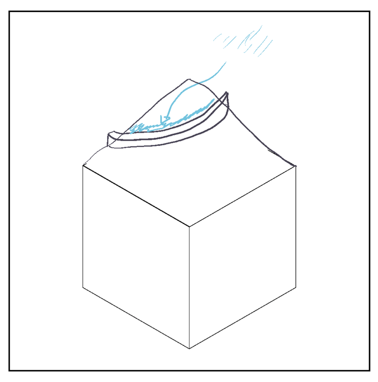
Pos di pia



Characteristics

Debrot (2009) refers to shallow hand dug water holes or pos di pia, a native Carib practice. Local resident Mary van Soest made an inventory of water supply related heritage. Soest describes a "sunken water hole" called Pos di orashon in Papiamento, which translates as 'source for prayer. Local people believe it was used by the native Caribs. It is possible that waterkuilen are either seasonally overflowing karstputten, sinkholes or dolines (geological terms), rainfed natural depressions (transformed by man) and/or manmade pools. The waterkuilen are fed directly and via runoff in brooks and streams (rooien) and via dams. Waterkuilen / pos di pia are usually located in forested terrain.

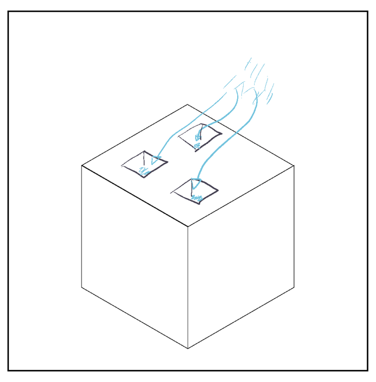
Faha



Characteristics

According to Renkema there were two types of dam systems in use. A small dam system and the large dam system. The small dam system could be found primarily on the domeingronden or unfavourable grounds of plantations with irregular and steeper terrain (Renkema 1981). As mentioned before during slavery these kostgrondjes were in use by the enslaved as kitchengarden. After 1863 the African-Caribbean community continued this practice as subsistence / small holder farmers. Renkema describes "many small dams as no higher than a few decimetres to maximum 1 meter" constructed "on the slopes and in small rooien". Henriquez (1962) describes the system in the Schottegat area (fig. 8). The small earthen dams are called faha (girdle in Papiamento) suggesting that they have a circular shape.

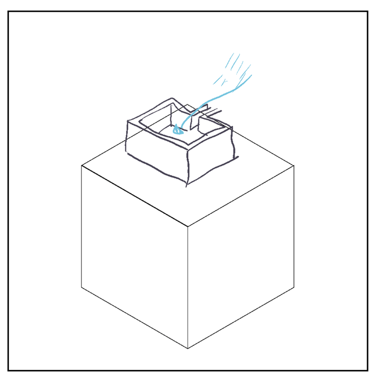
Tanki



Characteristics

The difference between a waterkuil and tanki (fig. 7) is not clear. It seems they both refer to pits or pools either manmade or natural depressions transformed by men. According to Werbata's definition a tanki is "dug reservoir for rainwater". tanki were fed by rainfall and runoff from the catchment area and consisted of a system of large stone dams, rooien and gutters directing water to the catchment pools: the tanki. This large dam system was based on the micro catchment waterkuil-faha system but adjusted and enlarged at the discretion of the landlords on their privately-owned plantation grounds in the valleys (Renkema, 1981)

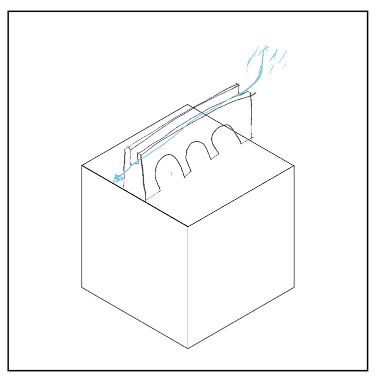
Cistern



Characteristics

Rainwater was collected from the roofs of the manor house and other buildings and directed to waterbakken or regenbakken (rainwater cisterns). These regenbakken were located near the manor house, usually half below surface (fig. 17).

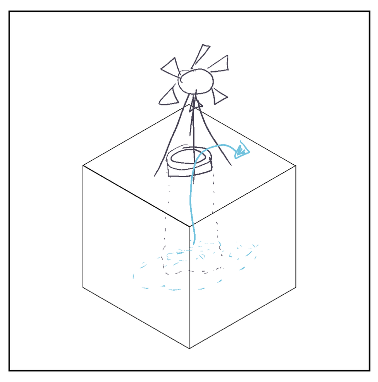
Aquaduct



Characteristics

The manor house of plantation San Juan is even supplied with rainwater via an aqueduct architecturally integrated in the architecture of the complex (fig. 14). Monumentenzorg (monuments, 2020b) describes the complex as "A group of magasina's with cistern connected with an aqueduct to the main building"

Windwell

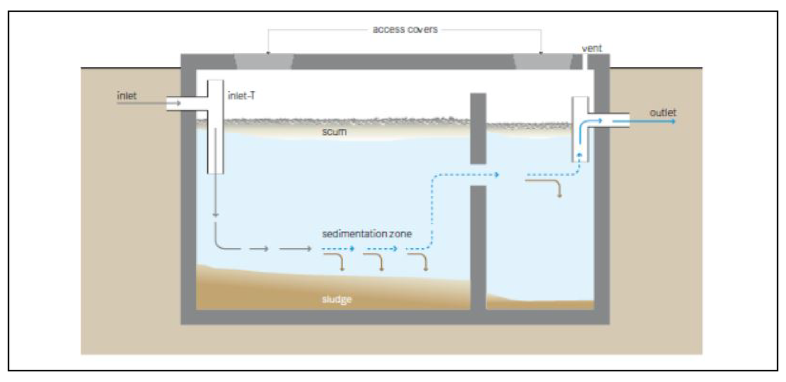


Characteristics

Plantageputten (plantation wells)
plantageputten were located in the valley just below the foot of the hills where the manor house was located. According to Renkema (1981) the plantageputten in the hof were surrounded by fruittrees, the owners vegetable gardens and sometimes slave gardens and huts all conveniently located near this source of putwater.

Windwaterputten (wind powered wells)
In the overseas territory of the Dutch Caribbean the windmills were applied to overcome water shortages by mining groundwater for irrigation and consumption. This extensive system of wind powered wells, waterbassins, terraces, stone gutters and iron pipes was only viable if the groundwater was sufficiently replenished with zakwater (infiltrated rainwater). The windmotoren also made work easier for so called 'waterplantages', plantation whose primary source of income was the selling of water (and salt) to the urban population, docking ships and army (Renkema, 1981).

Septic tank

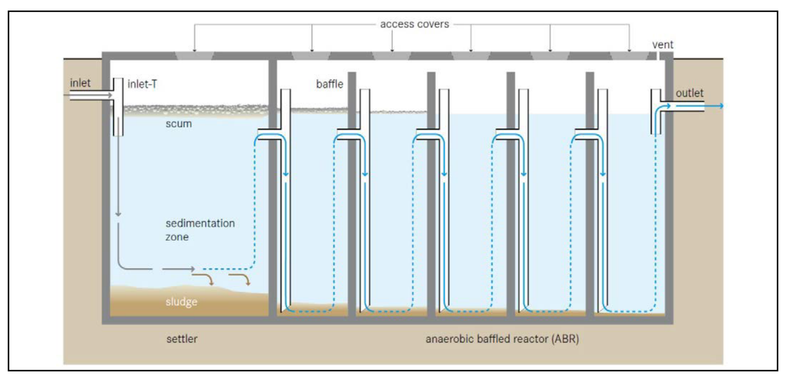


Characteristics

'inputs: blackwater and greywater. outputs: effluent and sludge.

A septic tank is a watertight chamber through which blackwater and greywater flows for primary treatment. settling and anaerobic processes reduce solids and organics, but the treatment is only moderate.
Removal of 50% of solids, 30-40% of BOD, and a 1-log removal of E.coli can be expected in the well-designed and maintained septic tank. The retention time should be 48 hours.' (Tilley, et al., 2014, p. 74)

Aerobic baffled reactor

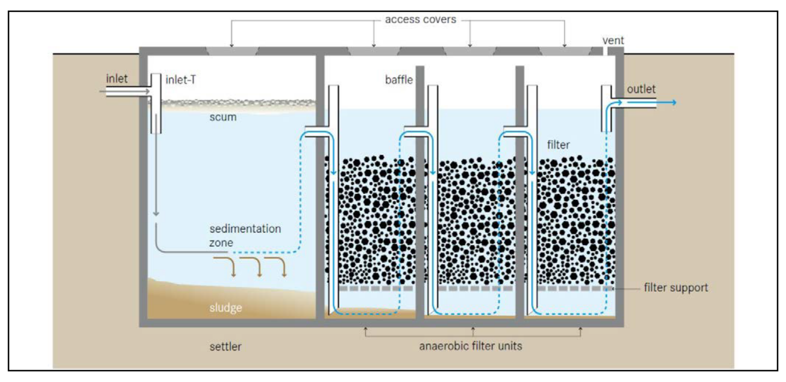


Characteristics

'Inputs: blackwater, greywater. Outputs: effluent, sludge.

An anaerobic baffled reactor is an improved septic tank with a series of baffles under which the wasterwater is forced to flow. the increased contact time with the active biomass (sludge) results in improved treatment.
BOD may be reduced by up to 90%. Typical inflows range from 2 to 200m3 per day. Retention time should be 48-72 hours. Usually, the biogas produced in an ABR through anaerobic digestion is not collected because of its insufficient amount.' (Tilley, et al., 2014, p. 76)

Anaerobic filter

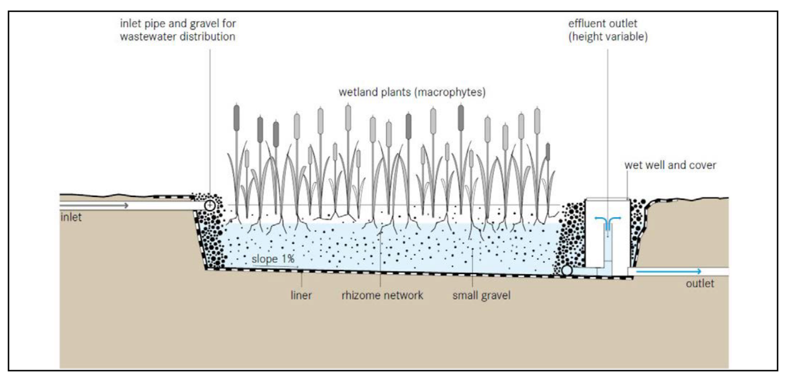


Characteristics

' Inputs: blackwater, greywater. Outputs: effluent, sludge.

An anaerobic filter is a fixed-bed biological reactor with one or more filtration chambers in series. As wastewater flows through the filter, particles are trapped and organic matter id degraded by the active biomass that is attached to the surface of the filter material.
Suspended solids and BOD removal can be as high as 90%, but typically between 50-80%. Nitrogen removal is limited and normally does not exceed 15% in terms of total nitrogen (TN).
Retention time should be 12-36 hours.' (Tilley, et al., 2014, p. 78)

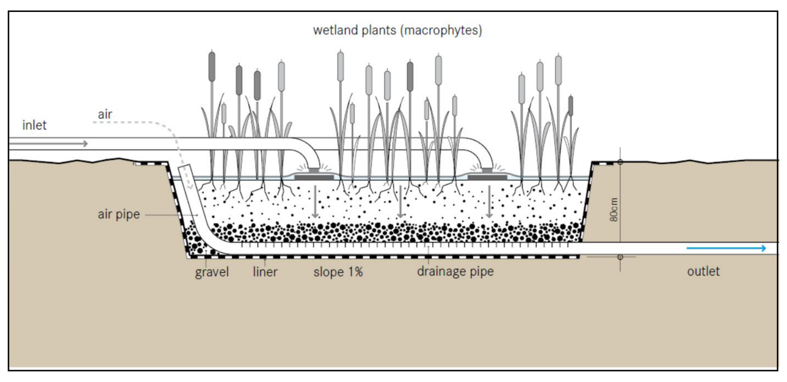
Horizontal subsurface flow constructed wetland



Characteristics

'A horizontal subsurface flow constructed wetland is a large gravel and sand-filled basin that is planted with wetland vegetation. As wastewater flows horizontally through the basin, the filter material filters out particles and microorganisms degrade the organics.' (Tilley, et al., 2014, p. 116)

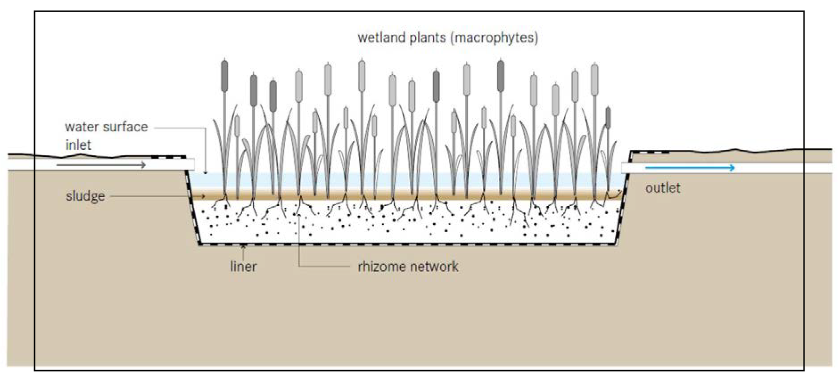
Vertical flow constructed wetland



Characteristics

'A vertical flow constructed wetland is a planted filter bed that is drained at the bottom. Wastewater is poured or dosed onto the surface from above using a mechanical dosing system. The water flows vertically down through the filter matrix to the bottom of the basin where it is collected in a drainage pipe. The important difference between a vertical and horizontal wetland is not simply the direction of the flow path, but rather the aerobic conditions.' (Tilley, et al., 2014, p. 118)

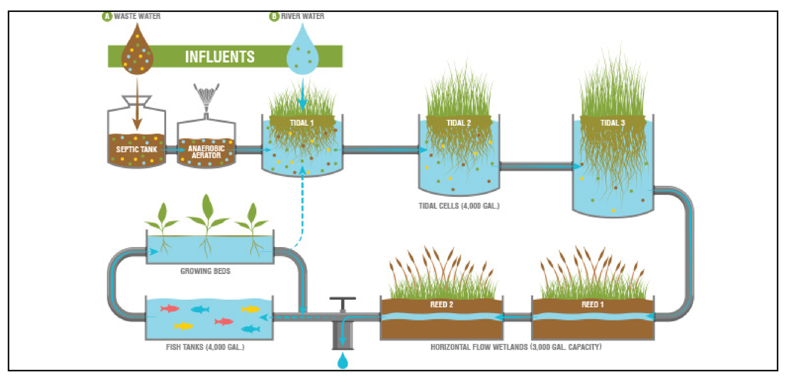
Free-water surface constructed wetland



Characteristics

'A free-water surface constructed wetland aims to replicate the naturally occurring processes of a natural wetland, marsh or swamp. As water slowly flows through the wetland, particles settle, pathogens are destroyed, and organisms and plants utilize the nutrients. This type of constructed wetland is commonly used as an advanced treatment after secondary or tertiary treatment processes.' (Tilley, et al., 2014, p. 114)

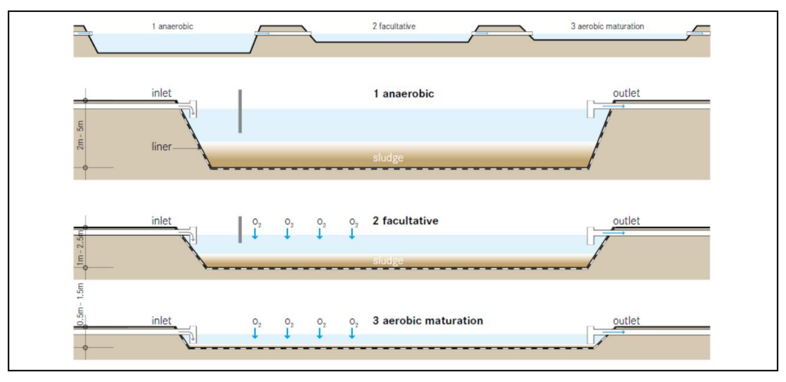
Living machine



Characteristics

A Living Machine (capital letters, it's a patented invention) is a series of tanks teeming with live plants, trees, grasses and algae, koi and goldfish, tiny freshwater shrimp, snails, and a diversity of microorganisms and bacteria. Each tank is a different mini-ecosystem designed to eat or break down waste.

Waste Stabilization Ponds

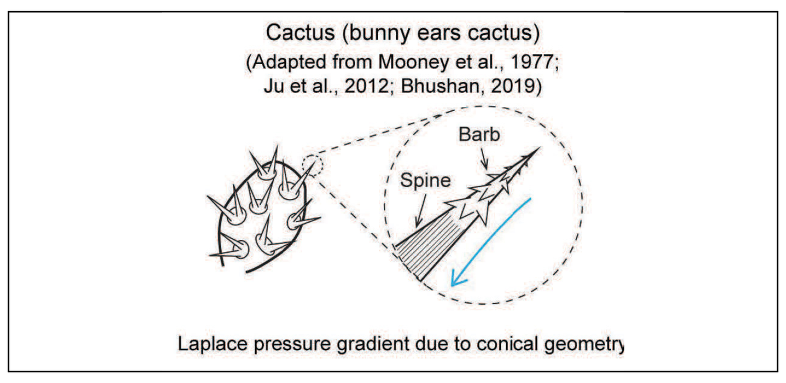


Characteristics

'Inputs: blackwater, greywater. Outputs: effluent, sludge.

Waste Stabilization Ponds (WSPs) are large, manmade water bodies. The ponds can be used individually, or linked in a series for improved treatment. There are three types of ponds, (1) anaerobic, (2) facultative and (3) aerobic (maturation), each with different treatment and design characteristics.

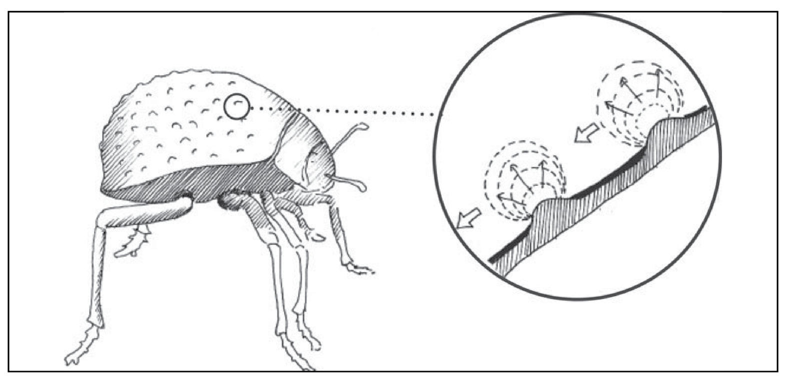
Capturing water (against gravity)



Characteristics

The Chihuahua Desert cactus (Opuntia microdasys) has evolved water-harvesting clusters of very fine conical spines. Its success relies on two physical phenomena: first, a gradient of Laplace pressure and, second, a gradient of surface-free energy. Laplace pressure refers to the pressure difference (between inside and outside) created within bubbles. When a droplet of water forms on the end of the conical spine, it forms asymmetrically – wider at the tip of the spine. The result is a pressure gradient that drives the droplet along the spine (even against gravity) towards the wider part of the cone. The effect is enhanced by microgrooves along the spine, which widen towards the base, creating another means by which the droplet is driven along the spine towards the base (referred to as a gradient of surface-free energy).

Capturing water (with gravity)



Characteristics

Namibian fog-basking beetle (Onymacris unguicularis) (fig. 102). This creature has evolved a way of harvesting its own fresh water in a desert. The way it does this is by climbing, at night, to the top of a sand dune and, because it is matt black, it is able to radiate heat to the night sky (the heat sink is actually outer space which is at a temperature of -273 °C) and become slightly cooler than its surroundings. When the moist breeze blows in off the sea, droplets of water form on the beetle's back. Then, just before sunrise, it tips its shell up, the water runs down to its mouth, it has a good drink and goes off and hides for the rest of the day. The effectiveness of this beetle's adaptation goes even further because it has a series of bumps on its shell that are hydrophilic and between them is a waxy finish that is hydrophobic. The effect of this combination is that, as the droplets form on the bumps, they stay in tight spherical form, which means that they are much more mobile than a film of water over the whole beetle's shell would be.

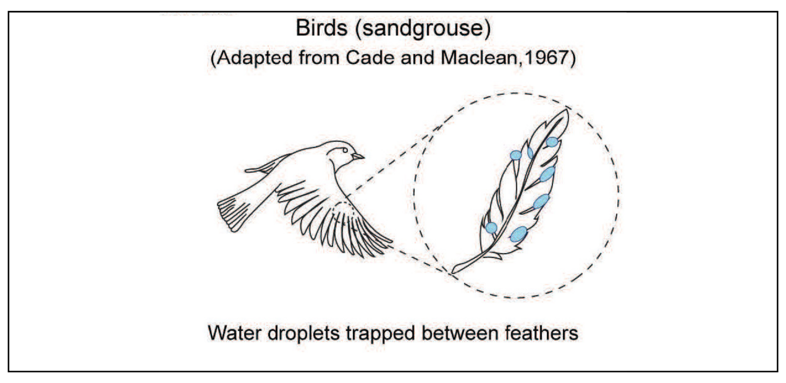
Water storage

Characteristics

The cacti's ribbed stems, which resemble concertinas, respond to this situation. These structures can absorb large quantities of water very quickly without any significant new growth – simply by expansion.

Other plants have adapted by storing their water below ground in large, swollen roots. An extreme example of this is the elephant foot – a species of yam that can grow tubers that weigh as much as 300 kg.

Minimizing water loss



Characteristics

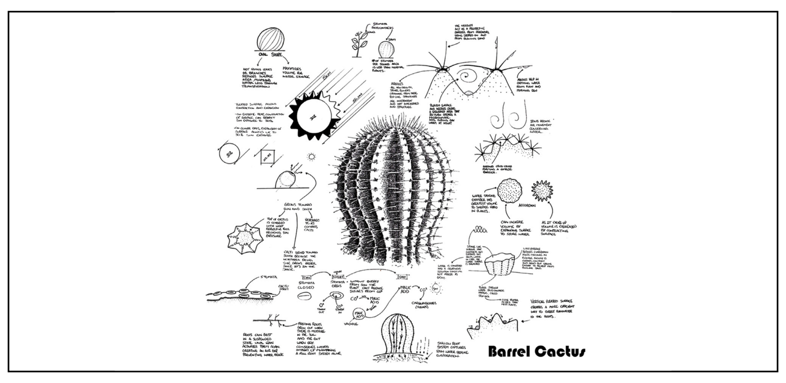
Some birds that live in deserts have black plumage, which might seem like a bizarre strategy but the feathers are protein structures (made from non-living keratin and containing UV-absorbing melanin) that, through their opacity, prevent most of the sun's heat reaching the birds' skin and consequently reduce water loss

Water transport

Characteristics

It may seem obvious that a straight line is the most efficient way to connect two points: but 'flow in nature is helical',133 Emeritus Professor Colin Caro at Imperial College London discovered. He has studied the flow characteristics in human arteries and demonstrated that a damaged artery fitted with a helical stent is subject to far less deposition of fatty substances than a straight stent. Deposits occur where flow stagnates, which a helical stent minimises. A spin-out company is now commercialising the use of helical tubing, focusing on specialist applications where an even flow rate is needed. As the manufacturing cost of helical pipework decreases, more widespread application of the idea in the construction industry is likely to follow, with the potential for significant energy savings and reduced maintenance.

Minimizing water loss



Characteristics

Numerous species of cacti are covered in fine white filaments, which not only reflect the sun but also help to trap humid air next to the living tissue so that the exchange of gases necessary for photosynthesis can continue while water loss is minimized.