TU Delft
Delta Intervention Studio , Sep 2015
P4-Report
Yi Chien Liao 4326202

Design Mentor: Esther Gramsbergen
Building technology mentor: Koen Mulder
External Examiner: Gerard van Bortel

Water Resilient Living in Houston

The Porch of Kashmere Gardens neighborhood

Photo credit: Brett Coomer/Houston Chronicle
People board a canoe from a parking lot before floating off into floodwaters near Bear Creek Park on Saturday, May 30, 2015, in Houston.

This report is a part of author's graduation project in Delta interventions studio at Delft University of Technology (TU Delft). The aim of this project to investigate water related architectural design which in this case is to develop water resilient living of a bayou coast community in Houston, Texas, USA.

The project site is located in a flood prone area in the suburb of Houston, Kashmere Gardens community. Regarding urban context and water context, the design is oriented to show a water resilient solution which can achieve a better environmental impact and provide an alternative water management method among residential development.

Hereby, I would like to thanks Ir. Esther Gramsbergen for all the supports of ideation and guidance of design. And thanks to Ir. Koen Mulder for the tutoring of building technology and all the technical engineering knowledge sharing.

Yi Chien Liao
Sep. 2015

TU Delft
Delta Intervention Studio , Sep 2015
P4-Report
Yi Chien Liao 4326202

Design Mentor: Esther Gramsbergen
Building technology mentor: Koen Mulder
External Examiner: Gerard van Bortel

Water Resilient Living in Houston

The Porch of Kashmere Gardens neighborhood

Content

1.Context

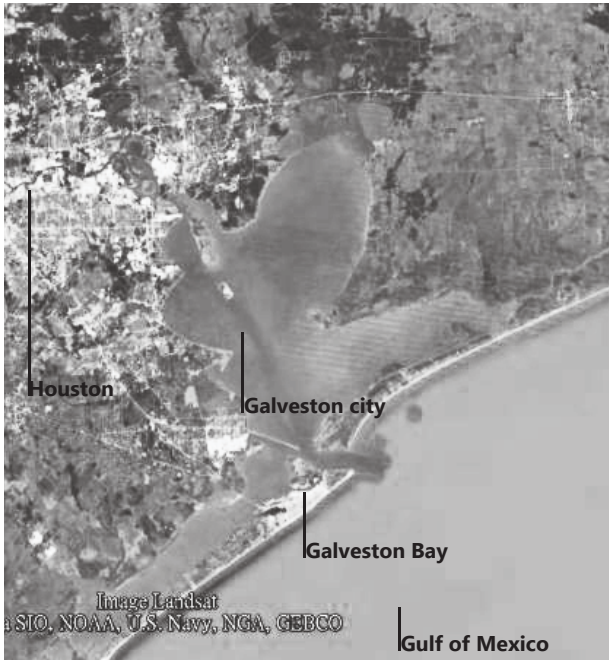
1.1 Global Context

More than 65% of populations all over the world live in cities. At the same time, these cities are mostly located in delta areas where several watersheds consist of. Water is a fundamental natural resourse for human life and cites. However, the tendency of urbanization increases the pressure on these delta cities' natural resourses, which are under threat of pollution or unbalanced usage. Moreover, the climate change, sea level rising, and natural disaster (i.e. earthquake) nowadays are challenging these delta cities to survive. In order to response these situations, delta cities not only have research adaptive solutions, but also need to concern the sustainability within urbanization. There have been several existing records that delta cities were damaged by flood, hurricane, typhoon, or tsunami on this earth, which damage not only human life but also living environment.

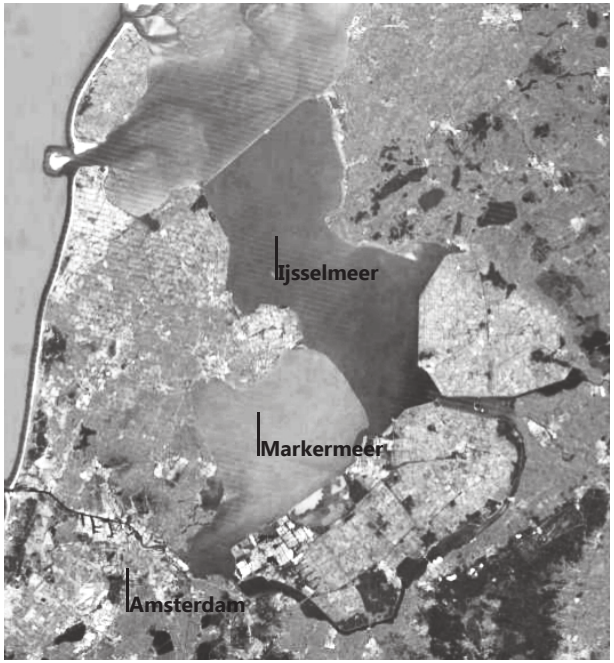
As a result, new interventions to engage water and urbanism on Delta areas are needed. It is necessary to develop safer and better water system, but also to stimulate stronger spatial identities between water and city.

1.2 Framework of project

The framework of Delta Interventions studio at TUDelft is based on global context, especially on climate change aspect. There are two given delta areas for investigation in Delta Interventions studio in this academic year 2014-2015, they are Galveston Bay in Houston and Ijsselmeer in Netherlands. Both of them are serving great elements of transportation, settlement, culture, and ecology on one hand, and risk for flooding on the other hand. The project in this report is located in Galveston Bay region. Therefore the following research will be oriented to certain climate situation of this region. Because of author's studying is in Netherlands, Dutch references and methodology will be deployed.



Galveston Bay & Houston
The chosen site for design project in this theisis
Source from google map



Ijsselmeer in Netherlands
Source from google map

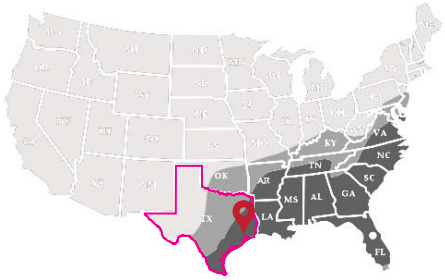
1.3 Galveston Bay context

Galveston Bay is the 7th largest estuary in the United States, and is the largest estuary in Texas, located along the upper coast of Texas. It is connected to the Gulf of Mexico and is surrounded by sub-tropic marshes and prairies on the mainland.

The delta around Galveston bay consists of 2 main streams which are San Jacinto River, Trinity River. The San Jacinto River drains an area of 3,976 square miles with almost two million acre-feet of runoff. The Trinity River is a 1,140 km river that is the longest river that flows entirely within the U.S. and the state of Texas.

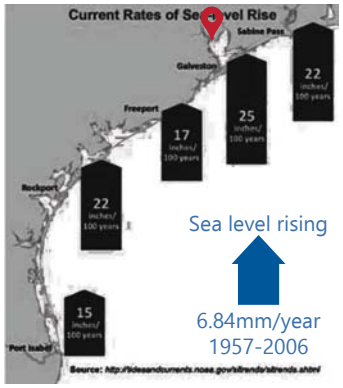
Galveston bay area is also a hurricanes prone area. Looking back to the history, hurricanes have brought many times of devastated damage for all the towns and cities around the Galveston bay. The Hurricane also changed the urbanization from Galveston Island to Houston city.

Hurricanes bring strong wind which can cause tidal surge, heavy rain fall can cause flood. Either of them can cause enormous damage in human life aspect, in economical aspect or in ecological aspect.



Humid subtropical zone
Transitional Humid subtropical zone
Project site

Source: http://www.guide-to-disney.com
Author editted



Trend of sea level rising

Delta studio Group work
Author editted

Major road network in Harris County, Houston is a transportation hub

Harris County & Housotn
Source: https://ceprofs.tamu.edu/

Waterscape & Houston city scape
Source from google map

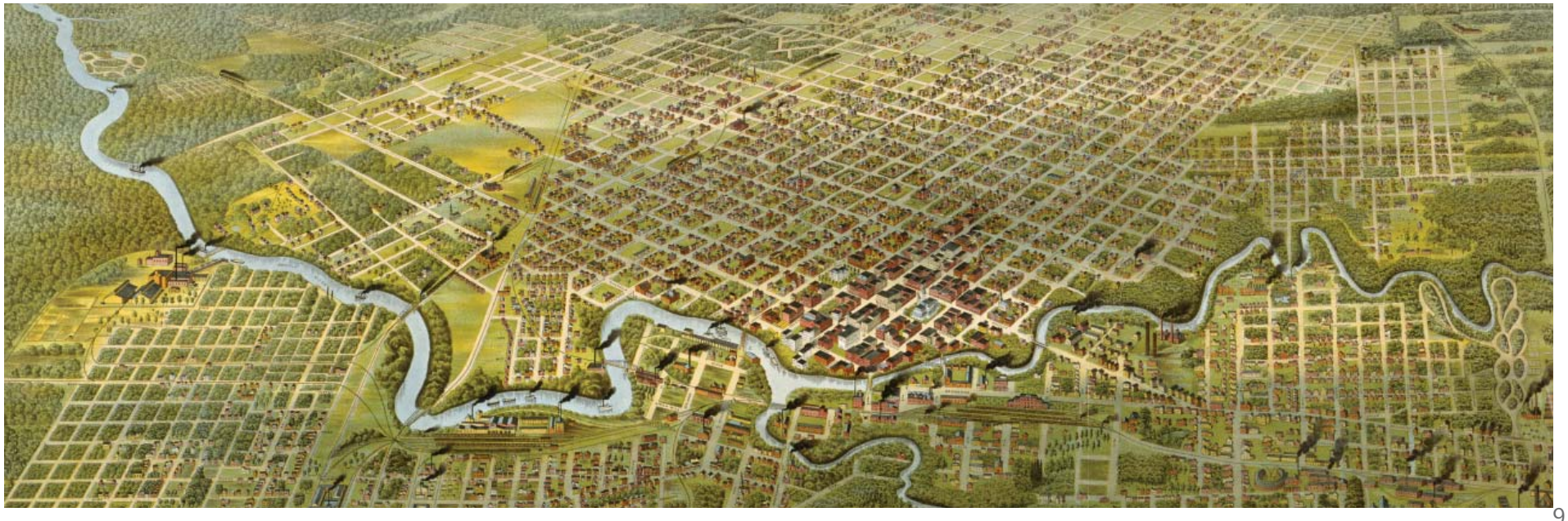
1.4 Houston Context

Houston is one of biggest metropolitan area in America. It has strong economy and dense population. The most important characteristic of Houston is oil industry. Houston is a city highly depends on oil industry. Since discovery of oil, Houston grew rapidly with enormous working population, shipping industries, railway transportation facilities. Houston which is the 1st petrochemical manufacturing area in the world is the leading building oilfield equipment

Until now, Houston is the 1st populous city in Texas, the 4th populous city in the U.S., the 5st metropolitan area in the U.S. the 10th largest port in the world, the 1st concentration of research and healthcare institutions in the world.

One of reasons for these fulfillments of Houston nowadays is water. Houston is also so called “Bayou City”, which describes directly the landscape of Houston. The water cultivated Houston, but also brings a huge potential risk of danger. Hurricane will cause Houston area flooded by tremendous amount of rainfall, and can possibly bring with storm surge which can cause serious harm on port industrial area. Therefore, channelization of bayous for drainage, construction of storm barrier and dike are seemed to be solutions for Houston to survive.

Houston & Buffalo bayou 1891
Source: http://www.maps.com/



1.5 3 x 3 x 3 Analysis

The 3 x 3 x 3 layers analysis is one of methodologies in this Delta interventions studio. This approach is aiming to investigate the urban context from 3 perspectives: urban fabric, landscape, and infrastructure in 3 different iconic years. Therefore, there will be 9 mapping results which can response to current situations.

Urban fabric

By 1865, Galveston Island had been the most populous area around the Galveston bay because of good trading location. In 1900, the Great Storm destroyed Galveston island. By 1905, the urban development had started to move from Galveston to Houston. 1901-1940s, was the era so called "oil boom", the Houston city grew rapidly. By, 1968 Houston city kept growing. Now, Western part of the Bay is developed. And Houston is still growing.

Waterscape

By 1865, the channel in the Galveston bay had been made for transporting goods. By 1905, Galveston Dike had been constructed. Galveston harbor had been developed. The Clear lake area had been developed. Artificial islands in front of port had been constructed with dredged materials. Crystal bay waterfront had been developed. Dams on the up streams of rivers had been built for controlling water flow. Several Ship channels had been constructed around Galveston bay.

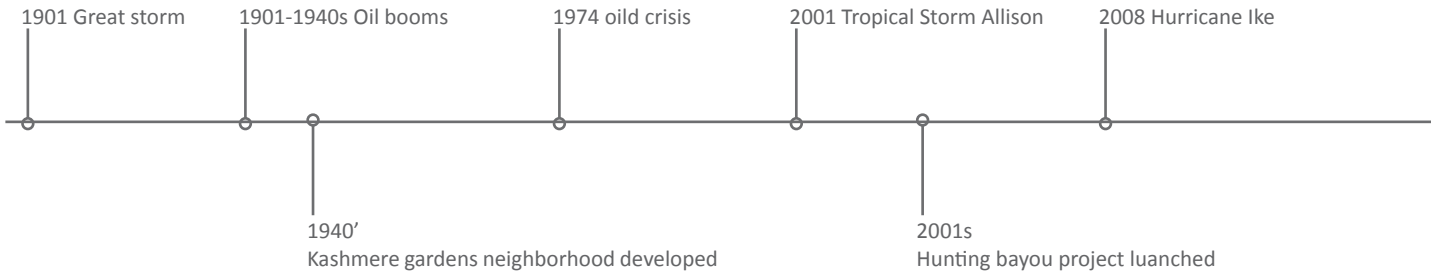
By 1968, more lake areas was developed. Galveston Dike had extended to the west south. Until now, the contour of waterscape in Galveston bay doesn't change a lot from 1865 till now. The red part shows the channelization for flood defend and transportation.

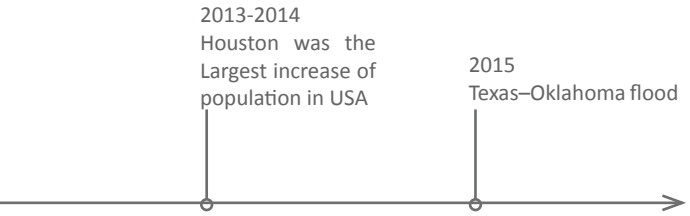
Infrastructure

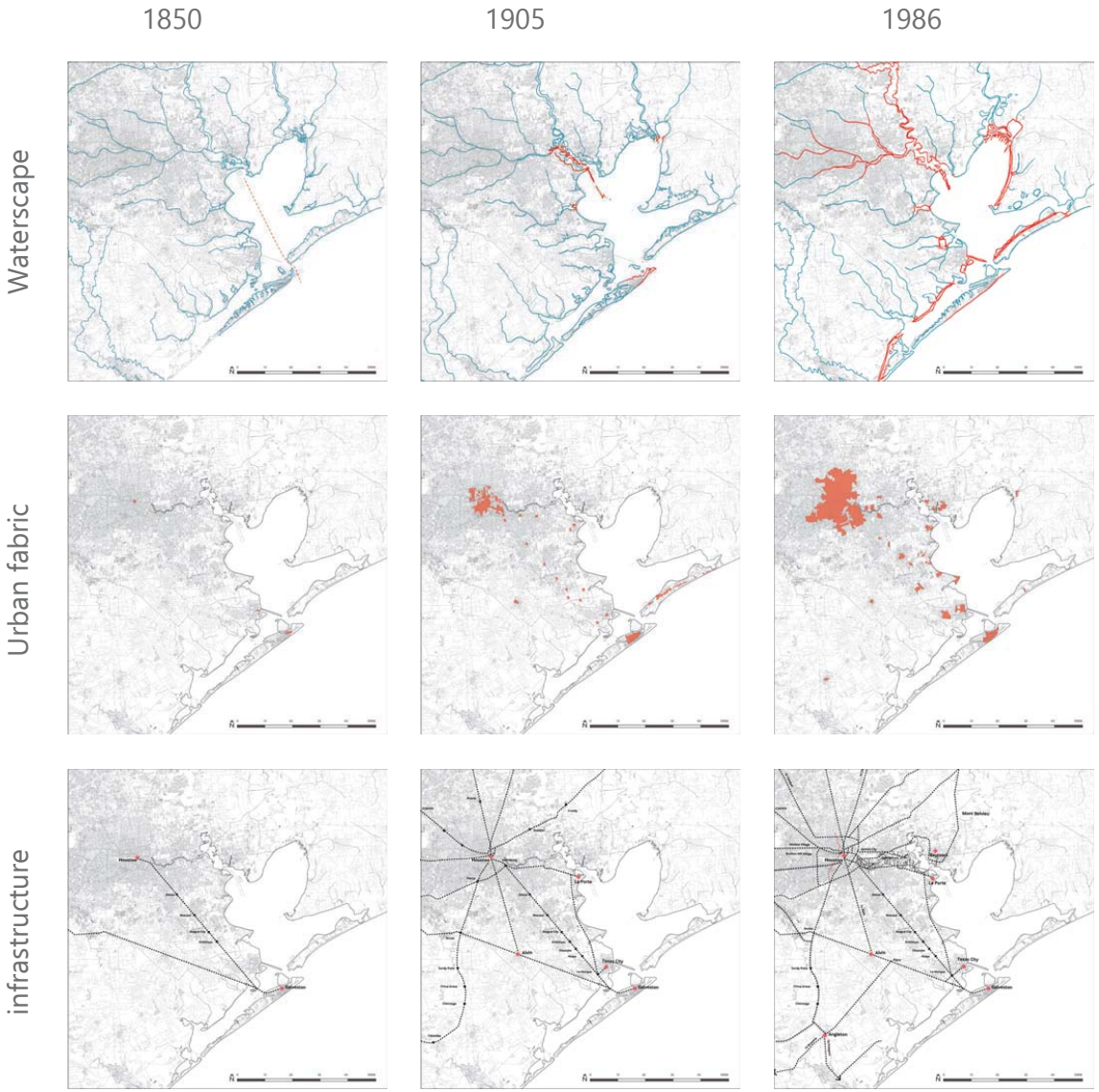
By 1865, railroad had been the main transportation on the land. Galveston and Houston was the terminal hub. By 1905, railroads expanded from Houston, stretching to radially to other cities. By 1968 Car roads had rapidly developed, cars started to dominate land orientated transportation. Now, cars are the essential land transportation way, and railroads only for cargos and industrial products transportation.

1.6 Time line

There is more than 65% population all over the world living in cities. At the same time, these cities are mostly located in delta area where several watersheds consist of. Water is a fundamental natural recourse for human being and cites. However, the tendency of urbanization increases the pressure on these delta cities' natural recourses, which are under threat of pollution or unbalanced usage. Moreover, the climate change, sea level rising, and natural disaster (i.e. earthquake) nowadays are challenging these delta cities which highly depend on water. In order to cope with this situation, delta cities not only have to dedicate to find adaptive solutions, but also need to concern the sustainability of urbanization. There are already several existing records that delta cities







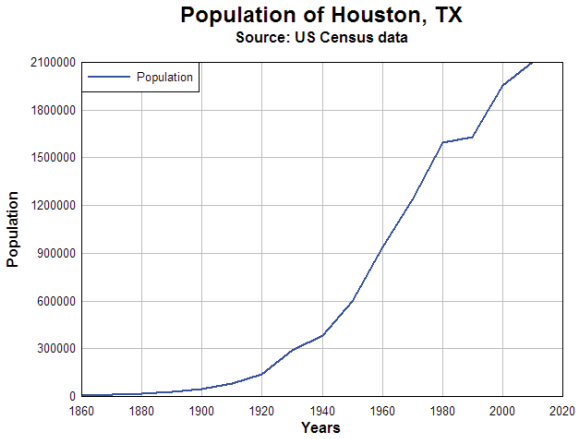
Galveston bay & Houston
3 x 3 x 3 layering analysis
Delta studio group work

1.7 Houston phenomena

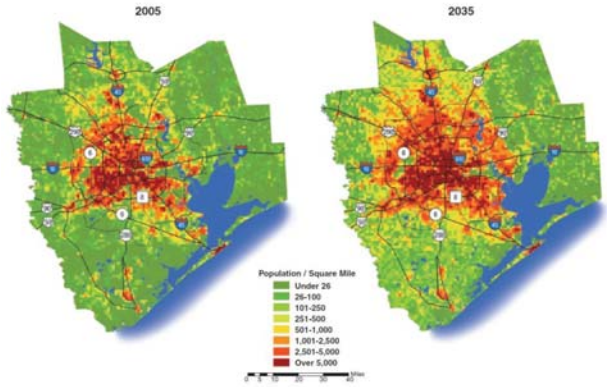
Houston, Bayou City, even though it has strong economy and rapidest population growing, it always has to find solution for the climate change. In addition to the climate challenges, this big metropolitan area meanwhile has several problematic phenomena.

The population growing is because of job opportunities increasing in Houston. People move into Houston for job and development. However, this growth and development are stretching only to the western part Houston, which cause **unbalanced emphasis for urbanization**. The city become bigger but the eastern suburban part area neglected. Moreover, in order to cope with the growth of western part of city, public infrastructures also focus on there. Therefore it turns out that people in eastern part of Houston are relatively hard to reach the downtown area. As a result, eastern parts of Houston become more isolated.

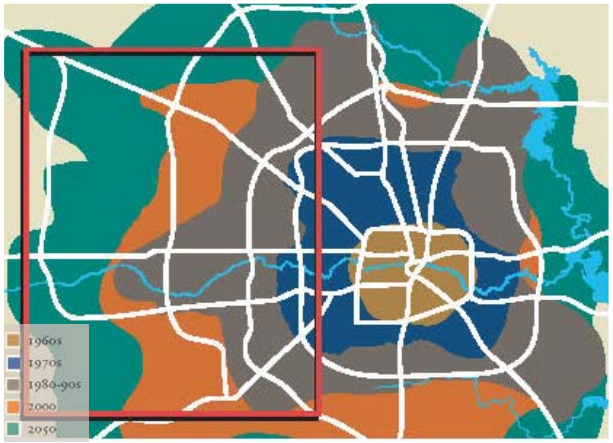
One of the reasons is that some people in eastern part of Houston in suburban refuse to develop public infrastructures, and then they don't need to share tax increase. Coincidentally, people in these eastern suburban areas have relatively lower income than other parts. Most of the families have been lived there from 50 years ago, which was period of modernization of Houston. Most of them were working class, until now this social structure doesn't change so much.



Population Growth Forecast
Source: US Census data

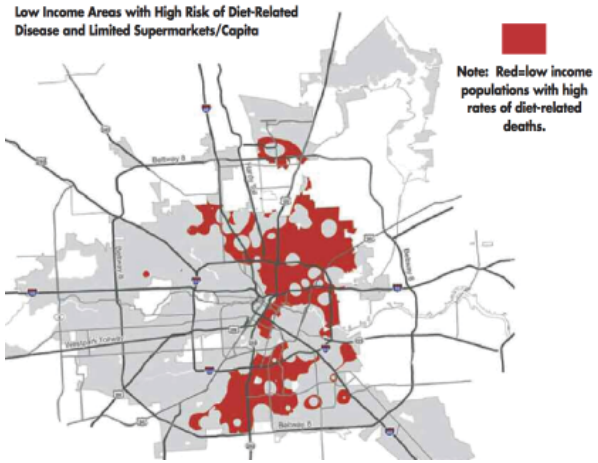


Population & Urban fabric Growth Forecast 2005-2035
Map Credit: Houston-Galveston Area Council

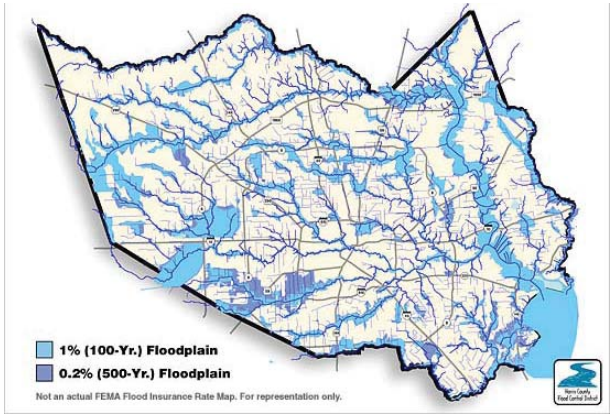


Based on data and population growth trend, local communities and organization are seeking new plan to cope with tremendous population growing in West Houston. GREATER WEST HOUSTON 2050 is one of the proposals
Source:West Houston.org

The phenomena are becoming a circulated loop:
Less income from government causes fewer resources for development. Less development causes unbalanced infrastructure distribution. Less public infrastructure cause isolated urban situation. Isolated urban situation causes people have less chance to reach opportunities which metropolitan center can provide. People has more cost on transportation to center and less money for living costing
Incomes areas relatively lower and moreover people have difficulty to support daily living. The “food desert” problems start to appear in these isolated and lower income regions. People would like to use money to support their least living in vulnerable flood prone areas rather than increase tax for government to development and conduct water management policies.



Low income distris are facing food desert issue.
Source:The Food Trust, 2011



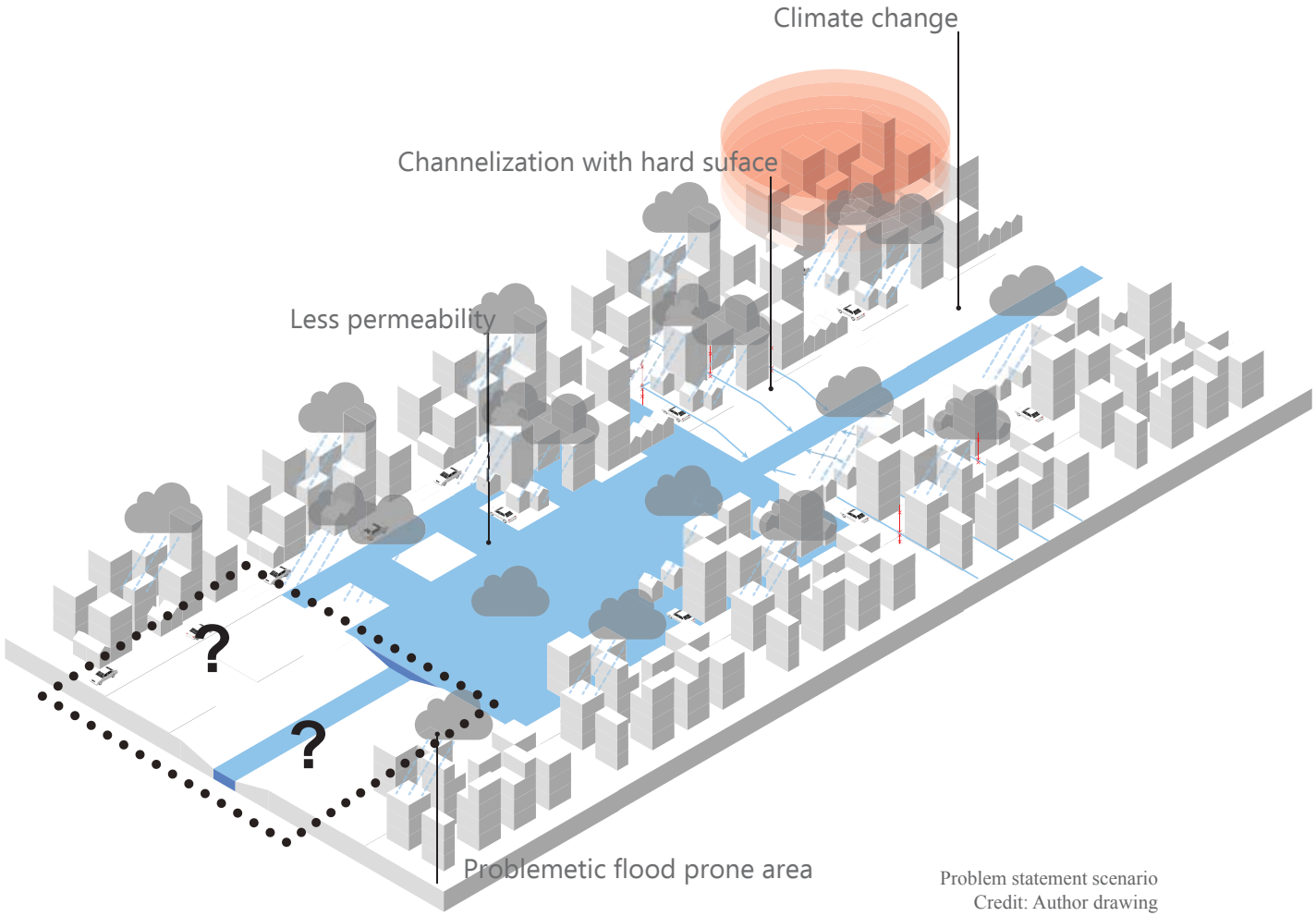
Flood plain in Houston
Source:Harris Flood Conctrol Distric


Downtown Looking South, Tropical Storm Allison, 2001.
Source:Harris Flood Conctrol Distric

1.8 Problem statement

Houston is a delta city which consists of several watersheds. Water not only brings Houston a flat landscape which is suitable for sprawl of city, but also causes the danger of flooding. Hurricanes and heavy rainfall result in flood very often in Houston. In order to drainage Houston city efficiently, concrete channelization of natural bayous was recognized as a solution, but at this moment, lack of water storage capacity and lack of permeability of the stream valleys causes an increase of flood risk. Especially at the lower parts of the city, for instance Kashmere Gardens, whole neighborhoods are under threat.

Many bayous are guided by concrete section without any strategy for people to approaching water. The lands between housing areas and bayous have become neglected and problematic lands, losing the connectivity between human activities and water. These open spaces are not well maintained and do not contribute to the quality of the living environment. Especially in the low situated, low income neighborhoods Kashmere gardens the above sketched problems are coming together. At the same time the area is facing other problems like isolated urban location and low quality housing stock.



Problem statement scenario
Credit: Author drawing

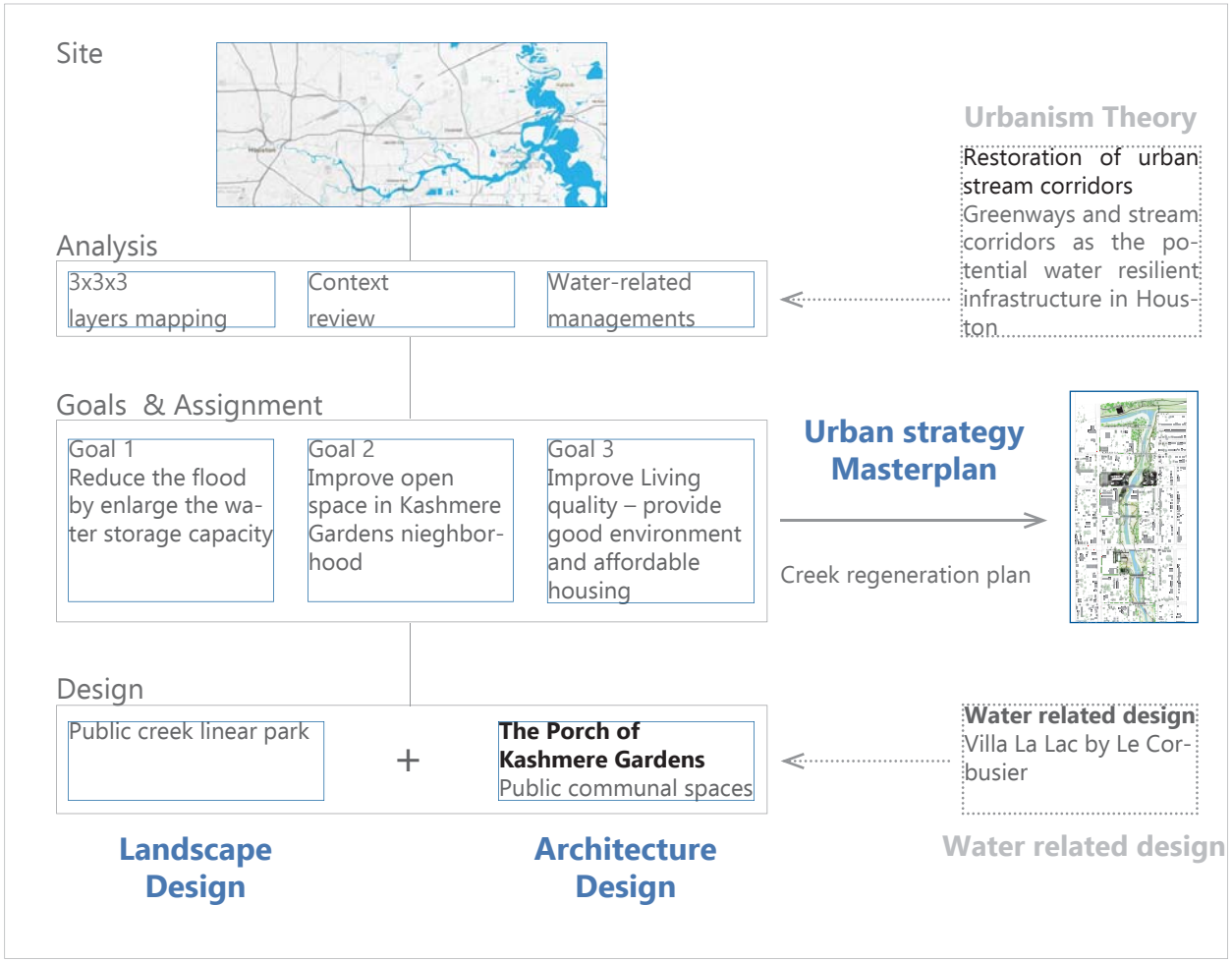
1.9 Research question

People are afraid of being forced to move out because of on-going water management interventions and losing their property. The initial desire of this project is aiming to provide a safer living environment and better quality along the water. Especially the preference of author of this report has preference to contribute his design for people who are really in need.

In Houston, there are several ongoing water management projects, which can also be part of the consideration in the project. Since the research realm is wide and various, the assignment should not be limited in architectural methods. The project proposal should always have wider perspective on urban scale and sociological aspect consideration. It is important to clarify the levels of research and design scale, and articulate aims in the project.

The project site is set up in Hunting bayou region where is relatively venerable, lower income and flood prone area in the Houston suburban, for example Kashmere Gardens neighborhoods.

How to integrate the restoration of urban stream corridor with water resilient living?

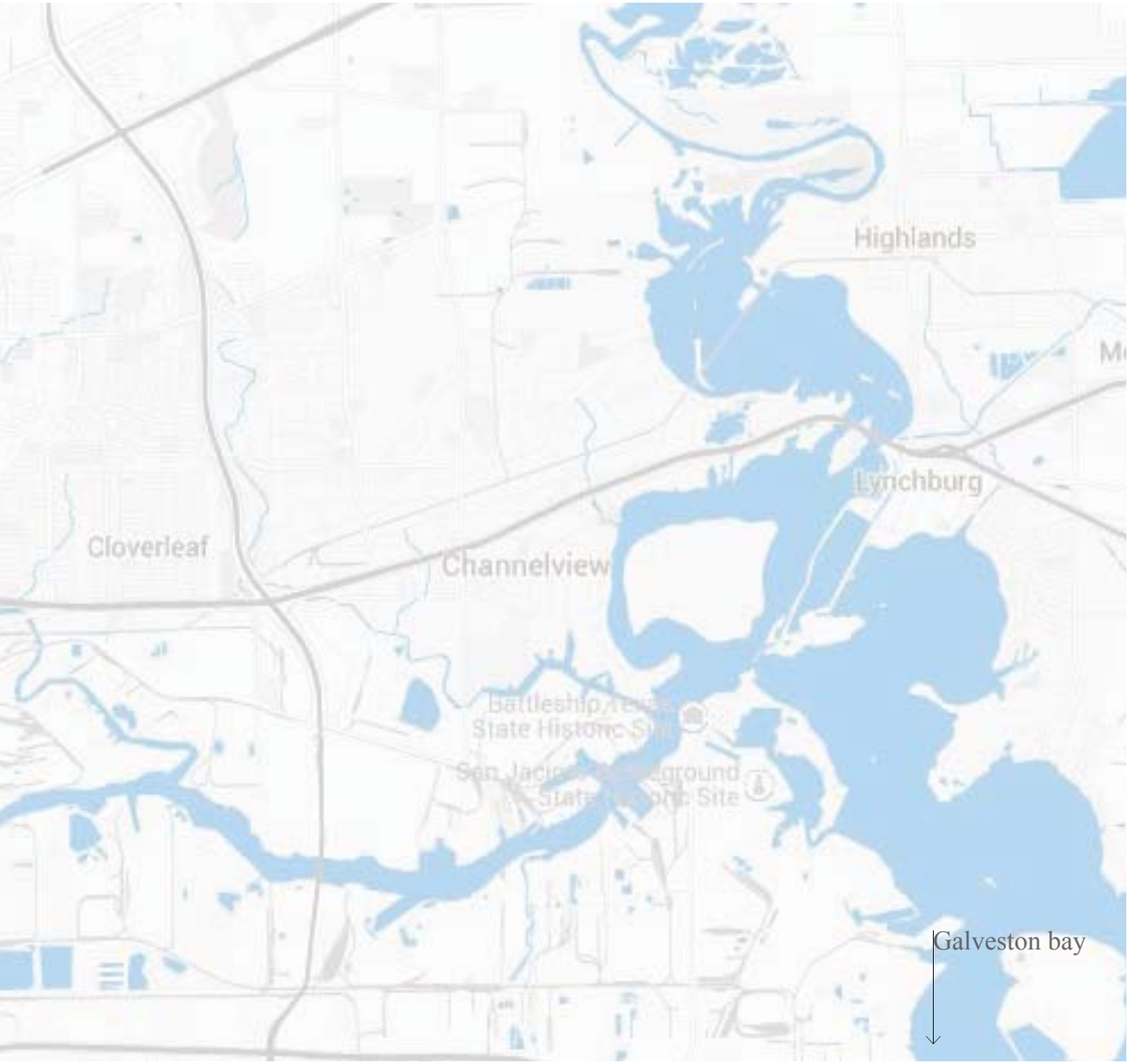


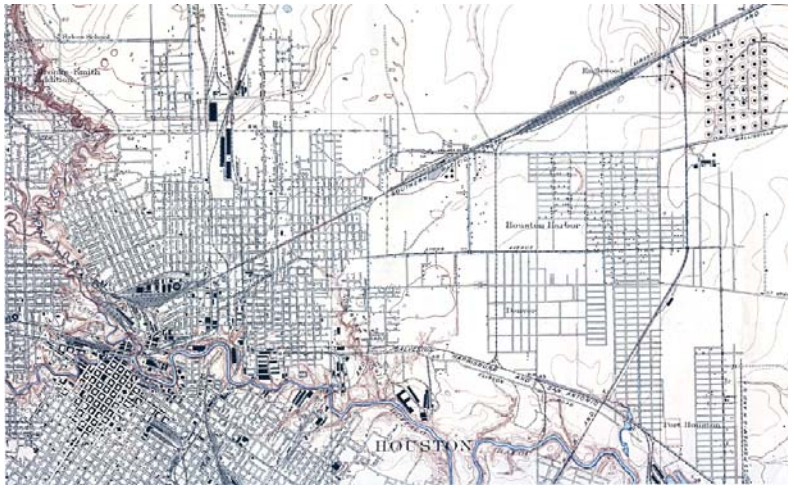
Overall the process of research & design
Credit: Author drawing

2. Hunting Bayou & Kashmere Gardens

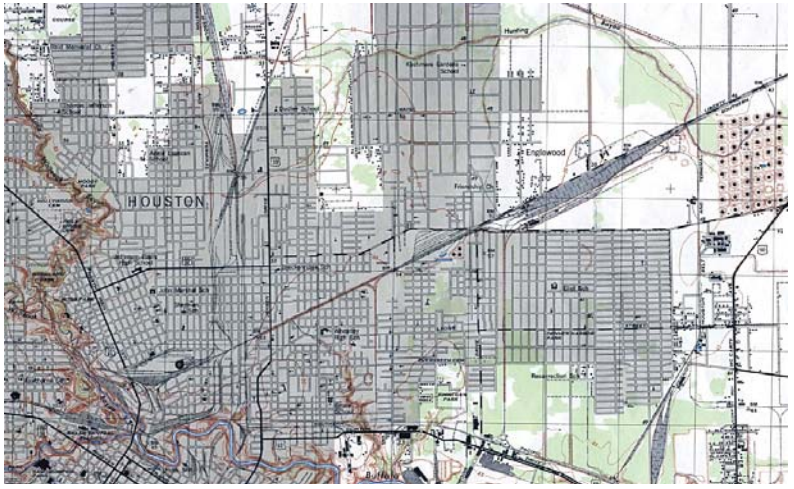
Houston watershades
Source:http://www.bayoupreservation.org/
Author editted

Relationship with Houston downtown, Buffalo bayou and Galveston bay
Source: Goole map
Author editted





Kashmere Gardens didn’t exist
Houston 1922

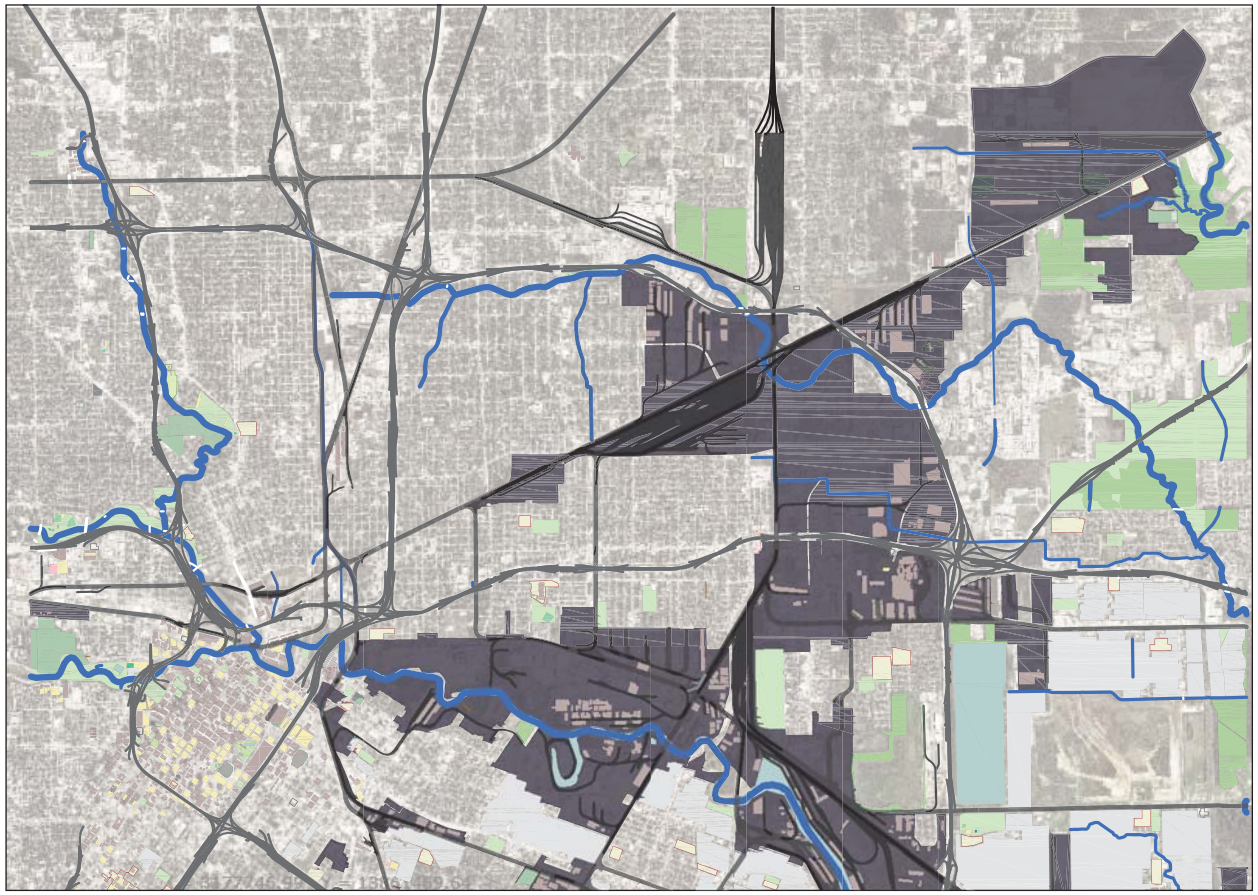


Kashmere Gardens had been planned
Houston 1946

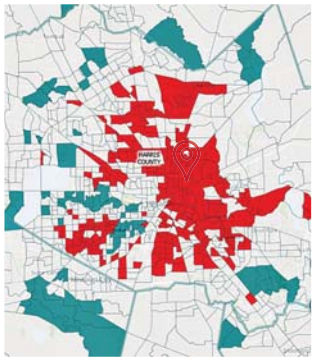
2.1 Hunting Bayou context

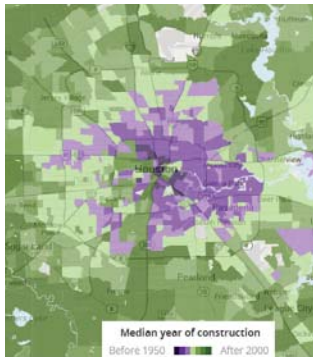
Hunting bayou is located at North-East part of Houston, the bayou watershed is mostly aligned the margin of the first loop of high way, which means this area has been developed from very earlier time than others. The growth of Houston urban fabric was in radial direction from the downtown to first loop in 1940s, and then in 1970s the second loop has been constructed. Normally within the second loop areas are the most populous areas. While in upstream of Hunting bayou region, especially in Kashmere gardens neighborhood, is declining on water safety aspect, financial aspect and urban densification. The upstream of hunting bayou area, especially in Kashmere neighborhood is surrounded by industrial districts and isolated by high way and railroads. While, the development of Houston is tending from downtown towards to the western part so that this region is relatively densified. The lack of connectivity with public amenities becomes one of issues for this region.

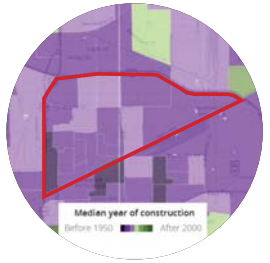
There are some other regional issues; for example, mostly the residents here are working class people who have relatively lower wages. It has been recognized as an urban poverty area.



Kashmere Gardens had been surrounded by industrial and railroads
(Railroad is only for goods and cargos, not for normal passengers)
Houston now







8%
16%
34%

Low income
High income

< $66,000
$66,000 - $90,000

1949
1951
1966

Less desification

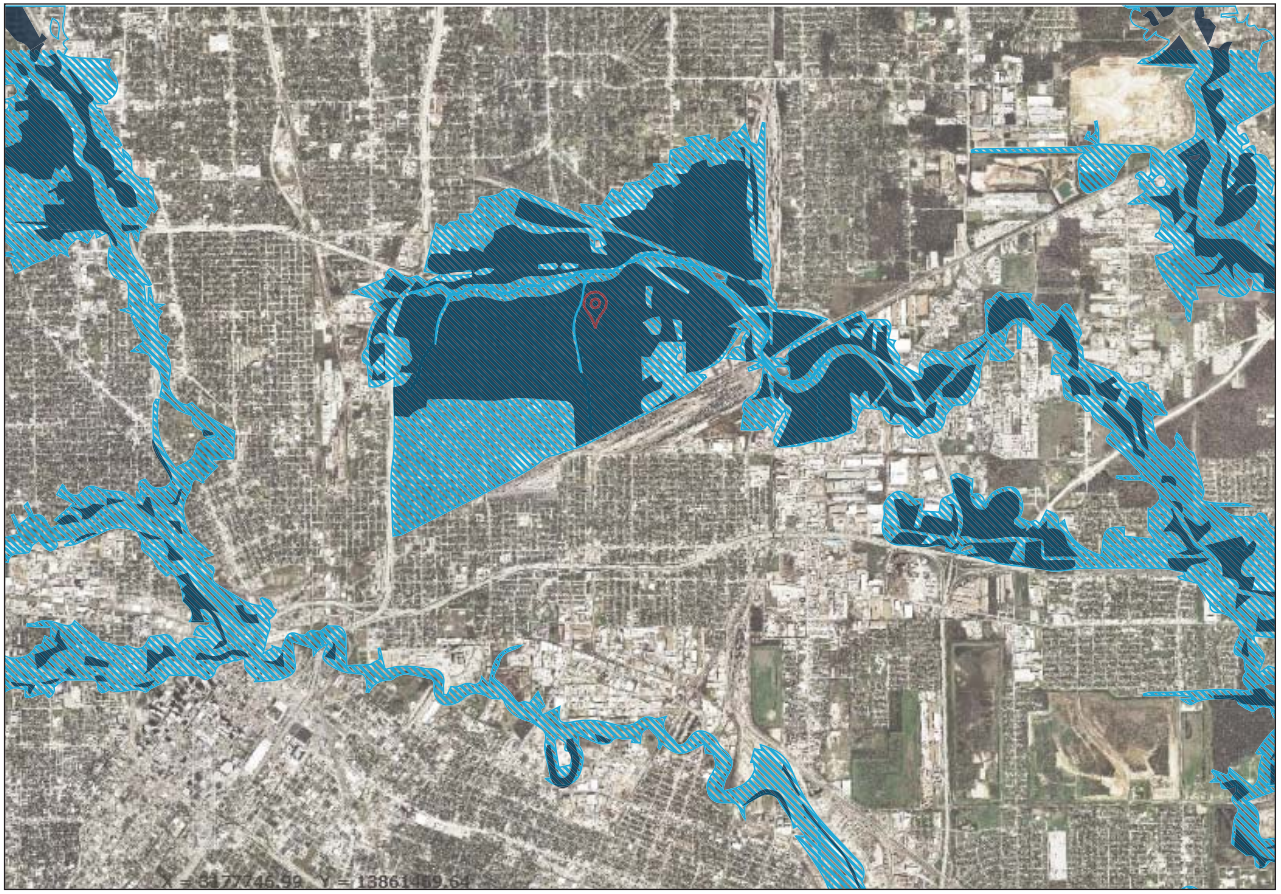
Lower income

Lower land value

Earlier developed , but-less maintained houses

2.2 Flood plain

The upstream area of hunting bayou is mostly located at 1-100 years flood plain. At the same time, the whole Kashmere gardens located at exactly within flood plain. The main reason for these situation is because of relatively lower altitude, which cause this region easy to be flooded when heavier rainfall coming. At the same time, the cities around Galveston bay including Houston are hurricanes prone areas. The hurricane always comes with enormous amount of rainfall which drainage systems in urbanization area might not have enough capacity to cope with it. Therefore, the flood will be happened in this case. Before, to channelize bayou with concrete section was seemed as an efficient way to cope with big amount of water. However, these hard surface section bayous are lack permeability and detention capacity, which is increasing the flood risk.

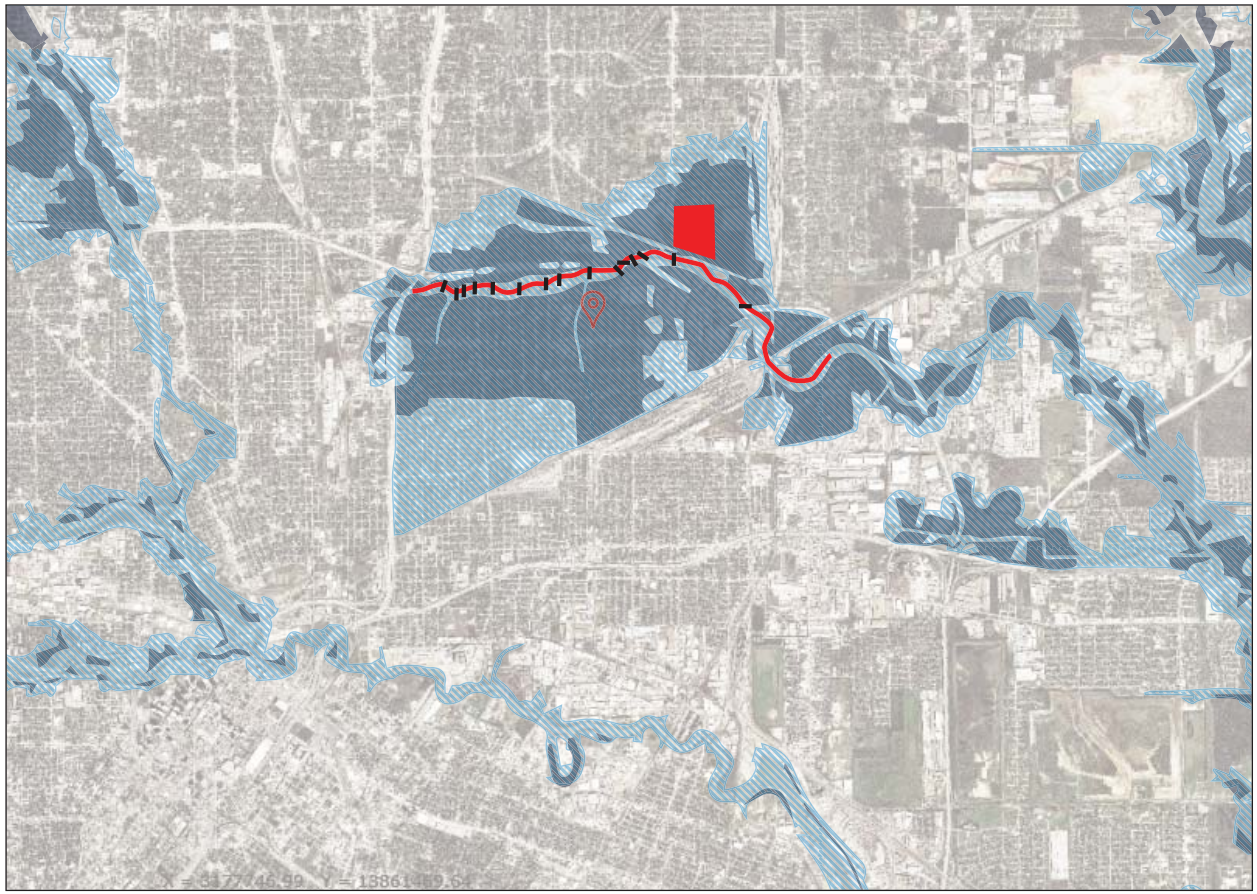


2.3 Current water management: Project Hunting

The Project Hunting is carried on by Harris County Flood Control District for already 20 years. The ongoing strategies are to excavate a storm water detention basin on a 75-acre site near the northeast corner of Homestead Road and Loop 610 (Northeast side of Kashmere garden neighborhood), to widen and deepen the mainstream of Hunting bayou with natural surface channel section. Replacing or modifying approximately 20 bridges.

When conducting Project Hunting, the water front area would be transformed into open public park for recreational activities and cycling path.

Due to Project Hunting, several households need to be removed. Some of residents are not willing to accept the removal. Therefore, an intelligent strategy to compensate removal and alternative reallocation should be causally considered.



Project Hunting, water management in Houston
Source: US Army Corps of Engineers

Project site

Tropical Storm Allison in 2001

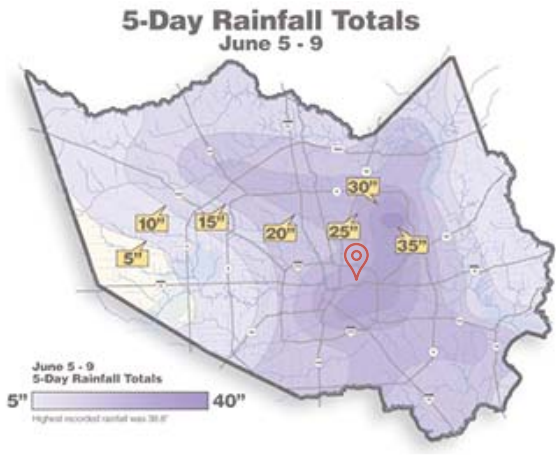
Tropical Storm Allison devastated southeast Texas in June of the 2001, especially brought the worst flooding in Houston. The storm came with tremendous quantity of rainfall along its path, peaking at over 40 inches (1,000 mm) in Texas.

Tropical Storm Allison caused Houston:

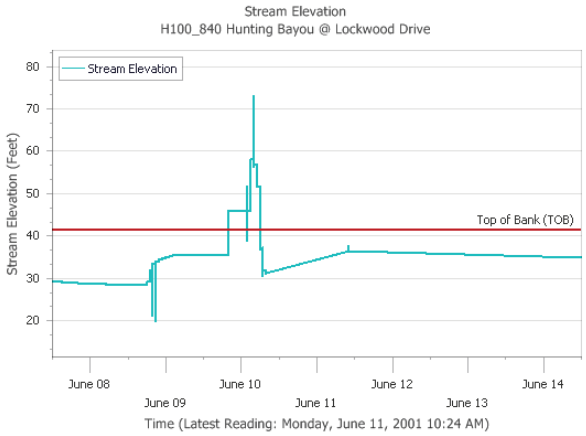
- Around 30,000 people became homeless
- Over 70,000 houses flooded
- 2,744 homes destroyed
- Downtown Houston was inundated with flooding, causing severe damage to hospitals and businesses.
- 23 people died in Texas, 41 deaths along its entire path
- $9 billion (2001 USD) in damage along its entire path

The rainfall was focusing on the north-east Houston, especially within loop 610.

Almost whole Kashmere Gardens neighborhood was totally inundated in flooding. The "Project Hunting" water management had been accelerated since Tropical Strom Allison.



Rainfall totals from Allison and its remnant from June 5-9, 2001.
Source: Harris County Flood Control District's network



Hunting bayou watershade, rainfall and water capacity of bayou
Source: Harris County Flood Control District's network

Kashmere Gardens neighborhood arial view during Tropical Storm Allison in 2001
Source: Harris County Flood Control District's network

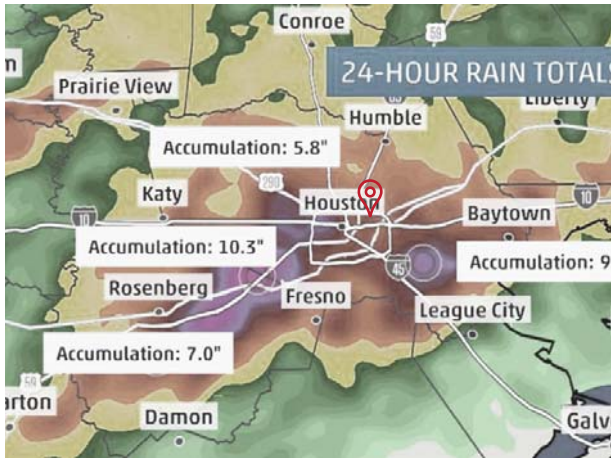
Kashmere Gardens neighborhood arial view during Tropical Storm Allison in 2001
Source: Harris County Flood Control District's network

Texas flood on Memorial Day, 2015

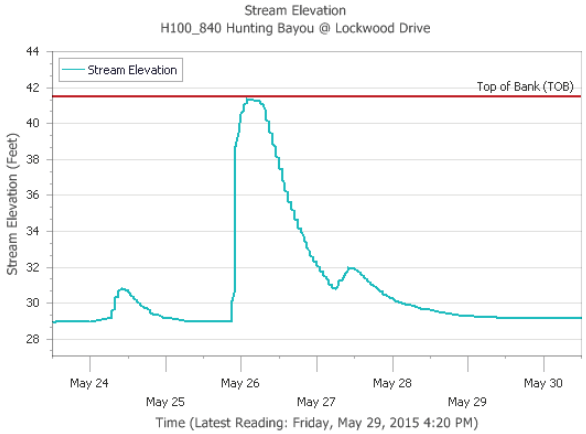
On 26 May of 2015, it was not only a usual Memorial Day holiday but also another sorrowful record in the Houston flooding history. “It was first Level 1 emergency activation for Harris County since Hurricane Ike in 2008.” (1) It was estimated that up to 4,000 properties with significant damage Houston Mayor Annise Parker on 26th May. (2)

Unlike Tropical Allison storm in 2009, Texas flooding was mainly focusing on west south of Houston city.

The Kashmere Gardens neighborhood was not flooded this time according to the Hunting Bayou monitoring system. However, according to the data of monitoring system, the water was almost exceeding the capacity of bayou.



24-hour radar-estimated rainfall totals in the Houston metro area through early morning on May 26, 2015.
Source: The Weather Channet



Hunting bayou watershade, rainfall and water capacity of bayou
Source: Harris County Flood Control District’s network

Mass flooding in the Houston, Texas on May 27.
Photo Source: MGN Online

(1) Houston Flood 2015: How Does It Compare to Allison and Other Historic Floods?, by Jon Erdman, The Weather Channet
(2) 2015 Texas–Oklahoma flood and tornado outbreak , Wikipedia

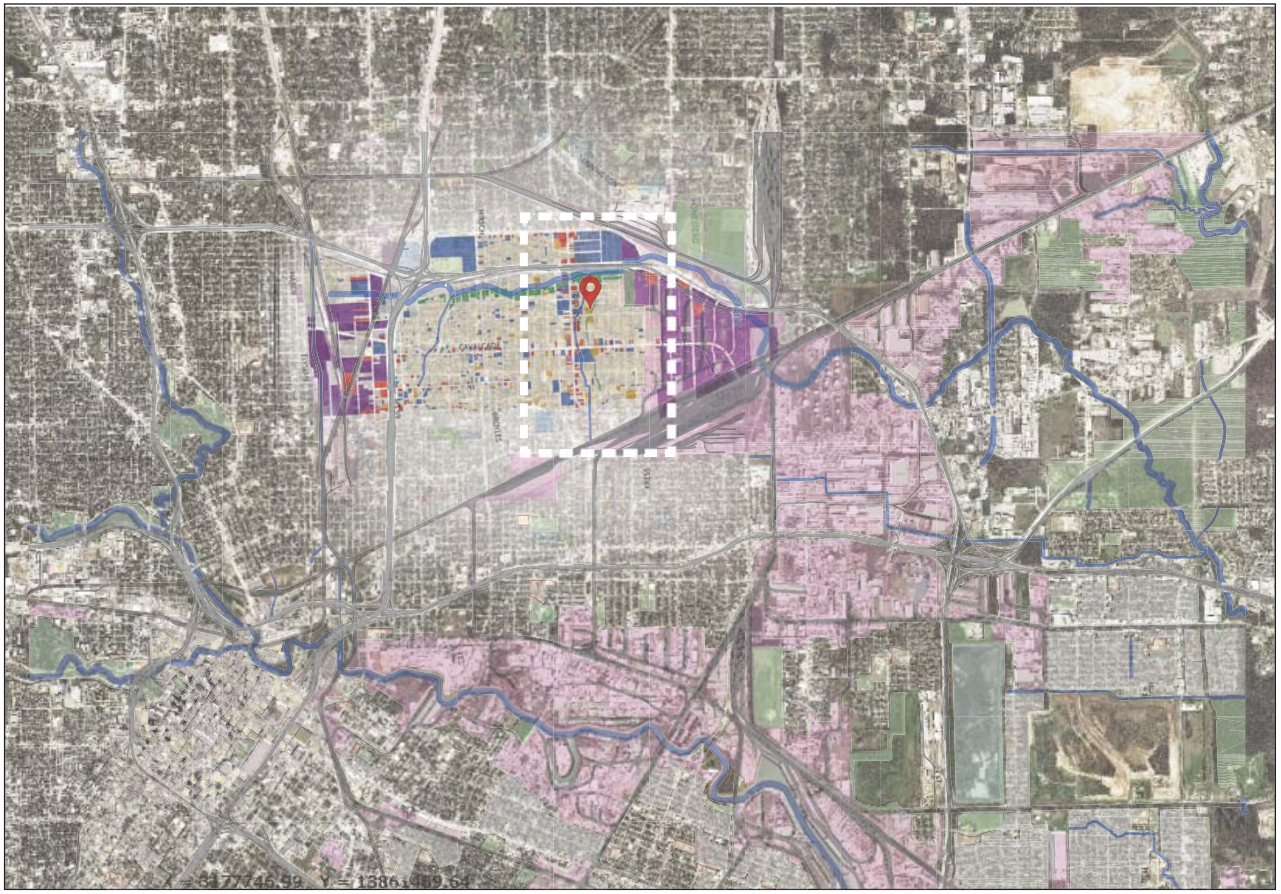
2.4 Master plan of Kashmere garden 2014

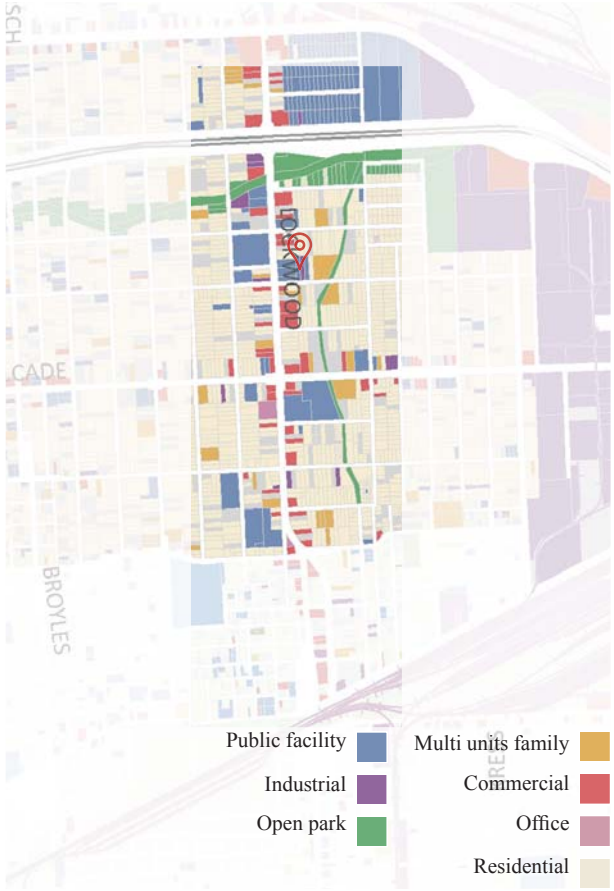
The image shows the land-using mapping in Kashmere Gardens neighborhood. From the map, it is obvious to tell that there is one road (Lockwood Dr.) where most of public amenities (i.e. community center, public library, and churches, school, bus lines), commercial plots and multi-unit apartments are located on.

This road (Lockwood Dr.) can be recognized as one the main street or urban axis in this region. This main street provides the north & south communal connection to link educational, transportation, grocery and eating function. At the same time, the creek which is parallel to the main street in Kashmerer Gardens neighborhood is relatively invisible and has flood risk.

Even though the creek and the main street are parallel and close to each other, there is no any spatial relationship in between these two urban linear elements. The water here doesn't contribute to the quality of living environment. While, the main street doesn't have any intention to guide urban fabric to relate to the water.

As a result, the lands in between water and urban fabric are becoming neglected (because of less maintain) or problematic (because of flood risk).





The following research will be narrowed down to focus on the creek which is parallel to the main street (the colorful street in the map) of Kashmere Gardens neighborhood.

2.5 Assignment

2.5.1 Conclusion of analysis

Above several issues can be categorized into 4 aspects which can bring the objects into my assignment.

1. Water safety aspect: How to reduce flood risk under the context of Hunting project
 >Possible solutions: widen & deepen creek and main stream

2. Sociological aspect: How to improve open space in Kashmere Gardens
 >Possible solutions: Open public park with vegetation and vistas

3. Economical aspect: How to level up the living quality in affordable way
 >Possible solutions: affordable materialization, collective housing

4. Spatial aspect: Sequence of experiences about main street and creek
 >Possible solutions: thematic identity

2.5.2 Theme of project

The theme of project will be categorized into 3 level, urban design, landscape design, and architectural design.

The urban design is based on the current water management policy: Project Hunting to rethink the ecofriendly strategies of stream corridor in Kashmere Gardens neighborhood. The strategies of urban design are indicating the main framework of whole project. The target site is a creek which is parallel to the main street in Kashmere Gardens neighborhood.

The aim of the Landscape design is to rethink the relationship in between water flood risk and residential living quality. The target site is along the creek, especially in Kashmere Gardens community center region.

The architectural design is to indicate the characteristic of this specific region. Regarding the characteristic, the entire water-related and urban fabric context will be in account. The target building design is an iconic architecture which attached to the bridge.

3. Urban Strategies

The aim of urban strategies is to give a framework for this architectural project. By means of 3 main goals setting, there are several methods came out. The main goals are mainly focusing on improving the relationship in between living and water risk.

The methods will be carried out in the urban masterplan. According to the masterplan, the targeted site for architectural and landscape design will be selected in the end of this chapter.

Housing Typology

Impermeable pavement

Problemetic lands along creek

Current street view of Kashemre Gardens and Hunting Bayou
Source: Author's photo

3.1 Goals & methods

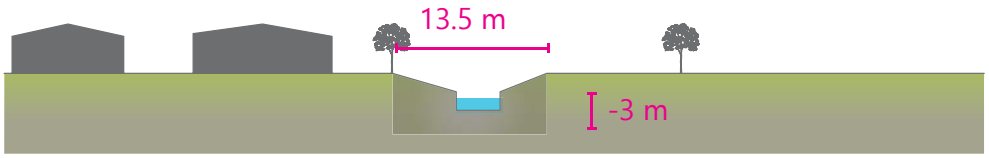
Goal 1

Reduce the flood by enlarge the water storage capacity

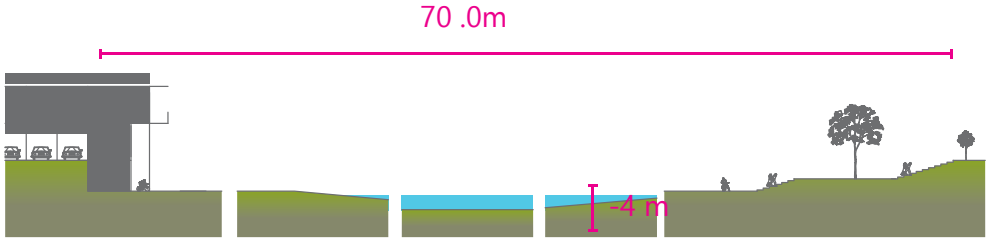
>Method 1

1.1-Widen and deepen the creek . The new system increase 5 times water detention capacity in whole region

1.2-Transform hard surface into soft surface



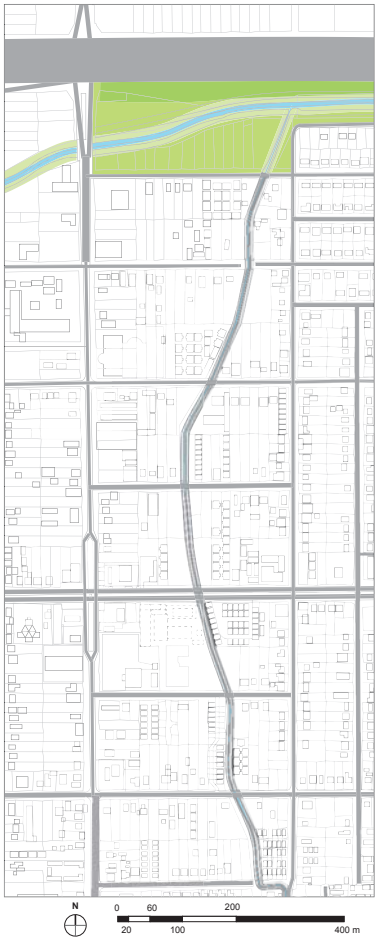
Current creek section

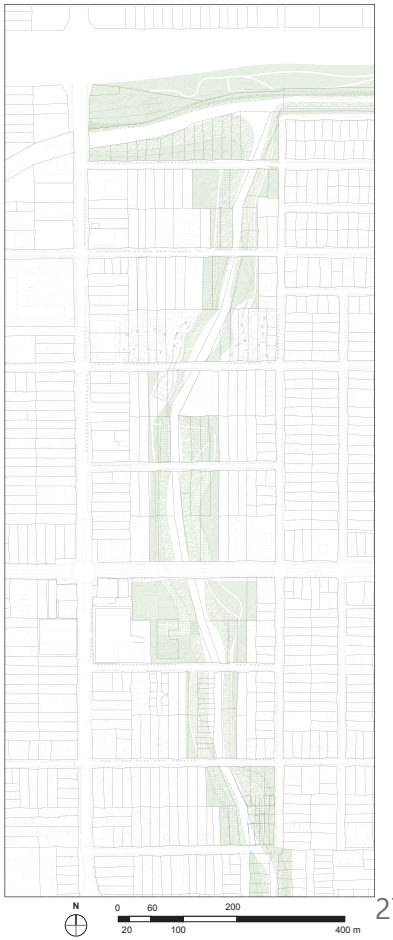


Project creek section

Vegetation surface

Hard surface





Goal 2

Improve open space in Kashmere Gardens neighborhood

>Method 2

2.1 Connection with water

2.2 Introduce new public facilities related to water

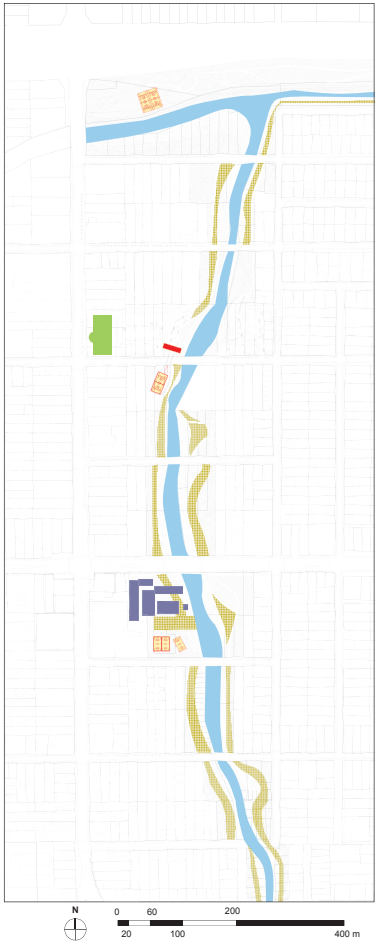
2.3 Enforce recognizability of Kashmere Gardens

- Sidewalk inprovement
- Cafe in community center
- Farming
- Ecological school
- Sport court
- Resteraunt & market
- Lawn
- Farming
- Wetland
- New Trees
- Existing trees
- Creek water

Left page

Right page

- Projected to be demolished
- Projected to be built



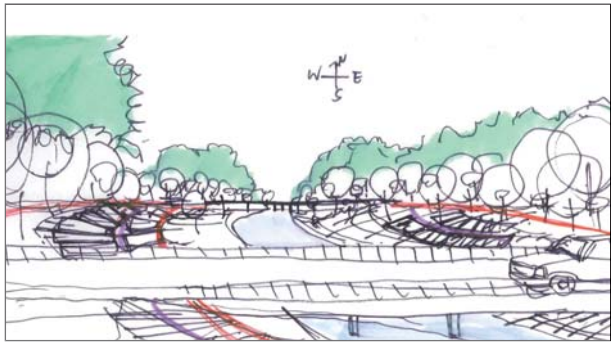
Goal 3

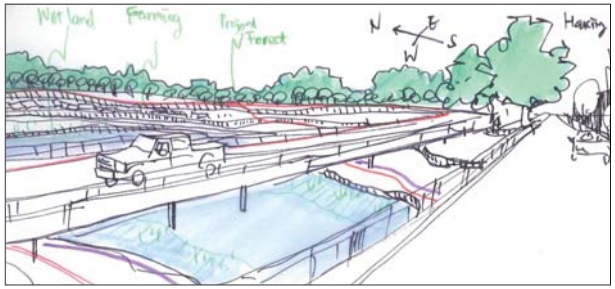
Improve Living quality – provide good environment and affordable housing

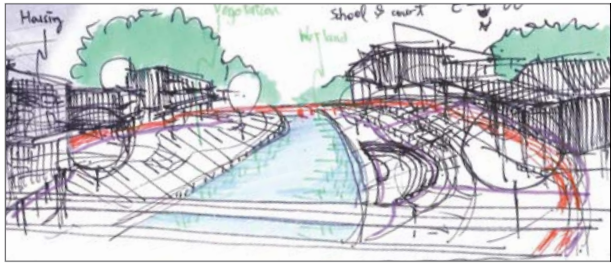
>Method 3

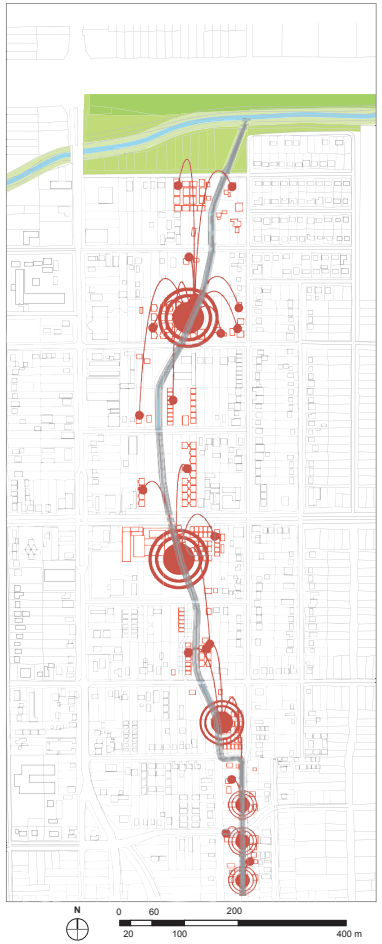
3.1 Replace free standing and detached housing by various housing type

3.2 Reduce the taxes and share safety measurement





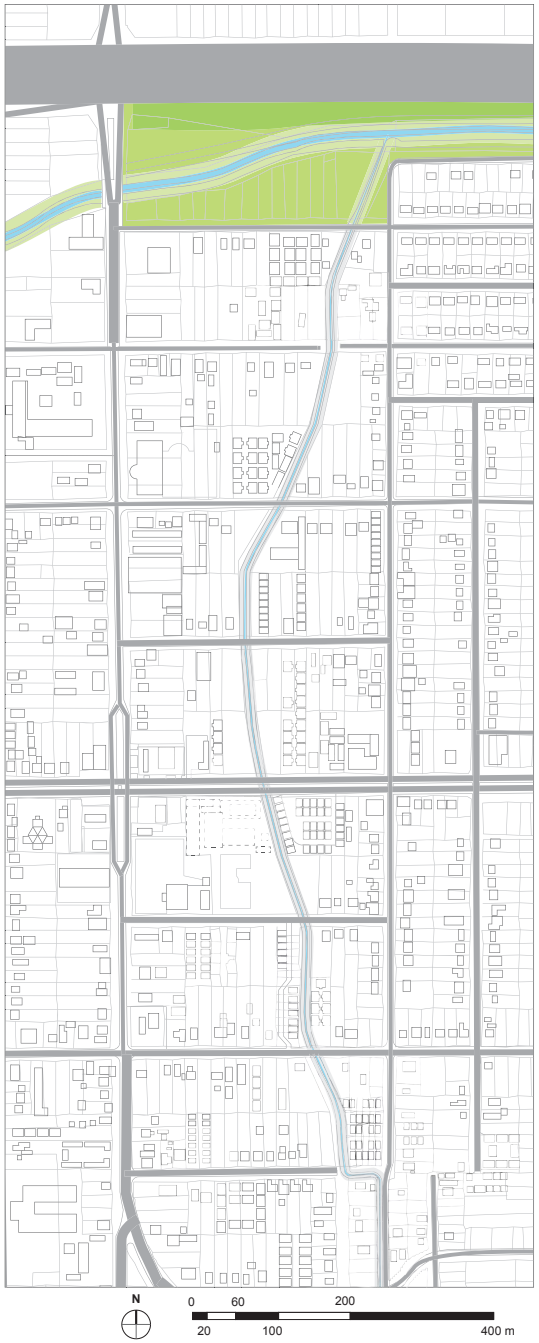


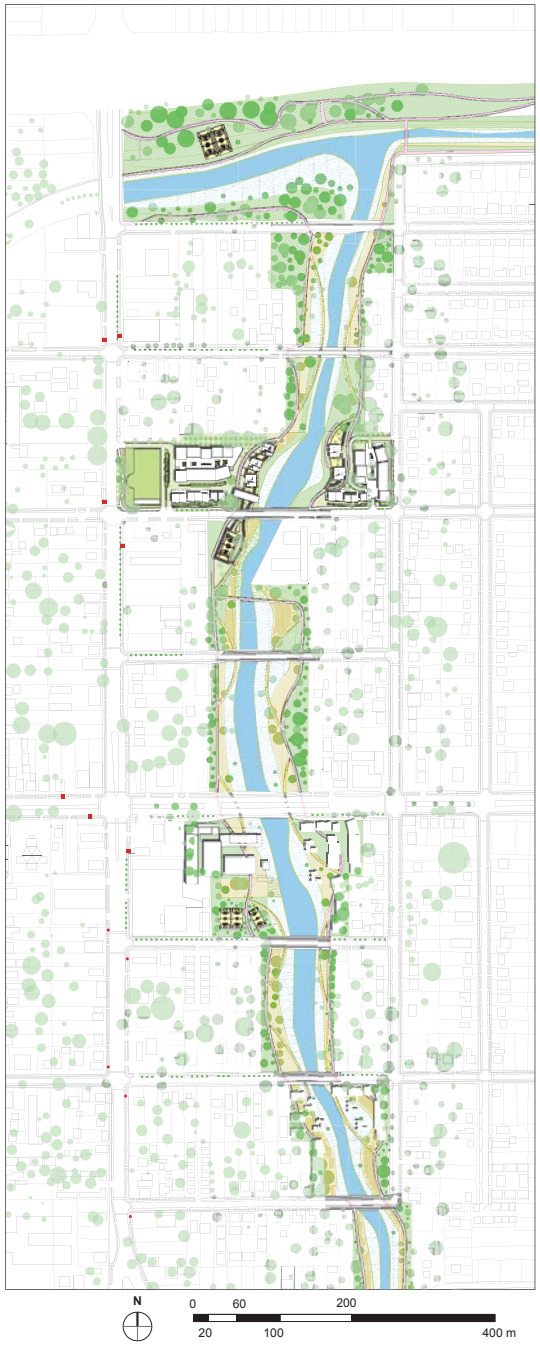


3.2 Master plan of urban design

The master plan is reflected to overall of three above strategies:

i. Reducing flood risk, increasing water capacity with greenery surface
ii. Increasing public characteristic amenities which are different from the main street, providing an alternative communal way
iii. Demolishing and removing vulnerable households, densifying communities along creek with collective housing.





3.3 Target Architectual & Landscape project site

From the master plan (drawing scale 1/2500, physical model scale 1/2500), it shows that bridges across the creek will be replaced or reconstructed repeatedly along the creek since the creek has been widened and deepened for increasing water capacity as another new detention basin in the context of Hunting project.

Therefore, in order to explore a fundamental architectural solution, choosing a characteristic site to test urban strategies will be the next phase for investigation in this report.

Clues for selection will be community scale which includes some essential elements, such as bridges, water, characteristic public amenities. For example, community center will be targeted as the context of characteristic public amenity.

4.Landscape + Architectural Design

This chapter is the aiming to show how to apply urban strategies on architectural design and also is the core of this report. Based on previous urban strategies, the Architecture design will be started from the community master plan and then narrowed down to the specific target site. At the same time, public spaces and architectural promenade routes will be designed. In order to achieve the materialization, corresponded building technology for this project will be investigated. Readers who are interested in architectural details and building technology are suggested to start from “4.14 Materialization”. For those interested in spatial atmosphere are advised to look into “4.9 Elevation, 4.10 Floor plan” first.

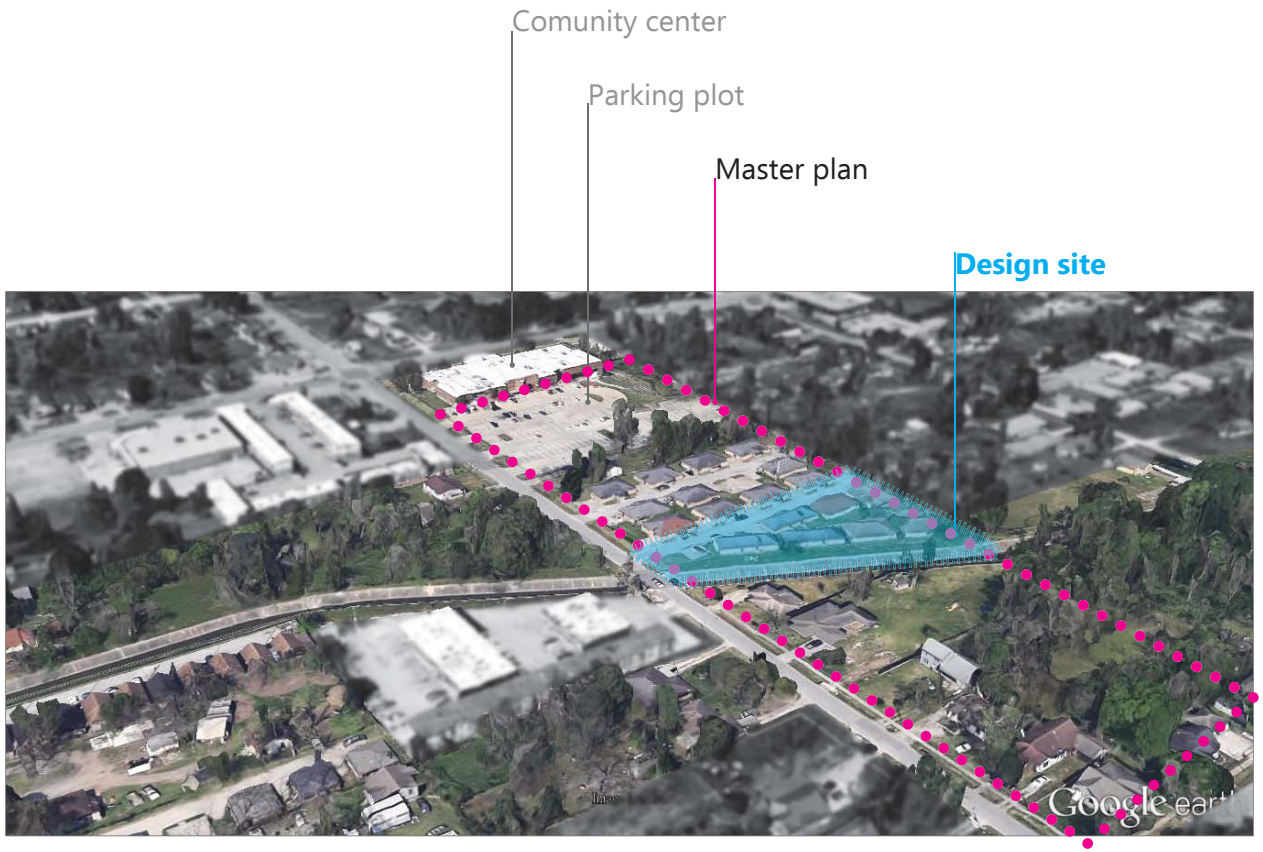
4.1 Design area

4.1.1 Location

The chosen area is situated near a reginal community center. The design area will be at the west side of the creek, in between community center and creek.

4.1.2 Area

The area of the project site is around 0.03 km2, which is like a market square in Delft city center. The design site will focus on the west side of creek front area which is around 0.02 km2, which is like whole architecture faculty (BK) block in TUDelft in Netherlands.



4.1.3 Why

According to the new water management in this report, several communities or bridges along the creek have to be regenerated or replaced. This project of the report is considered to be a pioneer project whose fundamental principle can be refined and then applied on the rest parts along the creek. Therefore, there is a need to choose a spot that can represent the characteristic of this neighborhood.
As a result, the plot between the community center and creek is considered to be an ideal location, reasons are following:

i. Community center can be the first impression for public, especially the project in this report is proposed as a pioneer project.

ii. Existing collective apartments show the needs for densification in this region.

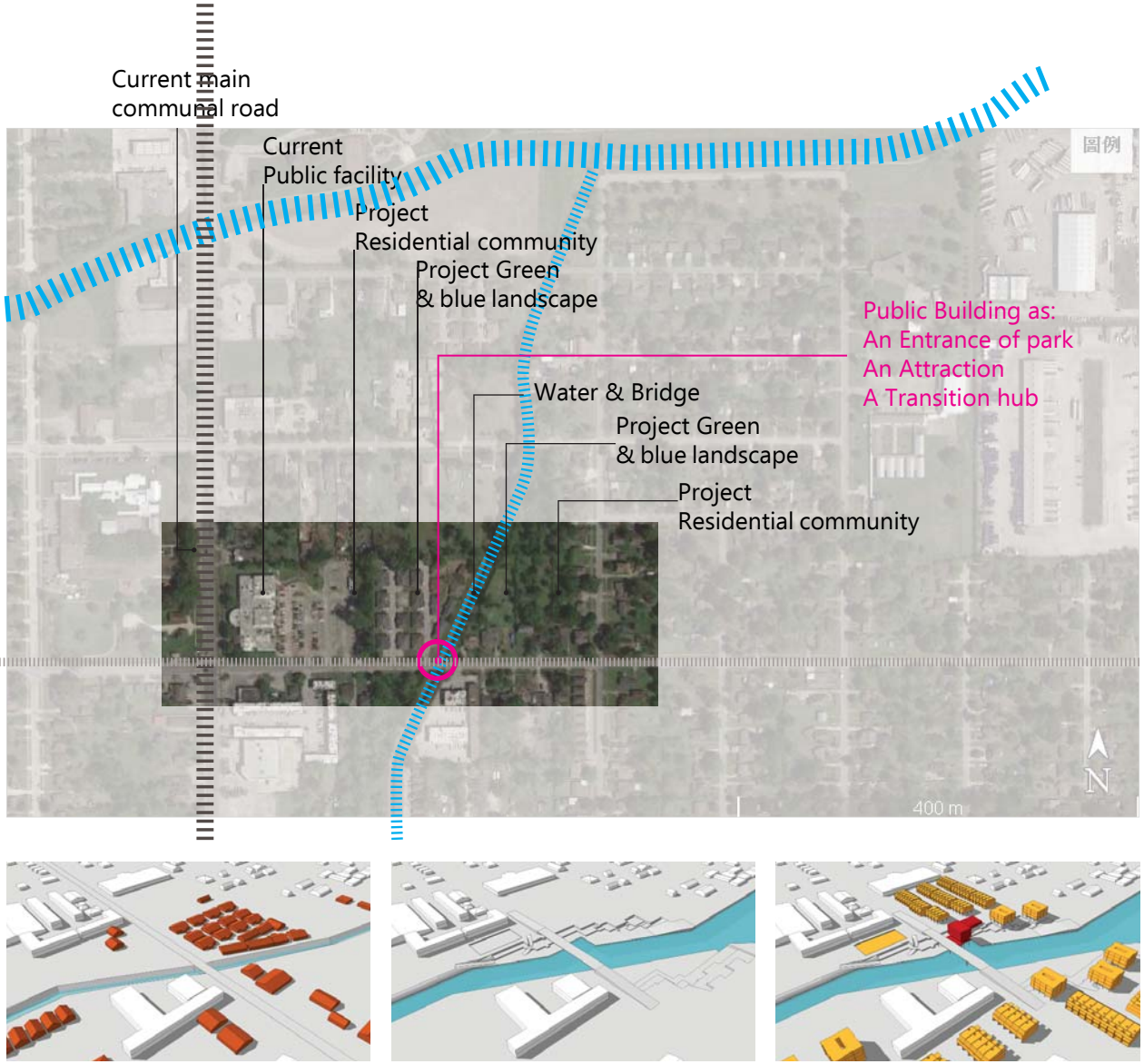
iii A huge parking plot of community center gives an impermeable impression to the flood prone area.

4.2 Zoning

4.2.1 Zoning Concept

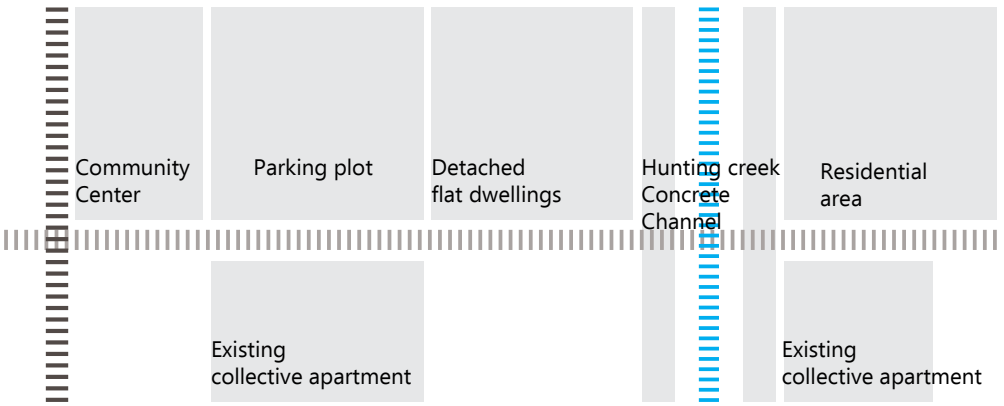
The goal of zoning is aiming to define a framework for following architectural program. The concept of zoning will accord to the existing element, such as cashmere community center, collective housing and a road bridge to arrange a logical series of spatial experiences.

Therefore, part of new zoning plan will be defined an extensional program of public space because of existing community center and creek front landscape.



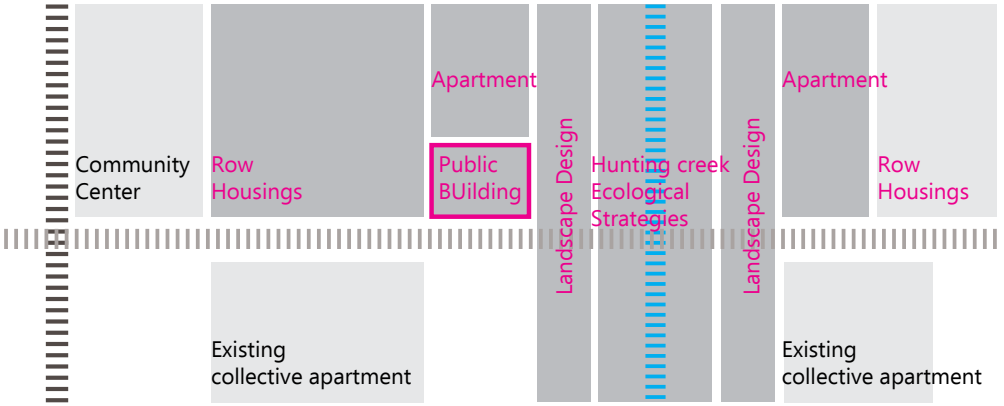
4.2.2 Interventions

The starting point of the zoning plan is original from creek and bridge.
These two elements are forming an junction, and providing an entrance of this community plot.
Therefore, the first phase of interventions is that: “Water resilient landscape”, “Public space”, “Public building” serves as extensional function of existing community center.
The first phase is acting an interface in-between open public and closed residential area.
The second phase is more than likely about private program. Therefore, row housing behind the existing community center is be defined. Then, detached tower housing will be located at the creek front, aligning with public building in certain rhythm.



Existing zoning plan

Project zoning plan



Current situation

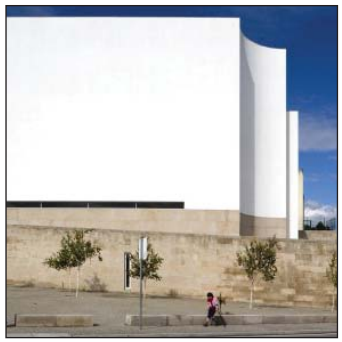
Interventions

Main road

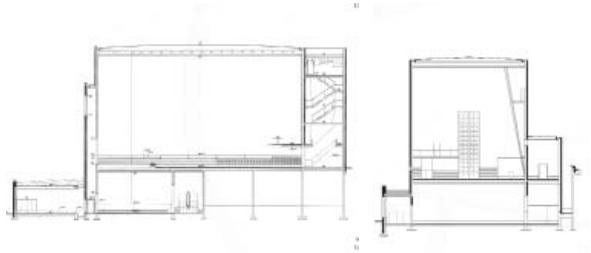
Secondary car road & bridge

Creek

4.3 Case study: Landscape + Architecture



Inspiration: Base, Division of material



The Church for Marco of Canaveses / Alvaro Siza

The church is an iconic building standing on top of a hill. Since the locational and functional facts, The concept of church referred to Acropolis of Athens. In terms of construction, the church is divided into 2 parts: a solid stone basement for offices, and a concrete hall for church.

Inspiration: Rythm of mass planning

Porto Faculty of Architecture / Alvaro Siza

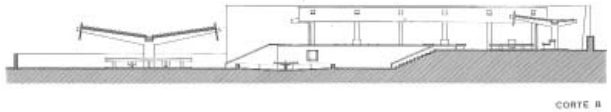
The plan of Porto Faculty of Architecture designed based on simple geometry. 4 similar volumes faced to the river are aligned in a certain rhythm. However, there is an exceptional one which only has a base without any volume upon it.

Inspiration: A platform with random boxes on it, Elevation

Commercial Building in Boavista /Eduardo Souto de Moura

The building is designed like a series of boxes standing randomly over a platform.

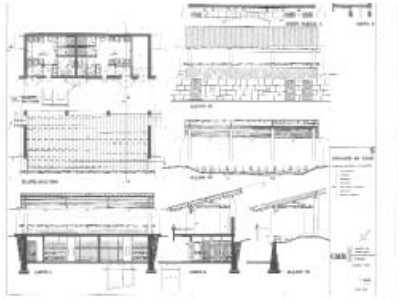
Inspiration: Landscape, Market function



Municipal market /Fernando Távora

The market is built according to its slope topography. The market is consisted of a solid base for storage and offices, and canopies for semi outdoor activities like selling goods. Parts of market are sunken, which can be seen as a response to the landscape.

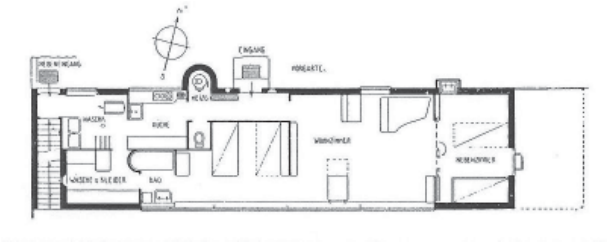
Inspiration: Landscape, Boundary



Tennis Pavilion /Fernado Tavora

The building is consisted two parts, the shower rooms for downer part and a terrace up on it covered by a tilted roof. The building which built on the retaining wall is formed of boundary for tennis court.

Inspiration: Landscape, View framing



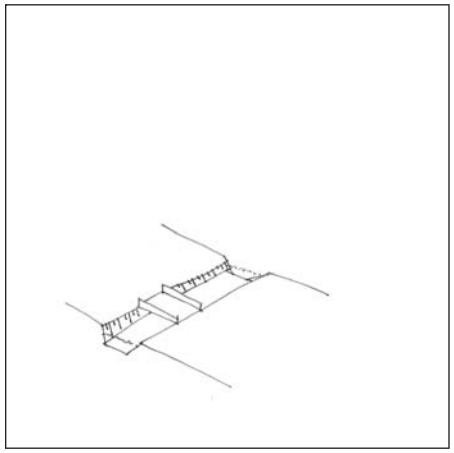
Villa le lac /Le Corbusier

Villa le lac is a summer house which located just along a lake. The architect always considered how the openings frame views. The building is a long shape volume, with a long panorama window view which is focusing the division line in between mountain and water.

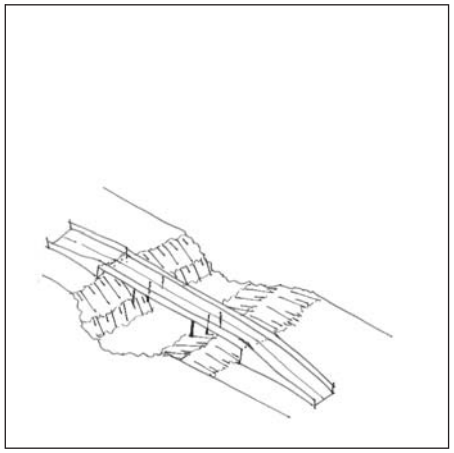
4.4 Landscape + Mass development

The main water issue here is that the current creek is lack of water capacity and permeability. As a result, following the context of "Project Hunting" & "Kashmere Gardens' master plan 2014", this project is proposing to widen & deepen the creek, as another detention basin.

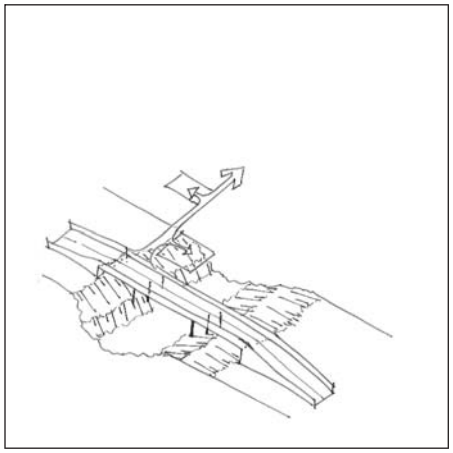
The order of mass development is like the order of zoning plan; both of planning is starting from water & bridge. The strategies of mass development are following: Bridging, Routing, Public volume growing, Zigzag, Orthogonal grid, Accessibility to water, and Greenery & Permeability.



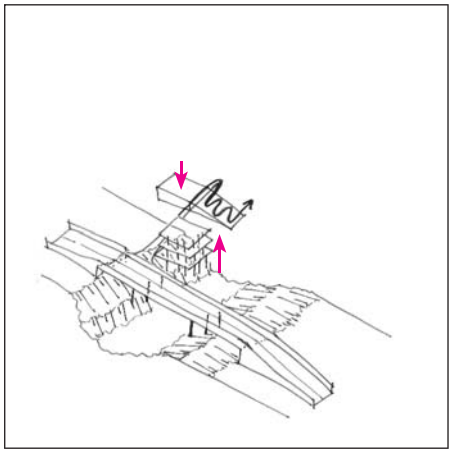
Current creek



Bridging

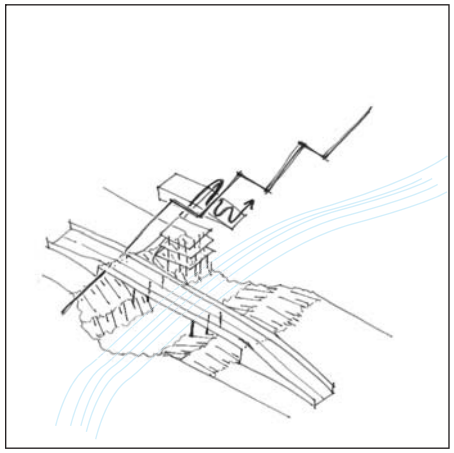


Routing

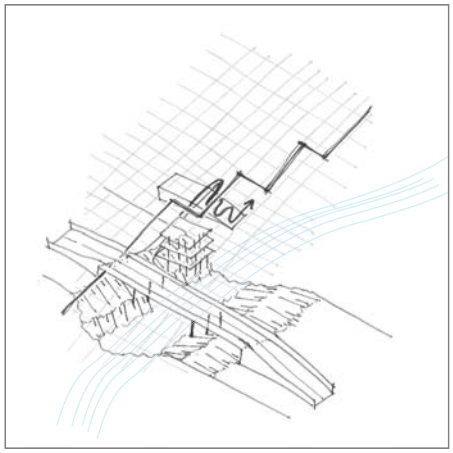


Public volumes growing

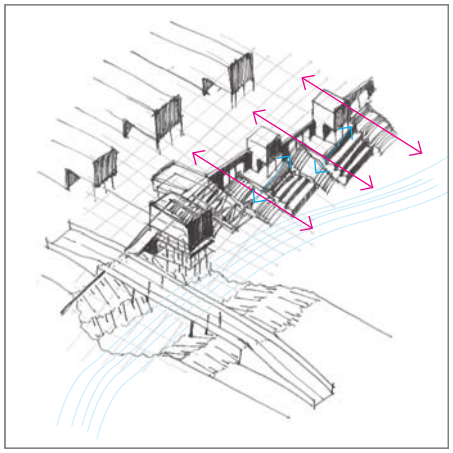
The relationship of zigzag landscape and architectural volumes is inspired by Architecture faculty in Porto by Alvaro Siza. Refer to 4.3 case study.



Zigzag

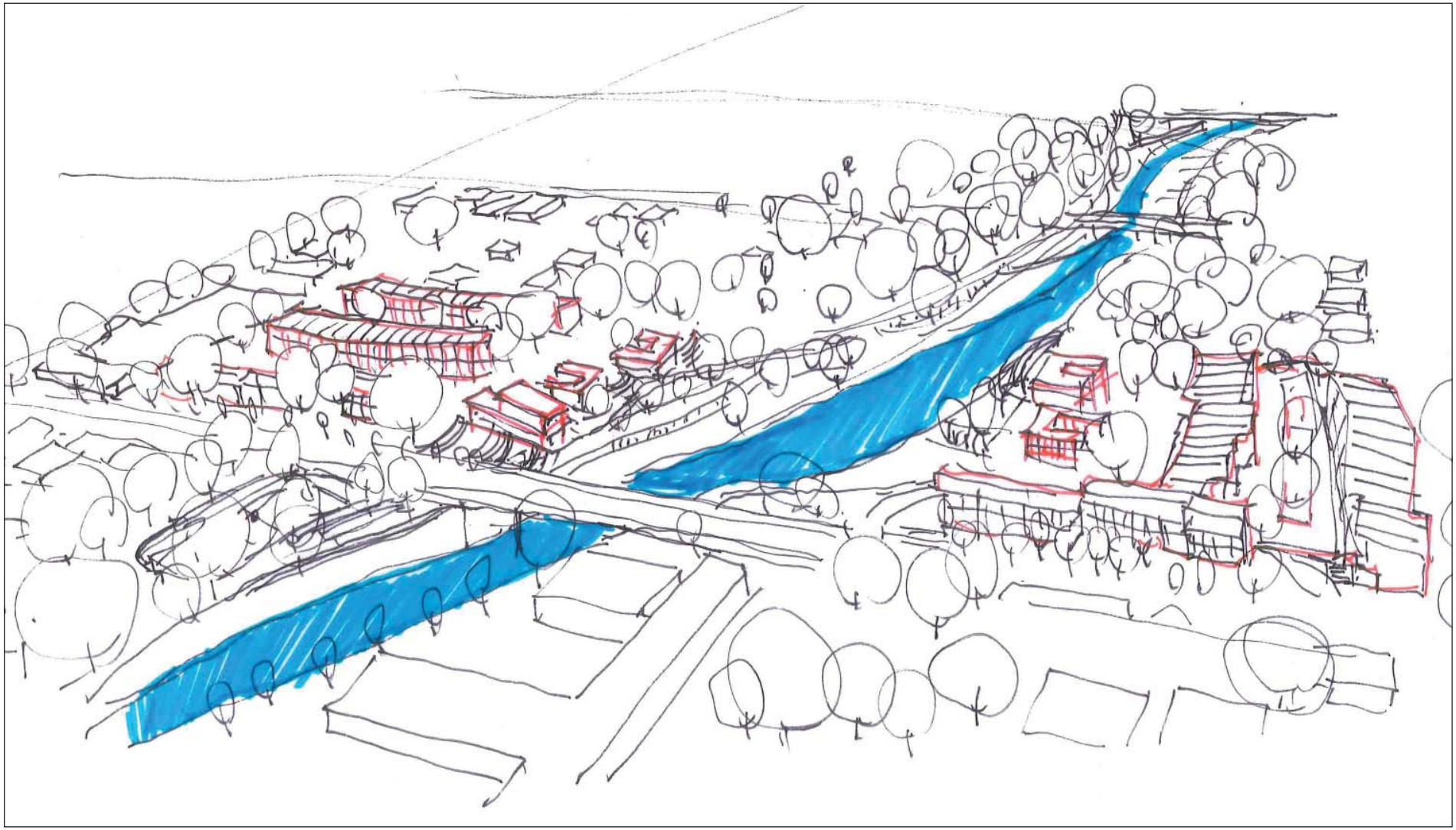


Orthogonal grid

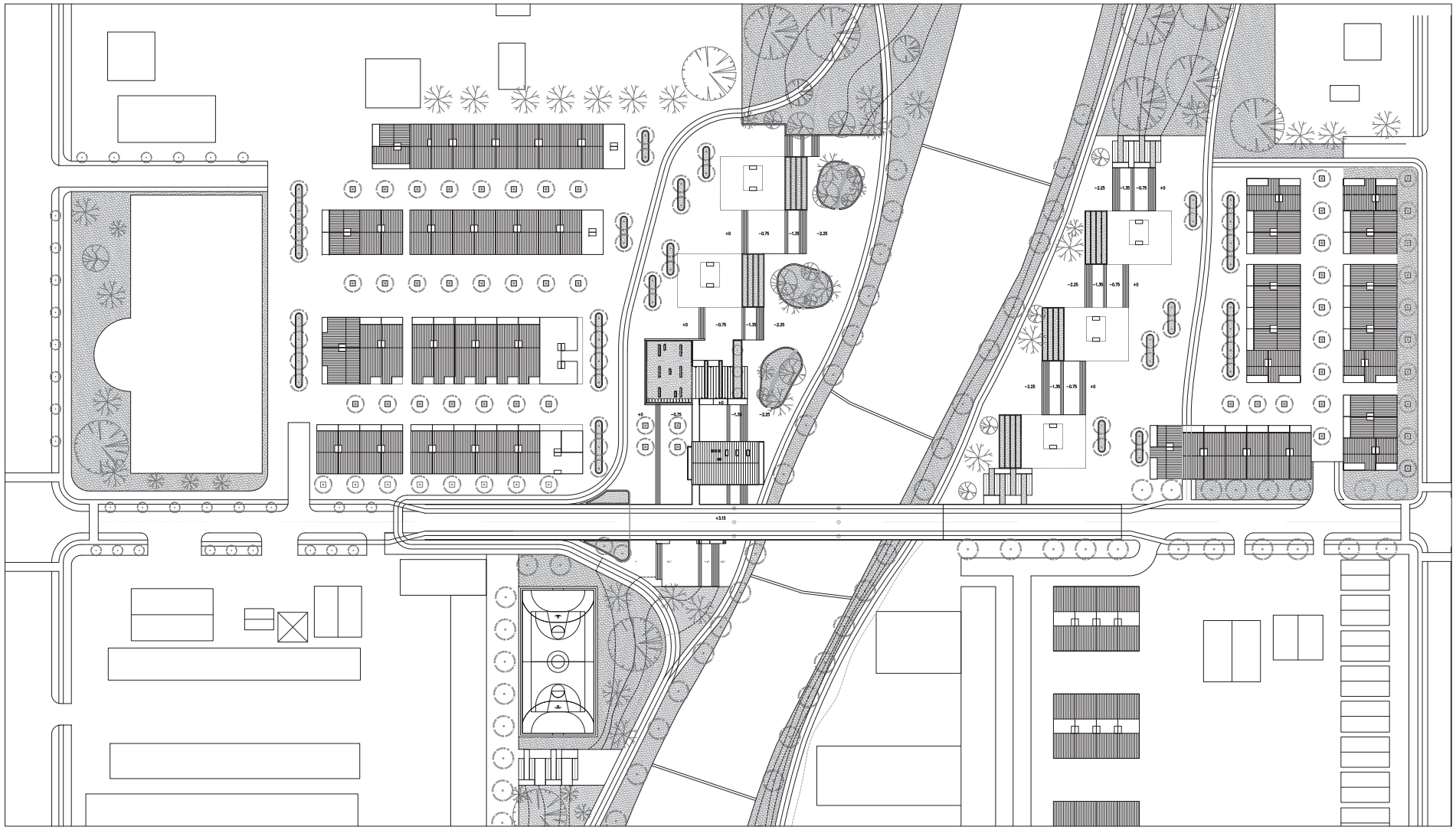


Accessibility to the water

Greenery and permeability

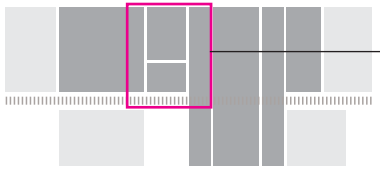


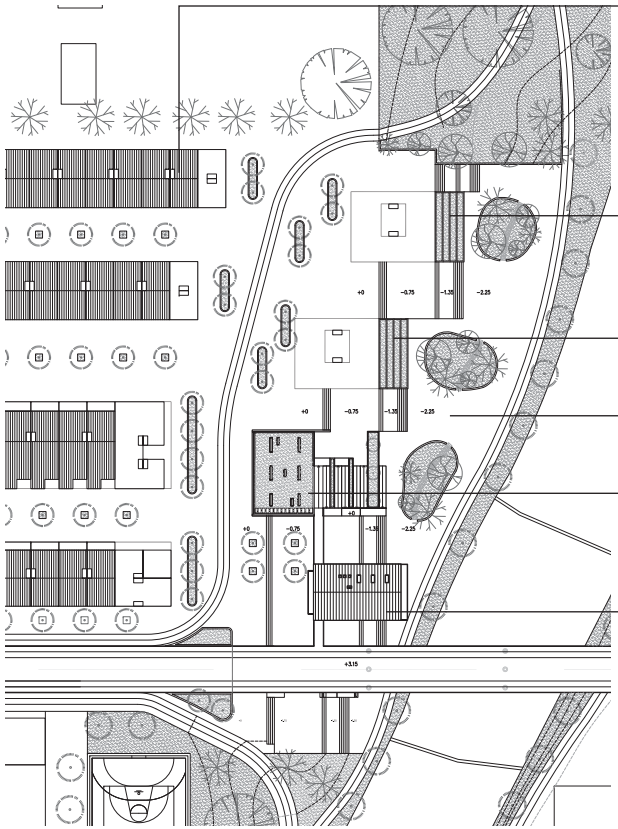
Conceptual sketch: Arial view of project master plan



Master plan of community plot

4.5 Programs





Design part
-Waterfront landscape
-Public spaces
-Inconic architecure

Row Housing
-Interface between
-Public and private

Apartment B
-GF: Communal using
-1~3F: 3 Housing units

Apartment A
-GF: Communal using
-1~3F: 3 Housing units

Landscape
-Greenery
-Bike path

Public Building
-Market
-Roof platform
-Toilet

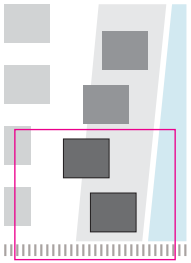
Public Building
-Kiosk
-Restaurant
-Multi functional hall
-Toilet
-Public Elevator (water proof)

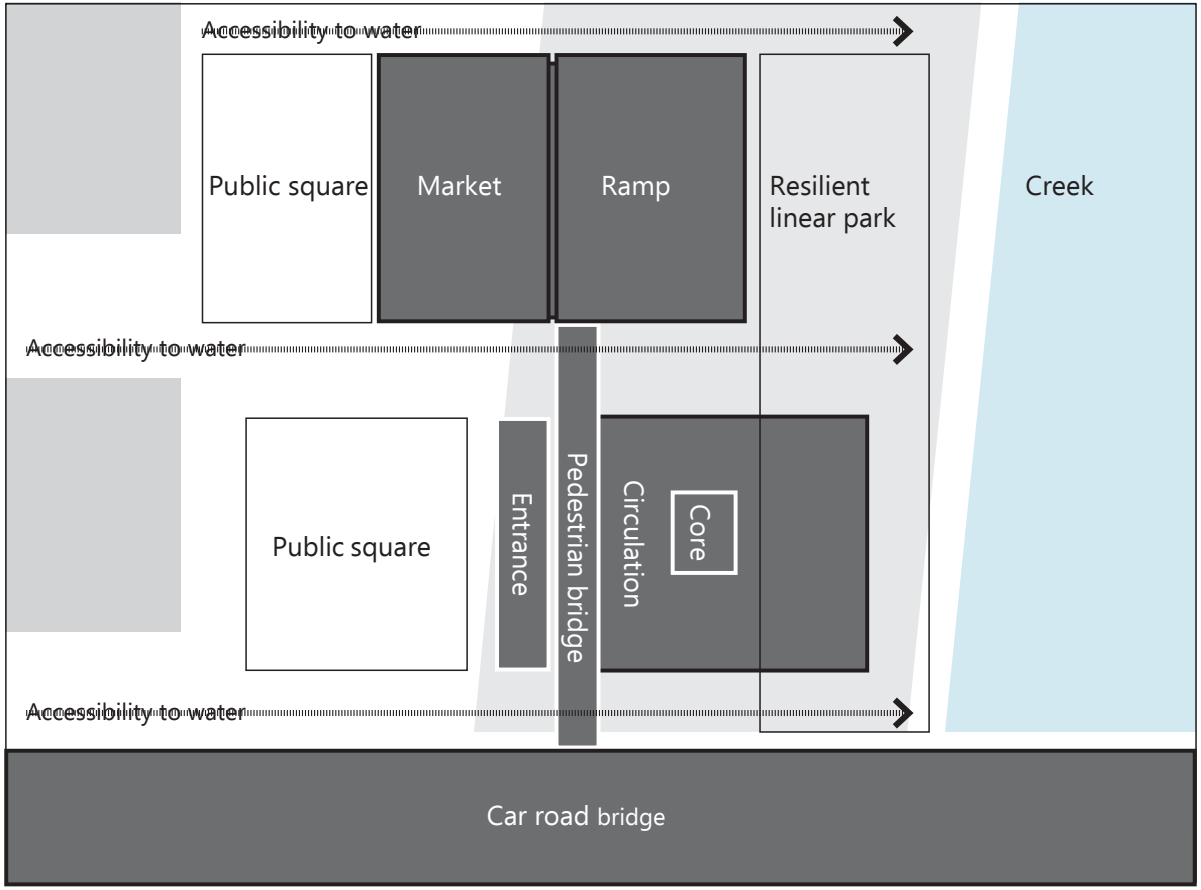
4.5.1 Architectural design part

According to the zooning plan, the intersection of bridge and creek is defined as the interface in between Water & Land, Communal & Residential, Entrance of community & linear park (water resilient landscape). Moreover, it is define as suitable public using spaces. Therefore, from here onward, the architectural design will focus on this intersection and nearby water front areas, especially for "public using spaces."

The Architectural project will more focus on public using spaces. The design level categories are below:

Deisgn Items	Deisgn level
Landscape	lv. 1
Row Housing	lv. 2
Apartment	lv. 2
Architure Design	lv. 1





4.5.2 Architectural program

Two building will be highlighted in this project.

1. The taller one will be the functional extension of current community center, where provide Kiosk for passengers, restaurant for visitors, multi-functional hall for community activities.

2. The lower building will be a shelter which will serve as a place for market or semi outdoor activities. This building will highly integrate with water resilient landscape so that all the activities can be stretched to terraces on landscape.

4.6 Concept of Architecutre

4.6.1 Inspiration: shot gun house

The shotgun is a narrow and long shape volume. "The rooms of a shotgun house are lined up one behind the other" Reference: The Greenwood Encyclopedia of Daily Life in America Daily Life

The origins of shotgun house are controversial. In general, it is from south of America, mainly provide accommodation for working class people. Most of them were Africa-American, Hatiain-American, in general black people who were slaves or labors at that era; it is original from early 1800s, becoming popular in late 1800s and early 1900s.

That period was characterized by the Texas oil boom and radical population growth in Houston. Therefore, shotgun house was considered as a cheapest and easy constructed housing typology in suburban where working class people live.

4.6.2 The Porch

The shotgun house is from West African architectural typology, and the porch is one of characteristic elements. When these people migrated into south of American, also bring this important architectural element into American architectural culture.

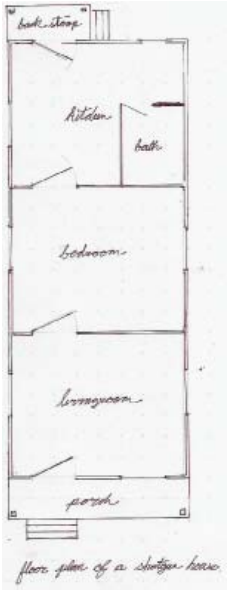
"By the early eighteenth century, porches appeared in the Americas. One century later, porches had become an integral element of American architecture." Reference: The Evolution of the American Front Porch website,

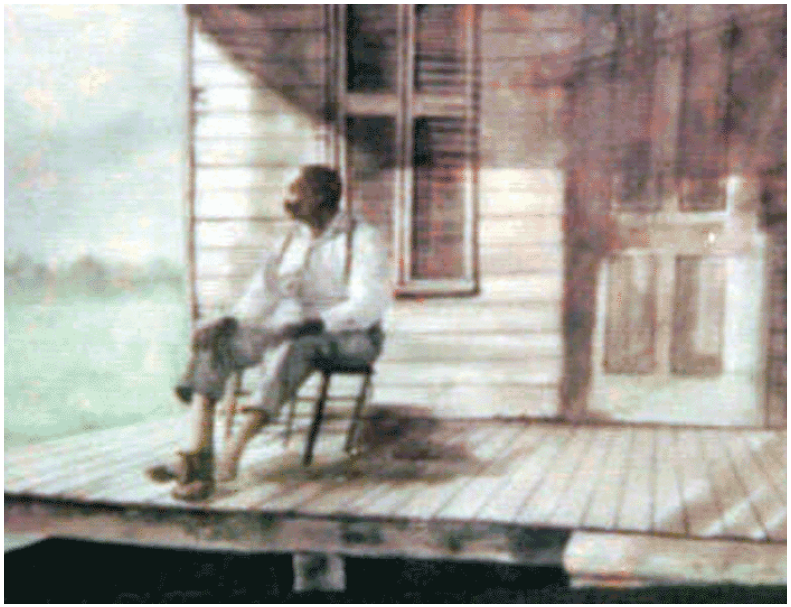
maintained by Scott Cook.
During the 19th century, the porches became prettied up with vernacular decoration.

4.6.3 The Porch of Kashmere Gardens

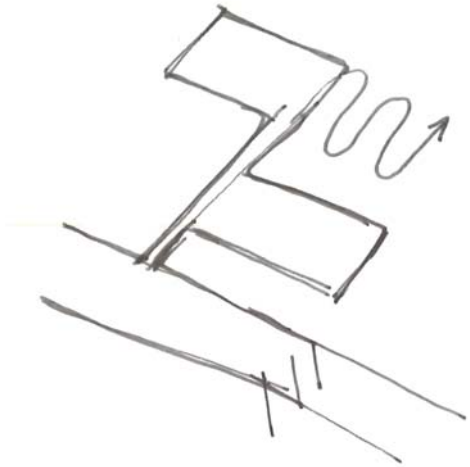
Since junctional public spaces in this project is acting an intermediator in this region, accessible and attractive and impressions of junctional public spaces are needed. Therefore, the identity of porch can be a metaphor for these junctional public spaces.

As a result, these junctional public spaces will be named as **"The Porch of Kashmere Gardens"** which is also the name of whole architectual project part in this thesis, and the taller public building will be so called **"Porch Building"** (this name will be mentioned in the following of report), the lower building will be named **"Market"**.

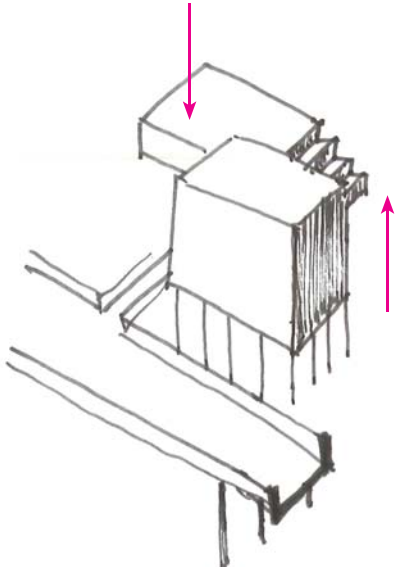




4.7 Architectural mass development

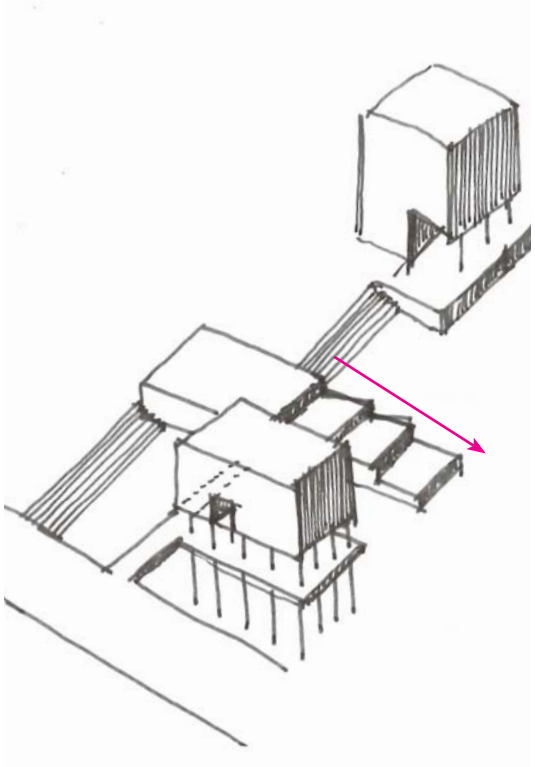


Routing from landcape
Three platforms
1.Bridge
2.Kiosk terrace
3.Market roof



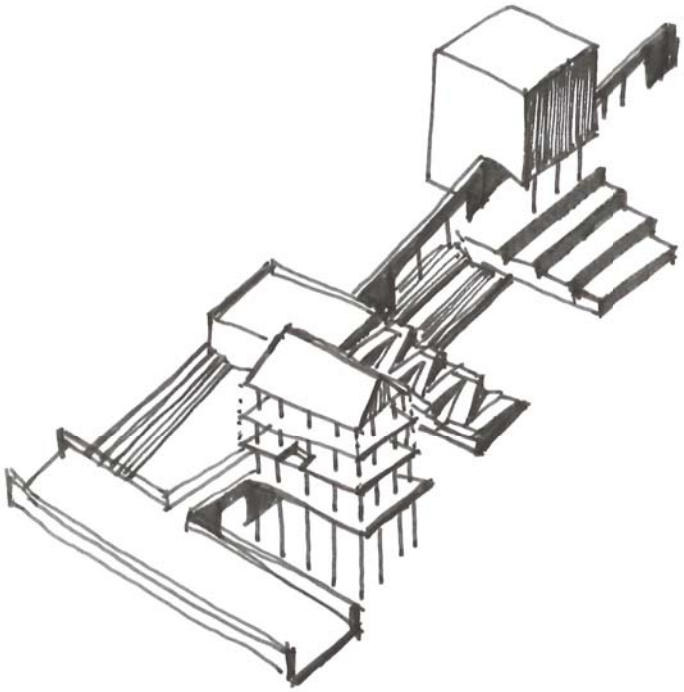
Volume growing Up/Down
The Porch Building: Straight up

Market lower: Sunken down to landscape



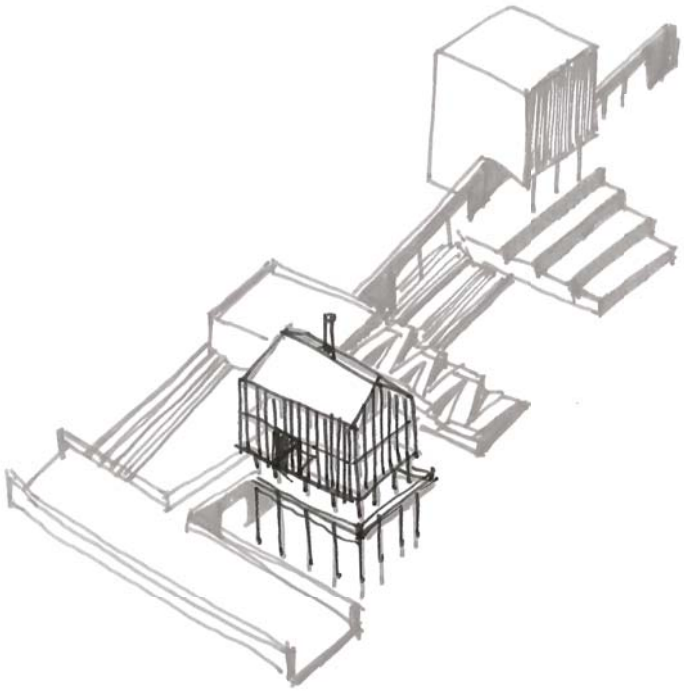
Attractive path
The Porch Building:
Kiosk for floating impression
Panorama view
Voild for connection of 1F & 2F

Market: Ramp with smooth slopes

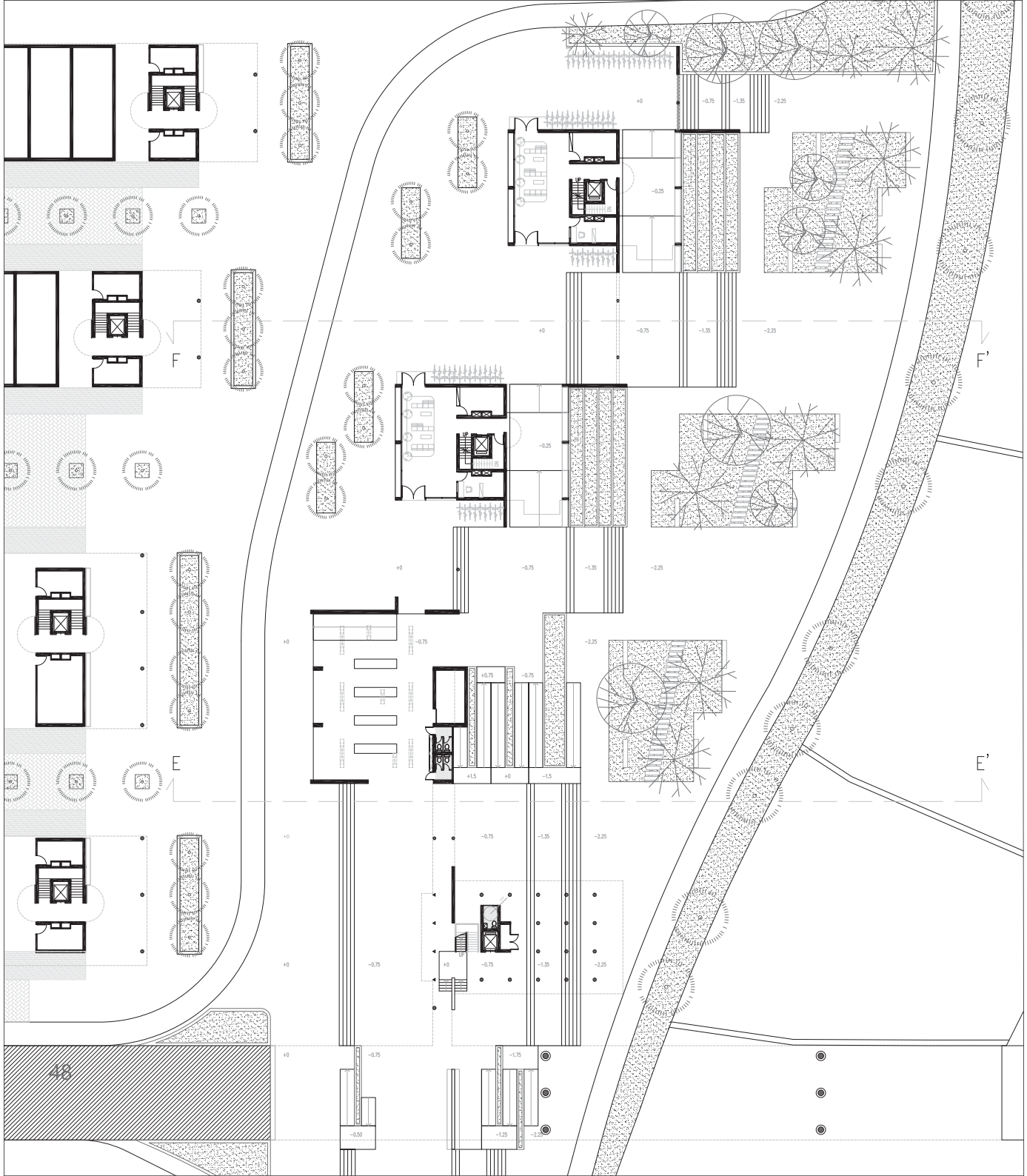


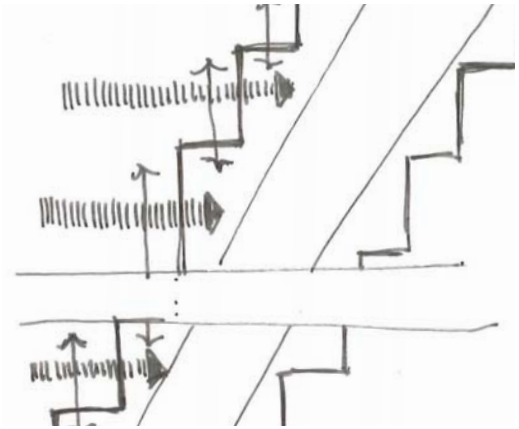
Structure & walls
Gable shape to represent shotgun house image
Open timber structure to show the transparancy as a public building

Walls
for keeping the differentiation line continuously
for framing views



Vertical louvers
to Keep the impression of taller volume
to ahceive an abstract mass which can be adjust by louvers


F
F'
E
E'
48



4.8 Site plan

The site plan is mainly to optimize the master plan of community plot, especially to achieve a series of good quality of spatial experiences in this water resilient landscape.

The planning is based on the concept of zigzag line landscape in order to achieve well organized circulations, especially the accessibility to the water.

The picture of phycical model, 1:200

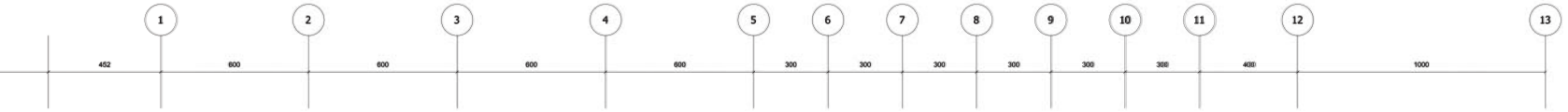
4.9 Elevation

4.9.1 West Elevation

West Elevation is aiming to show:

1. Entrance of the Porch Building
2. Sunken market
3. Accessibility and views are guided by walls
4. Family untis housing is arranged in the west side.

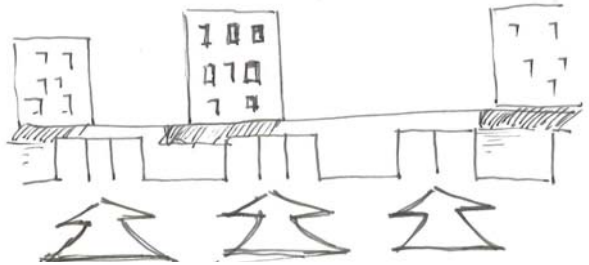
4. 3.


1
2
3
4
5
6
7
8
9
10
11
12
13
452
600
600
600
600
300
300
300
300
300
300
400
1000


+15.95
+12.05
+9.45
+6.3
+3.15
+0 GL
-0.75
-1.35
-2.25

2.

1.



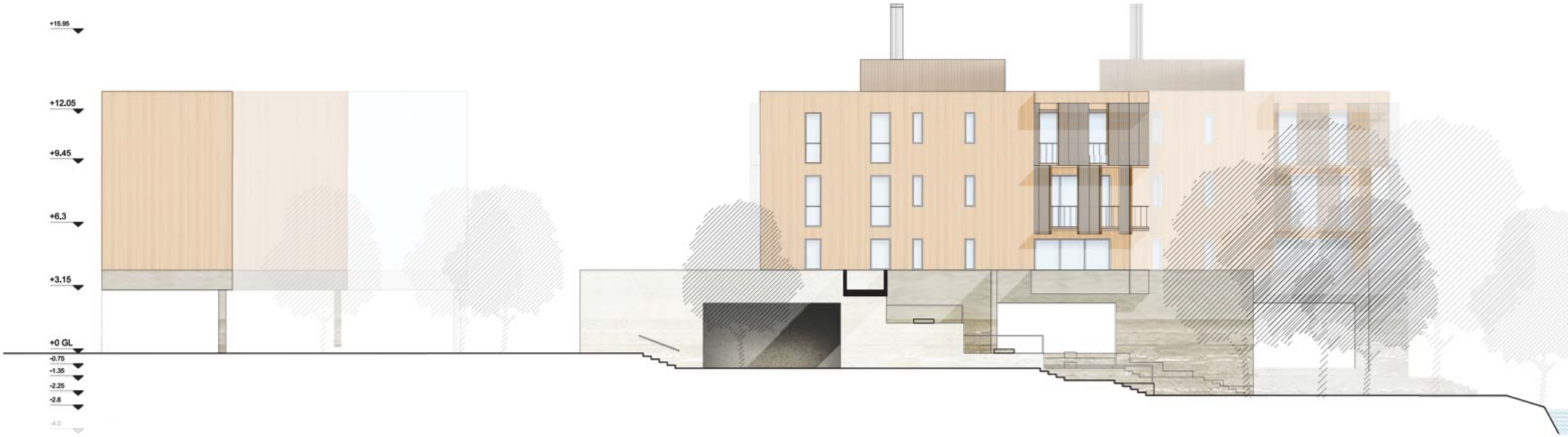

13
12
11
10
9
8
7
6
5
4
3
2
1
1000
400
300
300
300
300
300
300
600
600
600
452
748
+15.95
+12.05
+9.45
+6.3
+3.15
+0 GL
-0.75
-1.35
-2.25
-2.8
-4.0

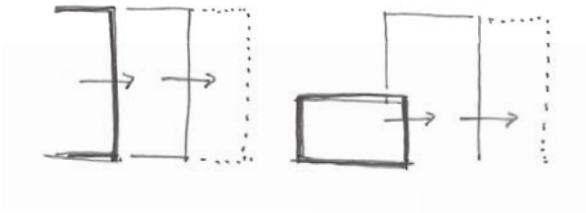
4.9.2 East Elevation

East Elevation is aiming to show the various landscape providing various approaches to reach the water

Upper part: accessible water view from housing.

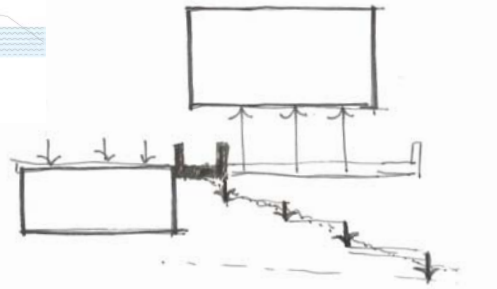
Downer part: physical approaches to the water.





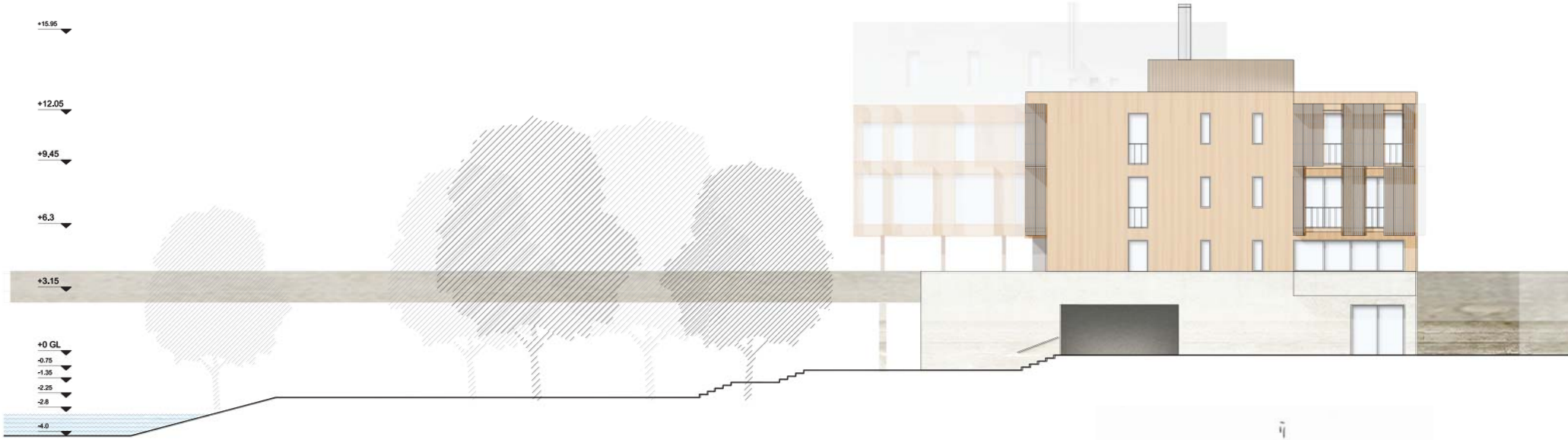
The effect of Zigzag layout

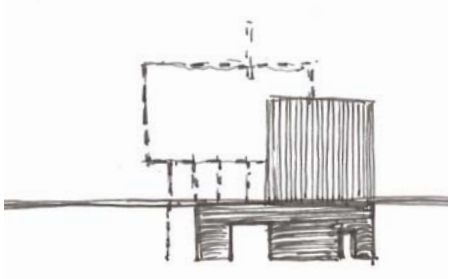
4.9.3 South Elevation



A route connect to two platforms
Development of volumes : up & down

4.9.4 North Elevation

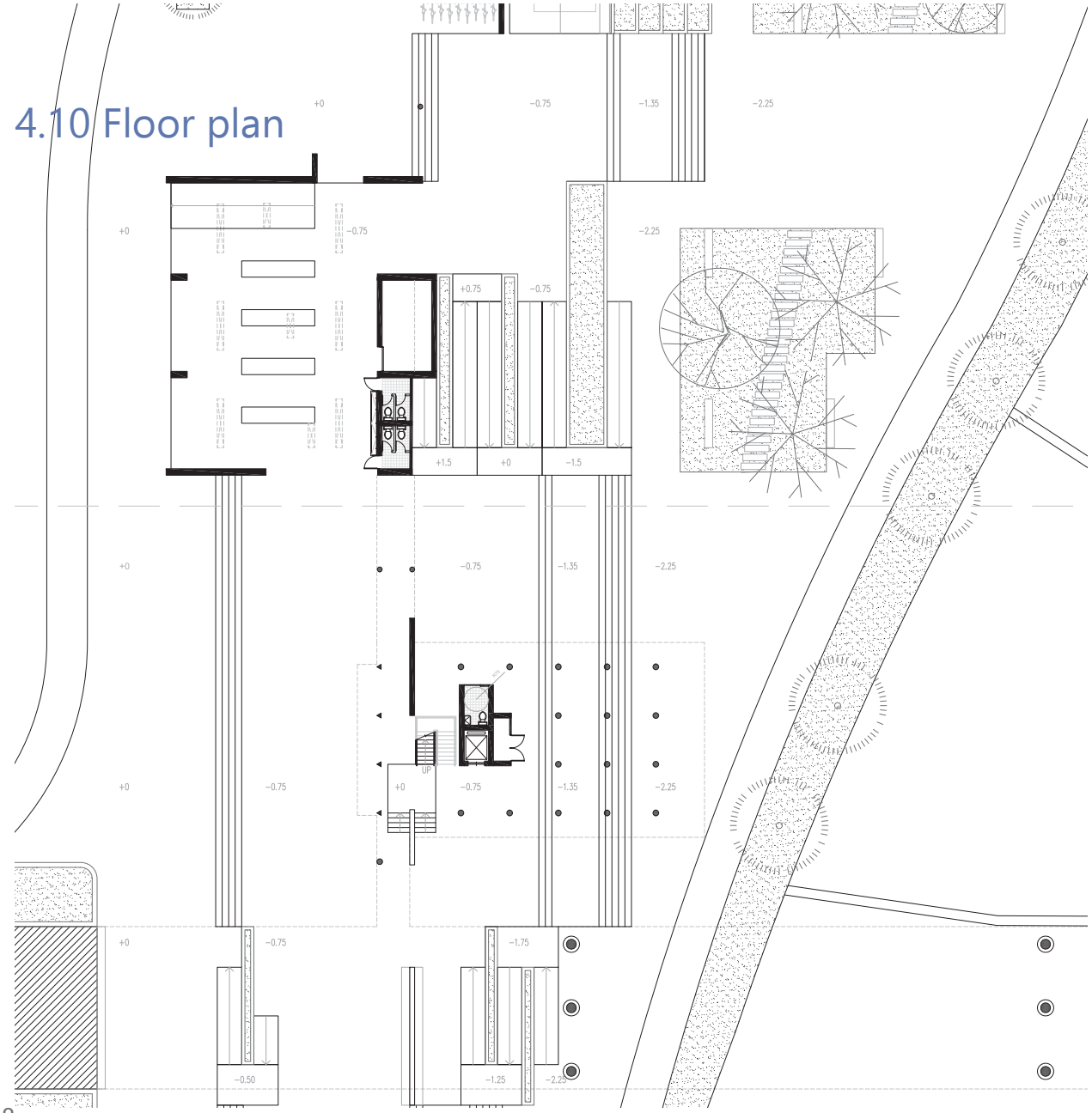




Relationship between closed structure and Opened structure.

Below the bridge is the concrete world. The bridge is the starting point of whole design

4.10 Floor plan



4.10.1 GL (-0.75m)

1. Entrance of Porch Building

There are 4 triangle shape columns in front of the entrance of Porch Building. They are hanged by the main concrete beams of Porch building, therefore, 4 columns don't have load bearing function. As a result, there are only very thin steel poles underneath 4 triangle shape columns to give an exceptional impression.

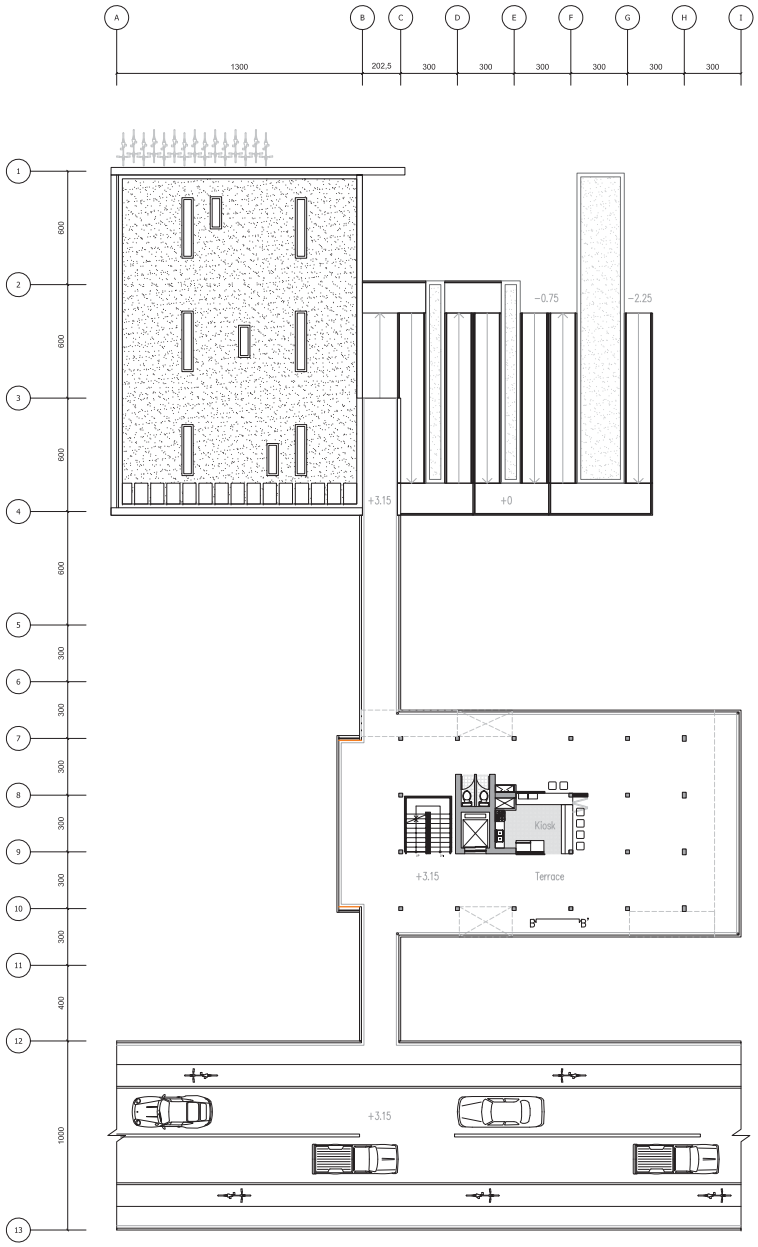
2. Market

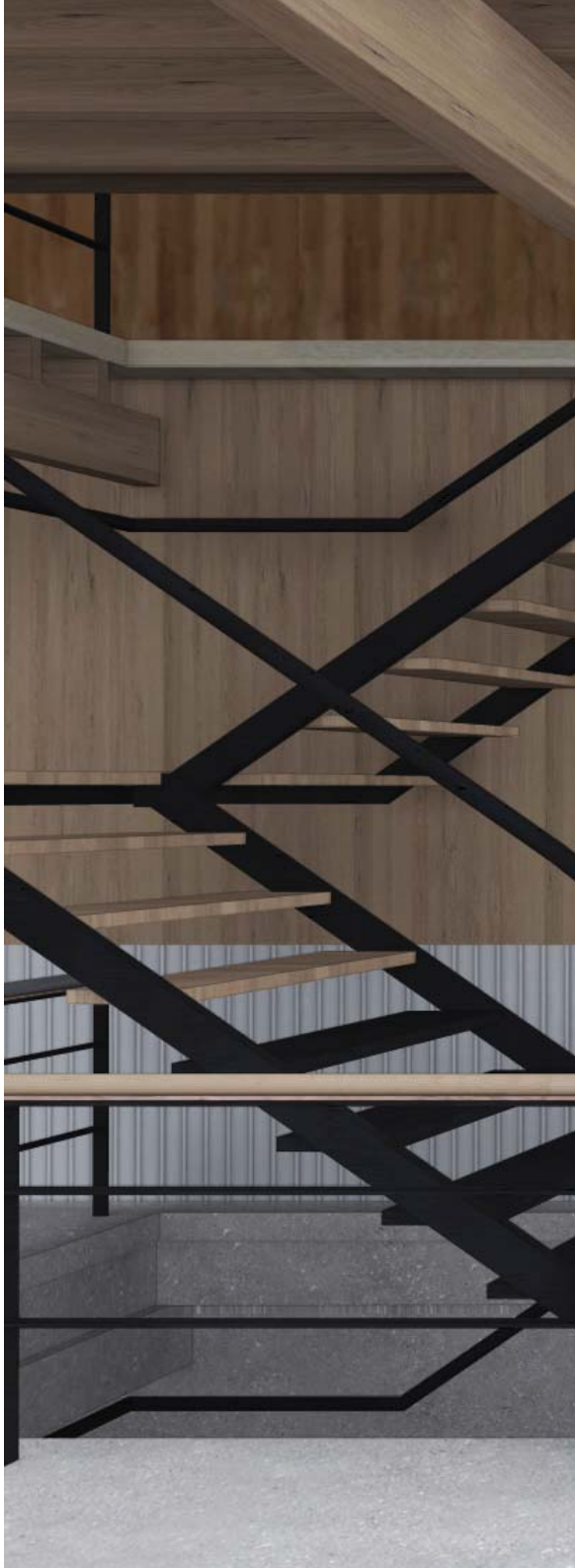
The market is half-sunken in the landscape.

3. Walls

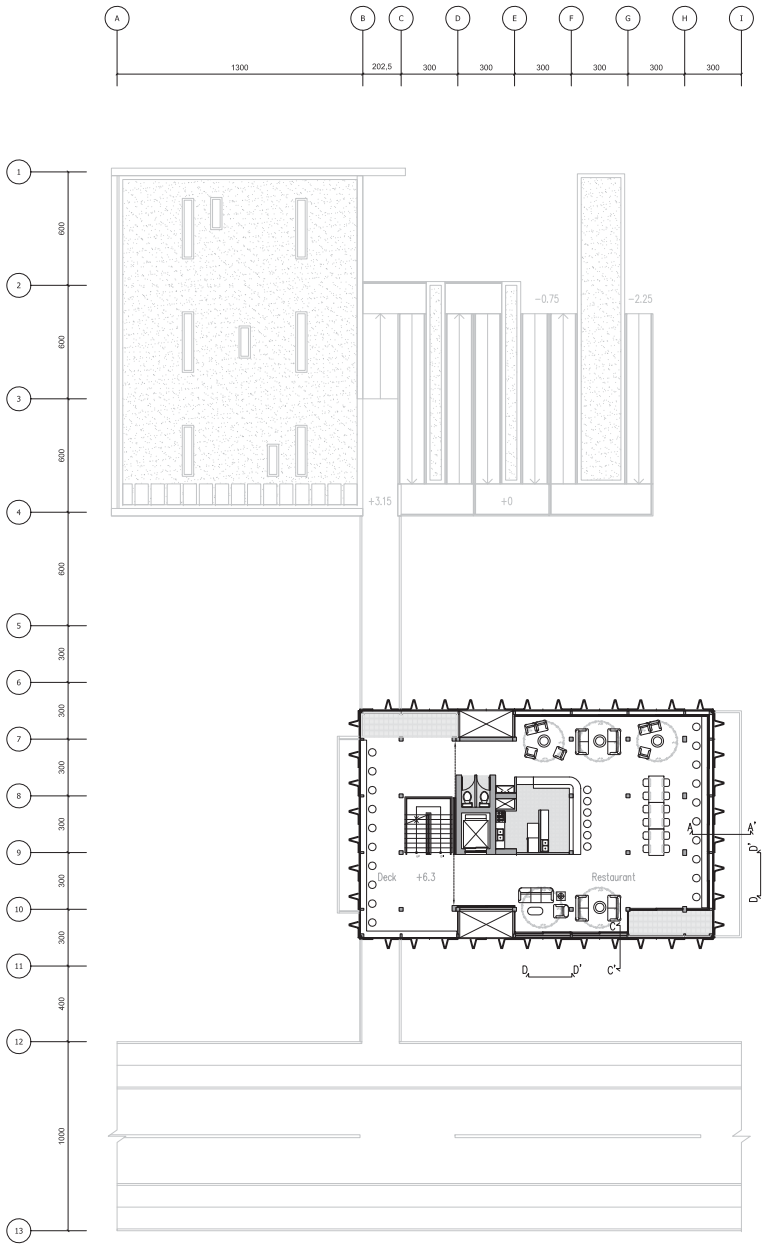
The walls which are made out of concrete are dividing the safe zone and the danger zone. Moreover, the walls can play the role to organize spatial arrangement in this project. At the same time, the texture on the walls can indicate the height level and bring the awareness of flood risk.

4.10.2 1F (+3.15)- Kiosk, Green roof of market



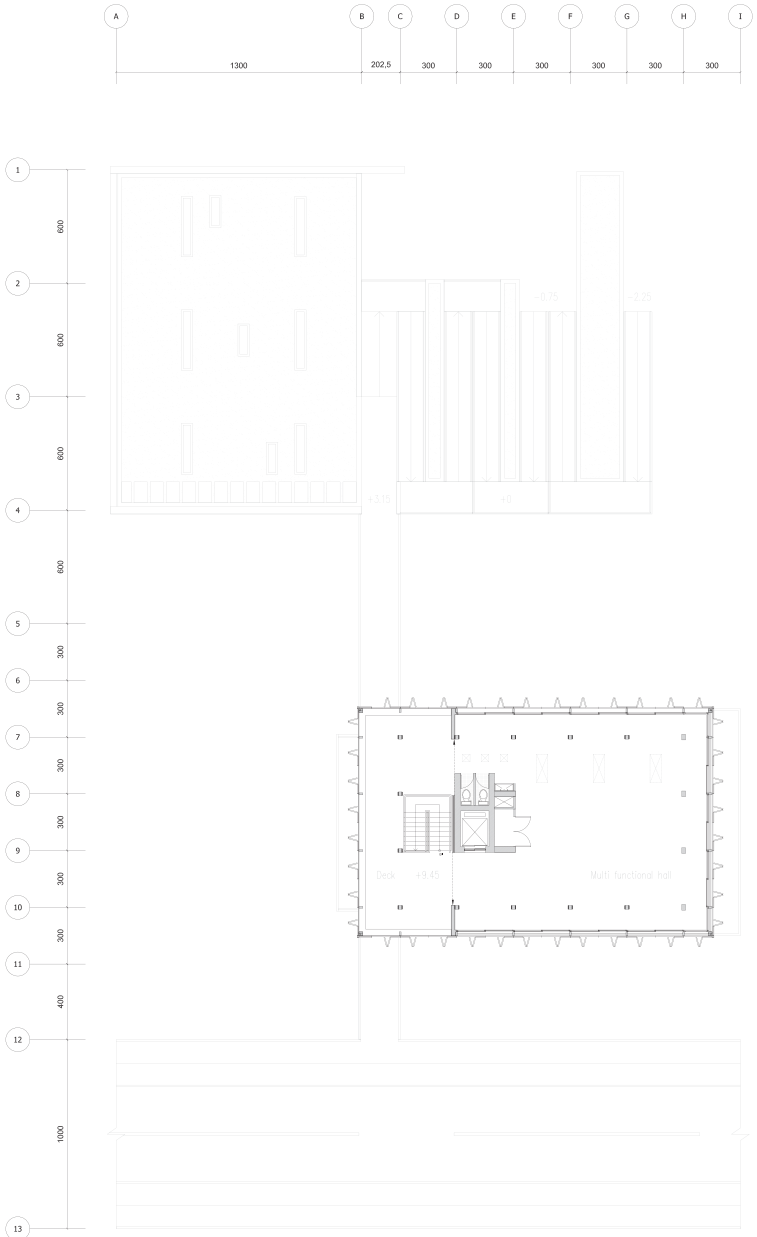


4.10.3 2F (+6.3)- Restaraunt

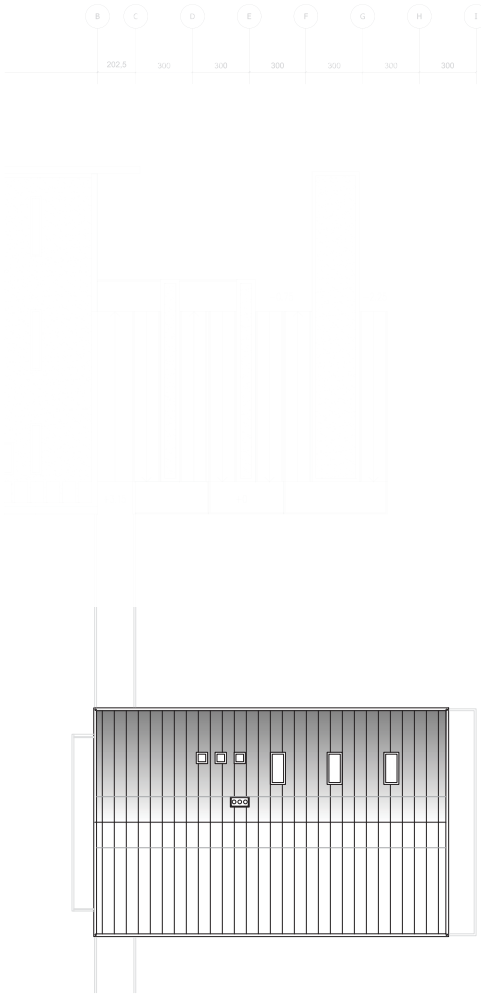



89
99
78
85

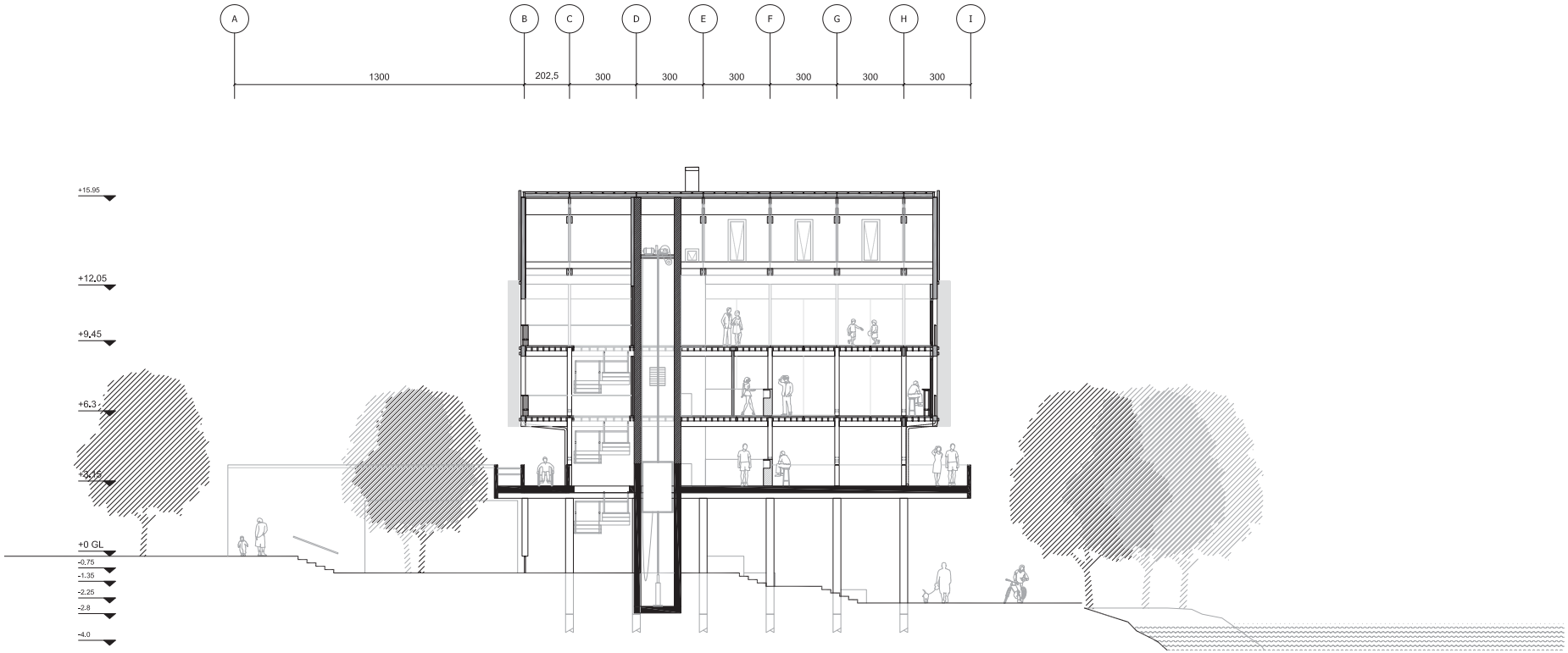
4.10.4 3F (+9.45)- Multi-functional communal hall



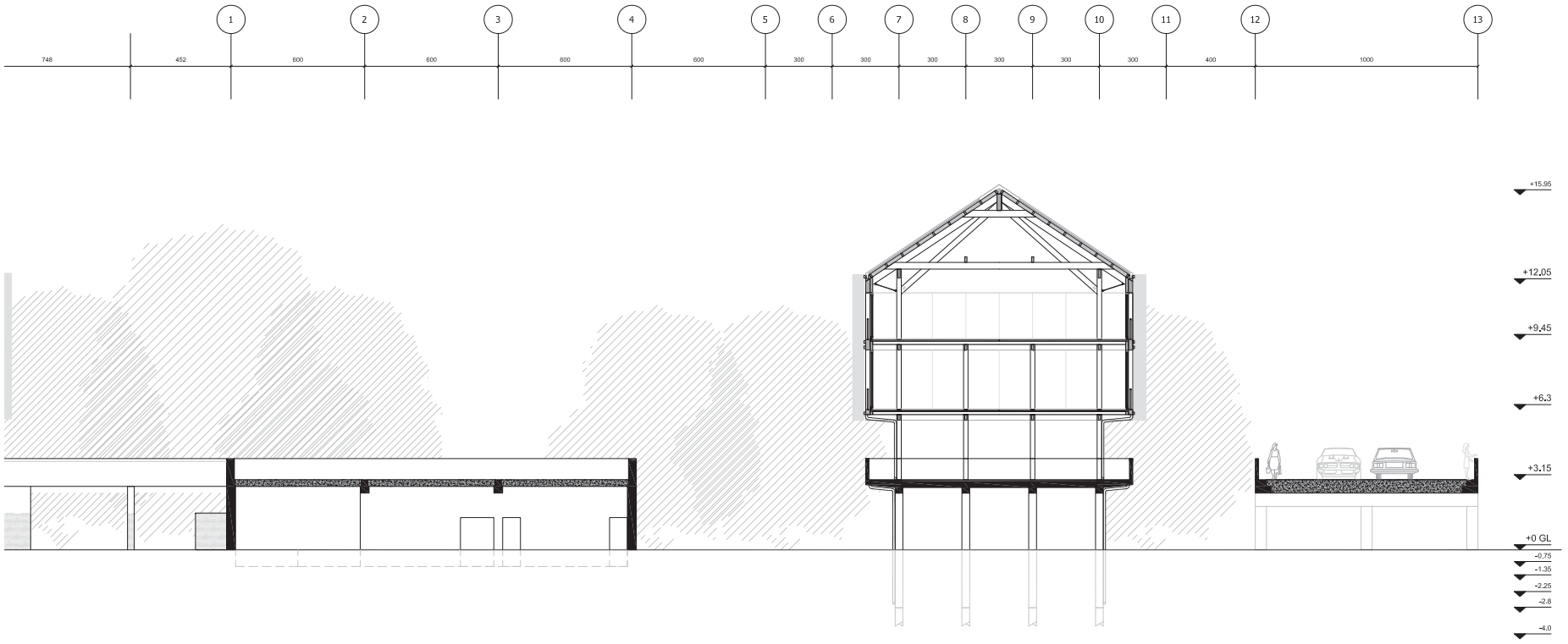
4.10.5 Roof plan



4.11 Section



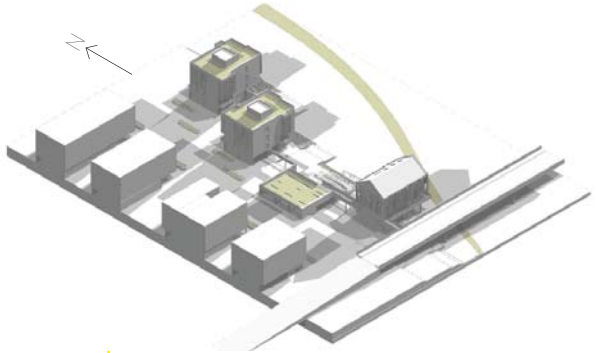
Long Section:a-a'



Short Section: b-b'

4.12 Climate Strategies:

4.12.1Summer

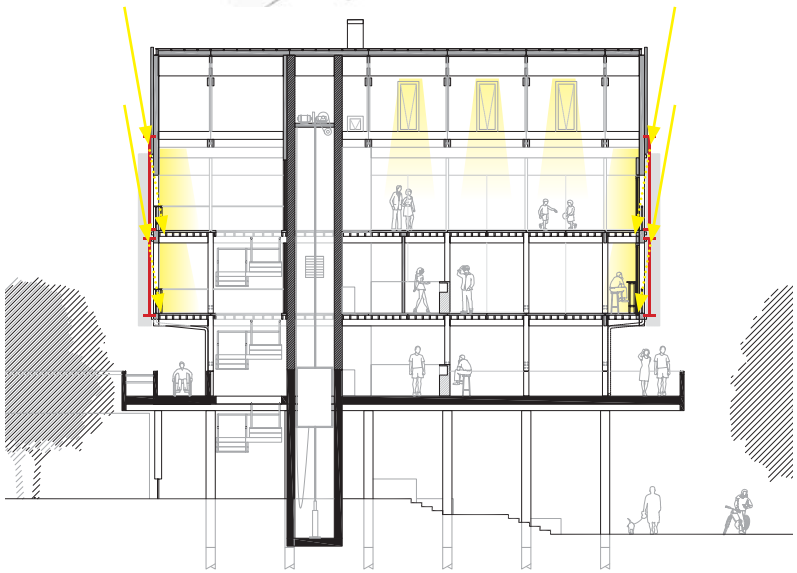


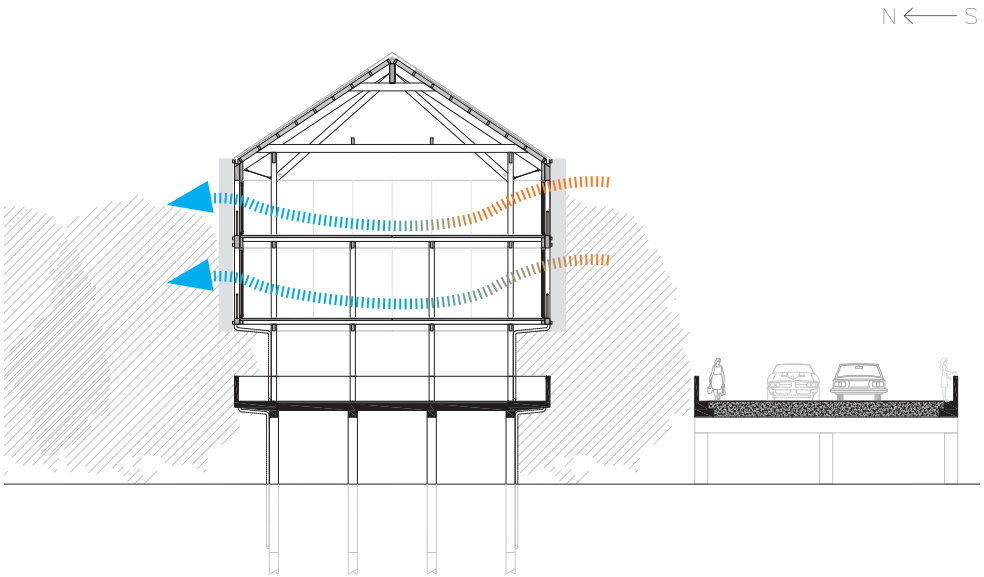
Natural daylight

In summer, the solar angle in Houston is 83° in June. Therefore the sun shading will be applied. There are two sun shading systems in this project: "Sliding & Folding vertical wooden louver panel", and "Roller sun blinding fabric screen". Two adjustable sun shading systems provide flexibility to reach the optimal natural daylight conditions.

Natural cross ventilation

The porch building is wrapped by sliding aluminum windows (from ceiling to floor), which provide panorama views for users. At the same time, sliding aluminum windows can provide big opening for natural cross ventilation. Moreover, electric fans can facilitate the efficiency of cross ventilation.





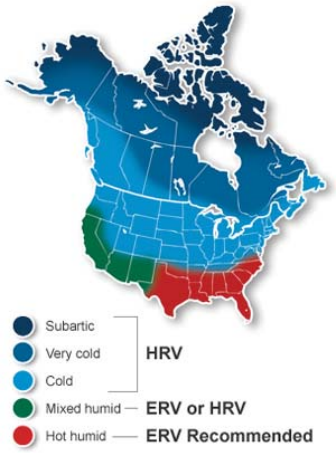
Insulated evenlope

In order to prevent overheating, functional spaces are insulated, which can make mechanical cooling system to be more efficient and reduce unnecessary energy consumption.

Mechanical cooling ventilation ERV+VRV

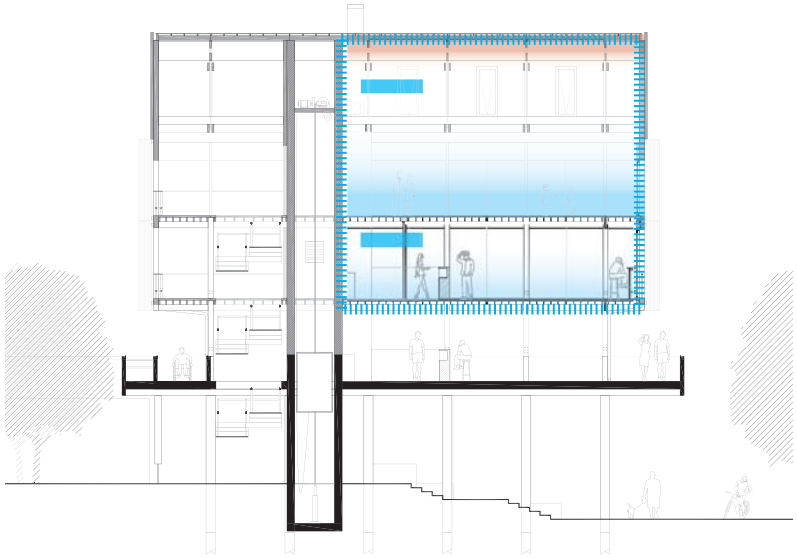
ERV (Energy recovery ventilator) integrates with VRV (Variable Refrigerant Volume). ERV system which is recommended in hot-humid areas can provide drier air fluent into interior space than HRV (Heat recovery ventilator), especially in this case, the insulated envelopes are constructed in timber structure and situated in hot-humid climate zone. In this case, Daikin VRVIII with Heat recovery outdoor unit and Slim Ceiling Mounted Duct Type indoor unit will be applied.

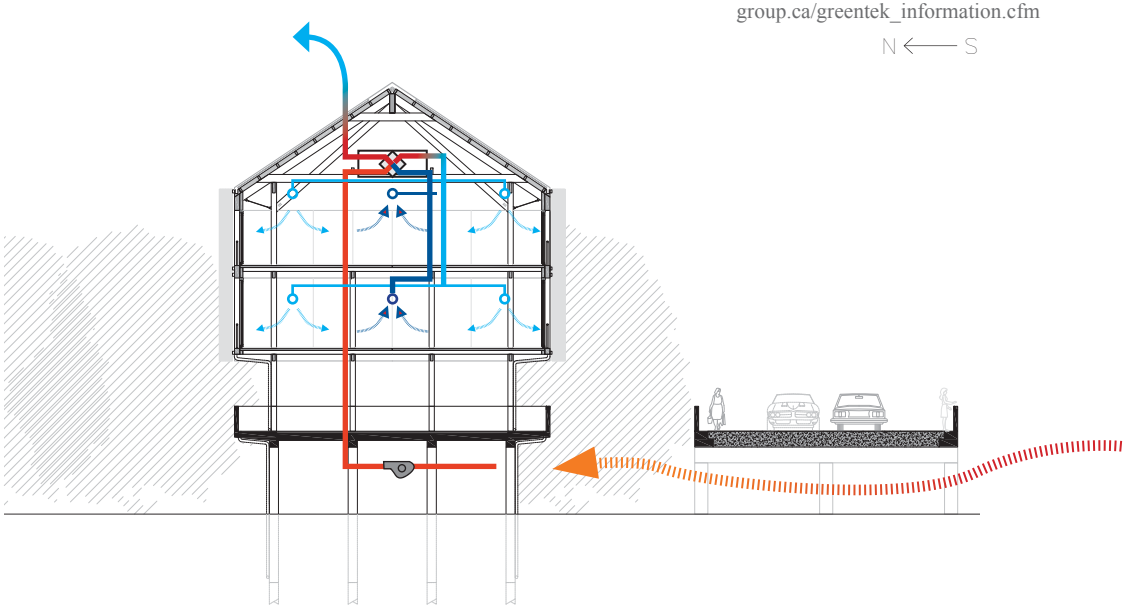
The wind normally comes from south side. In this case, the warm air will be pre-cooled by the water and big area shadow from bridge and porch building, then be sucked up to the ERV for air supplying.



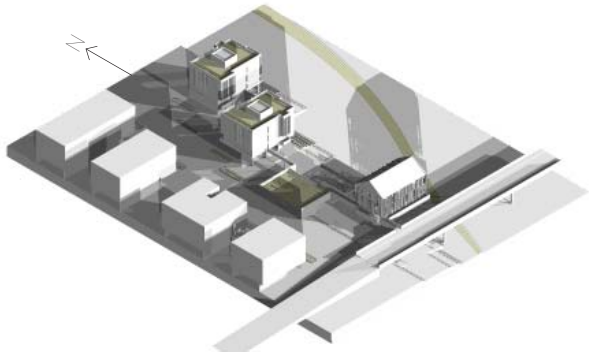
ERV system is highly recommaneded in hot-humid area rather than HRV. Source from: http://www.imperial-group.ca/greentek_information.cfm

N ⟵ S



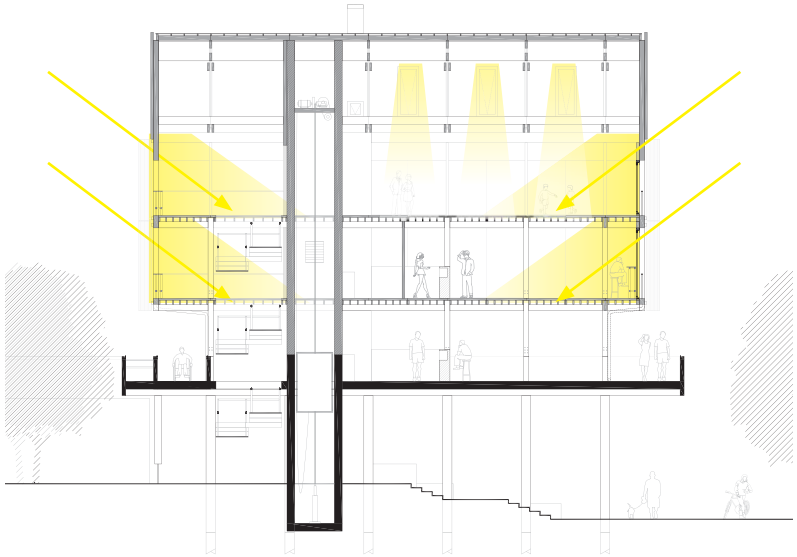


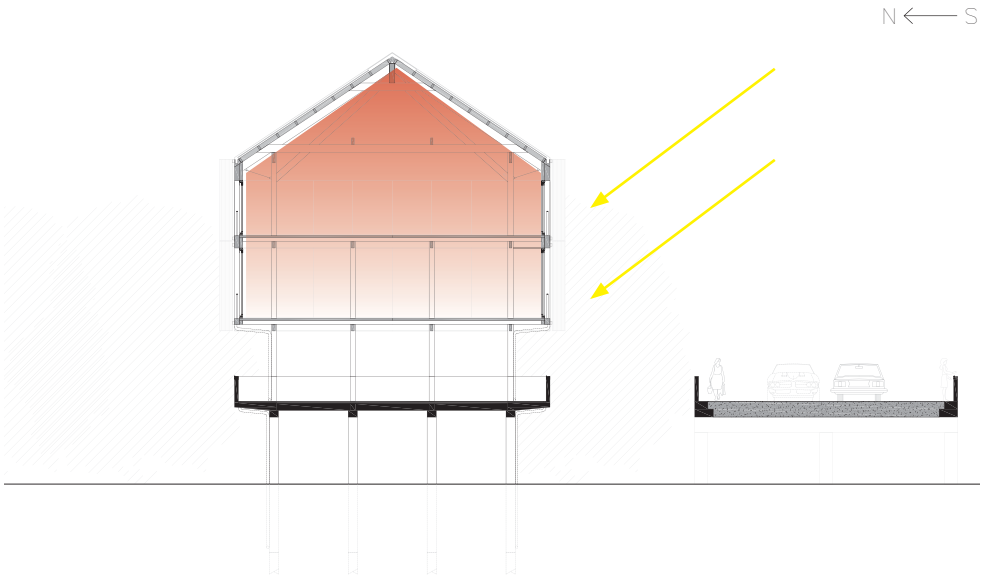
4.12.2 Winter



Natural daylight
In winter, the solar angle in Houston is 34° in December. Therefore, the sun shading will be opened widely. Two adjustable sun shading systems provide flexibility to reach the optimal natural daylight conditions.

Natural heating
Since the building is wrapped by glassing sliding doors, it can be easily heated up via greenhouse effect when shading systems is unused in winter, especially on the south side façade.





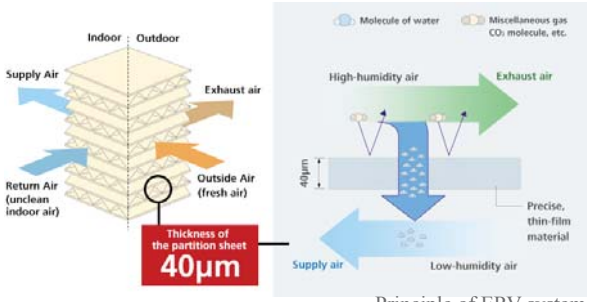
Insulated evenlope

In order to prevent energy waste, functional spaces are insulated, which can make mechanical heating system to be more efficient and reduce unnecessary energy consumption.

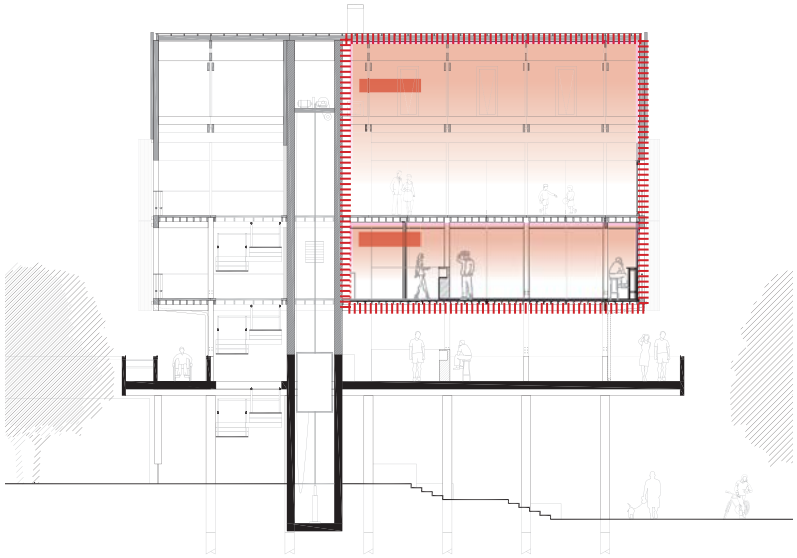
Mechanical heating ventilation ERV+VRV

ERV (Energy recovery ventilator) integrates with VRV (Variable Refrigerant Volume). The principle will be the same as summer situation, and air flows the other way around. ERV can help pre heating/ cooling the air to facilitate the efficiency of VRV.

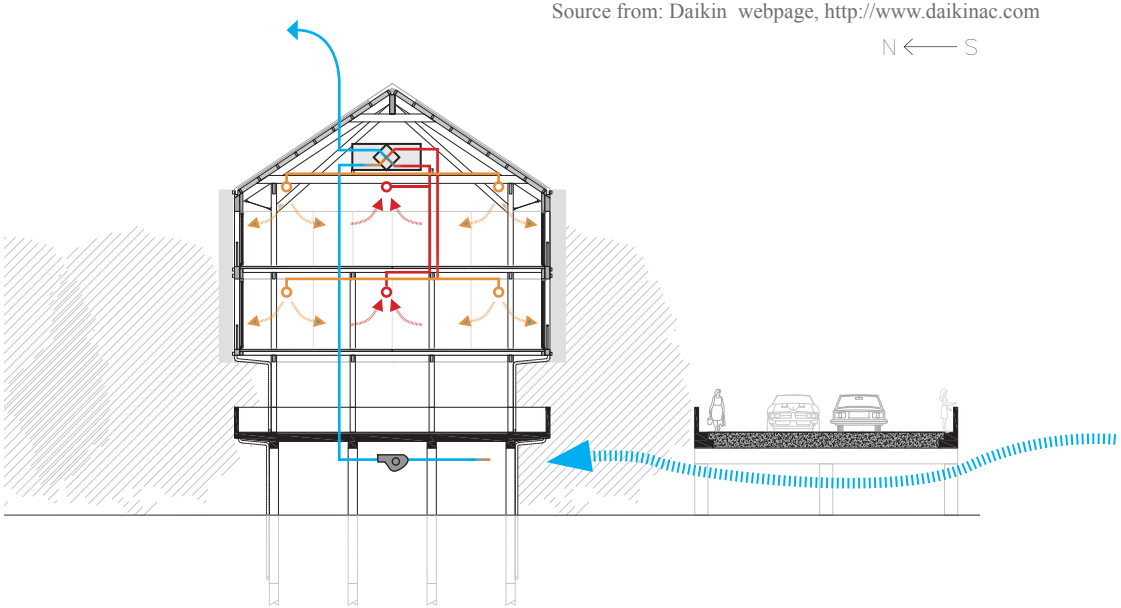
ERV unit VRV indoor unit
Slim Ceiling Mounted Duct Type



Principle of ERV system
Source from: Daikin webpage, http://www.daikinac.com



N ⟵ S



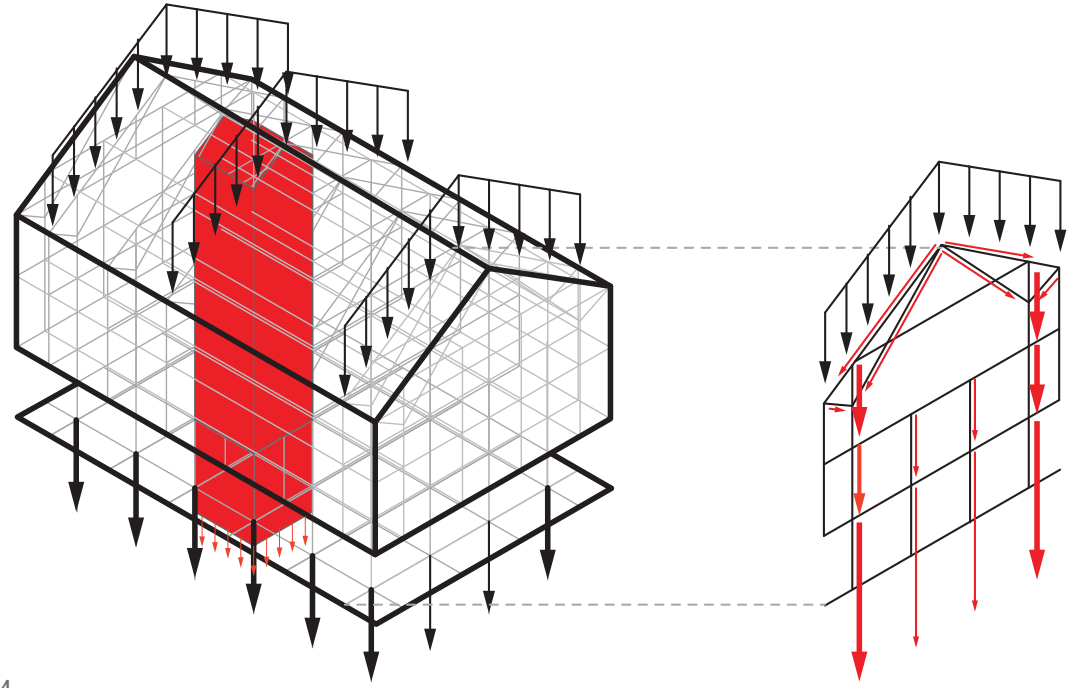
4.13 Structure

The structure of the Porch building is mainly consisted of concrete base and then timber structure up on it. This combination is to reflect the conceptual idea: “a free form creature on the stable concrete table locating next to the water.” All the planning in this project is based on the 3m x 3m grids. In order to make the porch building more outstanding, there are some exceptional structure fabrications.

4.13.1 Loading

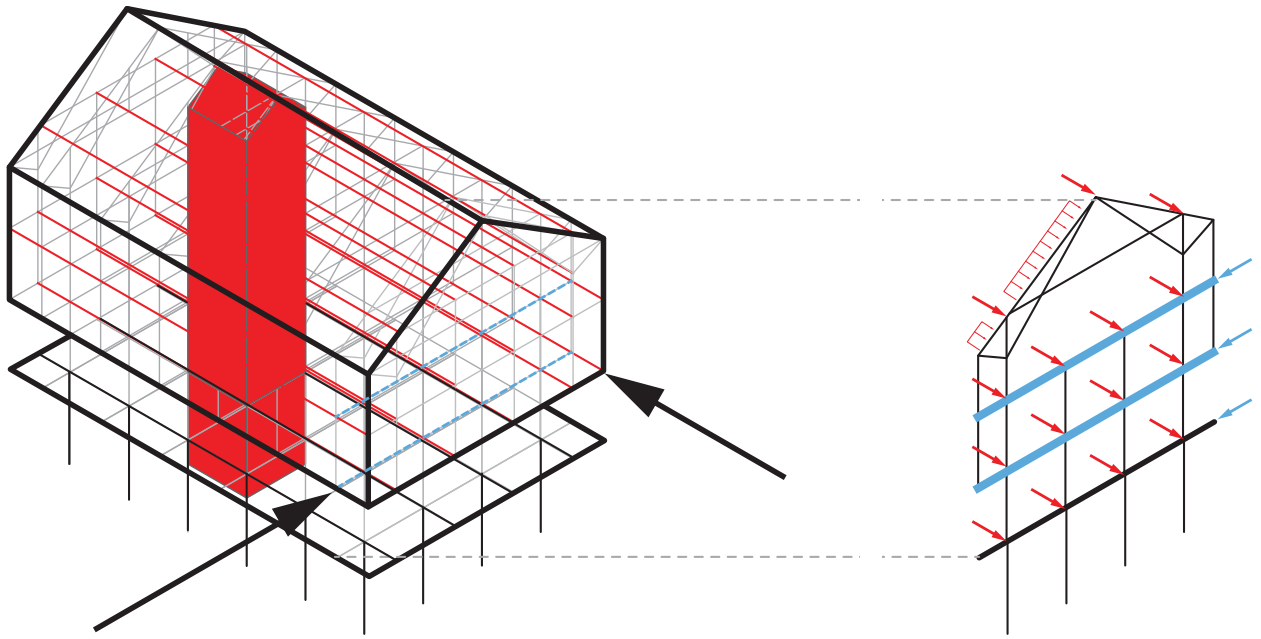
The materials division line is located at +3.9. Therefore, the columns below +3m are made out of concrete. From the short elevation of porch building, there are only three concrete columns under this ground floor of porch building, and four timber poles, which can reinforce the conceptual idea of free form.

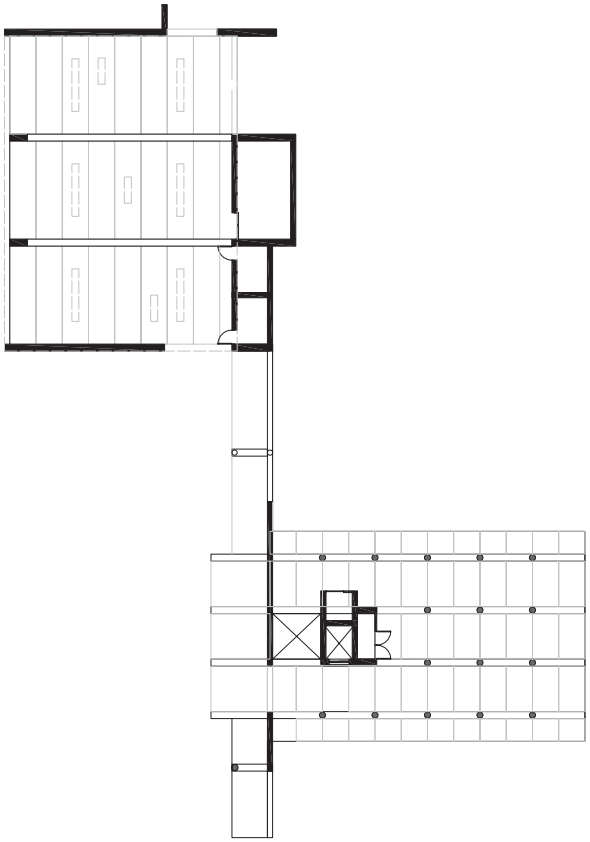
It reduces the dense of concrete columns which will cause pressure atmosphere for visitors. Meanwhile, it will increase the depth of beam to reinforce the stability for supporting all the floors and supporting the initial concept.



4.13.2 Rotation

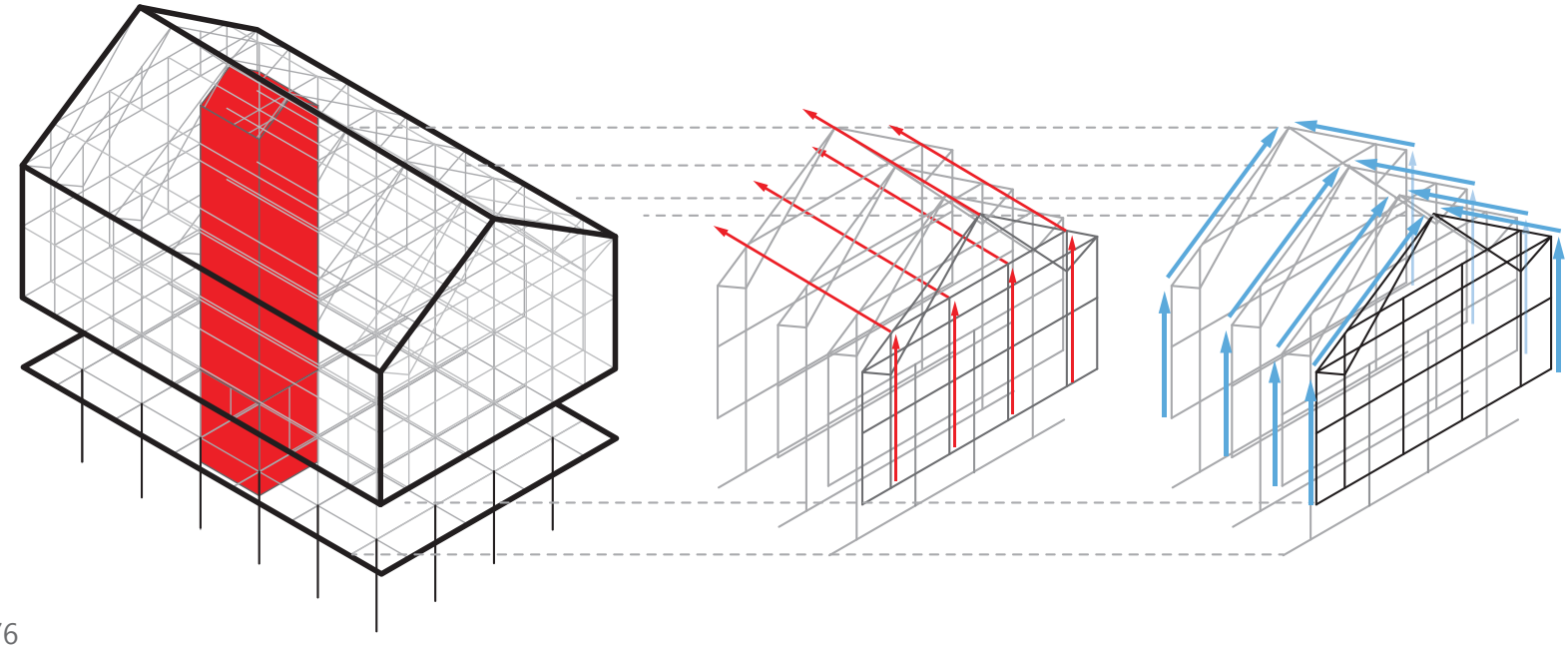
Since there is a core to increase stability on loading ability, the core will easily play a center for rotation when there is the wind load from the south or north. Therefore, there will be an exceptional timber beam which goes from north-south in the opposite side from core to resist the wind load.





4.13.3 Cantilever

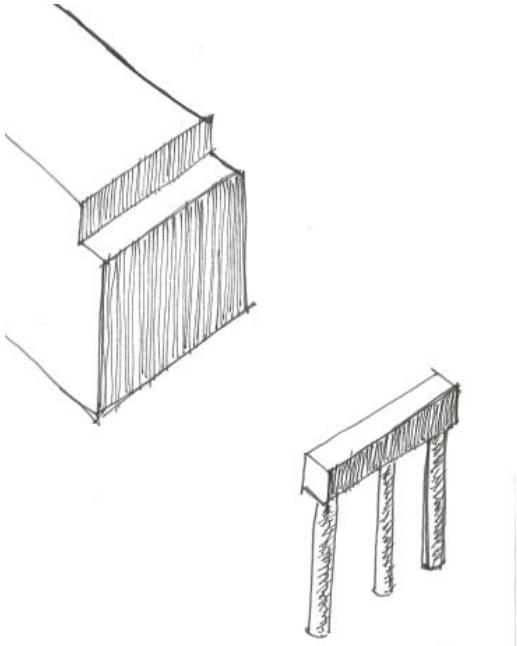
The porch building is surrounded by cantilevers which are not only supported by floor beams and suspended by purlins.

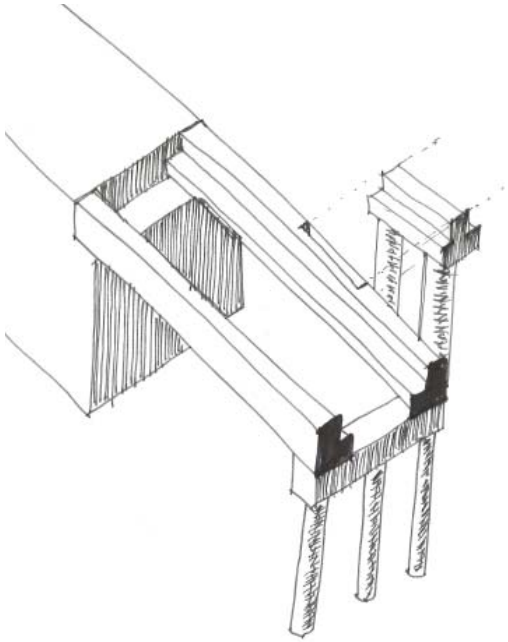


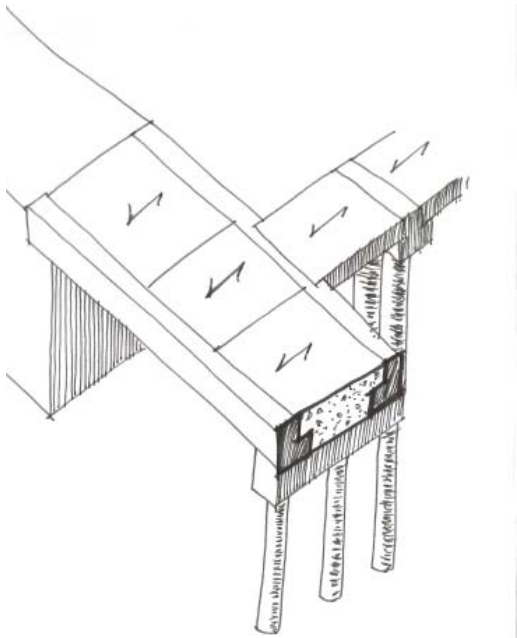
4.13.4 Bridge structure

1. Main beam direction goes in N-S direction, which can have possibility to reduce vibration by istalling damper pads at the connection parts.

2. The long span beam, E-W beams, can integrate with fundation of parapet and rainling by aling to the slabs ot increase more space underneath the bridge,







5.Architectonic

5.1 Facade

5.1.1 Facade

Since the program has been defined for public using, the impression of the porch building should be attractive. The design approaches are based on two perspectives, from exterior and from interior:

Conceptual idea: "A free form creature on the stable concrete table locating next to the water"

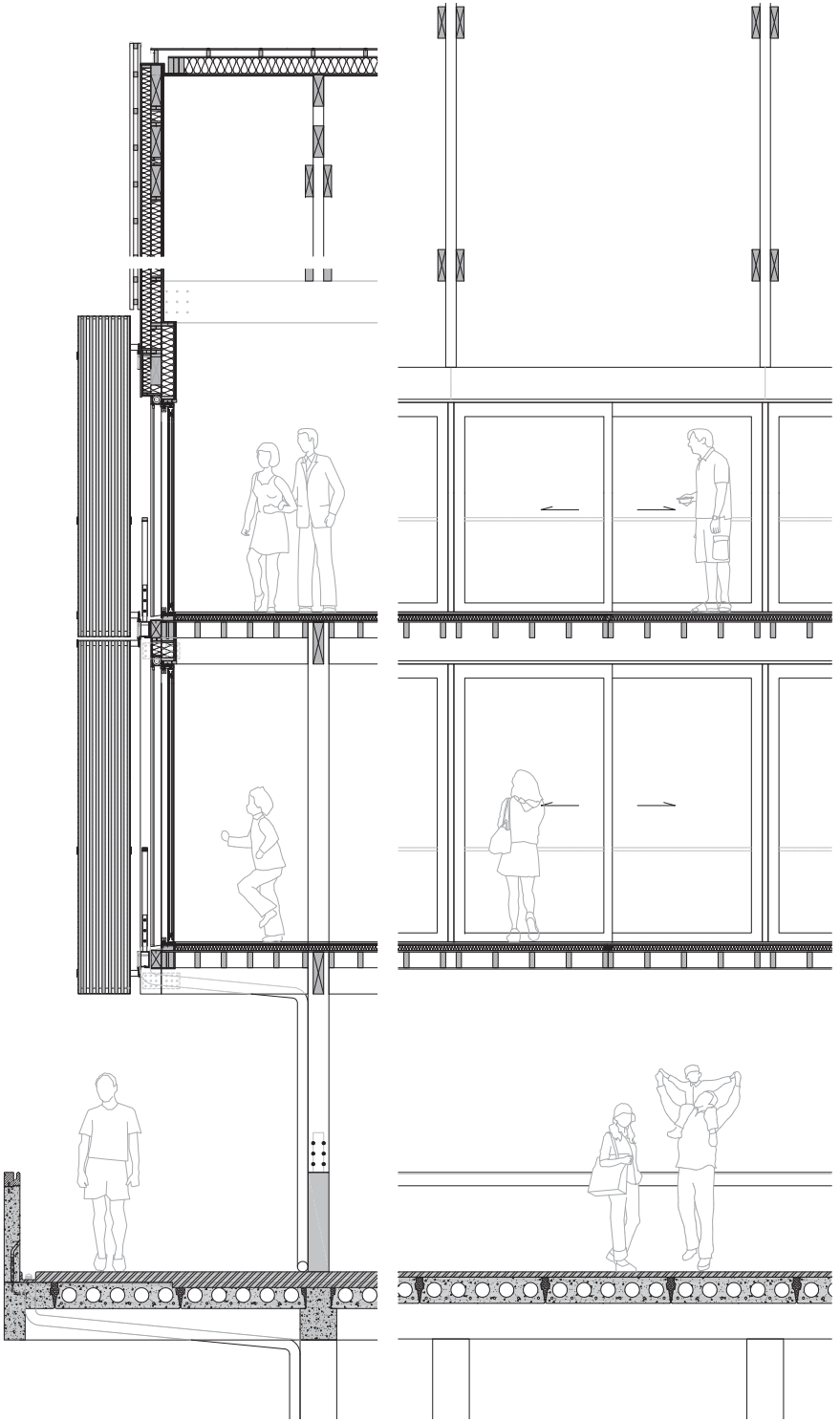
From interior

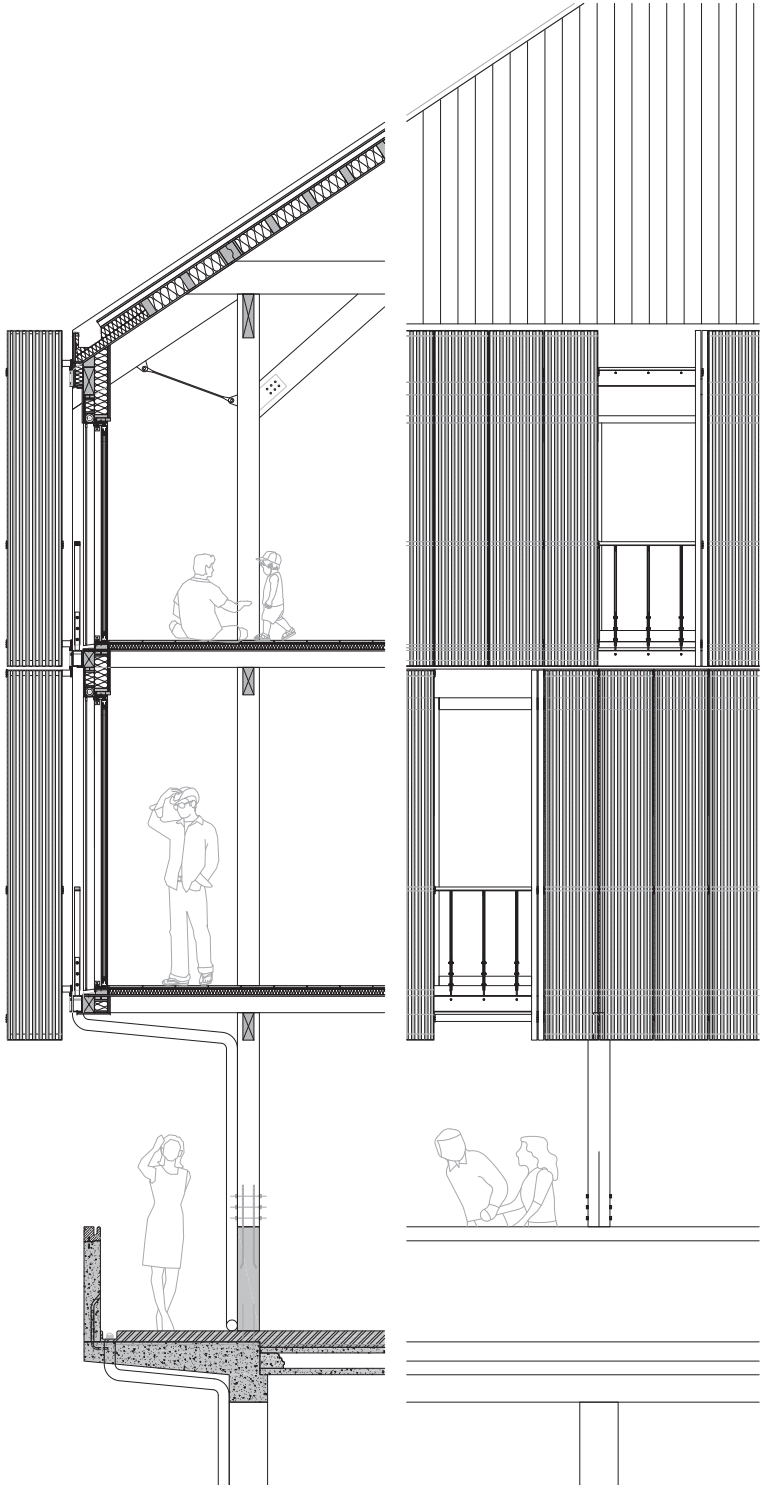
> Panorama view

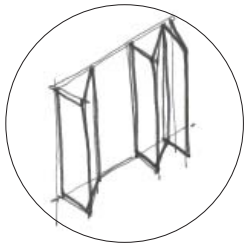
Since the location of the building is an important transition point in between land & water, public & private, and the entrance of the creek park, the panorama view from the building can provide understandable clues for users to know context of design. Therefore, big sliding aluminum windows will be applied as much as possible.

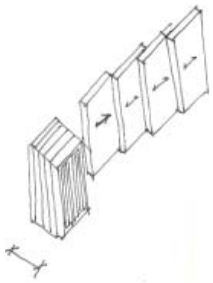
> Sun Shading

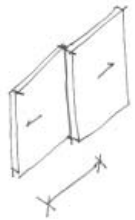
In order to prevent over-heating in the building, the sliding window will be covered by louvers. The louvers will provide certain opening and optional opening to adjust the light quantity. Therefore, the folding louvers can be considered the solution for optional opening and vertical image when it needs to open.

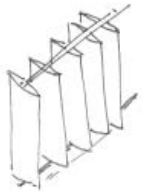


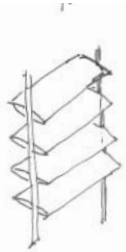












From exterior

> The abstract shape

The abstract floating box shape is an exceptional image in the rhythm of creek front buildings. The abstract floating box shape also reinforces the idea of differentiation of materials.

>Façade for uniting floors, vertical impression

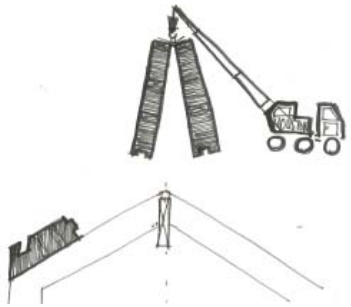
One of function of façade is to unite floors to achieve a box volume image. Meanwhile, the façade will show the vertical impression to interpret the timber construction and differentiate the horizontal landscape construction.

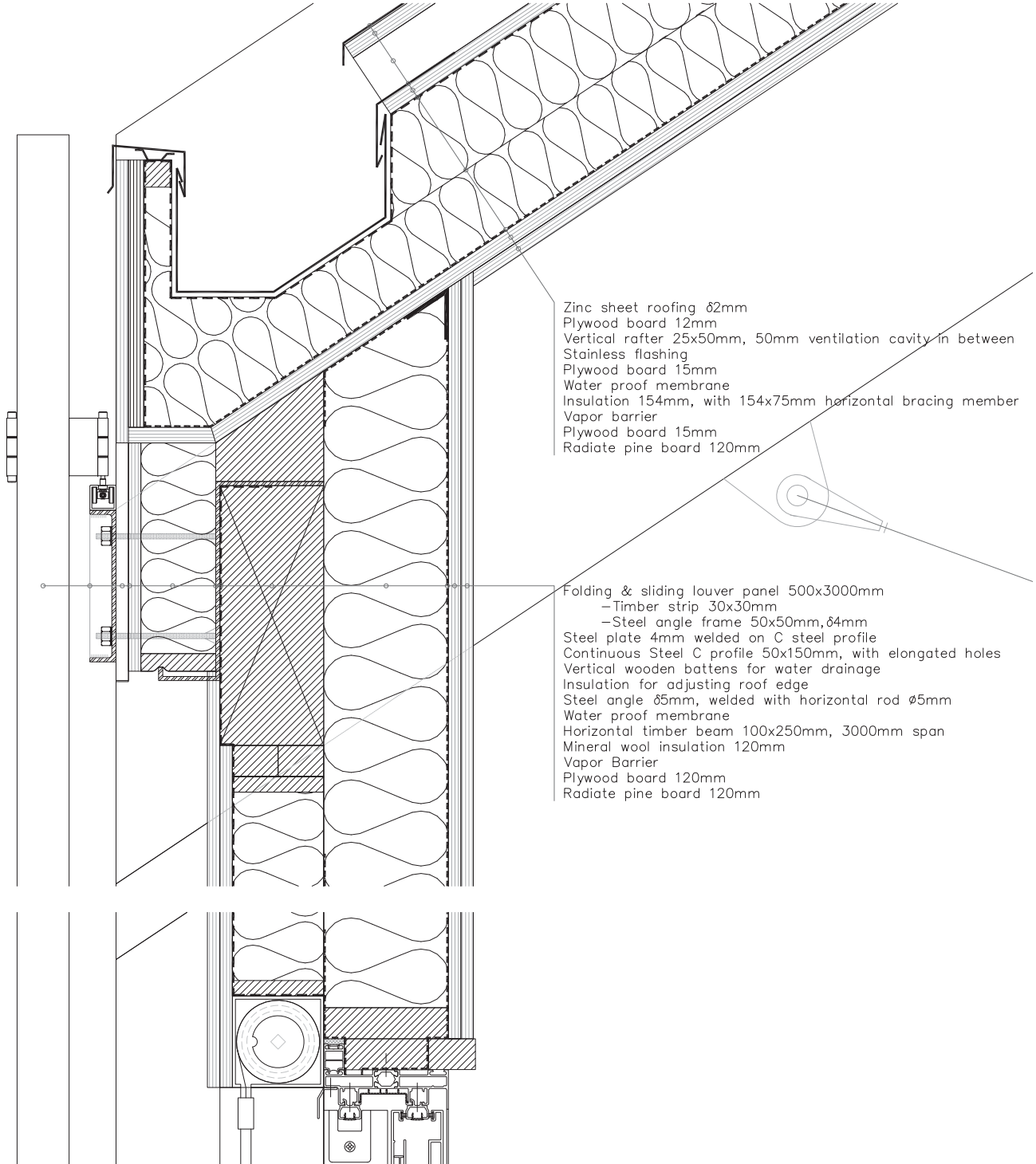
>Reinterpret the characteristic of timber structure

The main idea of façade is not only for sun shading, but also to show the delicate timber structure. Therefore, louvers will be considered as the solution.

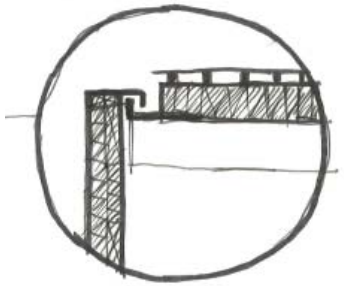
5.2 Roof construction

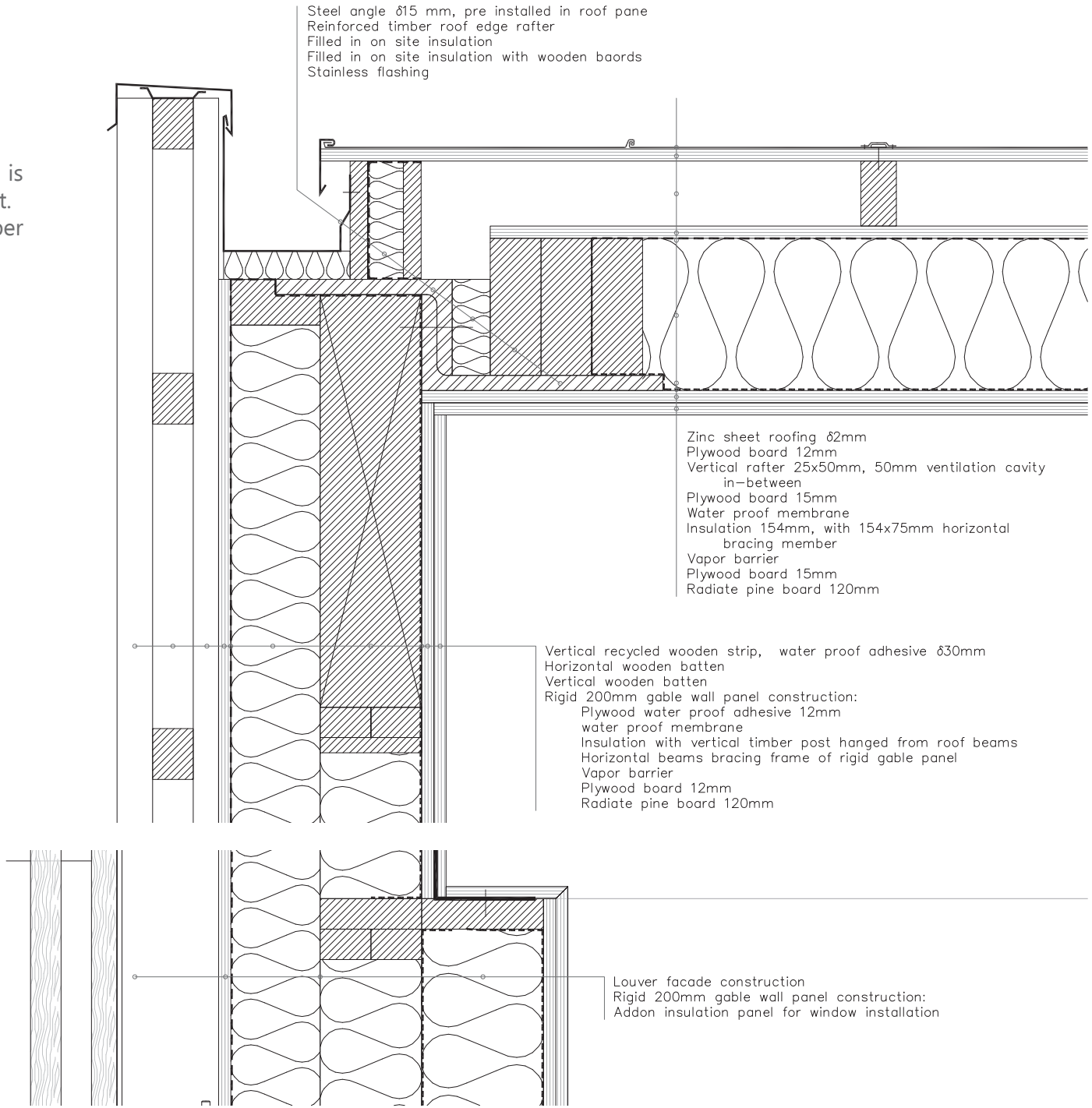
Prefab rigid roof panel





The pre fab rigid gable wall panel is hanged by Prefab rigid roof panel first. Then it will be screwed on the timber columns.

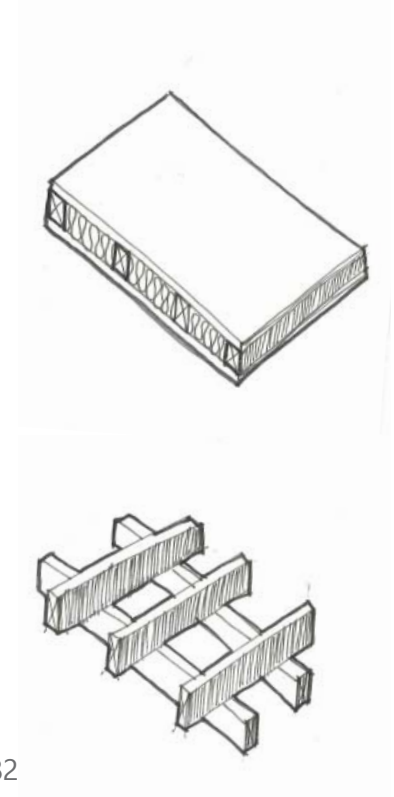


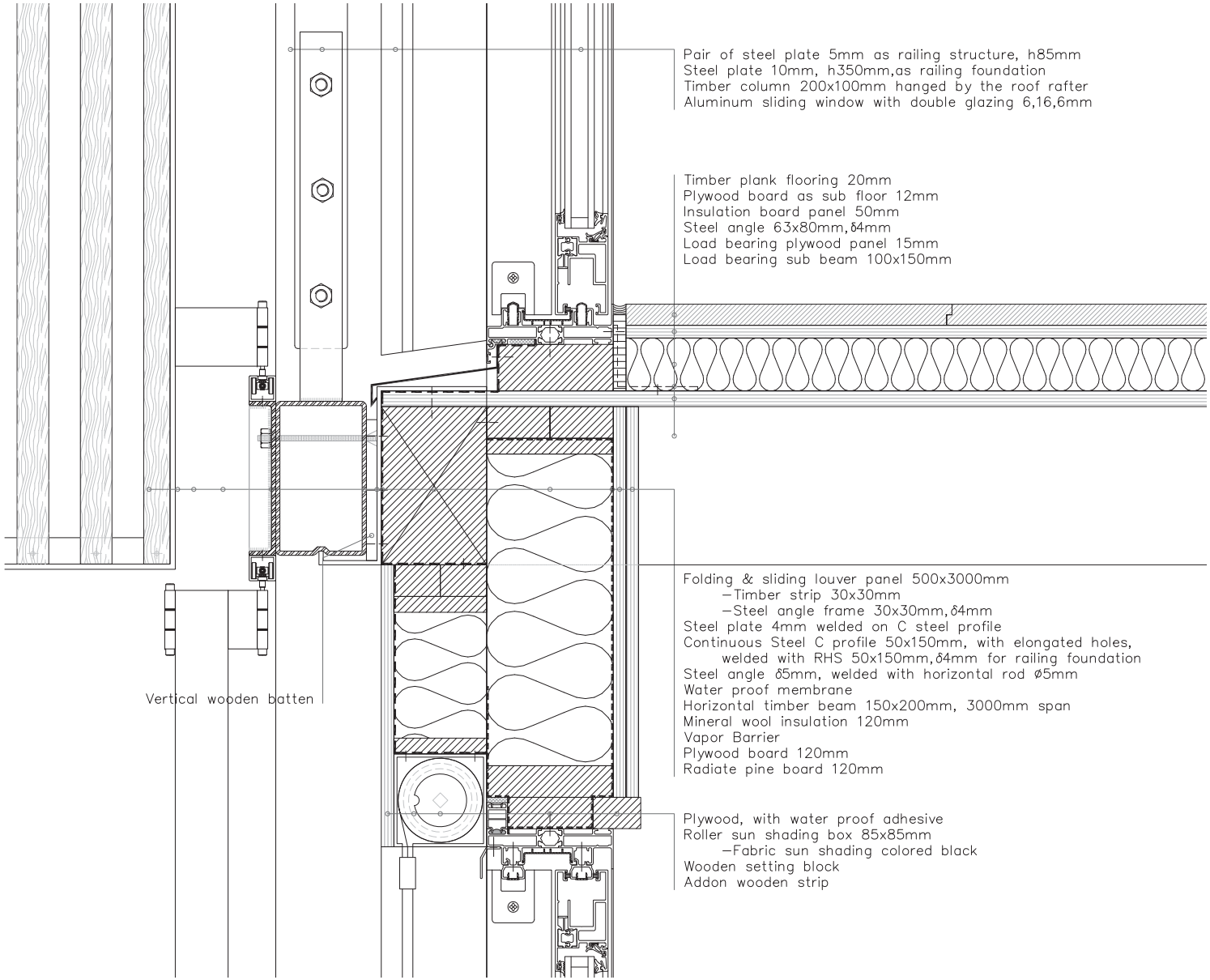


5.3 Floor & Ceiling construction

Ceiling

In order to show the characteristic of timber structure, the interior celling can have opportunities to indicate the orientation of timber main beams & sub beams.

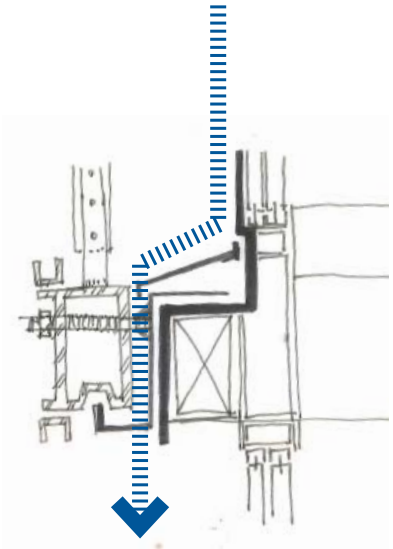


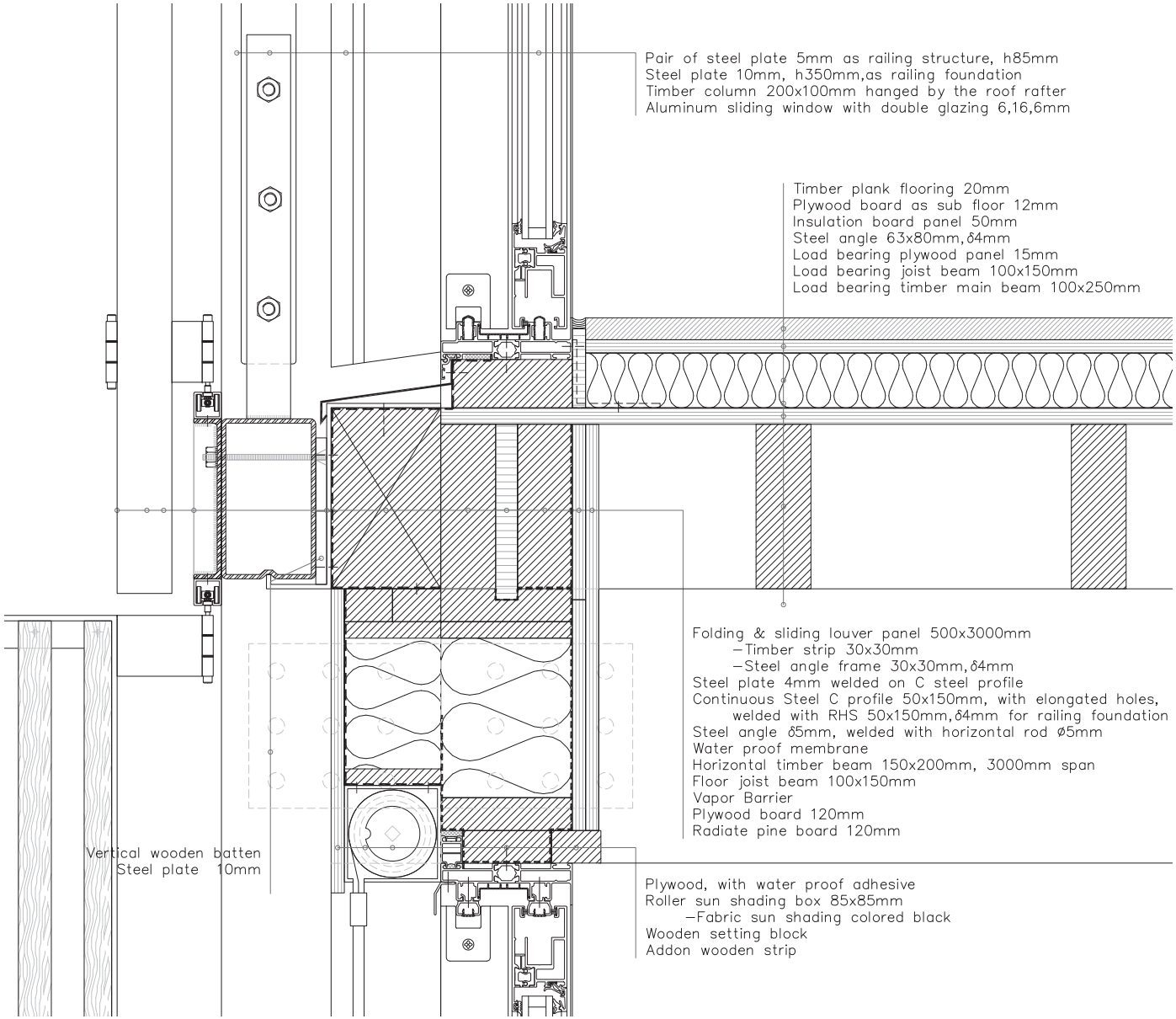


Flooring

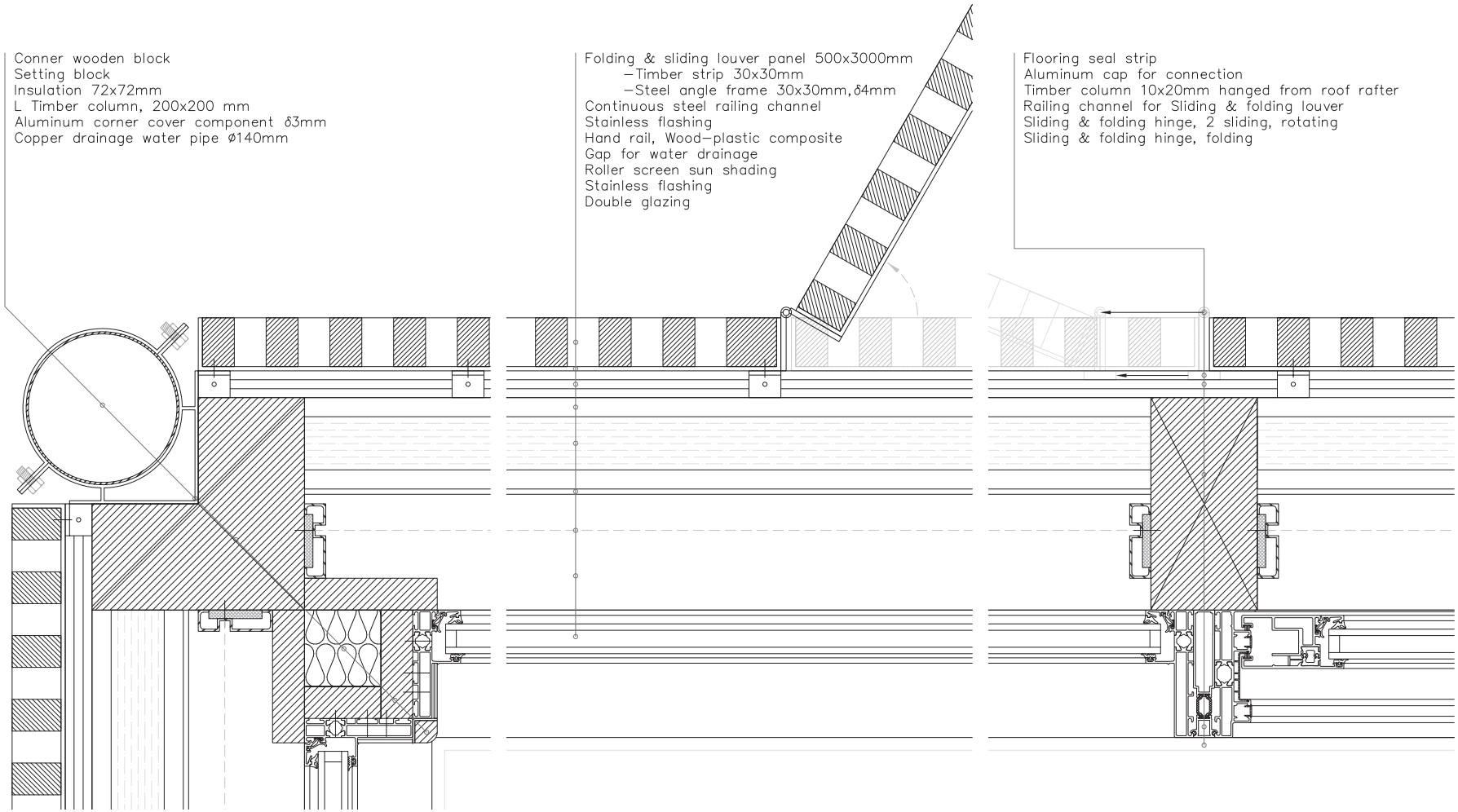
Since the floor is constructed by timber structure, the thermal insulation should be considered to make functional area into a warm envelope.

The railing, sliding & folding rail channel can be a specific detail which can unify the difference of height in the edge of floor, and acts as a water proof layer at same time.

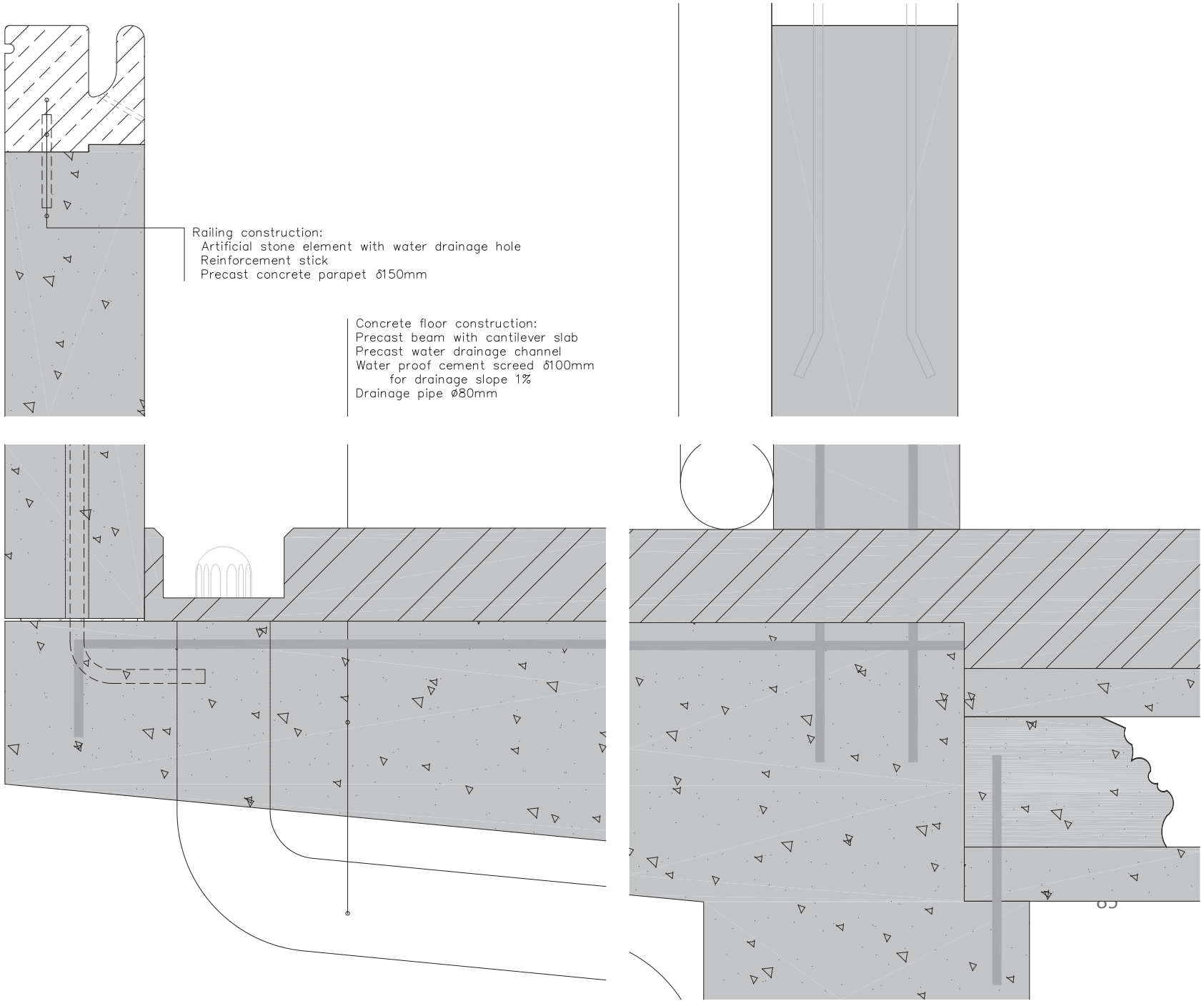




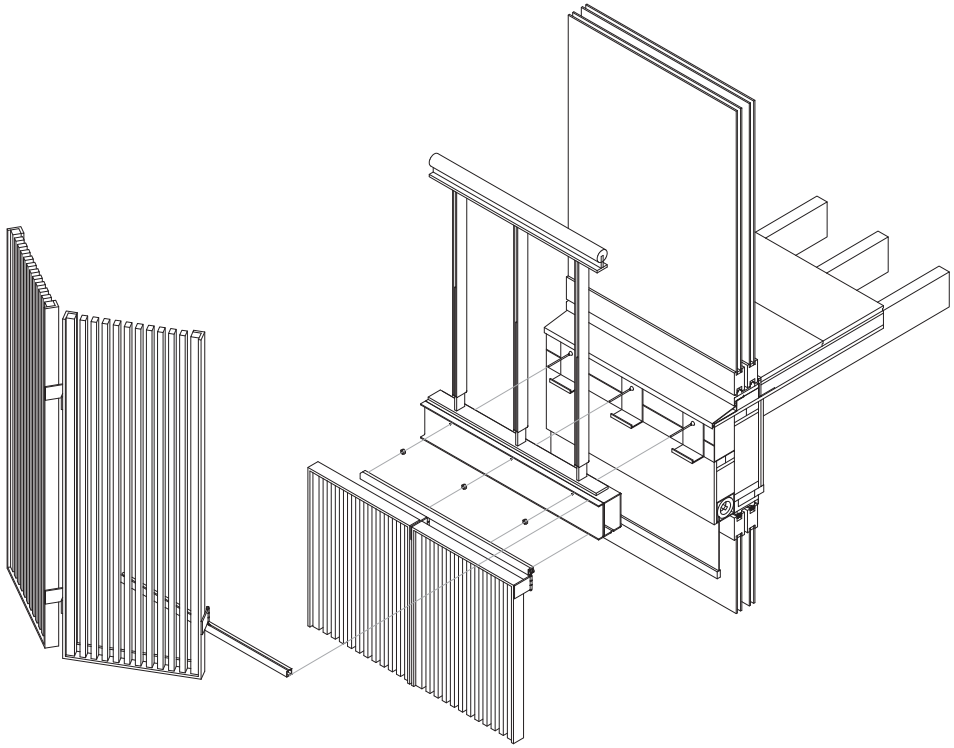
5.4 Corner constrcution

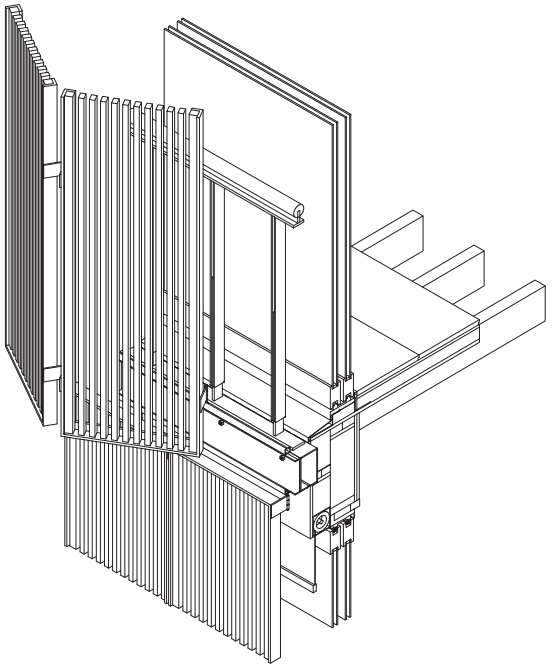


5.5 Parapet

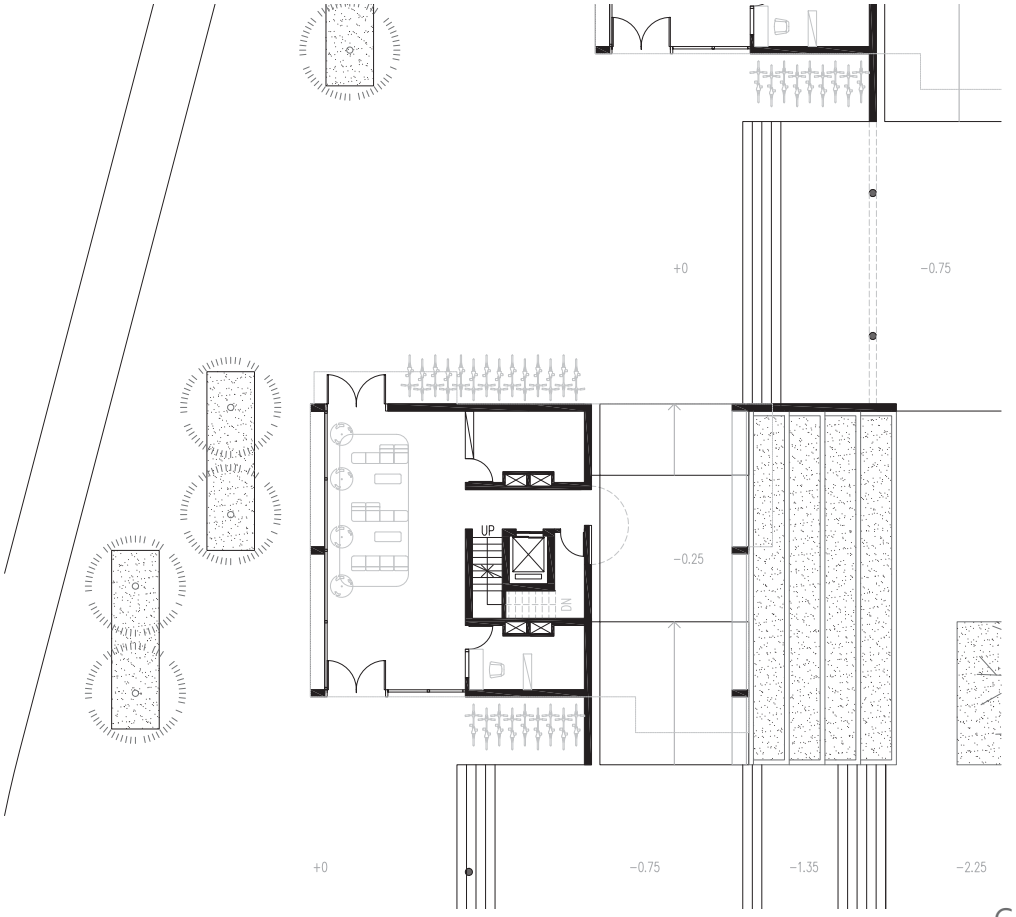

Railing construction:
Artificial stone element with water drainage hole
Reinforcement stick
Precast concrete parapet δ150mm
Concrete floor construction:
Precast beam with cantilever slab
Precast water drainage channel
Water proof cement screed δ100mm
for drainage slope 1%
Drainage pipe ø80mm

5.6 Principle of assembling

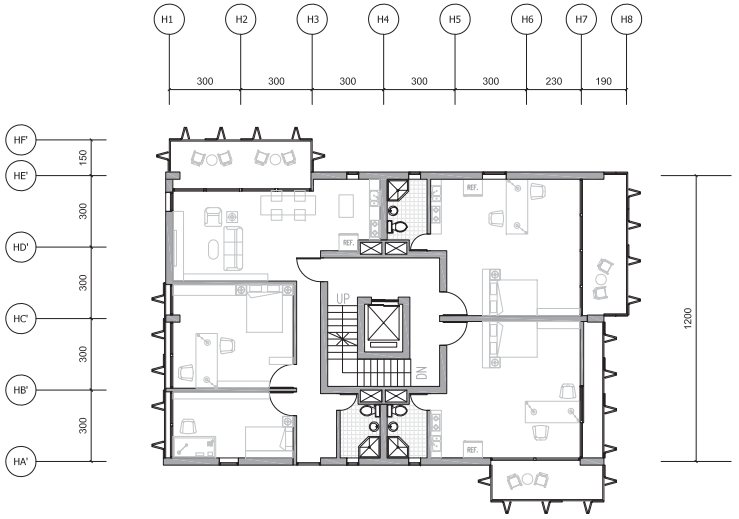




5.7 Principle floor plan of housing



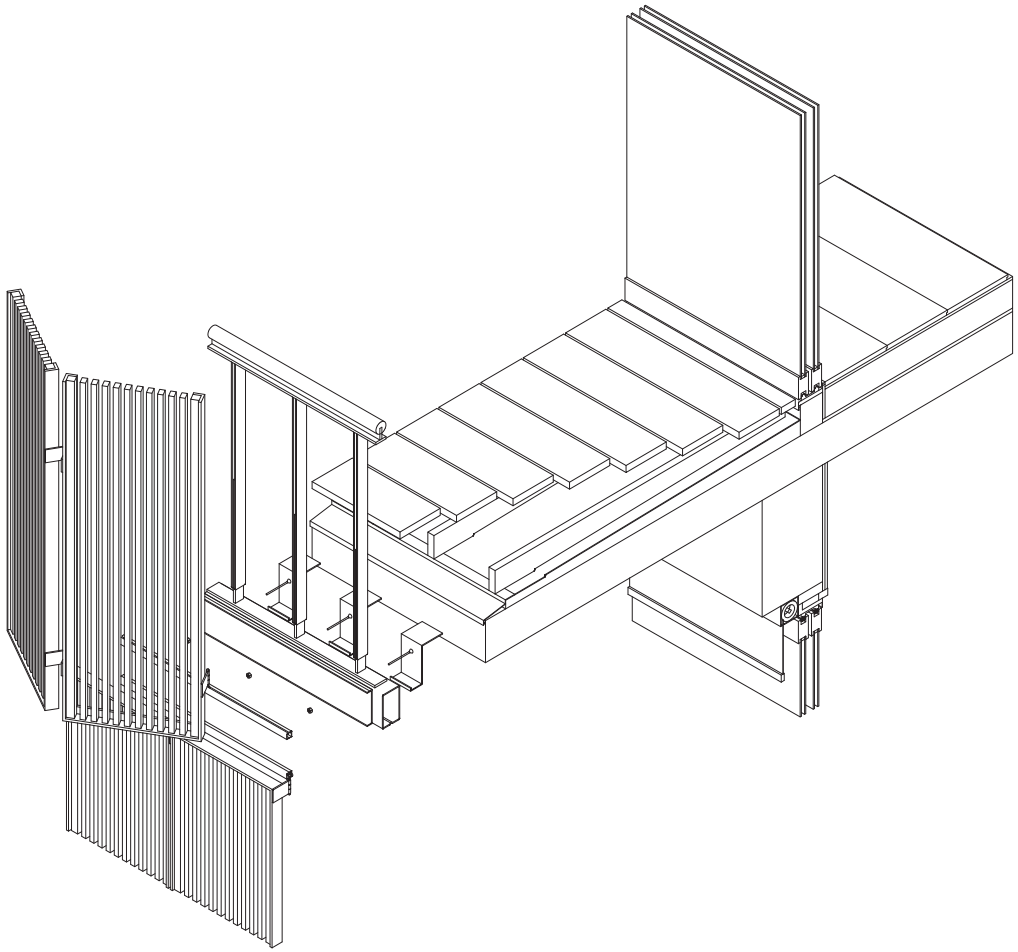
GL

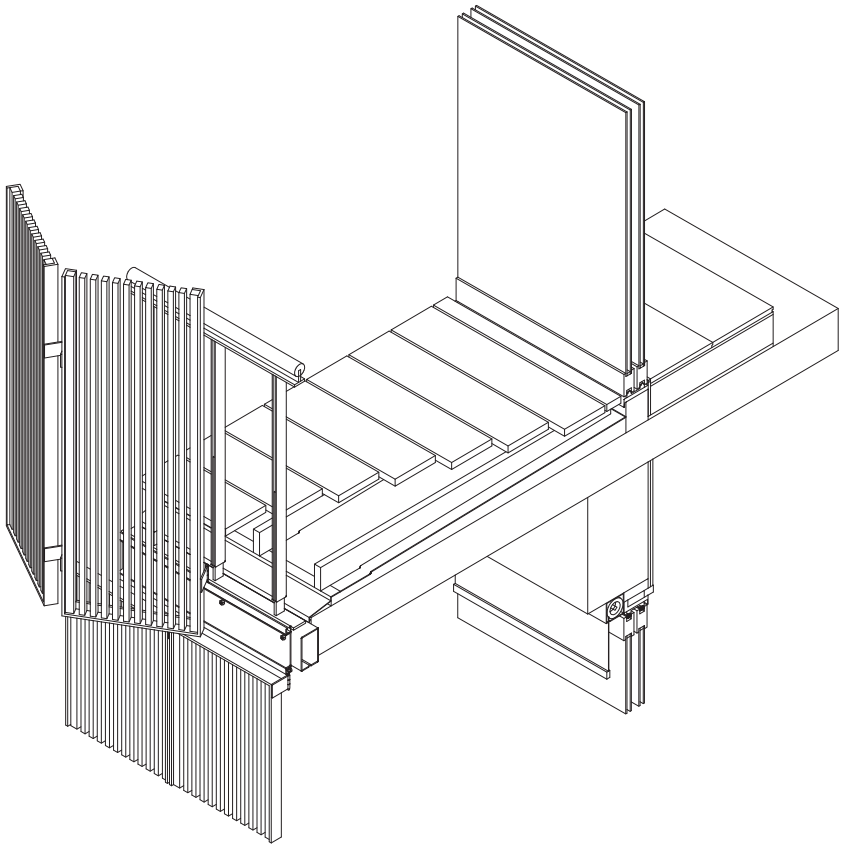


1F~3F principle plan

GF-Prefab Concrete structure
1F~3F- Timber frame + timber panel structure

5.8 Facade application on Housing





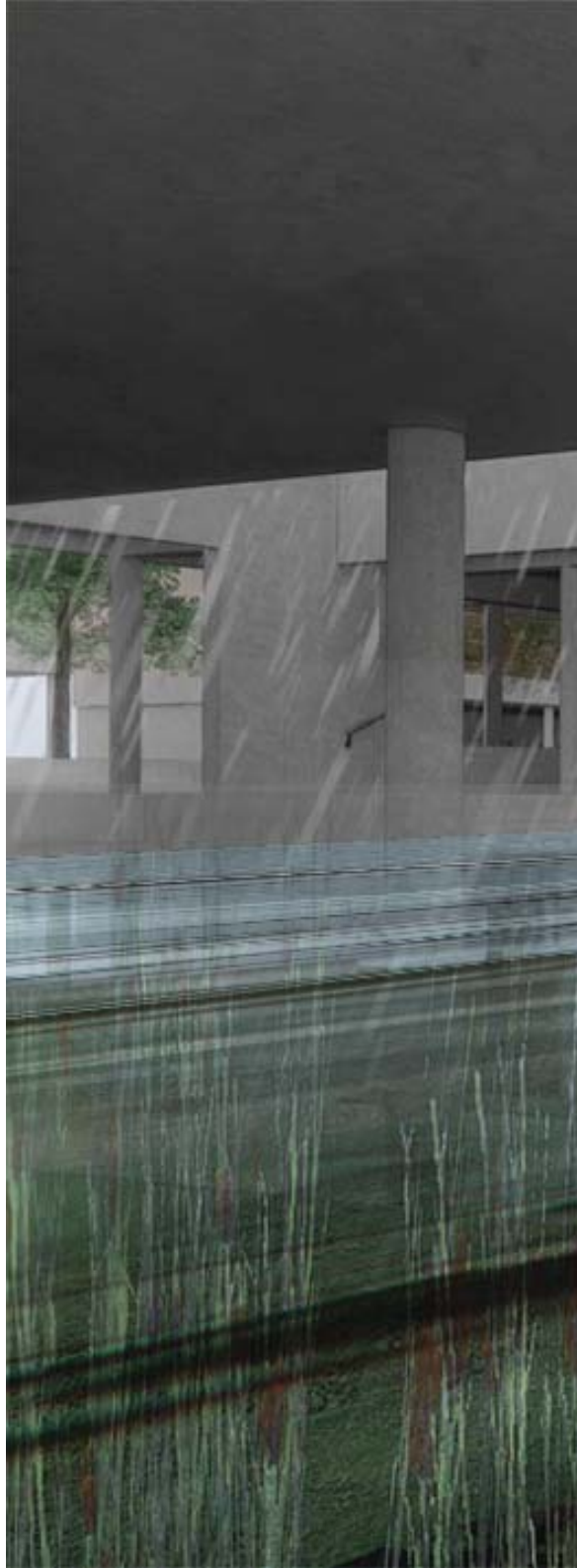
6.Architectural Promenade

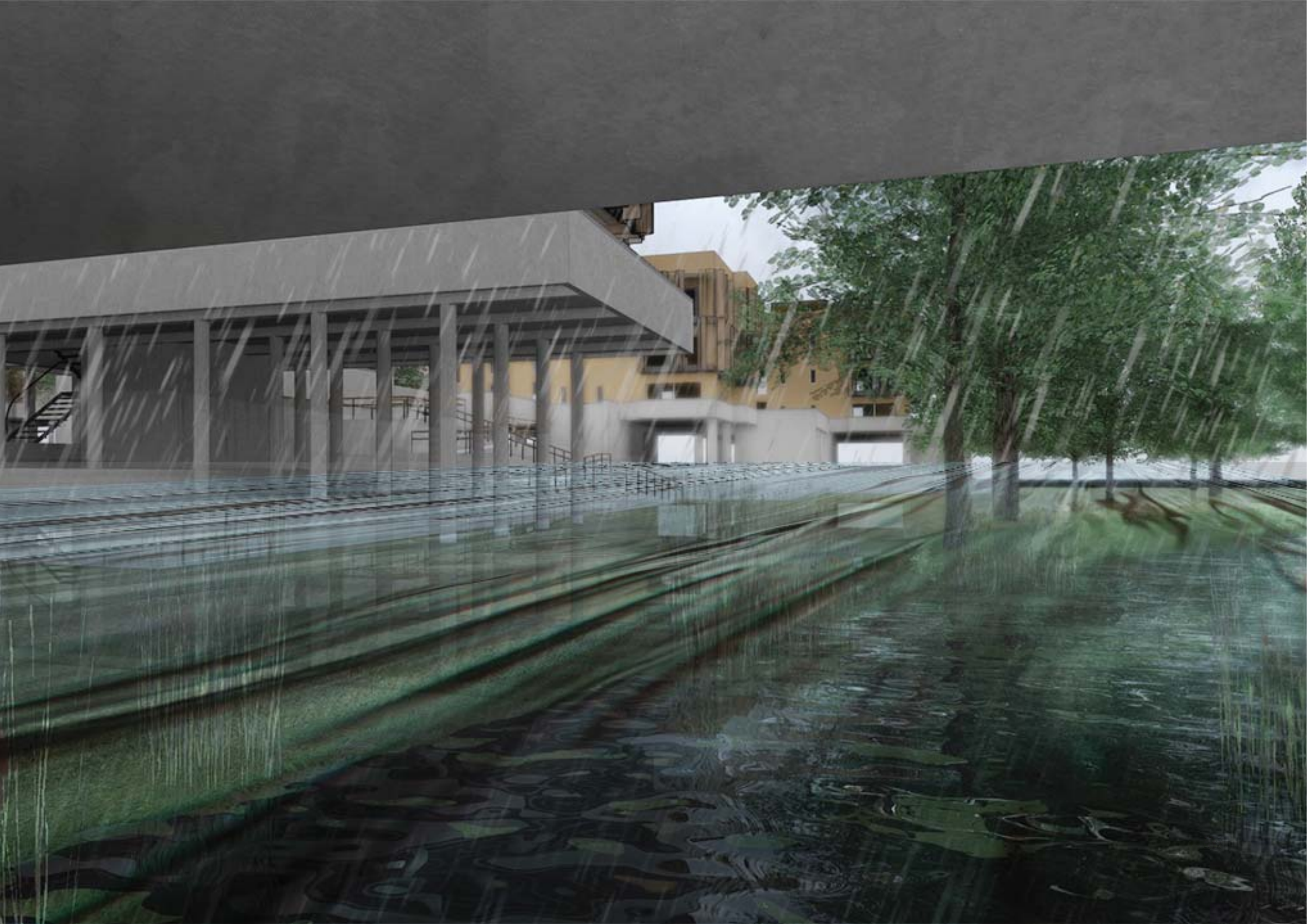
6.1 Under the bridge

6.1.1 Variety of landscape

6.1.2 Flooding under the bridge

This image shows the flooding level is more than 1in100 yr (water at -1.0 m level)

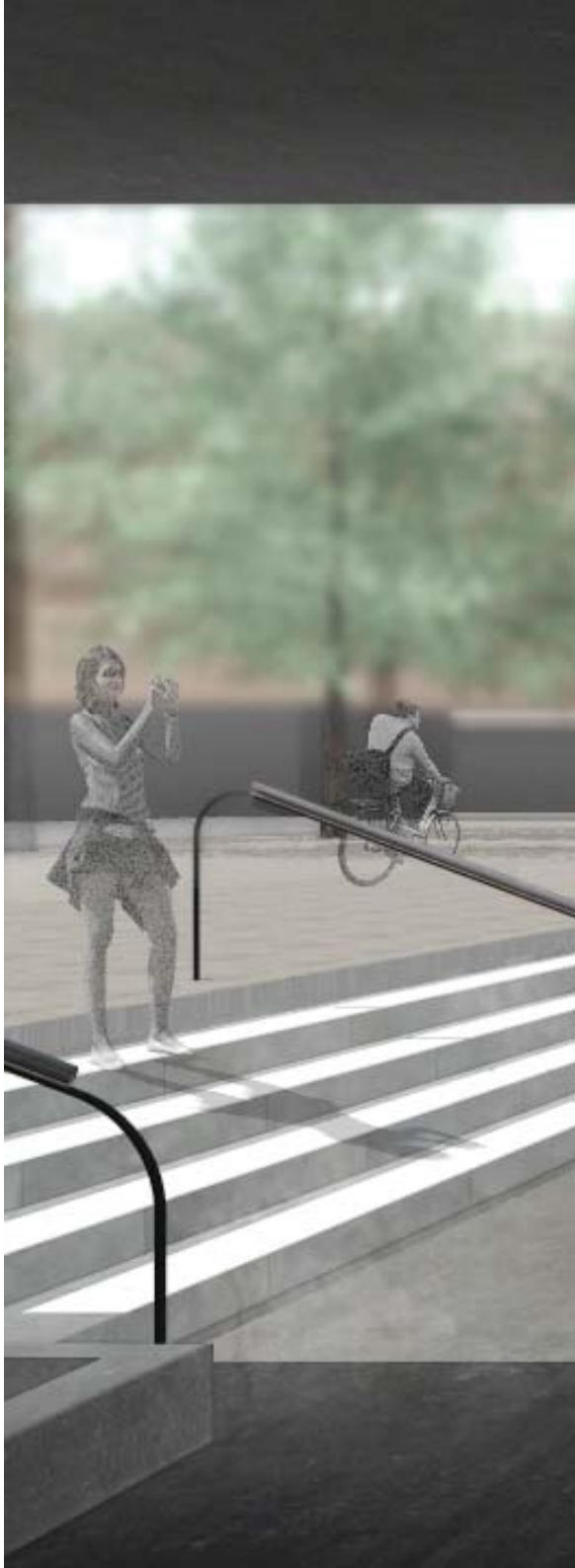


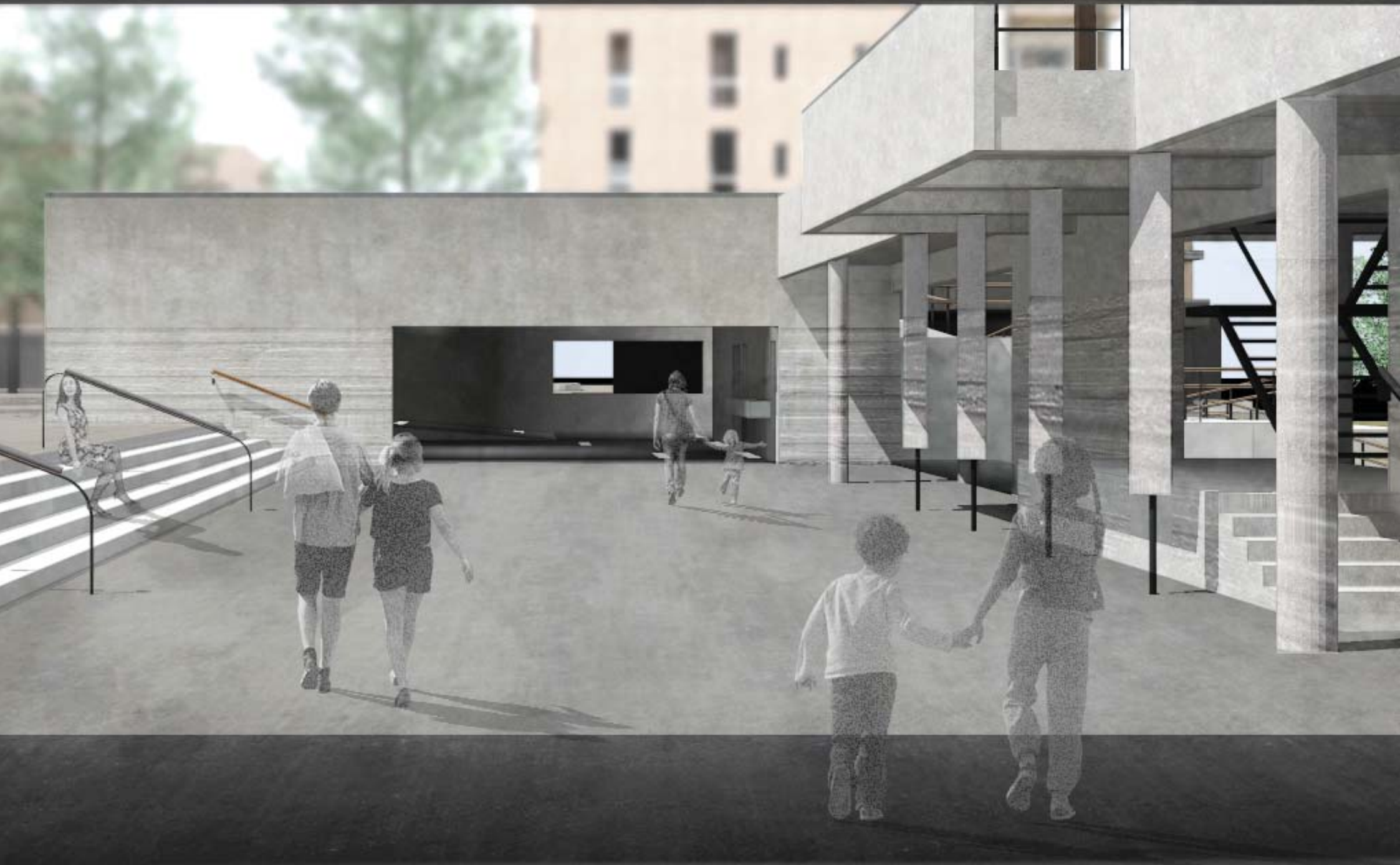


6.2 The Porch

6.2.1 Public square

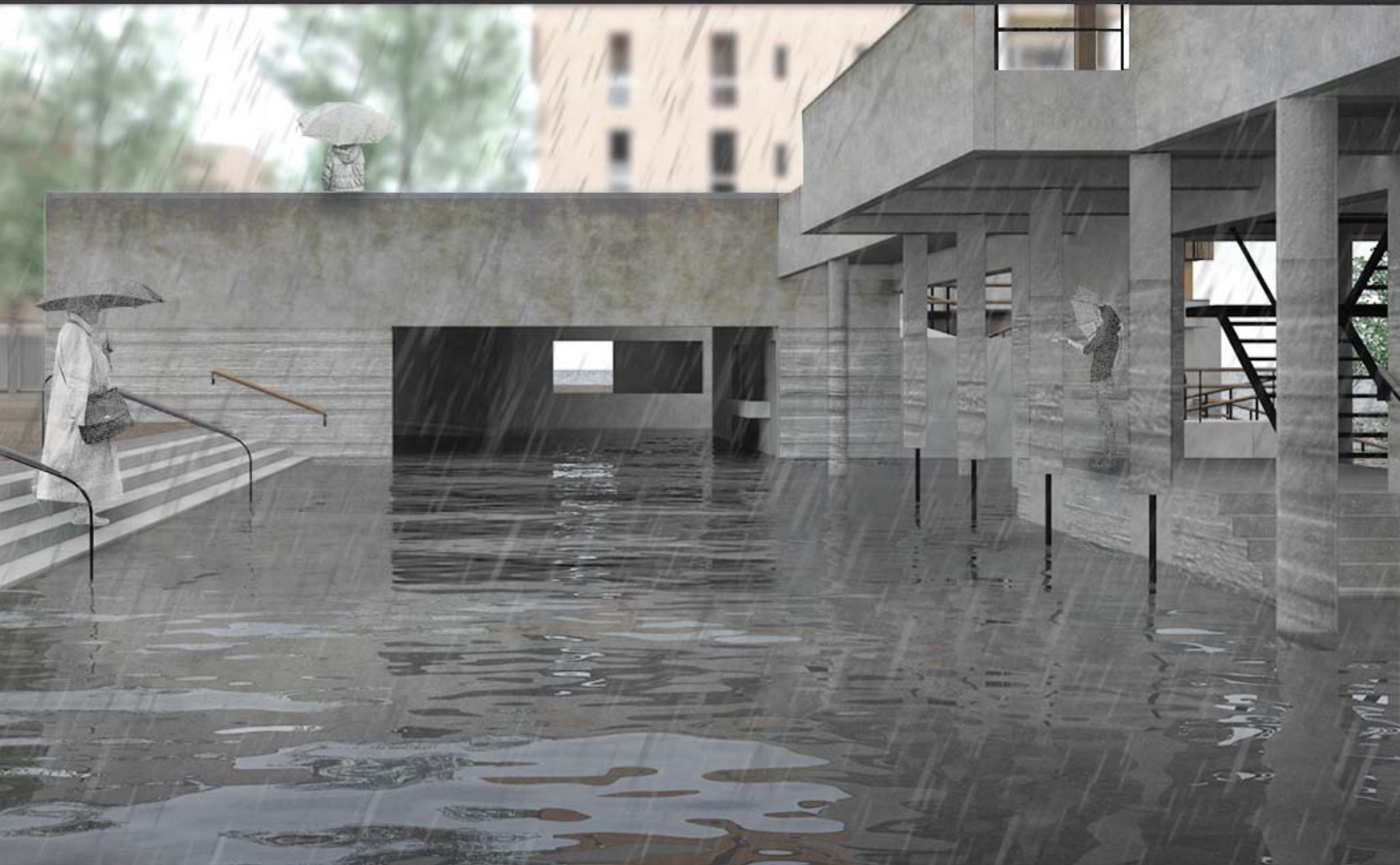
The entrances of both market and porch building are located at this public square (at -0.75m level). The porch building can be accessed via this square, ramp behind market and the road bridge.





6.2.2 Public square flooding

The image shows the extreme flooding situation (>-0.75m). At the same time, the porch building can be accessed via road bridge.



6.3 Routing principle

In this project, routing system is considered to be the fundamental principle for regeneration the creek from area, which can be applied on the rest part of creek front plot in this region.

Once all the junctional areas along the creek have been applied their own characteristic routing systems, the whole linear park can provide various architectural promenade.

Meanwhile, the creek provides an alternative communal corridor which is different from the main street, but also re-interpreted a new identities of flooding prone lands (in between creek and urban fabric) to form a bigger "Porch" in this Kashmere gardens neighborhood.

Reflection

TU Delft
Delta Intervention Studio , Sep 2015
Yi Chien Liao 4326202
Design Mentor: Esther Gramsbergen
Building technology mentor: Koen Mulder
External Examiner: Gerard van Bortel

Water Resilient Living in Houston

The Porch of Kashmere Gardens neighborhood

Aspect 1: the relationship between research and design

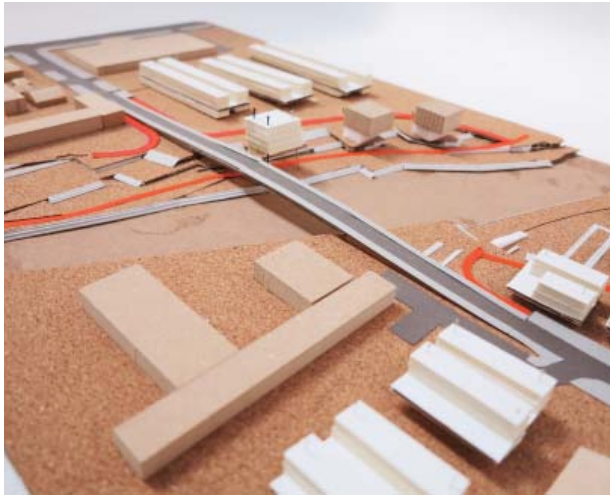
The research & deisgn of my graduation thesis included three phrases:

1.Delta research & Site selection
The initial research phase looks into the formation of a delta cities. In this phase, the specific geological datas are needed to be found. By collecting these data together with mapping, literatures review and observation, it gives me an general understanding of delta cities. At same time, current issues have been seen and then could be starting points for further investigation. The initial motivation of my design are set up to mainly focus on reducing flood risk and improving living environment along the water. Therefore the site has been chosen in this step in order to state my graduation assignment. The design product in this phrase is a master plan of a creek redevelopment corresponding with ongoing water management policies.

2.Bayou & community
The second research phase is to explore urbanism methods for better living quality with water resilient strategies and reducing flood risk. I choose one fragment along hunting bayou creek as my research target. The scale of this fragment is defined as a community scale which consists of a creek, rows of collective housing, a bridge and public amenities. The research and design from this phase are always reflecting to each other to examine every decision I made. The design product is a master plan of community.

3.Architecture & Construction
The third phase is to investigate the water-related architectural quality and design innovative architectonic strategies. The design product is series of construction strategies and architectural scenarios for users.

All in all, from second phase, research and design always worked together. In my personal research & design process, I was stocked at the community planning and landscape design since I always couldn't have an overall harmony vision to define my architectural research assignment. Then I was stocked again in architectural construction since I was lack of knowledge of building technology. Therefore, continuously researching was the solution. "How to translate the results of research into design" is the main challenging throughout whole process.



1:500 model helped me to figure out the essential concept of my planning. "The Porch of Kashmere Gardens" is the main concept of my project.

1:200 helped me to figure out the relationship between construction and architectural promenade.

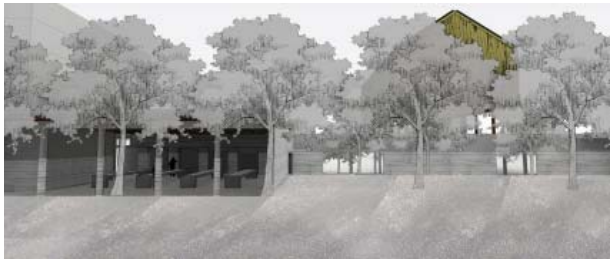
Aspect 2- The relationship between the theme of the graduation lab and the subject

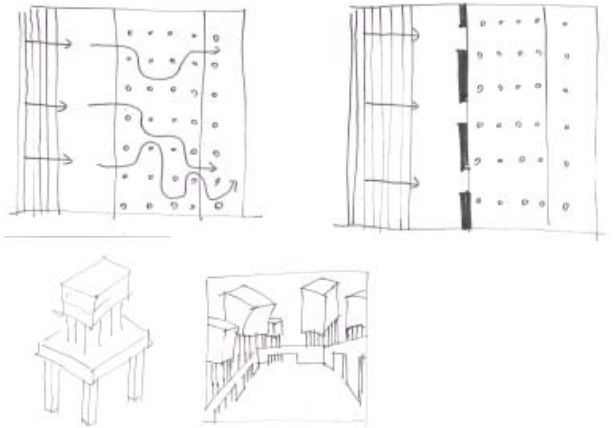
Delta Interventions studio is an inter-disciplinary studio which, on a wide variety of scales, deals with water-related issues in delta landscapes. Due to climate change and new insights concerning sustainability, new interventions for delta lands will be needed. At the same time, it is necessary to develop safer and better water system for urban development, but also to stimulate stronger spatial identities between water and city. As an architectural student, the assignment will mainly focus on water-related urban & architectural solutions and tectonic skill development. In 2014-2015 academic year, there are two given sites for investigation, Galveston Bay in Houston and Ijsselmeer in Netherlands.

Since my initial motivation of my graduation thesis is to improve the living quality for working class people who are relatively in need to have better and safer living environment, I select one of most vulnerable bayou system, Hunting Bayou, in suburban area of Houston as my research site. Houston is so called Bayou City, which means several water streams go through Houston. Water not only acts as pules for Houston but also bring a huge flood risk. There have been many flooding records in the history, which damage industries and human lives. At the same time, there are several ongoing water management projects in Houston.

However, in May 2015, another flood heated Houston deadly. In addition to the flood risk, Houston as one of biggest cities in US is facing many social issues. For example in Kashmere Gardens neighborhood, located at upstream of hunting bayou, complex issues such as flooding, water management, lower income, unbalanced urban development all come together.

As results, I set subject of project to research a solution about how to integrate water resilient architectural planning and better living quality. The solution is assumed to be a fundamental principle which can be applied not only in a community scale but also in larger scale, for instance a bayou scale.





Conceptual sketch & 3D draft model help me to test the architectonic and architectual quality

Aspect 3: The relationship between the methodical line of approach of the graduation Lab and the method chosen by the student in this framework

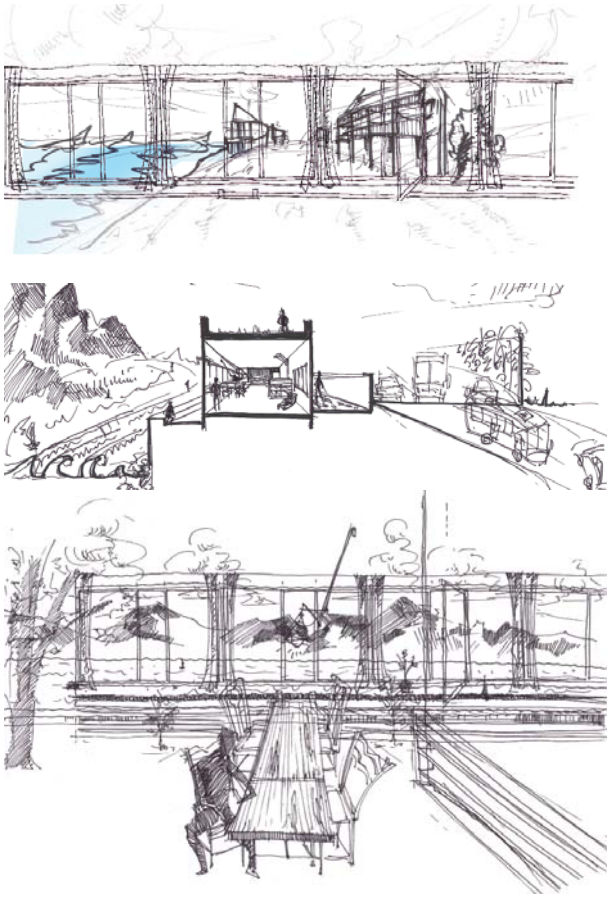
There are 4 main approaches which always support my research and design:

1.3 x3 x 3 layering analysis
By mapping different themes and history periods on the targeted area, I not only got much essential information about Houston in a very short time, but also I was stimulate to make some assumption of potential issues which could be my research direction.

2.Water related design
In "Water related design", each architectural student has to select one water related project for analysis, especially emphasizing on water view framing. This exercise inspired me how the water can contribute to the architecture design, and what kind of good architectural quality can be transformed to adapt on different waterscapes.

3.Site visiting & sketch
After the selection of site, the historical information was relatively insufficient for me to use 3 x3 x 3 layering analysis for research. It turns out that observation and communication would be my main approaches for investigation. Observation together with sketches is to understand the current situation and presume possible images in the future. During the excursion, I set myself in the Kashmere gardens neighborhood to communicate with residents, but also experienced the spatial scale by driving and walking.

4.Physical models making
Physical modeling is one of my approaches to investigate as well. I build model in 4 scales, 1:2000 for whole creek, 1:500 for community plot, 1:200 for architecture and 1:100 fragment for structure. These models help me to develop design and give my self-critical debate on spatial experiences. Especially when I was stocked at the planning of community and landscape design since I always couldn't have an overall harmony vision to define my architectural research assignment, 1:500 model helped me to figure out the essential concept of my planning. Moreover, 1:200 helped me to figure out the relationship between construction and architectural promenade.



Water related design, one of delta intervention studio methodical approaches,
To investigate how water can contribute architecture
To analysis water view framing, spatial experiences, and architectural promenade
Project study: Villa le lac , designed by Le Corbusier
Author's sketches

Aspect 4: The relationship between the project and the wider social context

The aim of this project is to investigate water related architectural design which in this case is to develop water resilient strategies and better living quality of bayou coast community. The implementation of this project is to carry out a design proposal in a specific urban context in Houston, Texas, USA. The design is consisted of public building as a conceptual porch of Kashmere gardens neighborhood, water resilient landscape as an urban public linear park, road bridge and collective water front housing planning.

The design which is located one of junction of the creek regeneration plan can be a principle to apply on the rest parts of the creek. Each junction not only can represent the regional identity but also stimulates communication of each plot. Therefore, the communities along creek would be revived. Especially this project site is located in one of the most vulnerable and lowest income neighborhood in Houston. Kashmere gardens neighborhood is relatively lower situated and almost whole region are under 1-100 years flood risk. In this neighborhood, many lands in-between human and water are problematic. As a result, the whole project will play an important role to encourage people to approach water and reengage this natural element in a safer way.

In terms of construction aspect, the project is to propose using materialization to response to water. The construction is made out of concrete and timber structure mainly. The conceptual impression of the project is that the concrete part acts as a base where flexible material like timber can stand on it. All the poles and mass in the site are designed in orthogonal matrix, which give visitor a clear circulation neatly.

For local planner or developer who are dedicating to Hunting Bayou regional redevelopment, this project can be one of proposals to be considered.

1:2000 model shows the overall situation of the creek.The project is assumed to be a solution which can be applied on the whole creek region.

Urbanism Theory

TU Delft
Delta Intervention Studio , Jan 2015
Yi Chien Liao 4326202
Mentor: Stephen Read

Restoration of urban stream corridors

Greenways and stream corridors as the potential water resilient infrastructure in Houston

Restoration of urban stream corridors

Greenways and stream corridors as the potential water resilient infrastructure in Houston

Yi Chien Liao

4326202 _ y.liao@student.tudelft.nl

Delft University of Technology, Department of Architecture

2014-2015 Delta intervention studio

Abstract –Restoration of urban stream corridor projects are being constructed in increasing numbers in many Delta cities. More recent, techniques of recreations are being employed that vary from "hard" structural approaches to "soft" bioengineering approaches.(Brown, 2000) Houston is a delta city which consists of several watersheds. Water not only brings Houston a flat landscape which is suitable for sprawl of city, but also plays as an important role in transportation at the beginning era of Houston city growth. On the other hand, water also acts a threating role to cause flooding in Houston. Hurricanes and heavy rainfall result in flood very often in Houston. In order to drainage Houston city efficiently, concrete channelization was recognized as a solution, leading water for reducing the flood risk. However, this channelization didn't give a solvable response towards flooding. Water is being regarded as a notorious element for Houston city because of flooding. Most of bayous are guided by concrete section without any strategy for people to approaching water. Dwellings keep away from bayou instead of gaining advantage from water because of flood risk. The lands between developed area and bayou are becoming neglected and problematic lands, losing the connectivity between human activities and water.

This paper will investigate the possibility to recreate the problematic land within flood plain, especially along with water stream in urban area, for bridging the relationship between water and human activities by investigating spatial designated approaches (i.e. greenway and stream corridor). First, literatures review is aiming to understand the existing issues which are about flooding and recent water management. Second, potential spatial methods as typology-study for restoration of urban stream corridor will be investigated. This part will discuss connectivity between urban fabric and water by ecological and water resilient way. The "Buffalo bayou project" will be the main spatial landscape case-study later on. This paper will be the framework of my own graduation project which is about recreating a stream corridor along with Hunting Bayou in to unite amenities in Kashmere Gardens Neighborhood in Houston, but also stimulate interdisciplinary consideration of urban landscape design.

Key words –flood, resilient, greenway, stream corridor, connectivity, urban fabric

1. Introduction

"Floods belong to the most threatening natural hazards for humans, their lives and their property (Blaikie et al., 1994; WBGU, 1999). The number of floods and the damage resulting from them over recent decades all over the world obviously require an ongoing improvement of analysis, mitigation and management."(Kubal, Haase, Meyer, & Scheuer, 2009) A flood occurs when a stream runs out of its confines and submerges surrounding areas.(Stephen, 2011) Another similar definition by Kates (1985) defines flood as an overflow of an expanse of water that submerges land. Many of the world's great cities are developed along with water, and they are highly depending on water because of optimal access for fresh water supplement, irrigation, trade and transportation. Stream water always provides a relatively flat land for human settlement and construction, but also brings the risk of flood. Houston is one of these kinds of city which is called delta city. Houston area consists of several watersheds and is suffering from flooding. Over the past decades, mitigating flooding is always one of issues for Houston. Meanwhile, exploring appropriate approaches to link water and urban fabric to provide a better urban life quality is also one of topics. This paper is based on literature review. It will investigate possibilities to recreate the problematic land within flood plain, especially along with water stream in urban area, aiming to bridge the relationship between water and human activities by investigating spatial designated approaches (i.e. greenway and stream corridor). In the beginning, brief background about relationship of Houston and water will be elaborated, which is aiming to understand how and why Houston grows, and management is. Then, potential spatial methods for recreation of urban steam corridor will be investigated, providing useful understanding of urban greenway and urban stream corridor. This part will focus more on connectivity between urban fabric and water. Later on, both greenway and stream corridor will come together to discuss what the ideal urban landscape design is. Moreover, the "Buffalo bayou project" will be the paradigm for case study. In the final part, the conclusion comes with recommendation for further recreation of urban stream corridor and be a theoretical framework of my graduation project which is intending to recreate a stream corridor along with Hunting Bayou to unite amenities and provide better life quality for Kashmere Gardens Neighborhood in Houston. This paper is mainly based on literature review, providing possibilities to stimulate the interdisciplinary consideration of urban landscape design and awareness of sustainable issue.

2. Background

Huston is one of cities around Galveston bay in Texas, which was described by Meyer & Nijhuis in 2014: "Over the last hundred and fifty years this region has developed from a sparsely settled agricultural and fishing hinterland into one of the most important industrial and urban concentrations in the world. Its population, economy, and industrial infrastructure continue to grow at a remarkable rate. The pressure of population growth and industrial expansion have pushed urban and industrial development into previously undeveloped agricultural and wilderness areas, as well as low-lying coastal and riverine flood zones."(Meyer & Nijhuis, 2014) In terms of Houston delta, it is consisted of seven watersheds. They are the Sabine, the Neches, the Trinity, the San Jacinto, the Brazos, the San Bernard, and the Colorado. These rivers formed a huge flat plan which is suitable for human settlement and urban development. Since 1900 the City of Houston has grown at a rapid rate, and now it has been ranked as fifth-most populated metropolitan area in the United States. The reason of growth is mainly due to the discovery of old gas. Houston is serving as the beginning or end point of numerous oil gas and products pipelines. Moreover, it is in leading in health care sectors and oilfield equipment. "The entire upper

Texas coast is essentially one giant industrial plant that is woven into the landscape, cities, water, and air along its path."(Meyer & Nijhuis, 2014)

Due to the flat topography and occasionally extremely heavy rainfalls, widespread riverine flooding has been a problem since the beginning era of Houston. (Meyer & Nijhuis, 2014)Therefore, Houston region indeed requires improvement of engineer analysis, flooding mitigation and water management. In order to drainage Houston city efficiently, concrete channelization was recognized as a preferred solution, leading water for reducing the flood risk. However, this channelization didn't give a solvable response to flooding. Furthermore, rapid urban growth resulted in runoff exceeding the capacities of these channels. (Meyer & Nijhuis, 2014)Water is being regarded as a notorious element for Houston city because of flooding. Most of bayous are guided by concrete section without any strategy for people to approaching water. Dwellings keep away from bayou instead of gaining advantage from water because of flood risk. The lands between developed area and bayou are becoming neglected and problematic lands, which is losing the connectivity between human activities and water. In 2001, while Tropical Storm Allison dropped tremendous rainfall in Houston, showing that the Houston urban area and suburb have a high potential for flooding. "More recent responses have included buyouts of repeatedly flooded properties, and removal of vast amounts of soil to increase channel sections and detain water in flood prone areas." (Meyer & Nijhuis, 2014) Recreation and wildlife habitation are main purposes for many of these improvements of drainage systems. Moreover, "Low Impact Development (LID) requirements are regarded as the most promising long-term response to rainfall flooding." However, flash heavy rainfall in Houston still causes flooding, which is ranked as the secondary threat compared to hurricane-related tidal surges. (Meyer & Nijhuis, 2014)

3. Potential treatment for flood prone plain

Because of repeated flooding in Houston region, it has increased everyone's awareness of the relationship between cities and waterfronts, but also ecology and culture in urban rivers. It is easy to know that urban area has comparatively high flood risk because of their high density of population, multiple economic activities and lots of infrastructure and property values. (Pelling, 2003) (Kubal et al., 2009)Moreover, the land subsidence and climate change aggravate the existing flood risk in Houston. Within literature review, it accepted that absolute flood protection is not possible to be achieved and planned (Schanze, 2006). "Instead, growing attention has been given to the new paradigm of flood risk management based on the effective establishment of both risk mitigation (structural technical flood defense measures such as dams, dikes or polders) and adaptation (non-structural, "soft" measures such as preparation of the local people, flood insurances, information management, social networks) measures."(Kubal et al., 2009) In this paper, the investigation on flood risk defense measures will focus on spatial interventions which are greenway and stream corridor.

4. Urban greenway & stream corridor

There are already numerous definitions of greenway have been offered, but a precise description is elusive partly because greenways take so many forms.(Searns, 1995)According to Searns's classification in 1995, stream corridors can be one type of greenways which was referred to "Generation 2 (Fig.1.): trail-oriented recreational greenways that provide access to rivers, streams, ridgelines, rail beds and other corridors within the urban fabric. Often, these greenways are automobile free." Another perspective, "Greenway are not only a tool to preserve and exhibit our past, they give the public access to historic feature while at the same time, provide educational opportunities and protect and preserve resources for future generations." (Habib, 2012)

Generation 1 Pre1700s-circa1960	axes, boulevards and parkways that were the ancestral greenways.
Generation 2 circa 19604-circa 1985	trail-oriented recreational greenways that provide access to rivers, streams, ridgelines, railbeds and other corridors within the urban fabric. Often, these greenways are automobile free.
Generation 3 circa 1985 and beyond	multi-objective greenways that go beyond recreation and beautification to address such areas as habitat needs of wildlife, promoting urban flood damage reduction, enhancing water quality, providing a resource for outdoor education, and other urban infrastructure objectives.

Fig.1. Category of The evolution of greenways by Robert M. Seams, 1995

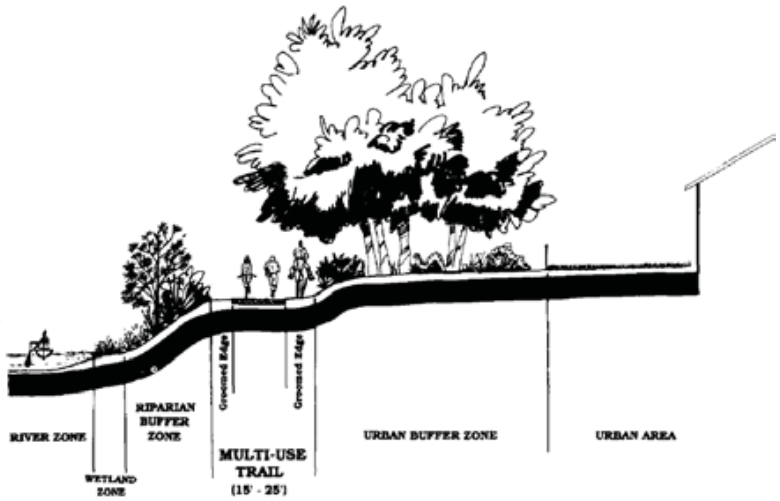


Fig.2. Cross-section of a greenway (Generation 3, defined by Searns, 1995)that attempts to integrate trail and preservation objectives (Urban Edges, Inc.)

4.1 Urban greenways

Since Charles Little published his influential book, Greenways for America, in 1990, many of urban greenways have been developed, and also came with various relative publications of reference. (Schwarz, Flink and Searns, 1993; Ryan, 1993; Mertes and Hall, 1995; Lindsey, 1999) "As more and more greenways have been developed, planners have begun to study them to identify factors that contribute to successful projects and to learn more about issues in design and management." (Lindsey, 1999) The reason why greenways have come to the forefront in urban planning largely is that greenways can serve as transportation corridors which are separated from the traffic of roadways and provide a sense of a respite and escape from the urban surroundings. (Groom, 1990; Luymes and Tamminga, 1995) In fact, greenways not only play important role in transportation on the one hand but also in recreation on the other. People can experience nature just nearby and see interesting flora and fauna during daily recreation or a travel to work. This type of human experience makes an urban place more enjoyable and livable. Urban greenways have been thought one of best responses to the shortage of quasi-natural park and open space environments in urban area. Urban greenways encourage positive face to face interaction with other people. (Shafer, Lee, & Turner, 2000) Many planners designed urban greenway as a systematic linear open space which doesn't serve the entire community but neighborhoods, and located urban greenway along natural or artificial corridors, such as riverfronts, streams, ridge lines, abandoned railroad right-of-ways, canals, or scenic roads. (Lindsey, 1999) "Greenway-based trials are a part of a resource that has the potential to influence many quality of life factors. Greenway corridors are often cited as being desirable in urban environments because of their potential to clean water and sustain wildlife populations (Smith, 1993). Keeping floodplains open and able to handle storm waters, main-

taining wetlands, providing vegetative cover and food for wildlife all contribute to quality of life in humans, albeit somewhat periodically and often indirectly."(Shafer et al., 2000)

4.2 Urban stream corridors

Stream corridors are usually part of drainage system for flood mitigation. In recent years, many rivers and streams have been channelized through drainage works and urbanization. It turns out that the natural environment along original stream corridor was devastated so that the accessibility to water stream has deteriorated.(Asakawa, Yoshida, & Yabe, 2004)

"Recently, river corridors are being focused on as important natural networks as well as cultural and recreational resources" (e.g. Baschak and Brown, 1994, 1995; Cook, 1991). (Asakawa et al., 2004) According to the literature review, the main ideas of urban stream corridors restoration are to achieve nature-oriented construction for more capacity of water detention and public involvement, meanwhile to create connectivity for natural networks, social networks and alternative transportation routes. More than likely, urban stream corridors are specifically referred to as urban greenways located along stream or waterfront. From Searns's classification in 1995, greenways of generation 3 within its evolution "are multi-objective greenways that go beyond recreation and beautification to address such areas as habitat needs of wildlife, promoting urban flood damage reduction, enhancing water quality, providing a resource for outdoor education, and other urban infrastructure objectives." Because of its linear typology, urban stream corridor has strong potential to achieve highly preferred promenade which combines natural and urban life scenarios. People can have sequential experience with variety and accessibility to water.

5. Connectivity

As like Searns described about greenways: "They are more than just parks or amenities; they also represent an adaptation which is a response to the physical and psychological pressures of urbanization."(Searns, 1995) Due the linear shapes of both urban greenways and urban stream corridors, both of them are certain kind of obvious trails to connect amenities in urban scale. Moreover, there is a lurk metaphor, connectivity, hidden in these linear trials. "Connectivity is a key concept for riparian and landscape ecologists and hydrologists, who use it as a measure of natural integrity in a river ecosystem. Urban designers and politicians use the same term to promote human access to riverfronts. Effective riverfront restoration requires reconciliation of these opposing definitions." (May, 2006) The connectivity is trying to explore more possibilities for finding common ground between interdisciplinary realms "through the pursuit of cognitive connectivity, or educational and aesthetic interventions that allow urban dwellers to experience their place in the urban watershed in ways that do not jeopardize its ecological systems."(May, 2006)

6. Challenges & opportunities

Because of complexity of planning, urban greenways and stream corridors will bring a number of new kinds of challenges. It might be more costly as well as more time consuming. There may also be an increased risk of becoming bogged down in the process. There is also an increased risk of such projects being labeled as environmental extremism, and of a backlash of opposition, especially if people fear more taxes or regulation. Since the restoration of stream-corridors is a multi-disciplinary cooperation, it requires organizational skills for consensus of interdisciplinary knowledge and technical management abilities. Also, there is the need for outstanding demonstration projects and successful local models to show that multi-objective plan-

ning can be accomplished expeditiously and in a cost-effective. With respect to balance between preservation and overusing, significant research is required in the area of greenway recreation to define possible approaches to fit a broad spectrum of users with less compromise of the environment. Integration of soft and hard infrastructure can be a way to approach the environment with a more comprehensive drainage system. Furthermore, there will be an opportunity to provide incentives which are related directly to the market benefits of providing greenways in conjunction with residential, office and commercial development. (Searns, 1995) Above all, these challenges and opportunities must need people to involve. "Many people were anxious about litter, water pollution, and crime prevention. The most popular kinds of maintenance activities were cleaning the streams and mowing the grass, and while it may be easily suggested that a large part of residents' anxiousness would be relieved by promoting these maintenance activities, consideration of growing concerns toward streams and the general aquatic environment in a given area. It is also important that the participation of residents in greenway planning would make it easier to take broader views, which assess the natural and cultural resources of a given area." (Asakawa et al., 2004)

7. Buffalo Bayou

In the past, Houston Buffalo Bayou was a neglected and flood prone water stream, transecting through Houston downtown. Over the past two decades, Buffalo bayou now has been transformed into a central, regional amenity of Houston downtown. Buffalo Bayou and Beyond, the master plan of Buffalo Bayou (2002), calls for "conscientious planning for land connectivity, for urban connectivity through space networks and centers, and social connectivity through lively and interactive gathering places, both built and natural''. (May, 2006) The concerns of Buffalo Bayou and Beyond are: (Buffalo Bayou Partnership, 2002)

- Rehabilitate the Bayou as an Ecologically Functional System
- Increase Floodwater Conveyance Capacity
- Promote Low-impact Development
- Improve Visibility of the Bayou
- Ensure Equity of Access
- Increase Residential Opportunities Downtown
- Maintain Affordability
- Create New Jobs and Revenue

Until now, this project is undergoing and fulfillments among projected goals are visible step by step. It has been a paradigm of water stream restoration example which can reflect to the complex existing context in Houston.

8. Conclusion

According to literature review, there are already numerous researches and developed projects which are related to restoration of urban stream corridor through nature-oriented way. Urban greenway and urban stream corridor are kind of tendencies or global movements. This paper provides useful understanding of urban greenway and urban stream corridor. Simultaneously, it is dedicating to elaborate that more than ecological and water resilient concerns, there are other lurk challenges and potential opportunities need to be concerned.

Buffalo Bayou restoration project not only has been a visible successful reference project, but also a continuous undergoing project. As like Searns (1995) said that good demonstration projects and successful local models are needed to show that multi-objective planning can be accomplished expeditiously and in a cost-effective. This paper can contribute to my graduation project about Hunting Bayou restoration in Kashmere Gardens neighborhood in Houston. Most part of this neighborhood is located in 100-year flood risk plain. Comprehensive

strategies are needed to protect the communities against flood instead of only channelization with concrete. Moreover, current amenities of this neighbor are less organized and less linked. As a result, the new strategies for restoration and architectural design not only serve as water resilient infrastructure but also provide the connectivity for linking amenities, ecological environment, and promoting better living quality, stimulating awareness of flooding risk. My position is to explore possibilities to recreate the problematic land within flood plain, especially along with water stream in urban area, for bridging the relationship between water and human activities by investigating spatial designated approaches (i.e. greenway and stream corridor). Framework is clear, and the connectivity would be the key concept which can reflect to the typology of landscape design and further architectural design. When it comes to further development of urban stream restoration, more complex and interdisciplinary thinking are always needed to be concerned

Bibliography

Urbanism Theory

Asakawa, S., Yoshida, K., & Yabe, K. (2004). Perceptions of urban stream corridors within the greenway system of Sapporo, Japan. Landscape and Urban Planning, 68(2), 167-182.

Brown, K. (2000). Urban stream restoration practices: an initial assessment. The Center for Watershed Protection. Ellicott City, Maryland, USA.

Habib, F. (2012). Green Infrastructure Embody an Exceptional Spiritual Relationship of People with Nature: Cultural Landscape, Implication for Sustainable Development. International Journal of Heritage in the Digital Era, 1, 301-306.

Kubal, C., Haase, D., Meyer, V., & Scheuer, S. (2009). Integrated urban flood risk assessment–adapting a multicriteria approach to a city. Natural Hazards and Earth System Science, 9(6), 1881-1895.

Lindsey, G. (1999). Use of urban greenways: insights from Indianapolis. Landscape and Urban Planning, 45(2), 145-157.

May, R. (2006). "Connectivity" in urban rivers: Conflict and convergence between ecology and design. Technology in Society, 28(4), 477-488.

Meyer, H., & Nijhuis, S. (2014). Urbanized deltas in transition. Amsterdam: Techne Press.

Searns, R. M. (1995). The evolution of greenways as an adaptive urban landscape form. Landscape and Urban Planning, 33(1), 65-80.

Shafer, C. S., Lee, B. K., & Turner, S. (2000). A tale of three greenway trails: user perceptions related to quality of life. Landscape and Urban Planning, 49(3), 163-178.

Graduation plan

Herman Hertzberger (2001), Lessons for students in architecture

Leupen, B. & Mooij, H.(2011), Housing design: A Manual

a+t research group, (2013), 10 Stories of Collective Housing

Henk Engel (2014), Renewing City Renewal: A call for strong design

Stefano Boeri (2011), Biomilano

Hiltrud Potz & pierre Bleuze (2012), Urban green-blue grids for usstainable and dynamic cities

Stephen, A. (2011). River Systems & Causes of Flooding.

James Howard Kunstler (2004): The ghastly tragedy of the suburbs , TED talk

Paul Rudolph fundation

Low Rise High Density' Exhibition" 25 Apr 2013. ArchDaily.

Water-related design

Association Villa « Le Lac » Le Corbusier (n.d.) Villa « Le Lac » webpage. Retrieved September, 2014, from: http://www.villalelac.ch/en/

Architecural design

Siza, A., & Trigueiros, L. (1995). Álvaro Siza : 1986 - 1995: Blau.

Távora, F., & Trigueiros, L. (1993). Fernando Távora: Ed. Blau, LDA.

de Moura, E. S., Grande, N., Cecilia, F. M., & Levene, R. C. (2009). Eduardo Souto de Moura: 2005-2009 ; [Teatros Del Mundo, Theatres of the World]: El Croquis Editorial.

Building Technology

Ching, F. D. K. (2011). Building Construction Illustrated: Wiley.

Kolb, J., LIGNUM, & Holzforschung, D. G. f. (2008). Systems in Timber Engineering: Loadbearing Structures and Component Layers: Birkhäuser.

Schittich, C., Staib, G., Balkow, D., Schuler, M., & Sobek, W. (2007). Glass Construction Manual: Birkhäuser.

Schunck, E., Oster, H. J., Barthel, R., & Kießl, K. (2003). Roof Construction Manual: Pitched Roofs: Birkhäuser.

Stichting Bouw Research (2007), Seriematige Woningbouw - Sbr Referentiedetails