Master of science program in Territorial, Urban, Environmental And Landscape Planning

Spatial Planning for Climate Change (Studio) (Ecology)

a.y. 2023-2024

Climate Planning

Prof. Maurizio Tiepolo, Camilo De Lima Amaral

Donato Casavola assistant

Urban Ecology & Urban Ecology

Prof. Stefano Ferrari

Prof. Giuseppe Mandrone

Team no.:2

Anjali Ketankumar Kharwar s314873

Dorna Hosseinzadehbonabi s315711

Ovi Prasad Karanjkar s313883

Pouria Navabpour s315648

C1

General Overview

# Site Introduction

### Site Overview:

The proposed development spans a 2.4-acre site in Portland, OR, strategically positioned between N Richmond Ave, N Crawford St, N Van Buren Ave, and N Bradford St within the St John district.


### Zoning Details:

The site is zoned into Commercial Mixed-Use 3 (CM3) and Residential Multi-Dwelling 1 (RM1). Properties 6620, 6636, and 8120 in the CM3 zone undergo a phased transition from commerce and street-facing offices to discreetly positioned residential units on upper levels.


### Climate-Responsive Development:

In response to the challenges of climate change, the development adheres to Portland's climate policies. The project integrates innovative solutions in site development, street design, vegetation planning, and stormwater management.

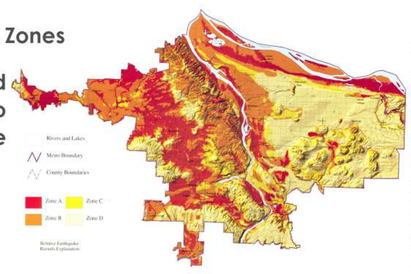
### LEED Integration:

The design emphasizes sustainability, aligning seamlessly with LEED (Leadership in Energy & Environmental Design) principles. This ensures the development not only addresses climate change impacts but also promotes responsible urban practices.

# Main Hydro-climatic threats

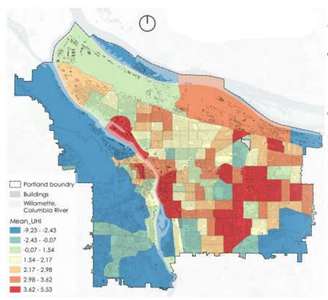
### Earthquake Hazard Zones

The site is detected in a moderate to high earthquake zone.



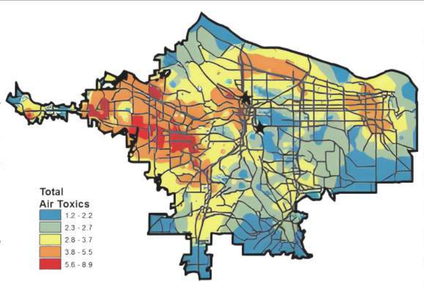

### Urban Heat Island Effects

Concerns about heatwaves affecting the site.
Existing greenery provides some natural cooling. Introducing more permeable surfaces to reduce the urban heat island effect and enhance resilience to heat waves.



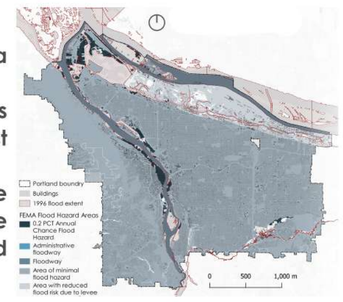

### Air Toxics

The site falls within a moderate air toxicity zone. Plans include strategies to improve air quality, such as introducing air-purifying plant species.

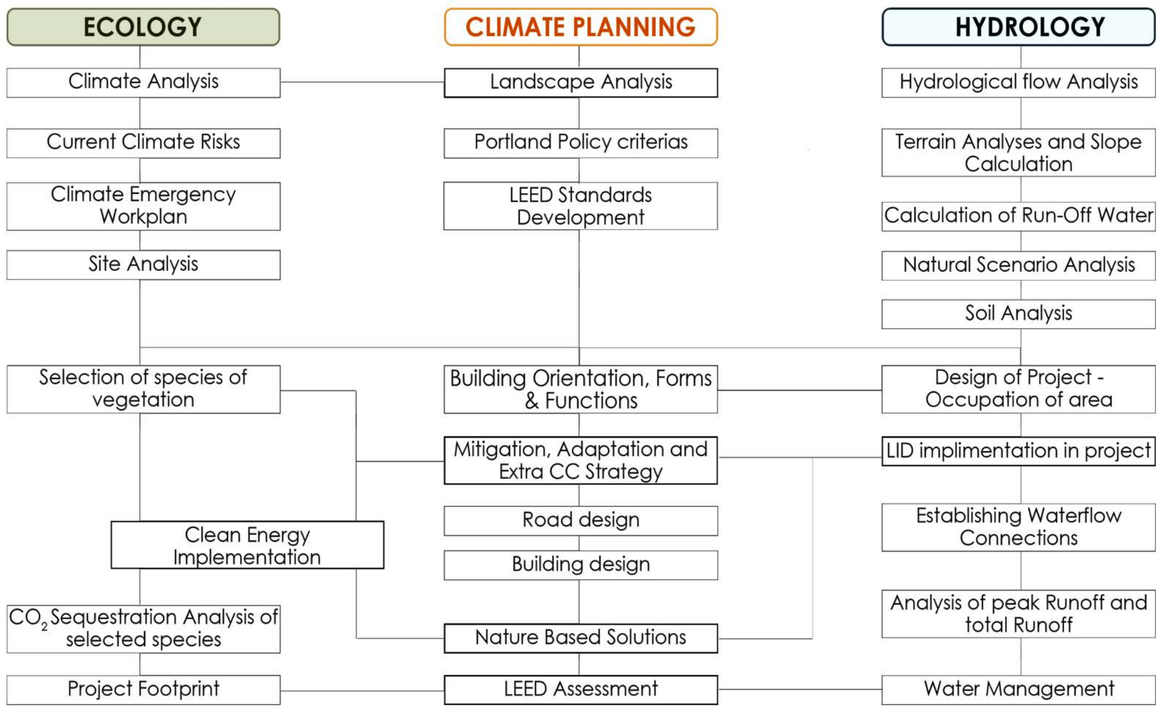



### Flood Risk

Location in a floodway poses a significant flooding threat.
The presence of green spaces offers a natural defense against flooding.
Proposal to introduce more permeable surfaces to manage water runoff and mitigate flood risks.




# Methodology

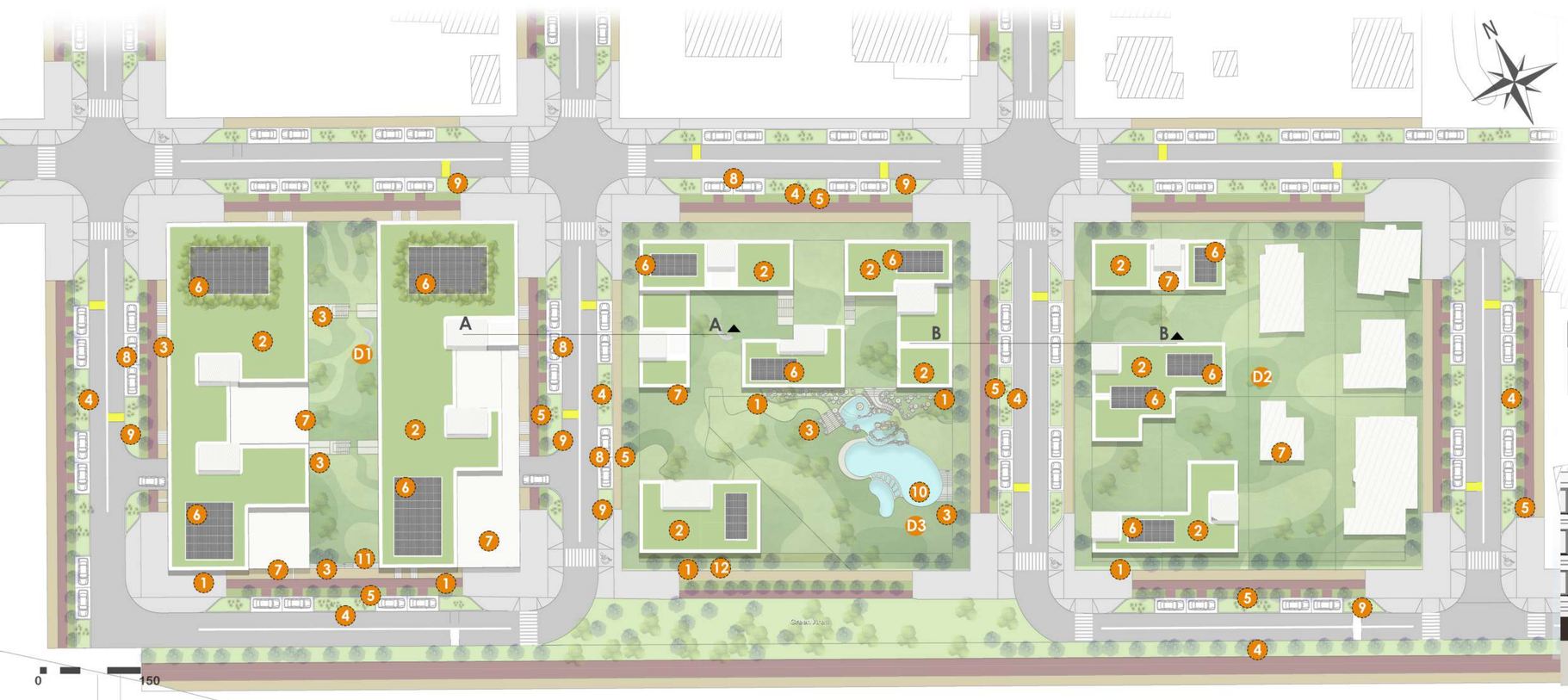



# Reqirements Commercial mixed use 3 (CM3) zone &

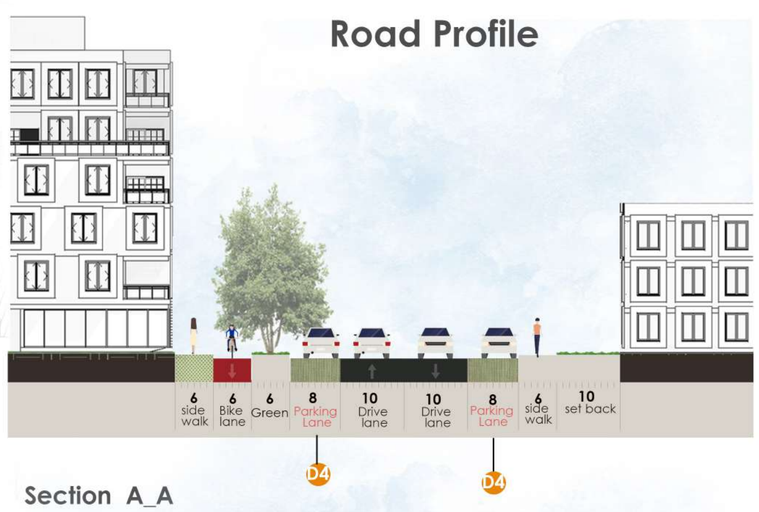
| | Density(FAR) | Height | Building setbacks | Coverage | Outdoor area |
|---|---|---|---|---|---|
| CM3 | 3:1 | 65 ft. (6 stories) | Min.: None for commerce<br>Max.: 10 ft. from street lot line | Max.: 100% | Sites more than 20,000 sq ft.: 48 sq ft. /dwelling unit |
| RM1 | 1:1 | 35 ft. (3 stories) | Front, min: 10 ft<br>Side and rear, min:<br>5 ft Garage entrance, min: 18 ft<br>20 ft. from street lot line | 50% | Minimum 250 sq ft per unit. |

| | Landscaped area | Parking | Windows | Ground floor | Façade articulation |
|---|---|---|---|---|---|
| CM3 | 15% property area for landscaping. | Larger developments (>30 units, >10,000 ft2) require 1 parking space per | Street facades: 15% windows/entrance | Residential floors must be 2 ft above sidewalk grade. | Every 200 ft, 20 ft wide, with a 20 ft setback |
| RM1 | Minimum 250 sq ft per unit. | Not required for sites <10,000 sq ft, up to 30 units. | 15% of street-facing façades must be windows or main entrance. | Residential floors must be 2 ft above sidewalk grade. | Every 200 ft, 20 ft wide, with a 20 ft setback |

# Site Plan




## Road Profile




# Climate Change Actions

## Mitigation

1 Shade Devices

Greenhouse gas emissions

Reduce heat gain, enhance comfort, and lower energy consumption by providing shade

(Climate Planning)

3 Slope angle reduction

Risk of landslides and Erosion

To enhance terrain stability and minimize soil erosion.

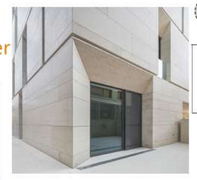
(Hydrological Climate Action)

5 Permeable paving

Surface runoff Stormwater Flooding

Lows water to pass through, reducing runoff and promoting natural drainage.

(Hydrological Climate Action)



7 Light colored materials

Urban heat island effect

To reflect sunlight, reducing heat absorption and mitigating the urban heat island effect

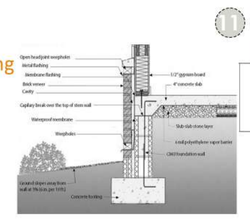
(Climate Planning)

9 Bioswale

Extreme weather events and addressing urban flooding

Bioswales manage stormwater through natural filtration and vegetation.

(Hydrological Climate Action)



11 Raised Foundation

Risk of flooding

To mitigate flooding risks and adapt to changing sea levels.

(Hydrological Climate Action)

2 Green Roof

Stormwater and Greenhouse emissions

Natural insulation, stormwater management, and increaased biodiversity.

(Ecological Climate Action)

4 Street Vegetation

Heat island effects

Street vegetation combats climate change by absorbing carbon, regulating temperatures, managing stormwater, and fostering biodiversity.

(Ecological Climate Action)

6 Solar Panels

Electricity-related greenhouse gas emission

To Generate renewable energy, reduce reliance on fossil fuels, and curb carbon emissions.

(Climate Planning)

8 Permeable Parking

Urban heat island

To reflect sunlight, reducing heat absorption and mitigating the urban heat island effect

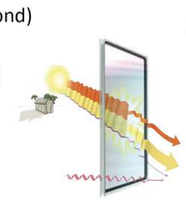
(Ecological Climate Action)

10 Bio Retention Cell (stepped pond)

Extreme weather events and addressing urban flooding

Stormwater storage prevents flooding by temporarily holding and controlling excess rainwater.

(Hydrological Climate Action)



12 Energy-Efficient Windows

Greenhouse Gas Emissions

Insulation and reduce the need for artificial heating and cooling.

(Climate Planning)

## Adaptation

# Section

South View

# Details


Landscape Design

Bio Retention Cell (stepped pond)

Infiltration Trench (Under Road )

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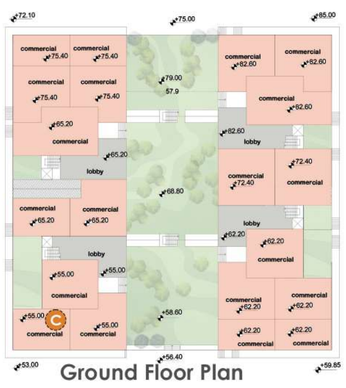
C2
General Overview

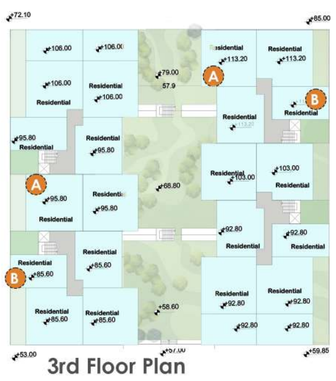
# Perspectives

# Planimetry

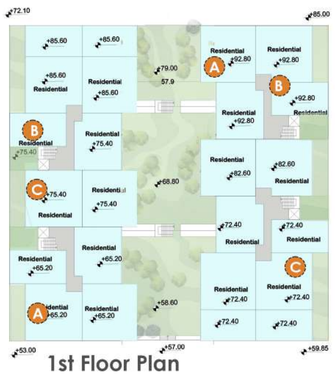
## CM3 Block 1



Ground Floor Plan

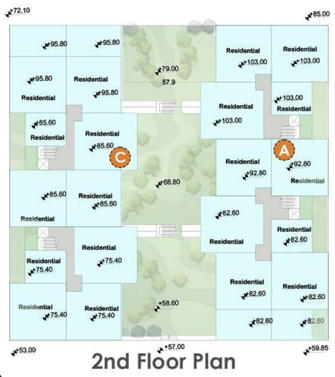


3rd Floor Plan

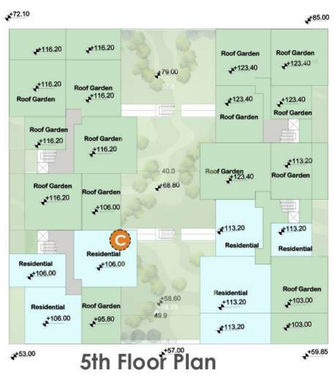


1st Floor Plan

4th Floor Plan

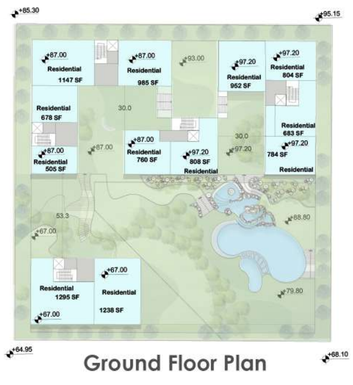


2nd Floor Plan



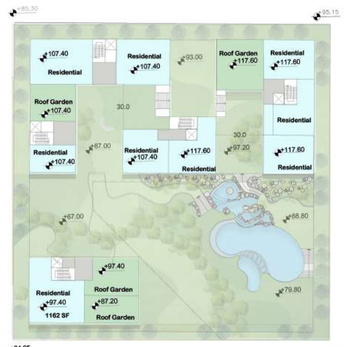
5th Floor Plan

## RM1 Block 2



Ground Floor Plan

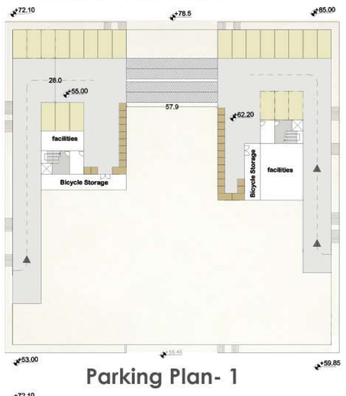
1st Floor Plan



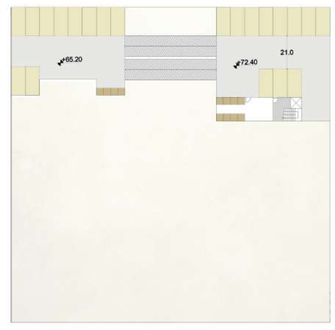
2nd Floor Plan

## RM1 Block 3

Ground Floor Plan



Parking Plan- 1



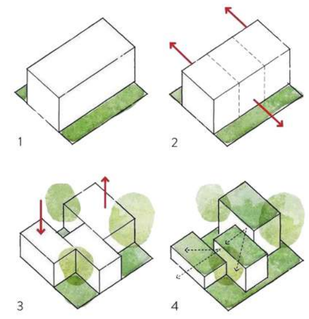
Parking Plan- 2

0 — 150

## South Elevation

## West Elevation

## Design Process



Standard Floor Layered

Shift

Adjusted unit placement both forward and backward to optimize southern sunlight, elevating them at varying heights for optimal views of the southern scenery.

## Residential Unit Types

Type A

Type B

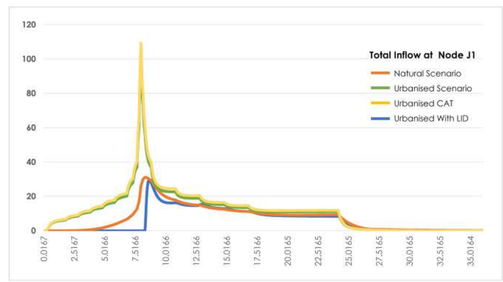
Type C

Unit designs are influenced by the A1 Project Clippership Complex, with adaptations made based on our architectural analysis for enhanced functionality and aesthetics.

# Assertion of development

| Zoning | Lot No. | Lot Area (SF) | Existing Buildings | | Construction Limitations and Licenced | | | | Design Parameters | | | | | | | Final Development | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Surface Area (SF) | Floors | Built-Up Area | Max Floors | Coverage | FAR | Built-Up Area Shortage | Design Surface Area | Design Coverage | Built-Up Residential Area | Built-Up Commercial Area | Design FAR With Commercial | Design FAR Without Commercial | Design + Existing Area (SF) | Design + Existing Coverage (SF) | Design + Existing Built-Up Area | FAR |
| CM3 | | 40,300.30 | | | 120,900.90 | 7 | 100% | 3:1 | | 28,739.96 | 71.3% | 98,265.49 | 21,857.96 | 2.98:1 | 2.44:1 | 28,739.96 | 71.3% | 120,123.45 | 2.98:1 |
| RM1 | 6610 | 28,402.86 | | | 28,402.86 | 3 | 50% | 1:1 | | 12,670.12 | 44.6% | 28,313.20 | - | - | 1:1 | 12,670.12 | 44.6% | 28,313.20 | 1:1 |
| RM1 | 7904 | 2,555.24 | 1,235.34 | 1 | 2,555.24 | 3 | 50% | 1:1 | 1,319.90 | | 0.0% | | - | - | | 1,235.34 | 48.3% | 1,235.34 | 0.48:1 |
| RM1 | 7916 | 9,988.45 | 1,238.95 | 2 | 9,988.45 | 3 | 50% | 1:1 | 7,510.55 | 747.85 | 7.5% | 1,495.70 | - | - | | 1,986.80 | 19.9% | 3,973.60 | 0.4:1 |
| RM1 | 6011 | 4,987.91 | 1,871.56 | 2 | 4,987.91 | 3 | 50% | 1:1 | 1,244.79 | 525.06 | 10.5% | 1,050.12 | - | - | | 2,396.62 | 48.0% | 4,793.24 | 0.96:1 |
| RM1 | 6623 | 2,478.08 | | | 2,478.08 | 3 | 50% | 1:1 | | 1,183.33 | 47.8% | 1,183.33 | - | - | | 1,183.33 | 47.8% | 2,366.66 | 0.96:1 |
| RM1 | 7926 | 19,971.41 | | | 19,971.41 | 3 | 50% | 1:1 | | 8338.94 | 41.8% | 19,231.74 | - | - | | 8,338.94 | 41.8% | 19,231.74 | 0.96:1 |

# Total Inflow Result




# LEED

**Evaluation of the Energy and environmental design table**

| Criteria | Max score | Points | Score justification |
|---|---|---|---|
| Site selection | 8/8 | 4 Previously developed<br>2 Infill<br>1 intersection within ¼ mile from site or sidewalks available<br>1 Bicycle storage ≥ 1 place per residential unit | 4 - The site was previously developed.<br>2 - Utilizing existing infrastructure and redeveloping previously developed sites (= Infill)<br>1 - there is an intersection within a ¼ mile from the project site, and sidewalks are available<br>1 - Bicycle storage = 1 place per residential unit |
| Compact development | 2/3 | 3 ≥ 80 dwelling units /acre<br>2 ≥ 55 dwelling units/acre<br>1 ≥ 30 dwelling units/acre | 2 - 156 dwellings in 2.5 acres (Land) ≈ 62 units / acre |
| Community resources | 2/2 | 2 ≥ 12 uses<br>1 Four to seven uses | 2- 18 Commercial units embbeded in the complex<br>Uses: food retail, pharmacy, clothing store, hardware store, bank, gym, hair care, laundry, café, educational facility, community center, adult/childcare, entertainment |
| Rainwater management | 1/3 | 3 ≥ 80% of lot area permeable<br>2 65-79% of lot area permeable<br>1 50-64% lot area permeable | 1 - Permeable area (Green area + Permable surface)-Roof/Land lot surface = [60,714+(36,146x0.15)]/108,684.25 sq ft. ≈ 60% lot area permeable |
| Garage pollutant | 1/2 | 2 No or Detached garage (no wall shares with residential units)<br>1 Exhaust fan running continuously | 0 - Parking provided underground |

| Criteria | Max score | Points | Score justification |
|---|---|---|---|
| Indoor water use | 5/6 | 2 Each lavatory faucet not exceed 1.5 gallons/minute<br>2 Each showerhead not exceed 1.75 gallons per minute<br>1 Each toilet not exceed 1.1 gallons per flush<br>1 Each clothes washer must be ENERGY STAR qualified | 5 - It's possible to consider in construction details the Lavatory Faucet, Showerhead, and Toilet criteria. |
| Outdoor water use | 1/2 | 4 Turf grass < 5%, native plants > 75%<br>3 Turf grass < 20%, native plants > 75%<br>2 Turf grass < 40%, native plants > 50%<br>1 Turf grass < 60%, native plants > 25% | 3- In the development design more than 75% native plants are considered |
| Active solar-ready design | 1/1 | 1-Photovoltaic or solar direct hot water panel | 1- 250 kWh solar PV array |
| Glazing | 2/3 | 1 South facing glazing area 50% greater than glazing E & W facing walls<br>1 E & W axis are within 15 degrees of due E & W<br>1 ≥ 90% south facing glazing is completely shaded at noon of 21 June | 1- RM1 units 60% > E & W<br>1 - Shading is provided in the design |
| **Total** | **23/30** | We prioritized land permeability over potential overbuilding, losing a point in Compact Development. We compromised in Rainwater Management, resulting in a 2-point loss balancing compact building and ground permeability. The need for underground parking on the CM3 lot cost us a point in the No or Detached Parking category. We opted not to score the clothes washer, considering affordability issues. Additionally, we forfeited a point in the direction of the Land category due to a 24-degree alignment outside the specified 15-degree range. | |

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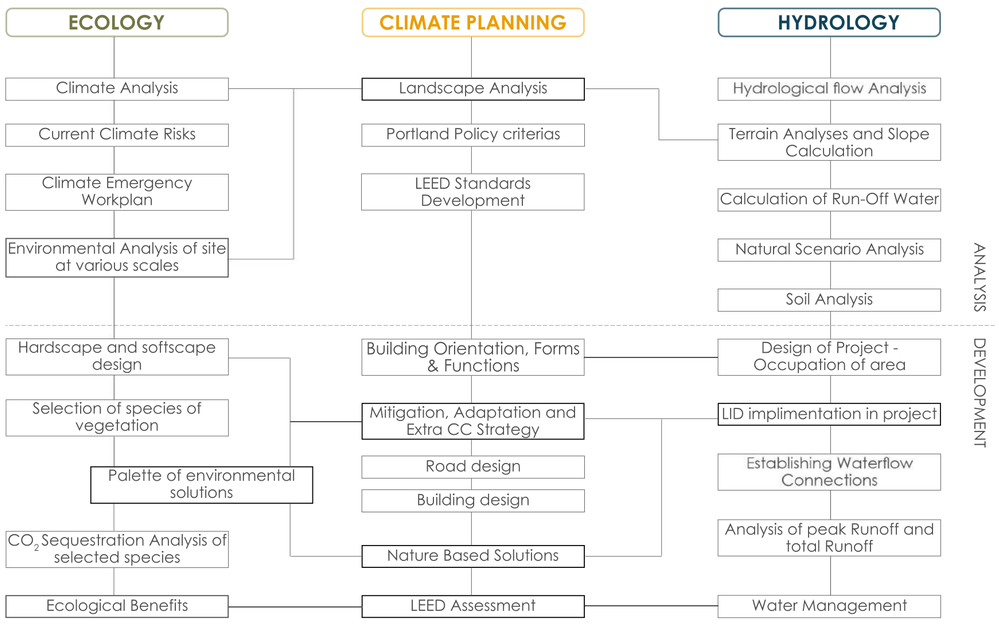
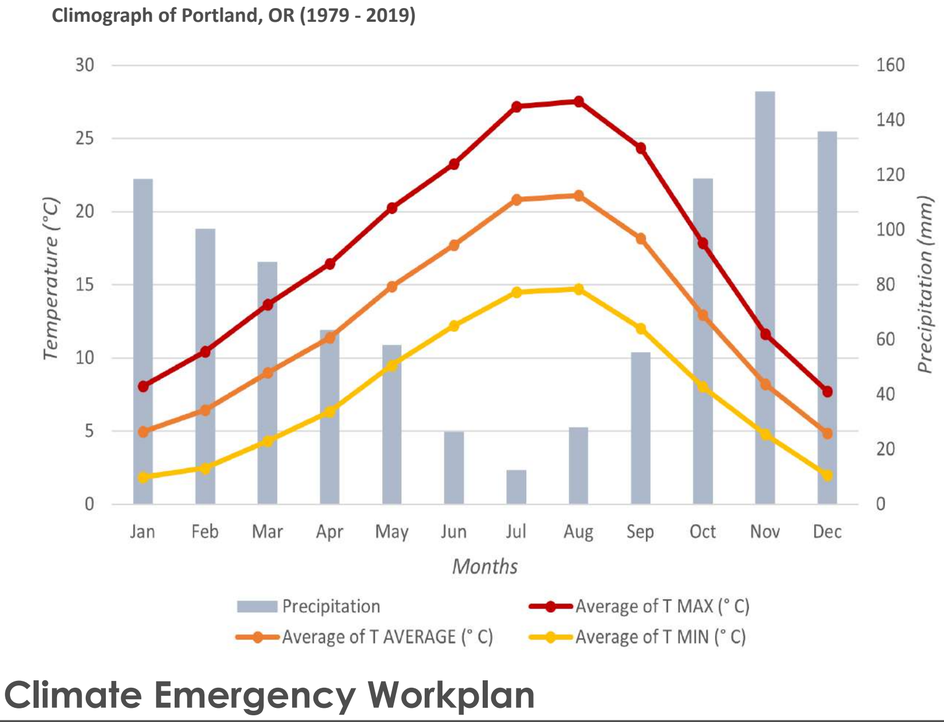
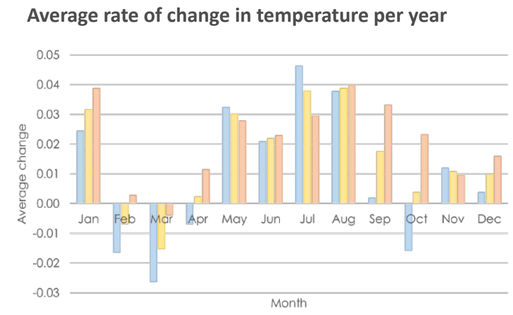
E1
General Overview

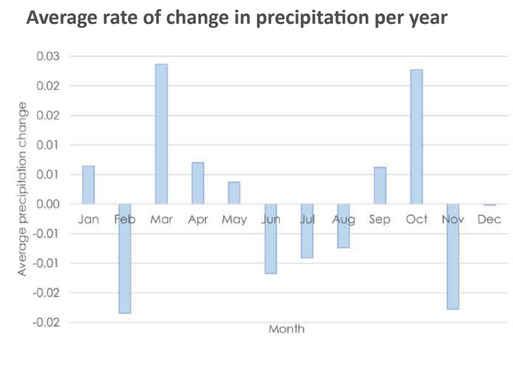
# Flowchart




# Climate Analysis

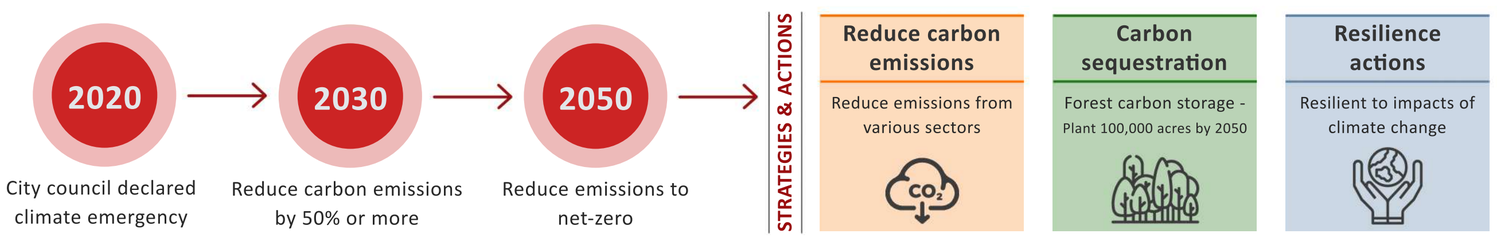


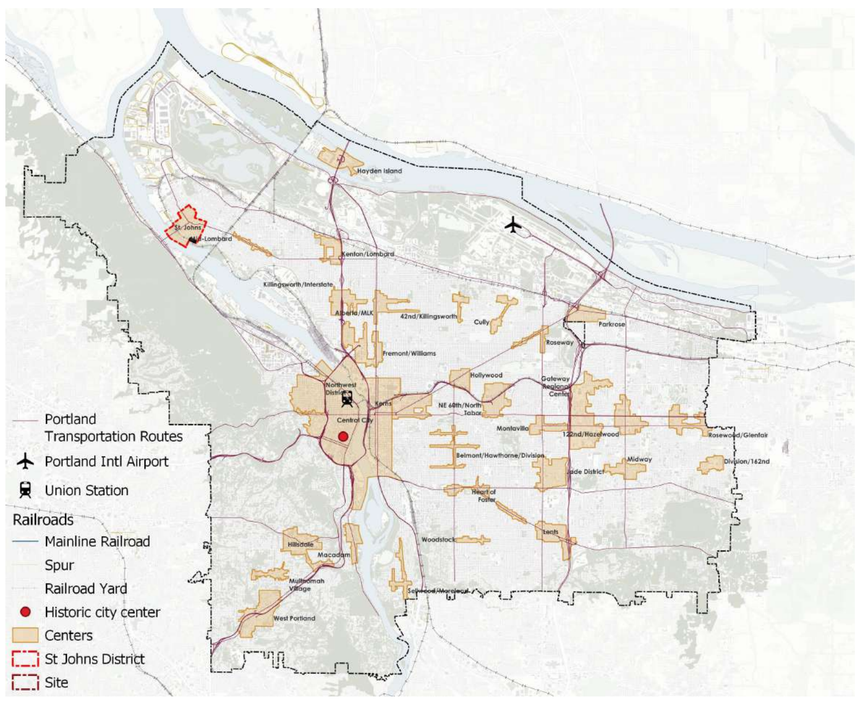




# Current Climate Risks

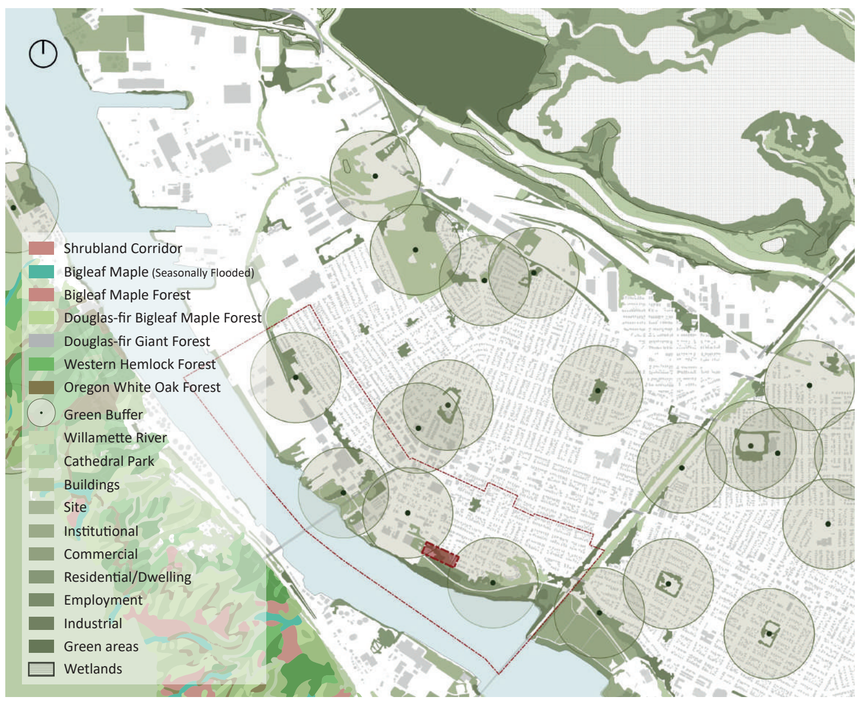

# Climate Emergency Workplan




# Connectivity within Portland

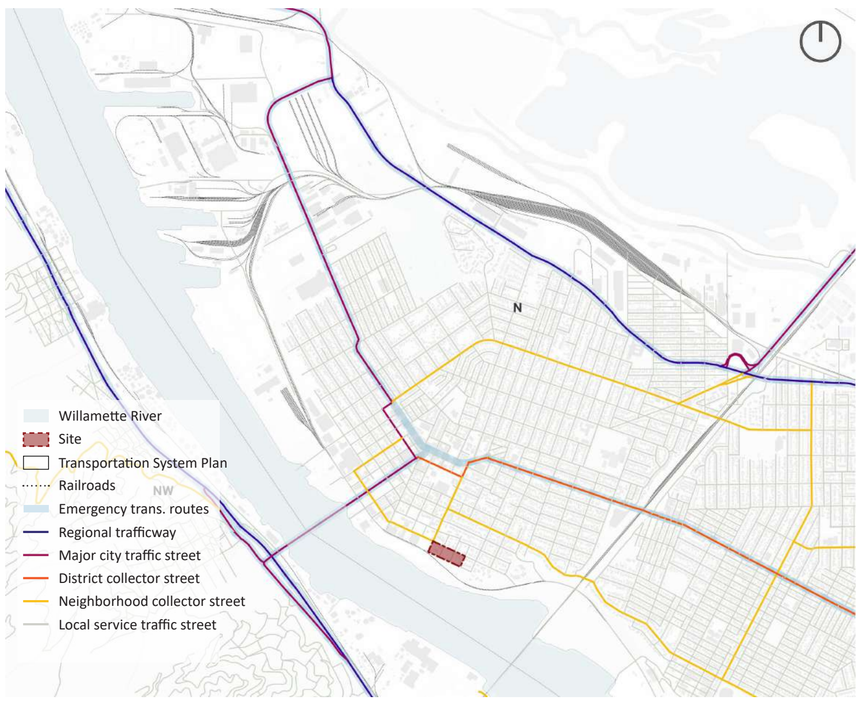



# Ecosystem diversity

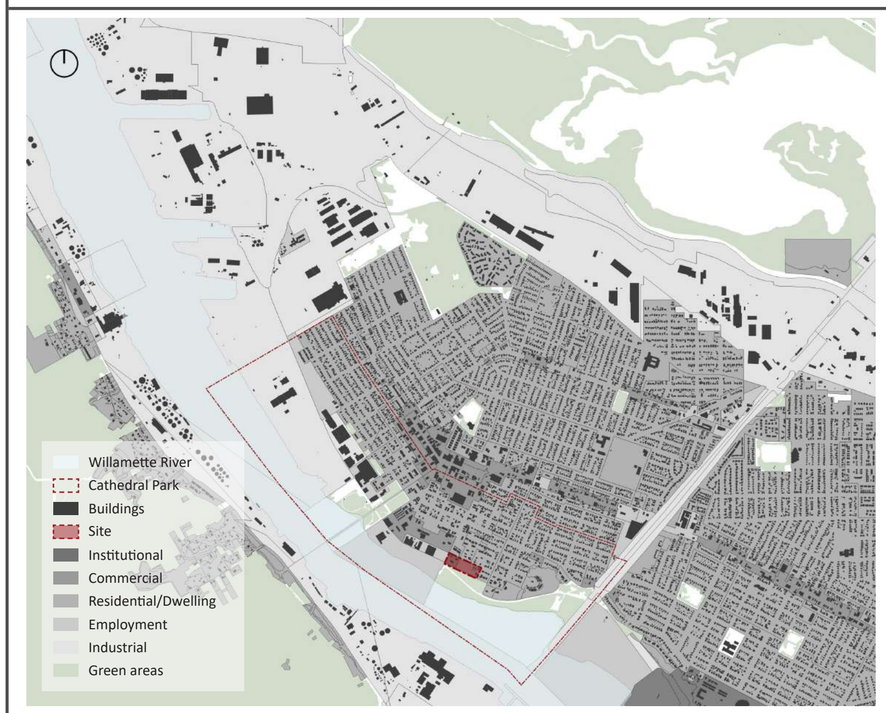





# Road Networks




# Land use and Zoning




# ANALYSIS

## S — STRENGTHS

Most bike friendly city in the U.S.

First city to have comphensive plan for reducing CO2

9400 acres of public parks and natural area

Walkable neighbor-hoods

## W — WEAKNESSES

Higher tempera-tures and increasing number of UHI

Risks of flooding

## O — OPPORTUNITIES

Comprehensive network of transit corridors, city greenways and urban habitat path-ways which links people, wildlife and water to different part of the city

Climate emergen-cy Workplan 2022; 2035 Comprehensive plan; 2040 Growth Concept Transport

## T — THREATS

Warmer tempera-tures and extreme heat events are expected to increase

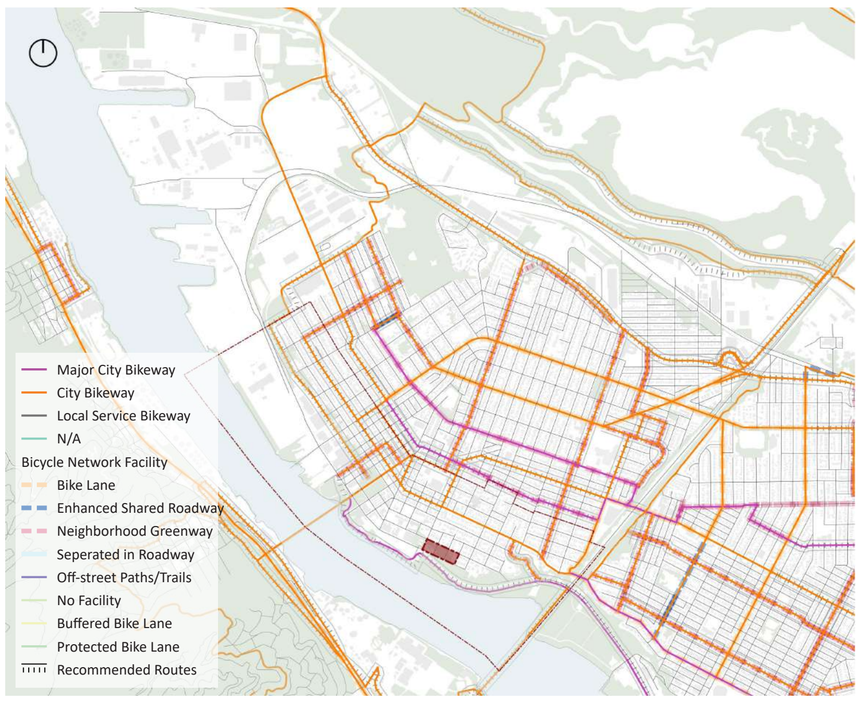
Increase of precipi-tation

Increae of flooding risk

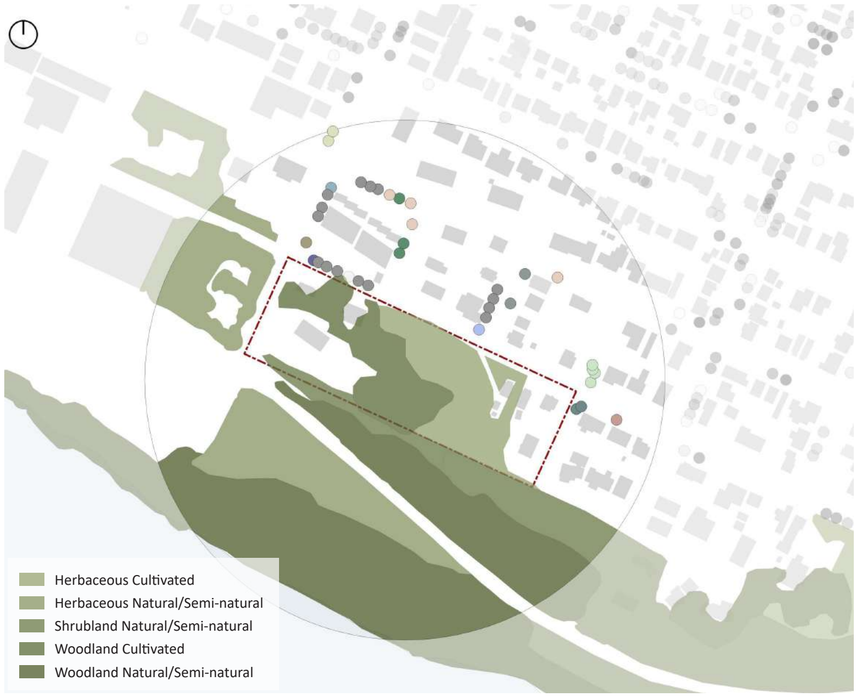
Decrease of snow-fall

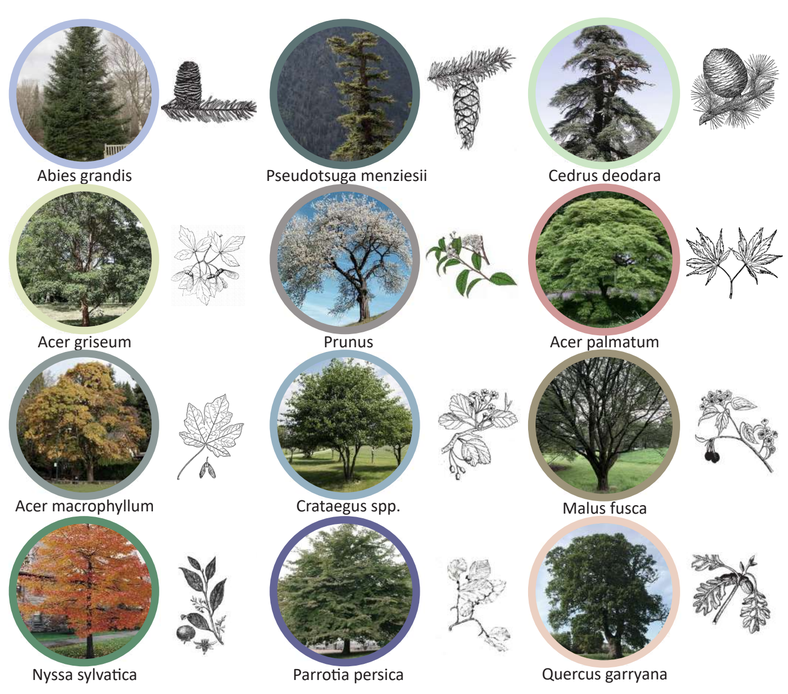
Increase of drough days

# Bike routes




# Vegetation around site



Master of science program in Territorial, Urban, Environmental And Landscape Planning

Spatial Planning for Climate Change (Studio) (Ecology)

a.y. 2023-2024

Climate Planning
Prof. Maurizio Tiepolo, Camilo De Lima Amaral
Donato Casavola assistant

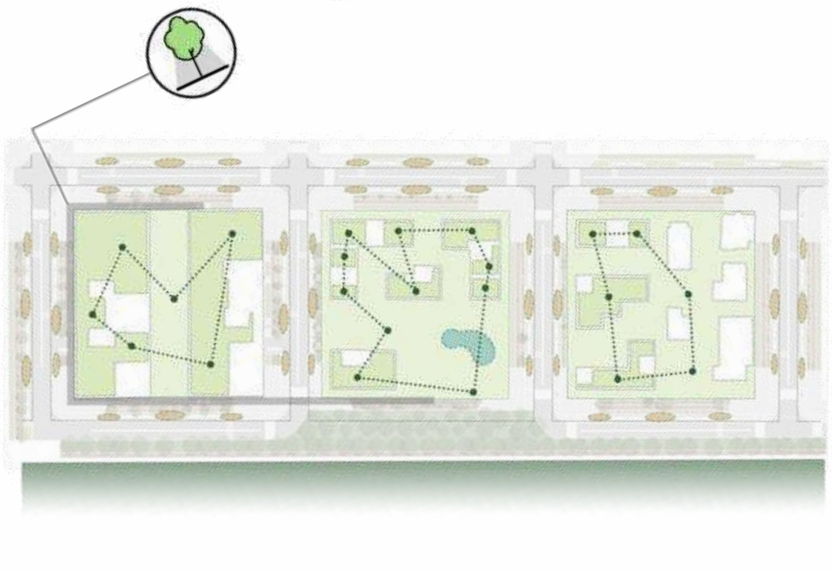
Urban Ecology
Prof. Marco Bonanno
Prof. Davide Canone

Team no.:2
Anjali Ketankumar Kharwar s314873
Dorna Hosseinzadehbonabi s315711
Ovi Prasad Karanjkar s313883
Pouria Navabpour s315648

# E2
Strategies

## Adaptation Strategies

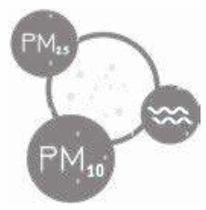
Acoustic Insulation
Green Connections
Stormwater Retention
Reducing Stormwater Runoff (Bioswales)
Providing more shadow



## Mitigation Strategies

Providing food
Sustainable Materials
Photovoltaic Panels
Absorbing more carbon

## Extra CC Strategies




Reducing Particulate matter

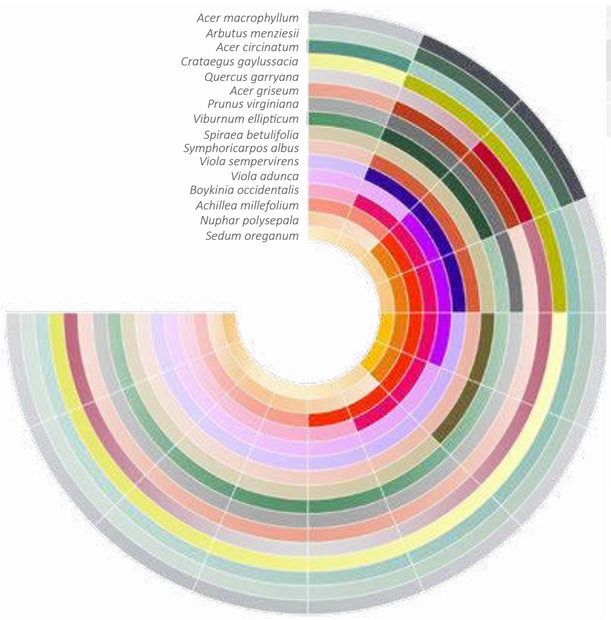
Recreational Function

Olfactory purposes

Promoting Biodiversity

## Trees Attribute

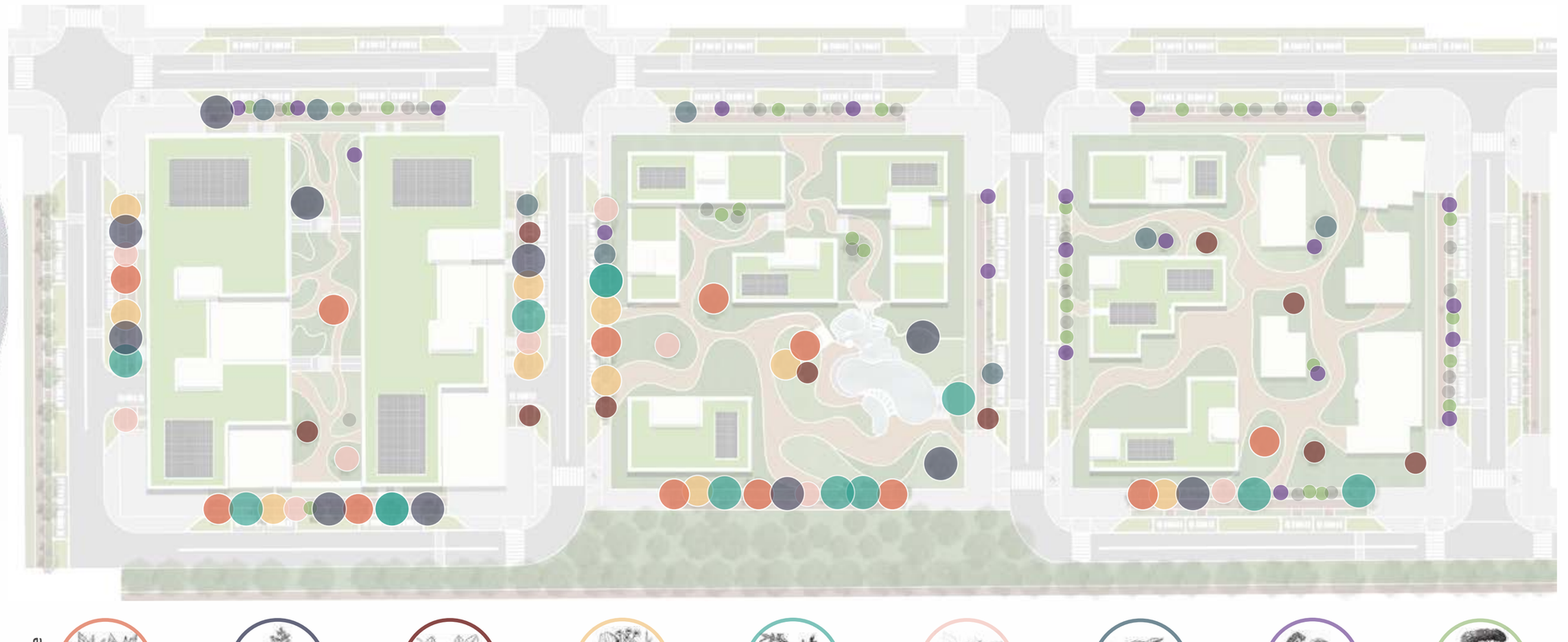
### Tree Flowering




### Tree Crown Sizes and locations

- 60’ Cathedral Park
- 45’ Courtyards
- 40’ South and West side of streets
- 35’ South and West Site Periphery
- 30’ Courtyards and around the Pond
- 25’ North and East side of streets
- 20’ Courtyards
- 10’ Green roofs

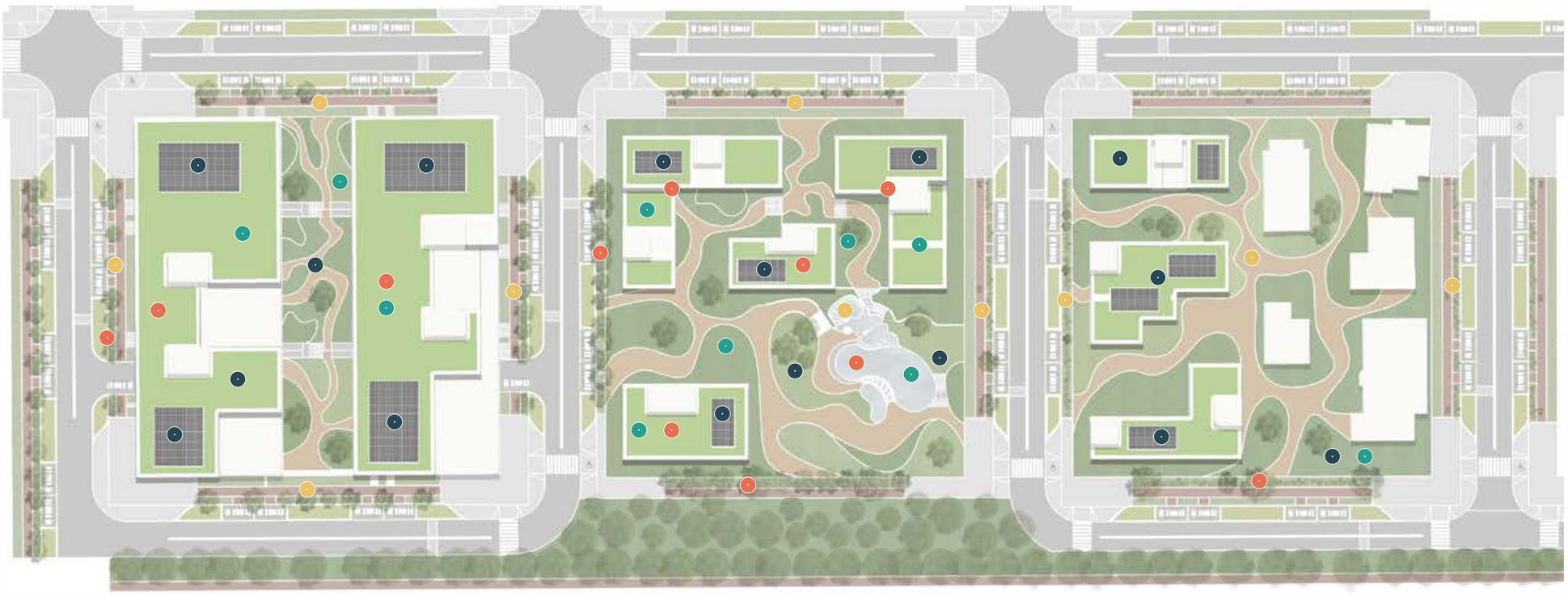
## Trees Location



### Planting Palette

12 *Acer macrophyllum* Bigleaf Maple
16 *Arbutus menziesii* Pacific Mandrone
10 *Acer circinatum* Vine Maple
10 *Crataegus gaylussacia* Suksdorf’s Hawthorn
11 *Quercus garryana* Oregon White Oak
09 *Acer griseum* Paperbark Maple
07 *Prunus virginiana* Common Chokecherry
21 *Viburnum ellipticum* Oval-Leaved Viburnum
25 *Spiraea betulifolia* Shiny-Leaf Spiraea
25 *Symphoricarpos albus* Common Snowberry
*Viola sempervirens* Evergreen Violet
*Viola adunca* Early Blue Violet
*Boykinia occidentalis* Slender Boykinia
*Achillea millefolium* Yarrow
*Beckmannia syzigachne* Slough grass
*Nuphar polysepala* Yellow Water-Lily
*Lupinus rivularis* Stream Lupine
*Sedum oreganum* Oregon Stonecrop

## Master Plan



### Ecosystem Services

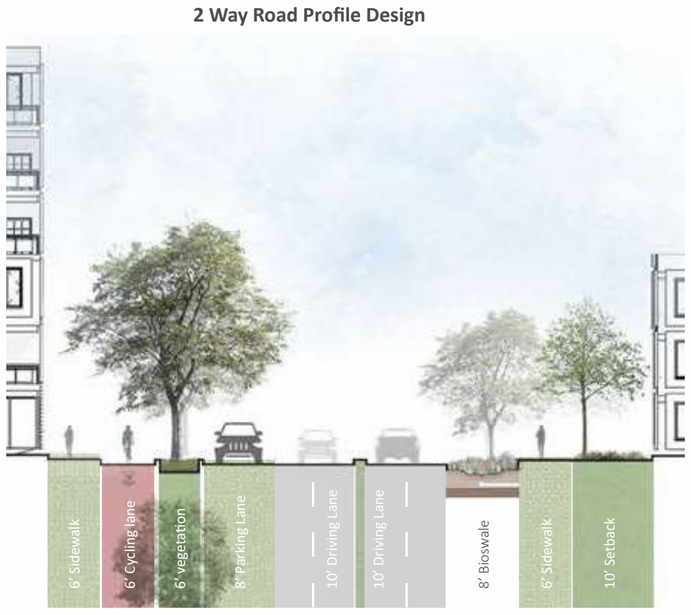
**Provisional Services**
- Cultivation area
- Renewable energy sources
- Ecological connectivity

**Cultural Services**
- Walkways
- Cycling/ biking tracks
- Community green areas

**Regulating Services**
- Stormwater Management (Bioswales, Water retention pond, green roof, etc.)
- Absorbing more Carbon

**Supporting Services**
- Reducing Particulate Matter (Air Quality)
- Low Carbon Footprint
- Providing Biodiversity

### 2 Way Road Profile Design




### Hardscape and Softscape

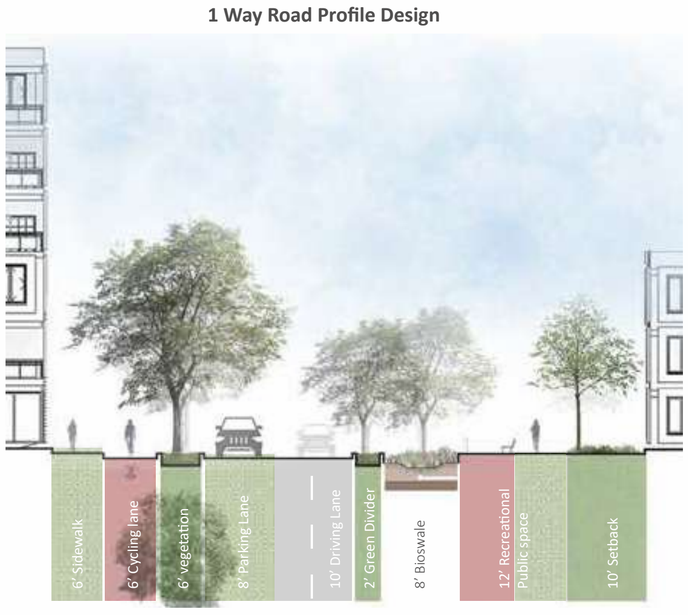
Rubber Mulch pavement

Bioswale

Permeable Grass-verge pavement

Green Roof & Ecological connectivity

### 1 Way Road Profile Design




### Carbon Sequesteration and Footprint

**-2254,5 t** Total footprint of the building inhab. of CO2 emmisions per year

**+5964,3 t** Total of emission saved yearly (Taking into account Photovoltaic, Cycling, CO2 sequestered by the trees)

In 50 years, this proposal is expected to sequester :

- 200 peoples’ worth Kg of CO2 from atmosphere and
-81 peoples’ worth Kg of particulate pollution like PM2.5

Master of science program in Territorial, Urban, Environmental And Landscape Planning

Spatial Planning for Climate Change (Studio) (Hydrology)
a.y. 2023-2024

# Spatial Planning for Climate Change
# Urban Hydrology

Prof. Stefano Ferrari
Prof Guiseppe Mandrone

Team no: 2
Anjali Ketankumar Kharwar [s314873]
Dorna Hosseinzadehbonabi [s315711]
Ovi Prasad Karanjkar [s313883]
Pouria Navabpour [s315648]

H1
General Overview

## Flowchart

**ANALYSIS**

- Hydrological flow analysis
- Terrain analysis & Slope calculation
- Calculation of run-off water
- Natural scenario analysis
- Soil Analysis

**PROJECT DEVELOPMENT**

- Design of Project- Occupation of area
- Subcatchments designated according to Urbanised Design
- Analysis on SWMM of urbanised proposal
- LID implementation in Project
- LID Used: Green Roof, Blue Roof, Bioswale
- Establishing water flow connections
- Analysis of Peak Runoff and total Runoff
- Build up scenario ≤ Natural Scenario

NO

Changes In LID

- LID Used: Green Roof, Blue Roof, Bioswale, Infiltration Trench
- Changing LID features (Berm height, storage thickness, etc)
- Analysis of Peak Runoff and total Runoff
- Build up scenario ≤ Natural Scenario

YES

YES

- Water Management

## Objective

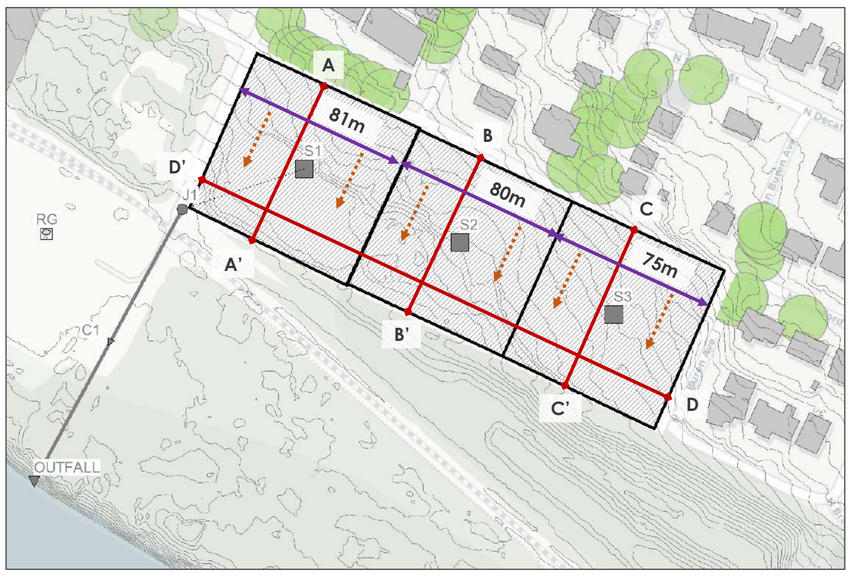
**Aim:** To make site runoff of the proposed project equal to the natural scenario

Using Infiltration method: **Curve Number as 72**

**1. Max Total flow < 31 LPS**

**2. Total Inflow Volume < 0.92 (10^6 ltr)**

## Natural Scenario: Analysis



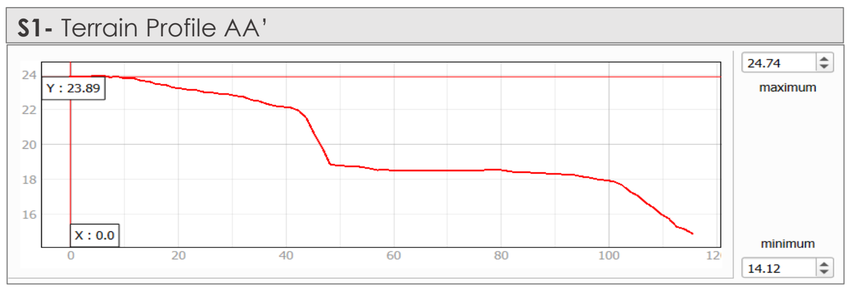

Slope Direction
Slope Profile Line
Sub-catchment Area
Dimension Line

## Introduction to Scenarios:

| SCENARIOS | 2023 (24 hrs 25 yrs) | 2060 (CAT) |
|---|---|---|
| I. **Natural Scenario** *(CN= 72; Imperviousness= 0%)* | **Scenario 1** | - |
| II. **Urbanised Grey Scenario** *(CN= 72; Imperviousness= variable)* | - | **Scenario 2** |
| II. **Urbanised Grey Scenario + LID Controls** *(CN= 72; Imperviousness= variable)* | - | **Scenario 3** |

## Terrain & Slope Analysis

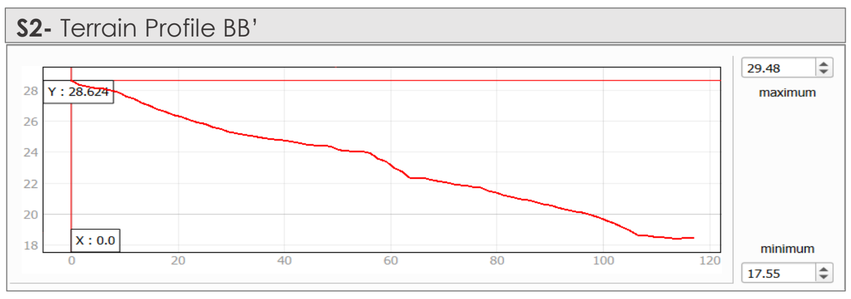
**S1-** Terrain Profile AA'




**Slope (%)= ((Max-Min)/ Length) *100**
=(10.62/**81**)*100 =**13.11%**

**Slope = 13.11%**

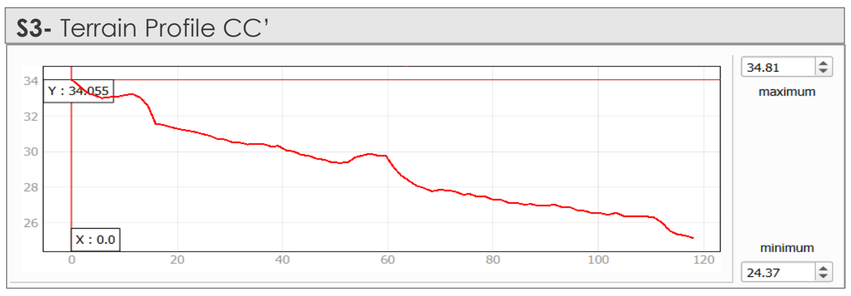
**S2-** Terrain Profile BB'




**Slope (%)=** ((29.48-17.55)/ Length) *100
=(11.93/**80**)*100 =**14.91%**

**Slope = 14.91%**

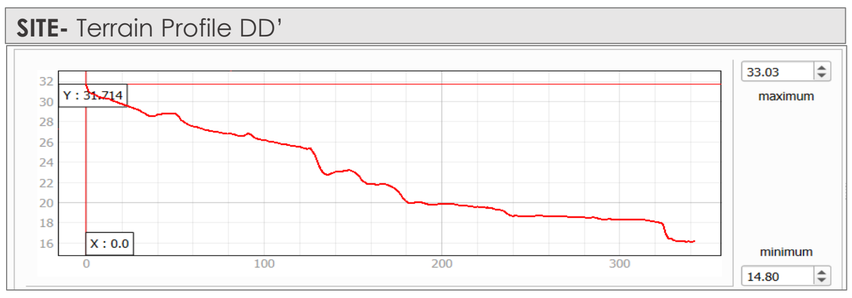
**S3-** Terrain Profile CC'



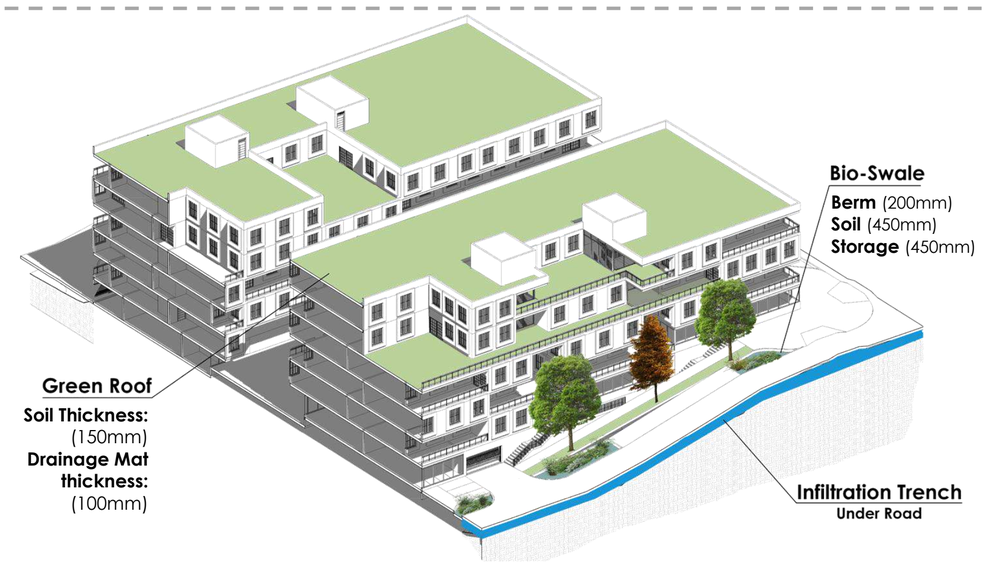

**Slope (%)=** ((34.81-24.37)/ Length) *100
=(10.44/**75**)*100 =**13.92%**

**Slope = 13.92%**

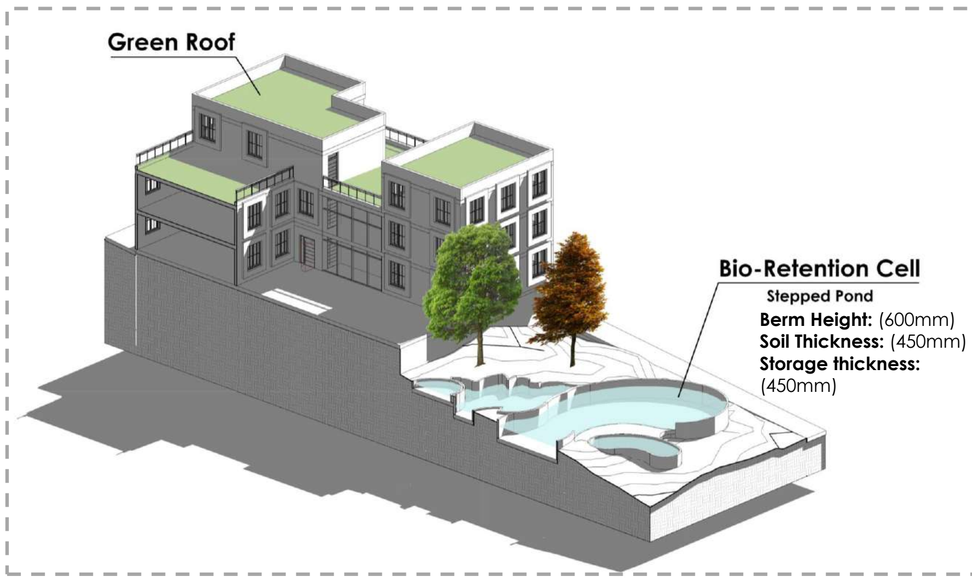
**SITE-** Terrain Profile DD'




## LID CONTROLS: Subcatchment-1



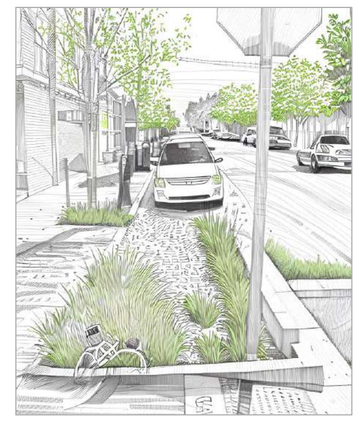

## LID CONTROLS: Subcatchment-2

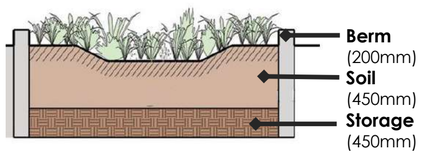



## LID Control: Details

### Bio-Swale

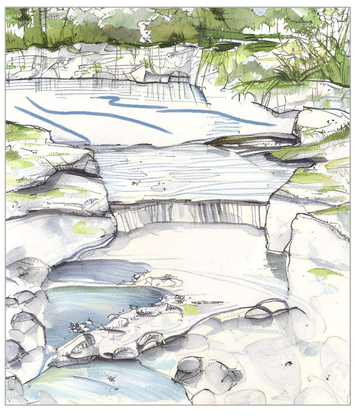
Bio-Swale in our proposal is positioned at the south-west- natural to the flow of the slope. It is connected to every sub-catchment individually.



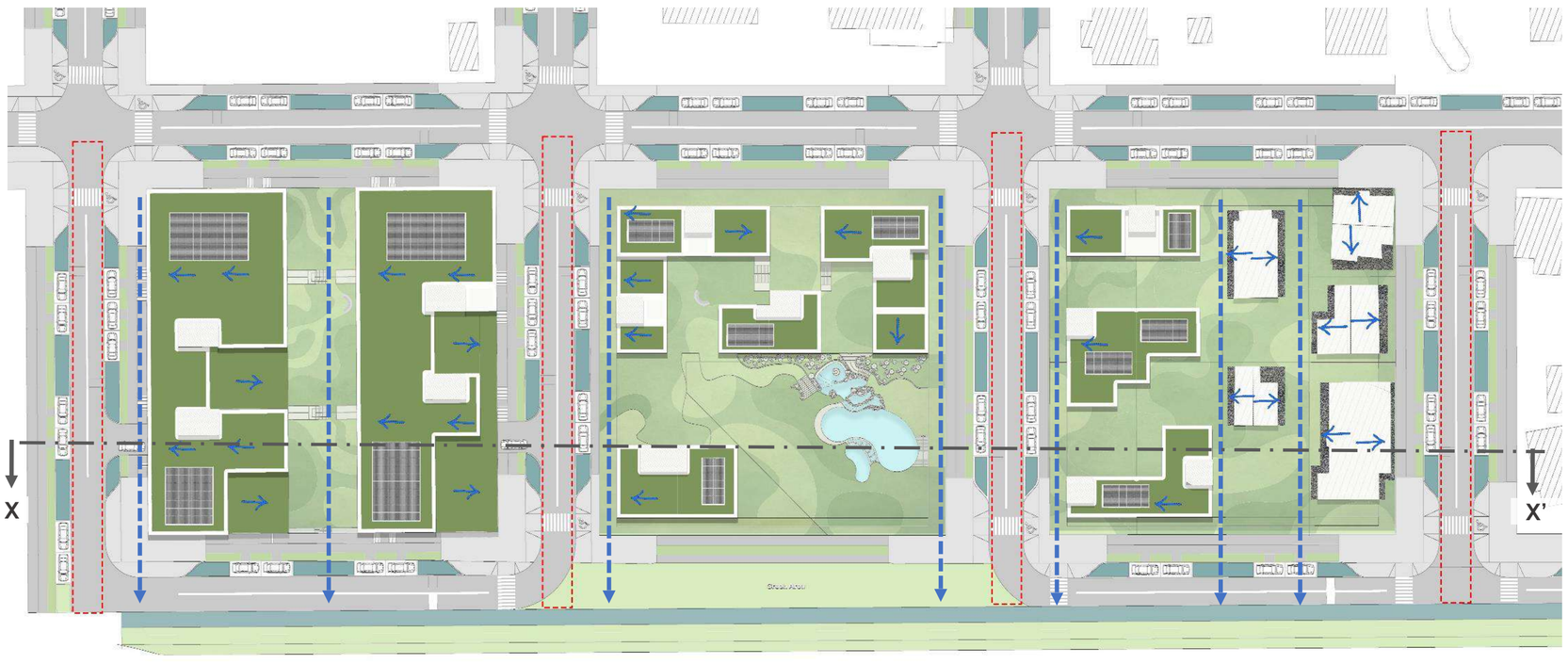



### Bio-Retention Pond

Placed in S2- the stepped pond acts as a bio-retention cell to help seepage of water.



## LID Implementation in design




**LEGEND**

- Impervious Surface
- Pervious Surface
- Water Direction

**LID Controls**

- Green Roof
- Bio-Swale
- Bio-Retention Cell (Pond)
- Rain Garden
- Infiltration Trench (Under Road)

## Schematic Water Path- Section XX'

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Spatial Planning for Climate Change (Studio) (Hydrology)
a.y. 2023-2024

Spatial Planning for Climate Change

# Urban Hydrology

Prof. Stefano Ferrari
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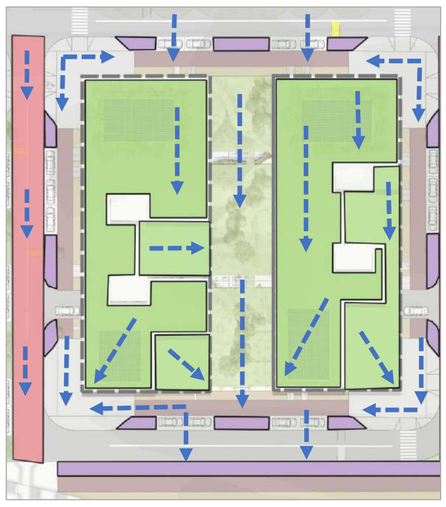
H2
General Overview

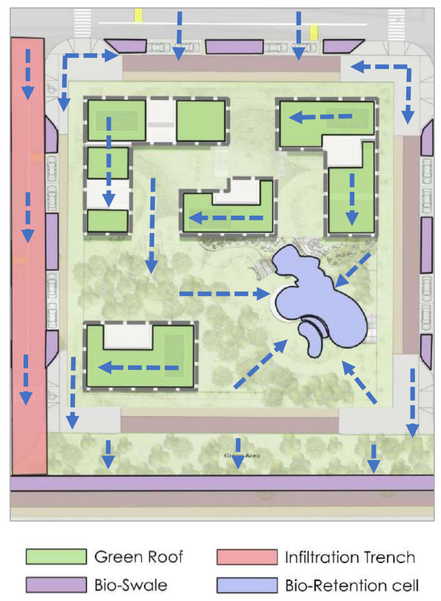
## SUBCATCHMENT: 1




| Subcatchment Area [S1] | Area [Sq.m] | Area [%] |
|---|---|---|
| Impervious Area | 1669.98 | 25.29 % |
| Pervious Area | 1517.66 | 22.98 % |
| LID Controls Area | 3415.24 | 55.40 % |
| Subcatchment Area (S1) | **6602.88** | **100%** |

| LID Controls Subcatchment Area- 1 | Area Covered | | Impervious Area Treated | | Pervious area treated | |
|---|---|---|---|---|---|---|
| | [Sq.m] | [%] | [Sq.m] | [%] | [Sq.m] | [%] |
| Green Roof 1 | 1099.72 | 16.6 % | - | - | - | - |
| Green Roof 2 | 86.43 | 1.3 % | - | - | - | - |
| Green Roof 3 | 251.39 | 3.8 % | - | - | - | - |
| Green Roof 4 | 1171.19 | 17.7 % | - | - | - | - |
| Green Roof 5 | 150.56 | 2.2 % | - | - | - | - |
| Green Roof 6 | 116.73 | 1.7 % | - | - | - | - |
| Bio-Swale 1 (x2) | 157.99 | 4.7 % | 530 | 8 % | 465 | 7 % |
| Bio-Swale 2 (x2) | 111.71 | 3.3 % | 530 | 8 % | 465 | 7 % |

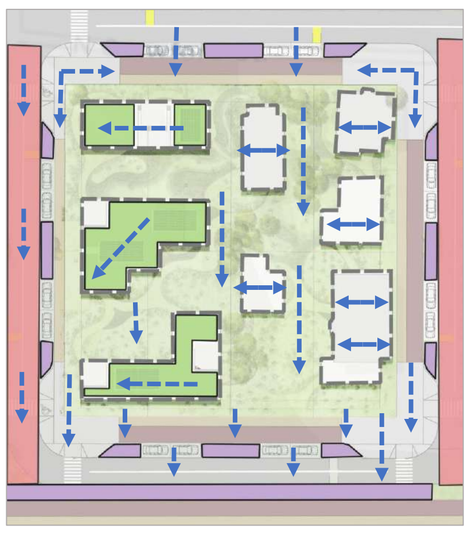
## SUBCATCHMENT: 2




| Subcatchment Area [S2] | Area [Sq.m] | Area [%] |
|---|---|---|
| Impervious Area | 1446.00 | 21.69 % |
| Pervious Area | 2217.38 | 33.27 % |
| LID Controls Area | 3002.23 | 45.04 % |
| Subcatchment Area (S2) | **6665.61** | **100%** |

| LID Controls Subcatchment Area- 2 | Area Covered | | Impervious Area Treated | | Pervious area treated | |
|---|---|---|---|---|---|---|
| | [Sq.m] | [%] | [Sq.m] | [%] | [Sq.m] | [%] |
| Green Roof 1 | 236.15 | 3.56 % | - | - | - | - |
| Green Roof 2 | 308.27 | 4.65 % | - | - | - | - |
| Green Roof 3 | 145.26 | 2.19 % | - | - | - | - |
| Green Roof 4 | 310.50 | 4.69 % | - | - | - | - |
| BioSwale 1 (x2) | 196.56 | 5.9 % | 365 | 5.46 % | 260 | 4 % |
| BioSwale 2 (x2) | 238.29 | 7.14 % | 365 | 5.46 % | 260 | 4 % |
| Infiltration Trench | 501.30 | 7.76 % | 505 | 7.6 % | - | - |
| Bio-Retention cell (Pond) | 550 | 8.52 % | 200 | 3 % | 1040 | 15.6 % |

## SUBCATCHMENT: 3




| Subcatchment Area [S3] | Area [Sq.m] | Area [%] |
|---|---|---|
| Impervious Area | 1616.73 | 24.50 % |
| Pervious Area | 2403.44 | 36.43 % |
| LID Controls Area | 2577.97 | 39.07 % |
| Subcatchment Area (S1) | **6598** | **100%** |

| LID Controls Subcatchment Area- 1 | Area Covered | | Impervious Area Treated | | Pervious area treated | |
|---|---|---|---|---|---|---|
| | [Sq.m] | [%] | [Sq.m] | [%] | [Sq.m] | [%] |
| Green Roof 1 | 186.80 | 2.90 % | - | - | - | - |
| Green Roof 2 | 282.62 | 4.39 % | - | - | - | - |
| Green Roof 3 | 220.35 | 3.43 % | - | - | - | - |
| Infiltration Trench | 501.30 | 7.80 % | 460 | 7.1 % | - | - |
| Rain Garden | 81.78 | 1.26 % | 1150 | 18 % | - | - |
| Bio-Swale 1 (x2) | 201.86 | 6.27 % | 560 | 8.5 % | - | - |
| Bio-Swale 2 (x2) | 199.26 | 6.19 % | 560 | 8.5 % | 460 | 7 % |

## SWMM MODEL


### MODEL COMPONENT'S

**S1/2/3:** Subcatchment Area (connected to **BS**)

**BS:** Bioswale (Connected to **J1**)

**J1:** Junction (connected To **Outfall**)

**C1:** Conduit (Between **JI** and **Outfall**)

**RG:** Rain Gage

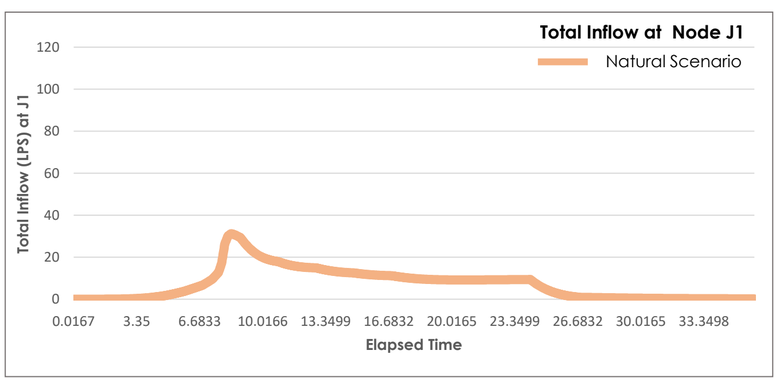
**Outfall:** Outfall

**Curve Number= 72**

## Scenario 1: Natural scenario

| Sub-catchment Area | Total Precipitation (mm) | Total Infiltration (mm) | Total Runoff (mm) | Total Runoff (10^6 ltr) | Peak Runoff (LPS) |
|---|---|---|---|---|---|
| S1 | 99.04 | 50 | 48.83 | 0.32 | 13.80 |
| S2 | 99.04 | 49.96 | 48.88 | 0.31 | 13.36 |
| S3 | 99.04 | 49.95 | 48.89 | 0.30 | 13.22 |

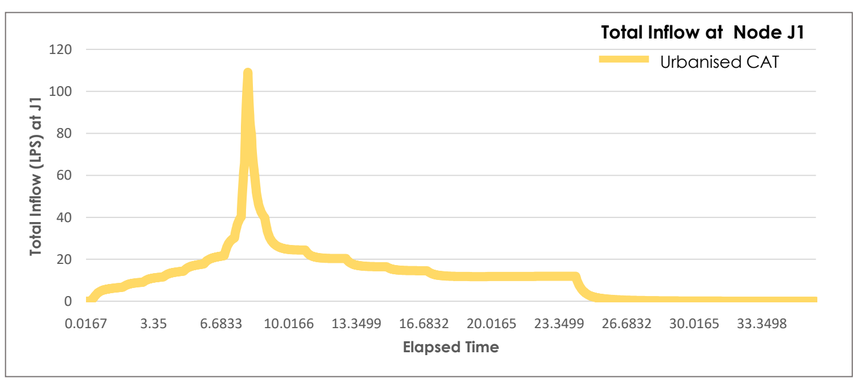
| Outfall Node (Scenario 1) | Maximum Lateral Inflow (LPS) | Maximum Total Flow (LPS) | Total Inflow Volume (10^6 ltr) |
|---|---|---|---|
| J1 | 31.16 | **31.16** | **0.92** |




## Scenario 2: Grey Urbanised Area + CAT (2060)

| Sub-catchment Area | Impervious Area [%] | Total Precipitation (mm) | Total Infiltration (mm) | Total Runoff (mm) | Total Runoff (10^6 ltr) | Peak Runoff (LPS) |
|---|---|---|---|---|---|---|
| S1 | 71.3% | 105.94 | 12.78 | 92.96 | 0.61 | 51.94 |
| S2 | 44.6% | 105.94 | 28.44 | 77.26 | 0.49 | 36.80 |
| S3 | 41.1% | 105.94 | 30.25 | 75.45 | 0.47 | 34.68 |

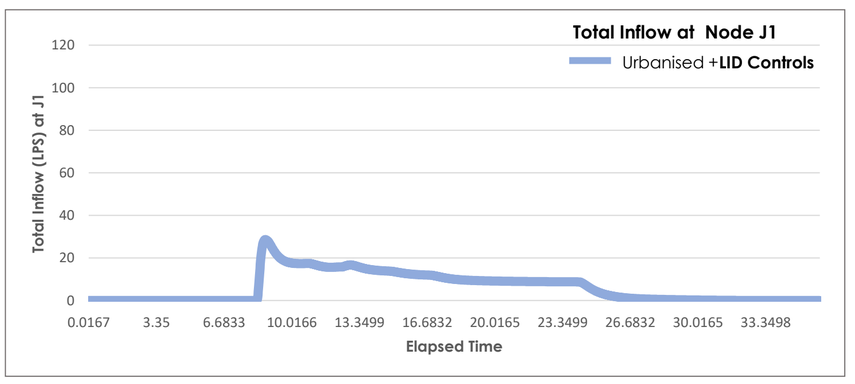
| Outfall Node (Scenario 2) | Maximum Lateral Inflow (LPS) | Maximum Total Flow (LPS) | Total Inflow Volume (10^6 ltr) |
|---|---|---|---|
| J1 | 112.92 | **121.92** | **1.56** |

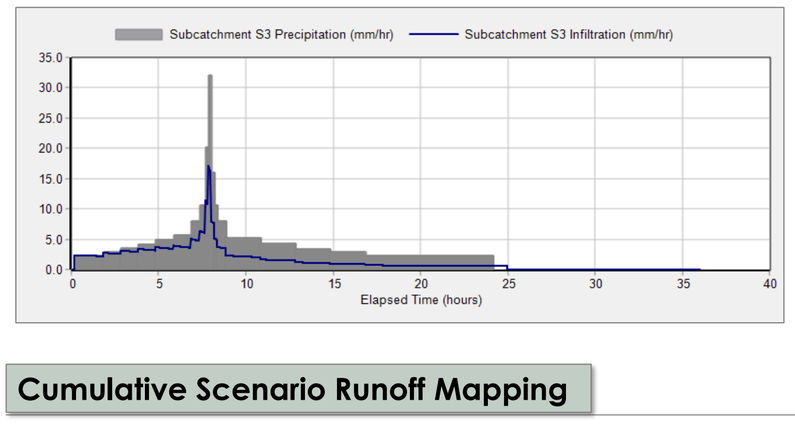


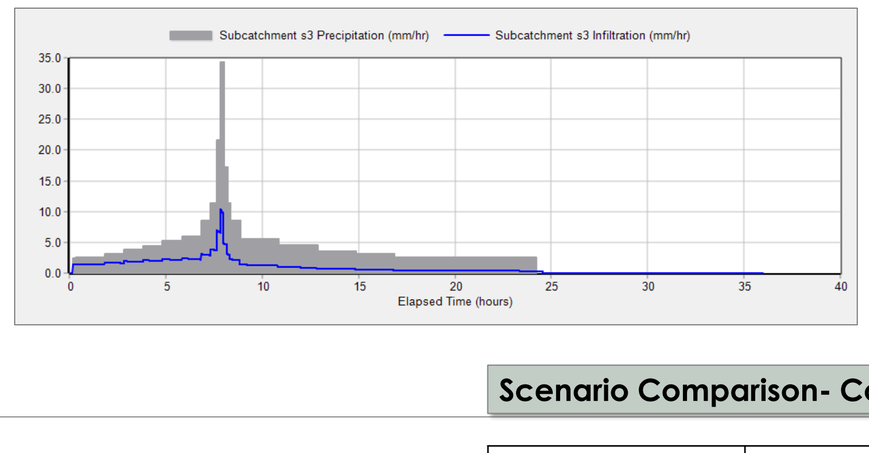

## Scenario 3: Grey Urbanised Area+ CAT + LID Implemented

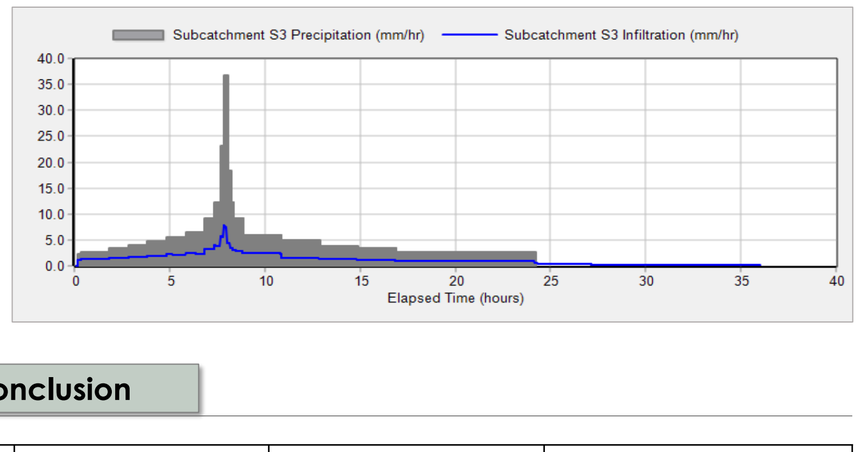
| Sub-catchment Area | Impervious Area [%] | Total Precipitation (mm) | Total Infiltration (mm) | Total Runoff (mm) | Total Runoff (10^6 ltr) | Peak Runoff (LPS) |
|---|---|---|---|---|---|---|
| S1 | 25.29 % | 113.14 | 26.21 | 69.70 | 0.47 | 19.14 |
| S2 | 26.69 % | 113.14 | 39.60 | 48.96 | 0.34 | 18.44 |
| S3 | 49.97 % | 113.14 | 43.26 | 57.06 | 0.40 | 26.85 |

| Outfall Node (Scenario 3) | Maximum Lateral Inflow (LPS) | Maximum Total Flow (LPS) | Total Inflow Volume (10^6 ltr) |
|---|---|---|---|
| J1 | 24.83 | **24.83** | **0.73** |

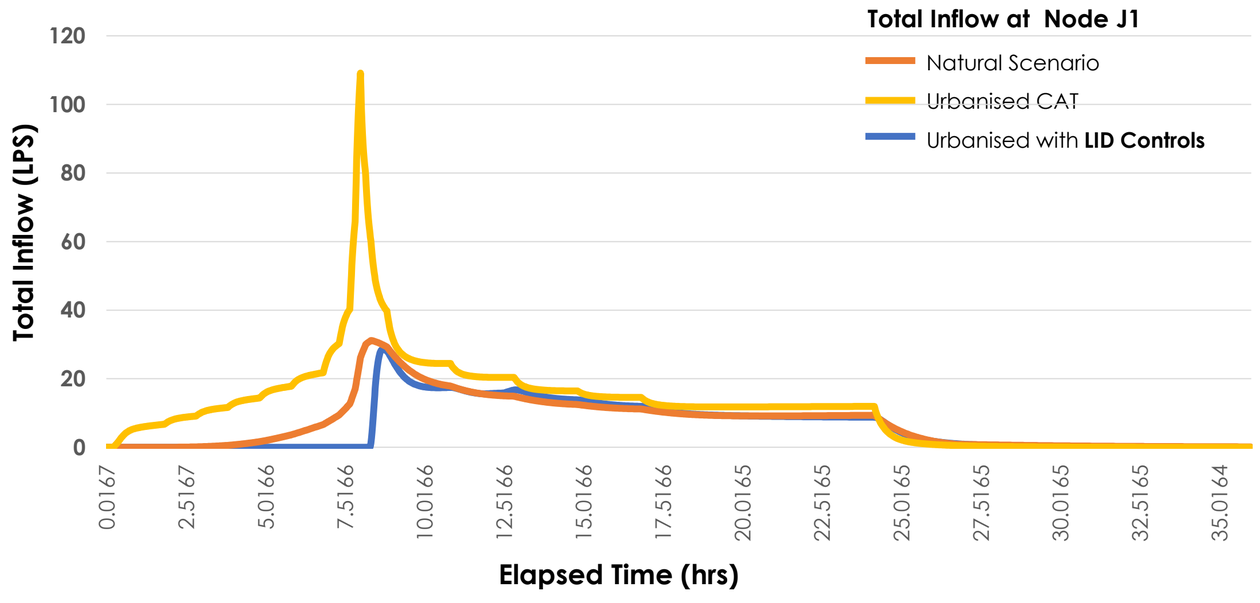



## Cumulative Scenario Runoff Mapping




## Scenario Comparison- Conclusion

| Scenarios | Total Precipitation (mm) | Total Runoff (mm) | | | Peak Runoff (LPS) | | | Node Inflow (J1) | |
|---|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S1 | S2 | S3 | Max. Total Inflow (LPS) | Total Inflow Volume (10^6 ltr) |
| Natural (Present) | 99.04 | 48.83 | 48.88 | 48.89 | 13.80 | 13.36 | 13.22 | **31.16** | **0.92** |
| Grey Urbanised+ **CAT (2060)** | 105.94 | 92.96 | 77.26 | 75.45 | 51.94 | 36.80 | 34.68 | 112.92 | 1.56 |
| Urbanised + **CAT** + **LID Controls** | 105.94 | 69.70 | 48.96 | 57.06 | 19.14 | 18.44 | 26.85 | **24.83** | **0.73** |

**Build up scenario ≤ Natural Scenario**