ASFPM
INTERNATIONAL
COMMITTEE

Mission

Provide a platform to:

- ❖ Exchange knowledge at a global level
- ❖ Discuss the best practices on the wise use of floodplains in order to reduce flood losses, manage water resources, and promote sustainability in the built and natural environment

ASFPM
INTERNATIONAL
COMMITTEE

What do we do?

Plan

to identify interesting topics
@ our bi-monthly online meetings

Learn

from other flood risk management experiences
@ ASFPM conferences, newsletters & webinars

Connect

to create a network of people dealing with flood issues around the world. We would like to meet you in person @ the ASFPM conference!

DR. NIAN SHE

Dr. She has more than 28 years of experience in river/lake restoration, sediment remediation, water quality, hydrologic/hydraulic modeling, stormwater management, and water resources planning and management. He was a senior civil engineering specialist with City of Seattle before joining Tsinghua University Innovation Center in Zhuhai. He is also a distinguish professor in Guangzhou University and a guest professor in Shenzhen University of China.

Dr. She has been working in LID/GSI since early 1990s and working on hundreds of LID/GSI projects worldwide. In the past three years he has been working on dozens of pilot sponge cities from planning, engineering design, construction, operation, and maintenance.

Redrawing Grey Cities to Climate Resilient Sponge Cities

Dr. Nian She
Tsinghua University Innovation Center in Zhuhai

Rapid Urbanization in China

Forest of Concrete

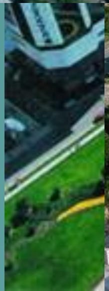
“BBQ” Square in Jieyang, Guangdong

Dalian City Square

Concrete River

Senseless aesthetics

Landscape in Northern China (Precipitation 450-550mm/yr)

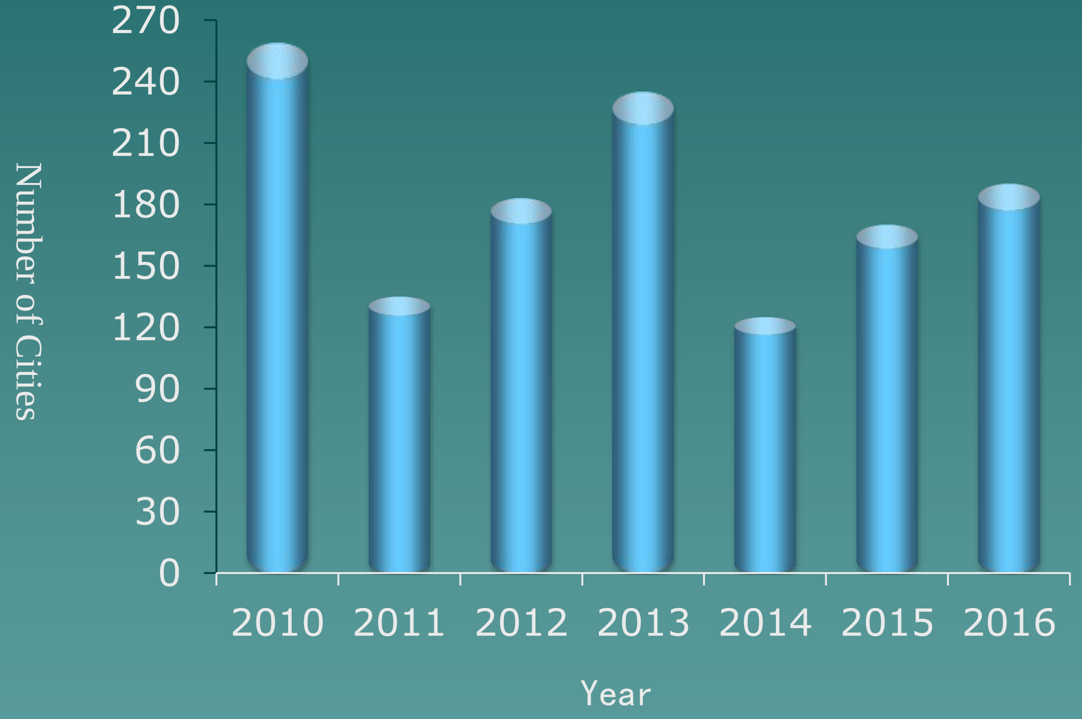


In 1980s This Blvd Becomes a Model for Many Chinese Cities

Don’t Understand Why the Landscape Architects Designed the Road in such a Way

The Consequences
7/21/2012 Beijing

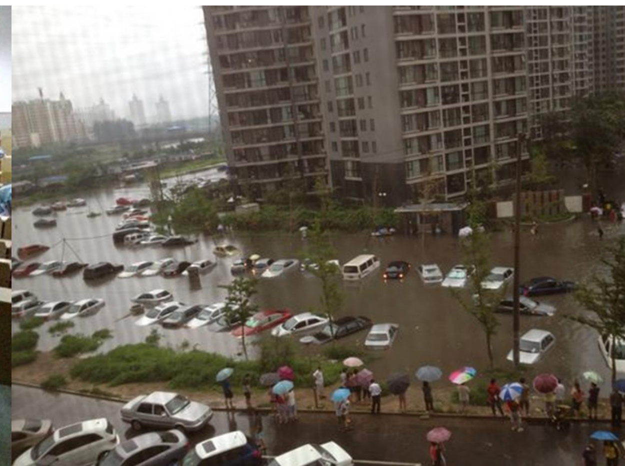
Number of cities suffering from flooding threats in China from 2010 - 2016



Eutrophication of Lakes

How to Solve These Problems

Flooding
Water Pollution
Extreme Weather Caused by Climate Change
Aesthetic Perception



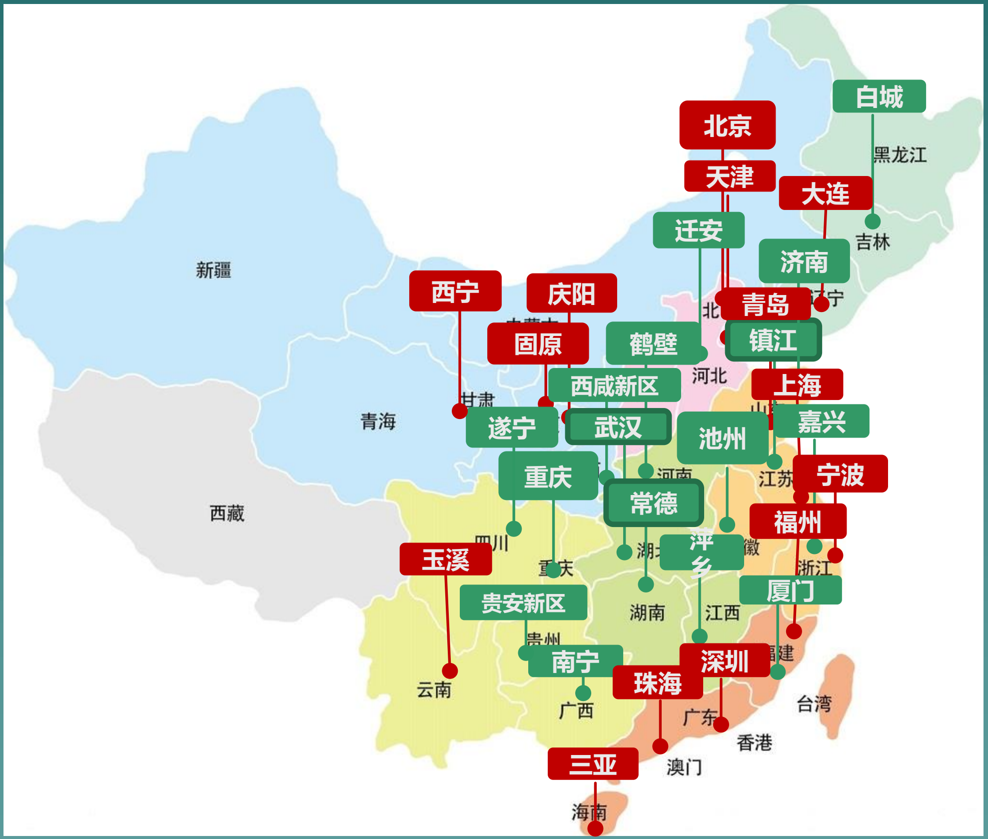
Sponge City

The Sponge City is referred to sustainable urban development including flood control, water conservation, water quality improvement, natural ecosystem protection, and water resources utilization. It also makes cities more resilient to climate change.

Today's Concrete Forest

Functioning like Forest

30 Pilot Sponge Cities Chosen by the Central Government (2015 – 2016)



- **First（16 Cities）（2015）**
  Qianan, Baicheng, Zhenjiang, Jiaxing, Chizhou, Xiamen, Pingxiang, Jinan, Hebi, Wuhan, Changde, Nanning, Chongqin, Suining, Guian New District and Xixian New District
- **Second（14 Cities）（2016）**
  Fuzhou, Zhuhai, Ningbo, Yuxi, Dalian, Shenzhen, Shanghai, Qinyang, Xining, Sanya, Qingdao, Guyuan, Tianjin, Beijing

Sponge City Construction

- By year 2020, 20% developed urban area must be retrofit to meet the sponge city target
- By year 2030, 80% developed urban area must be retrofit to meet the sponge city target
- The construction cost is about \$15-22.5 million USD/km^2
- The total investment is estimated about \$0.9 trillion USD

Source: Economic Information Daily

Investment of Pilot Sponge Cities

- Wuhan: $2.44 billion
- Chongqing： $1.05 billion
- Nanning： $1.3 billion
- Zhenjiang: $1.2 billion
- Jinan: $1.17 billion
- Jiaxing: $0.34 billion
- Among the first 16 pilot cities, the total area is 450 km^2
- The investment is about $12.97 billion with 3 years, $3.6 billion come from the central government.

Where does the money come from

- Central and provincial governments fund part of the construction cost as incentive to these
- Public-Private Partnership
  - Private sectors provide initial fund for the constructions
  - Governments will purchase the services to pay for part of the cost
  - Pay-for-performance
  - Pay for the operations and maintenances
- Sponge City Construction Industry Alliance
  - System design
  - Investment and finance
  - Implementation
  - Innovation
  - Products/Production

ZHENJIANG SPONGE CITY

Project Overview

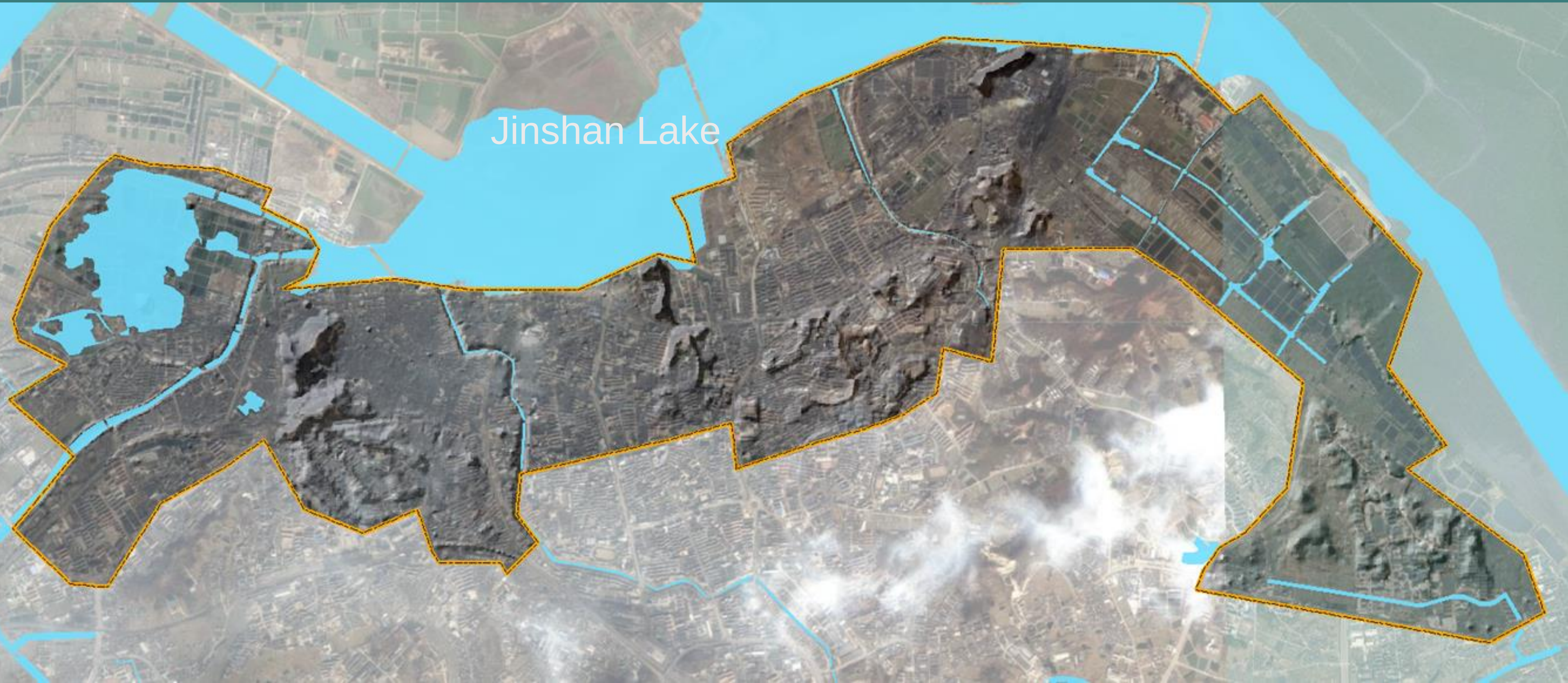
Project Scope: Assess and plan stormwater management retrofits for 22 km^2 of watersheds within the City of Zhenjiang

Project Goals:

- Convey 30-year storm event (with no city water-logging)
- Improve Water Quality of Receiving Water to Chinese Class III
- Treat 75% of annual runoff volume
- Reduce annual TSS load by 60%.

Background

- Zhenjiang City is located at Jiangsu Providence of China
- It is one of the 16 pilot “sponge cities” chosen by the federal government in 2015
- The pilot area is 22 square kilometers of old high density urban residential and business neighborhood



The Problems

1. Flooding （2015-06-29）

2. Water Quality Deterioration caused by CSO/Stormwater Runoff

A6 北固湾水体污染

北固湾望江亭附近水域浑浊发黑

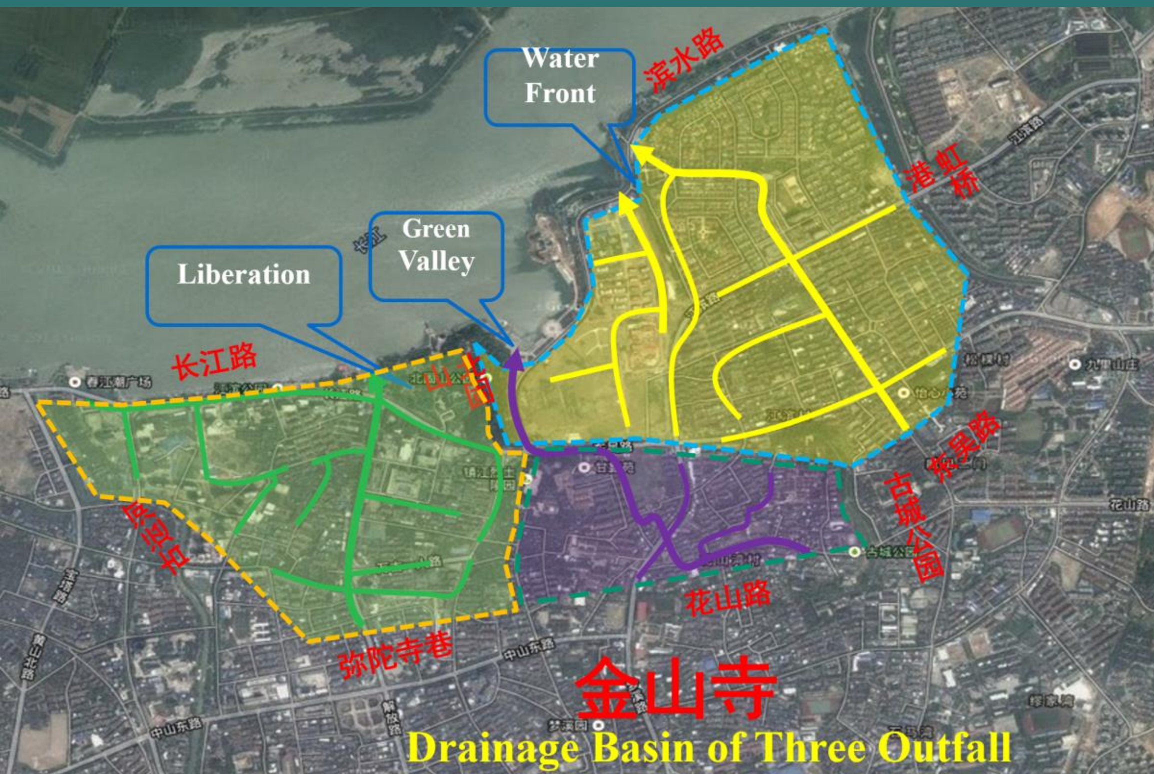
污染源或为初期雨水和生活污水

待“城市面源污染治理”实施后可望解决

望江亭水域浑浊发黑
环保确认不是企业排污

传统排水工程
难进一步改善水质
面源污染治理
将大有可为

Grey Solutions before the Sponge City



- Outfall No.1 serves 120 ha business and residential area
- Outfall No. 2 serves 70 ha mainly business area
- Outfall No. 3 serves 190 ha mainly high density residential area

Original Proposal:

- Built 4 detention tanks
- Total Volume = 60,000 m^3
- Total Cost: $150 million

<u>But</u>, can not solve flooding problem

Alternative Solution

LID at the Source

Inline storage and treatment

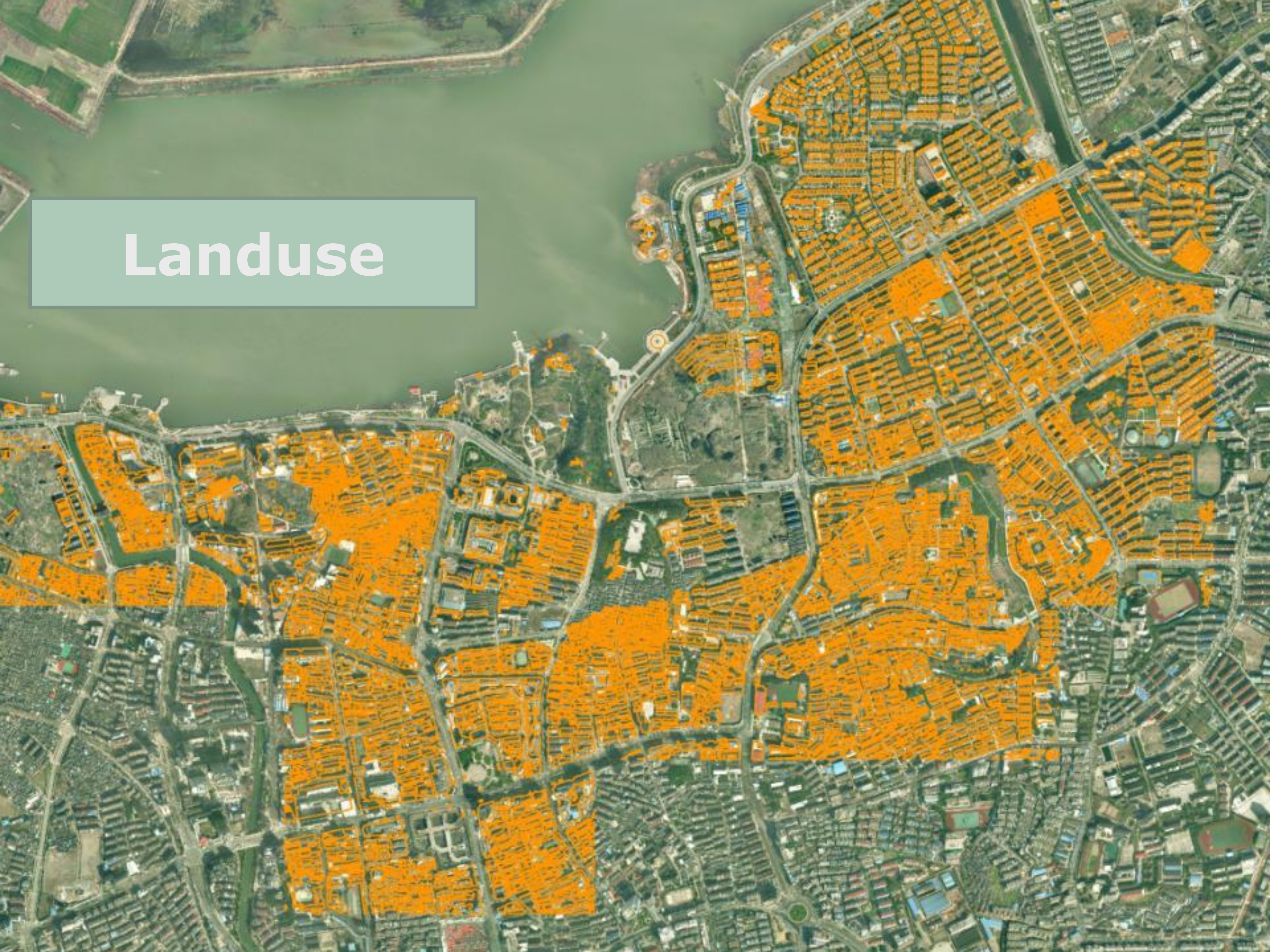
Regional facility near outfalls

Solve WQ & Flooding

Data Collection and Initial Investigation

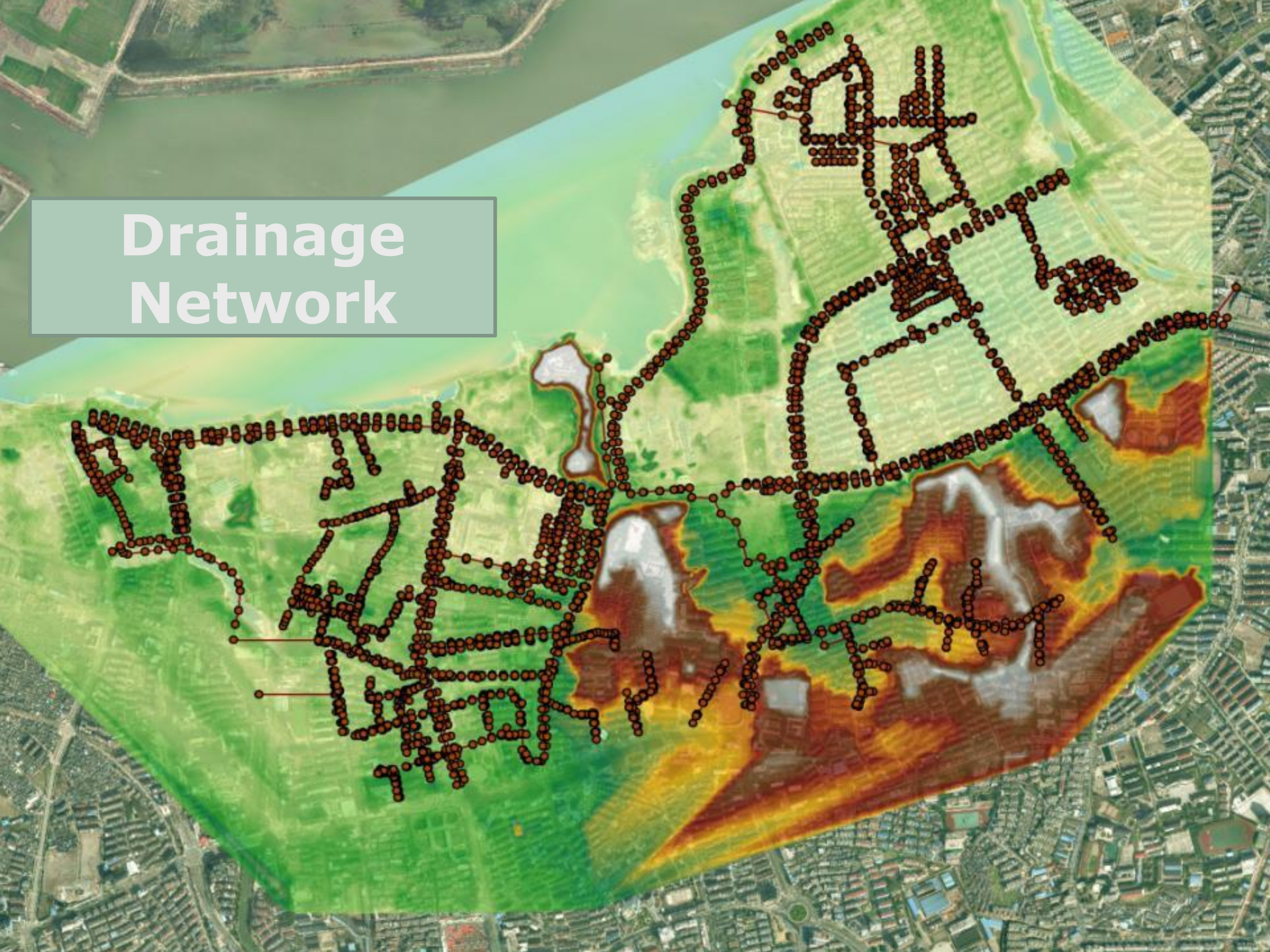
- Weather data
- Topo
- Land use
- Drainage network
- River and Lakes
- Site visit
- SWMM model
- Monitoring network
- SWMM Calibration
- Flood location identification


Arial Photo

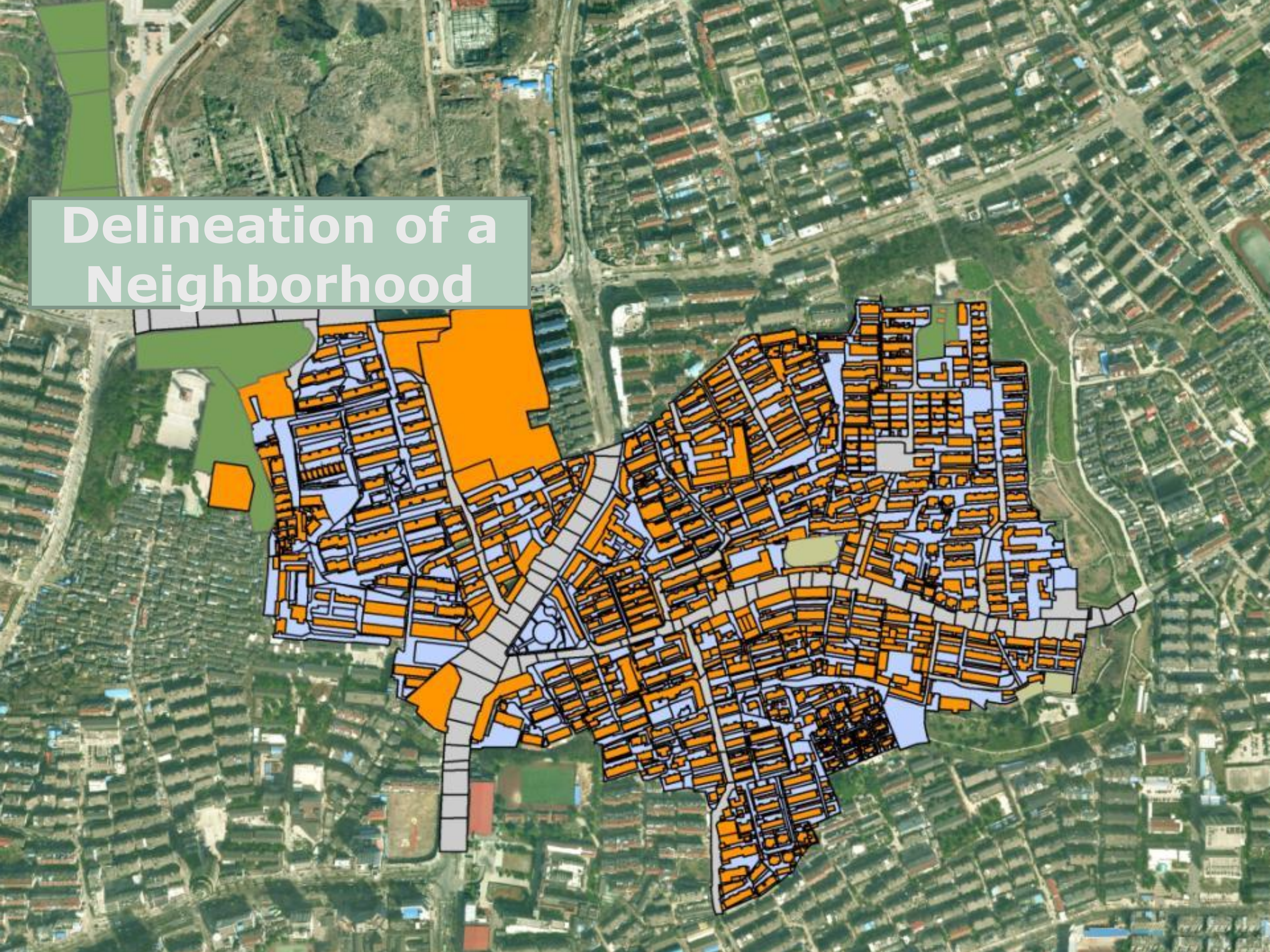

Landuse

Topography

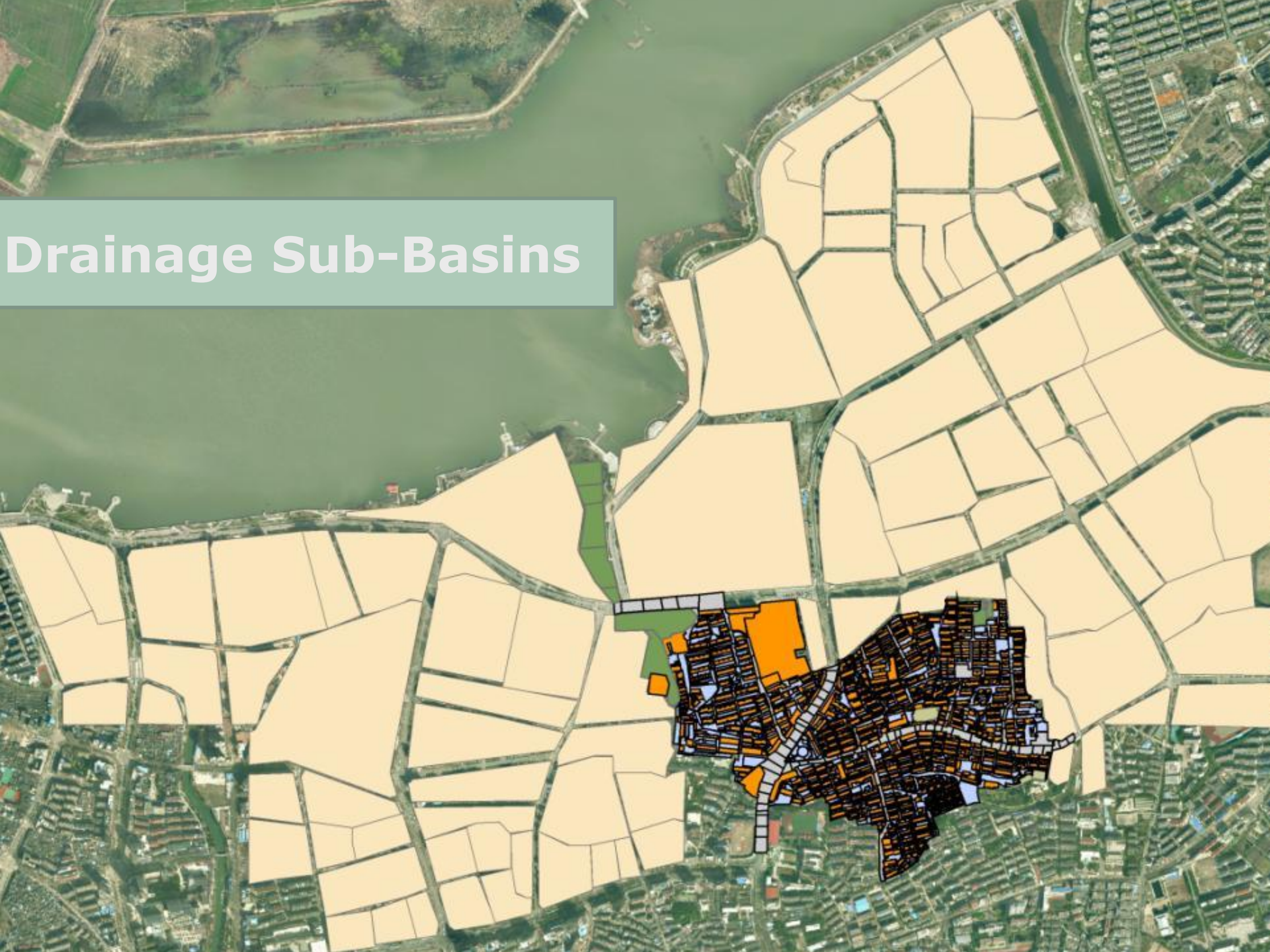
Drainage Network



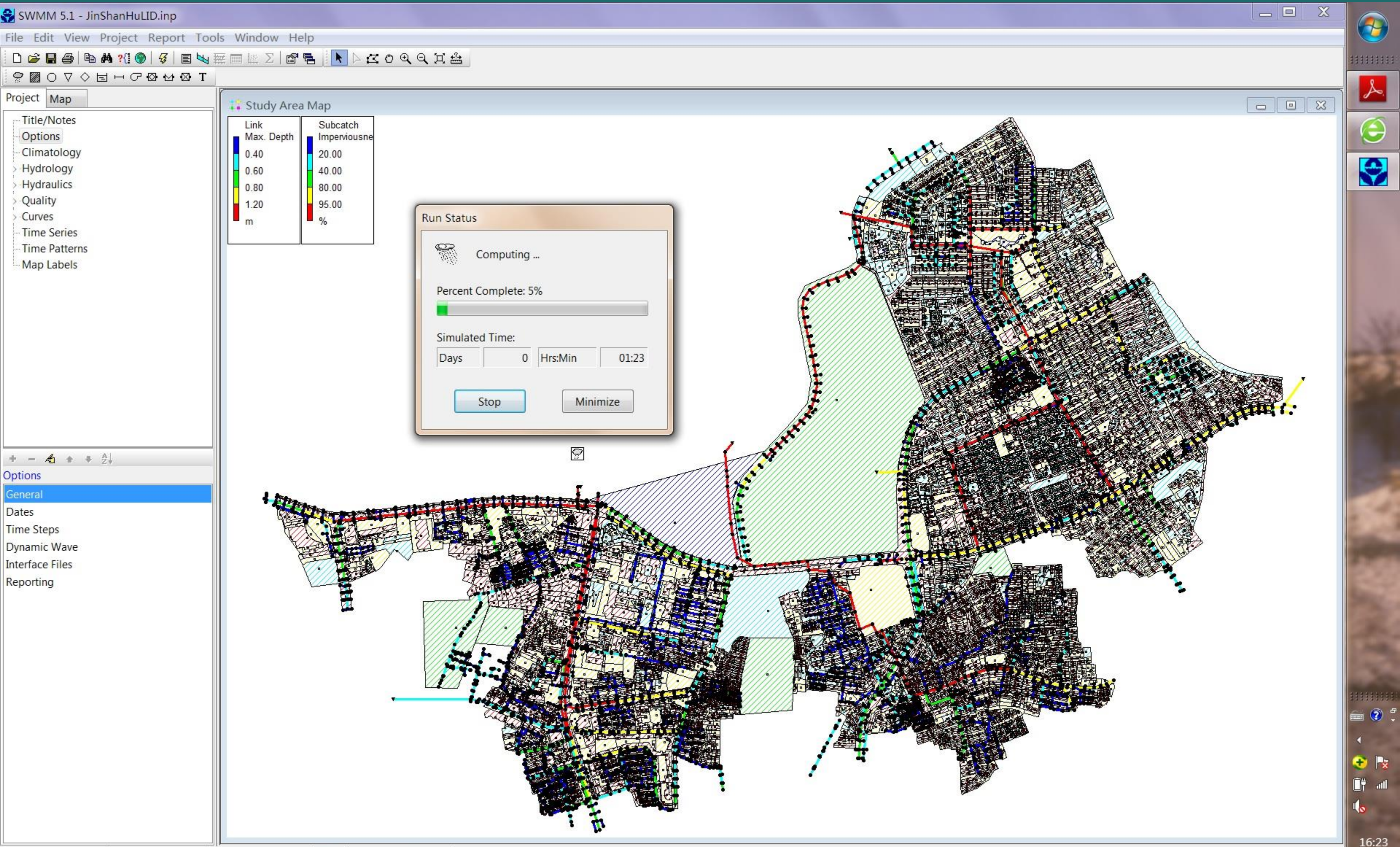
Delineation of a Neighborhood



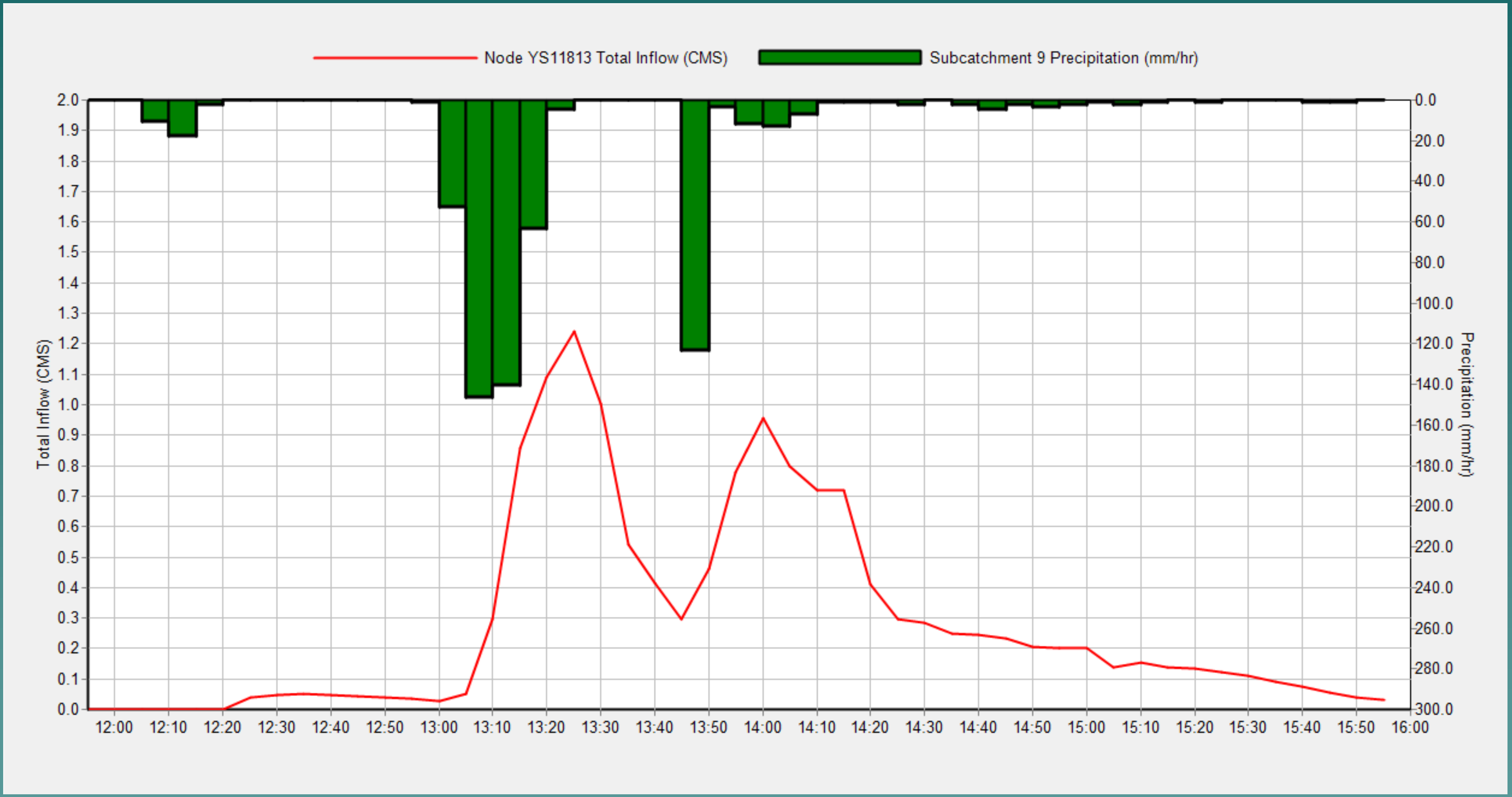
Drainage Sub-Basins



SWMM Model

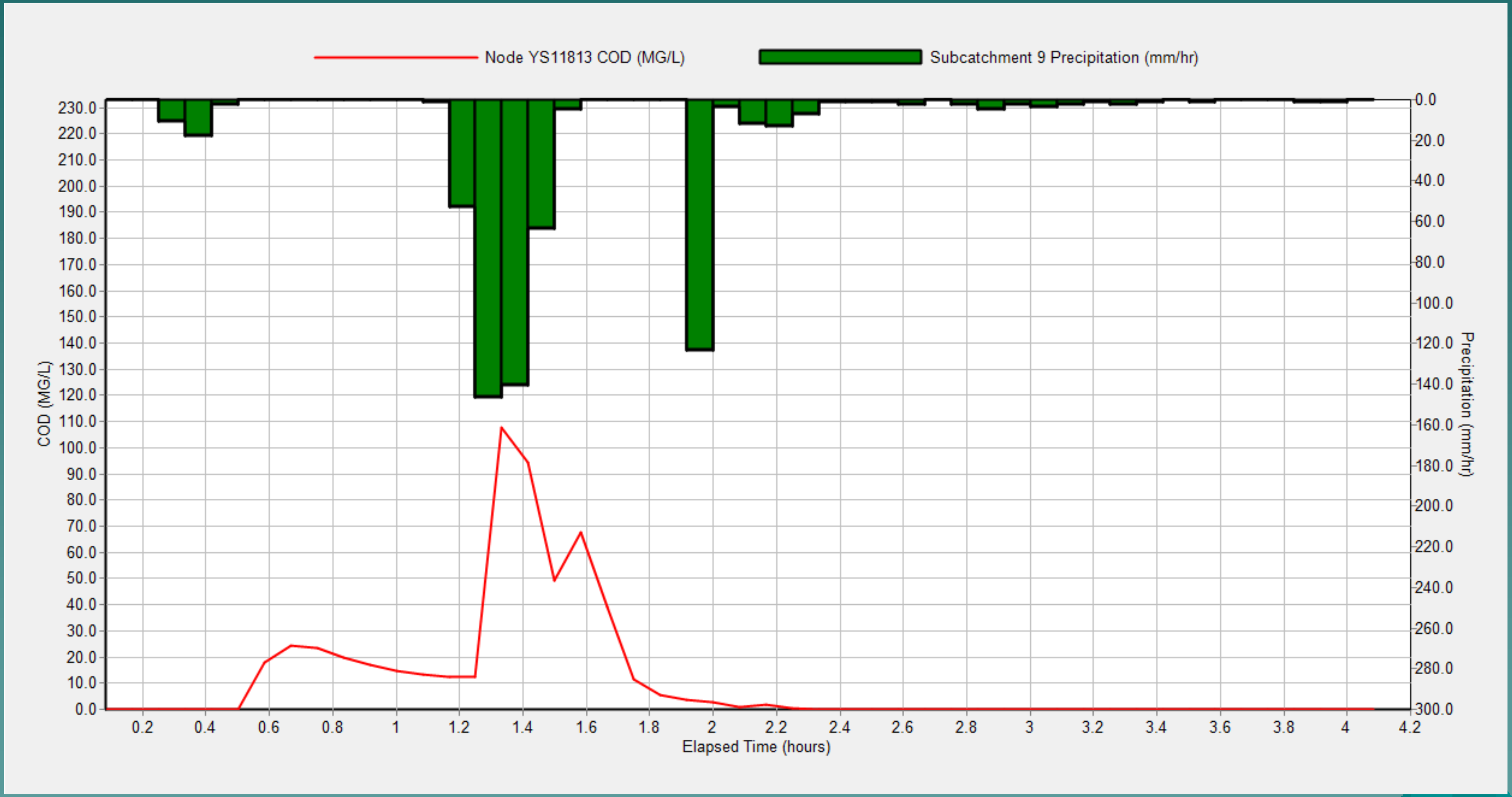

SWMM 5.1 - JinShanHuLID.inp
File Edit View Project Report Tools Window Help
Project Map
Title/Notes
Options
Climatology
Hydrology
Hydraulics
Quality
Curves
Time Series
Time Patterns
Map Labels
Options
General
Dates
Time Steps
Dynamic Wave
Interface Files
Reporting
Study Area Map
Link Max. Depth
0.40
0.60
0.80
1.20
m
Subcatch Imperviousne
20.00
40.00
80.00
95.00
%
Run Status
Computing ...
Percent Complete: 5%
Simulated Time:
Days 0 Hrs:Min 01:23
Stop
Minimize
16:23

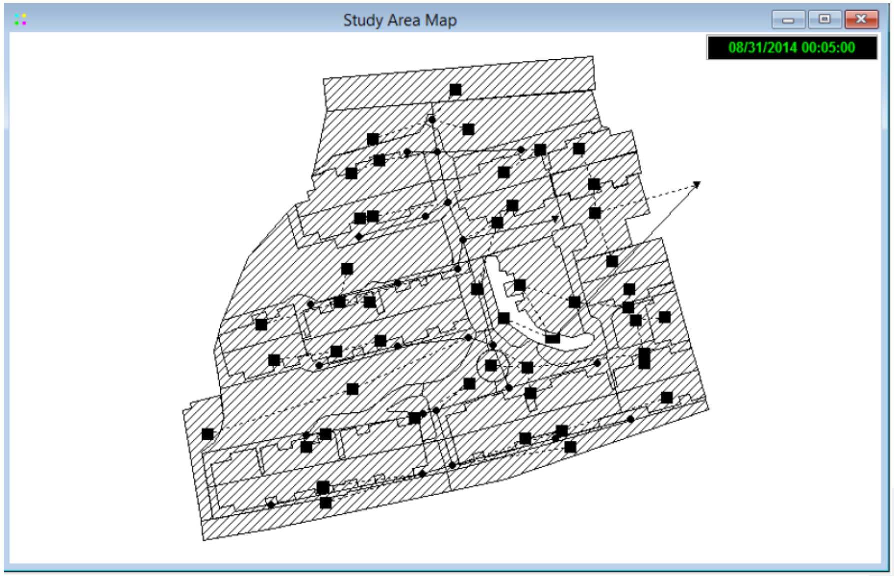
Initial Validation



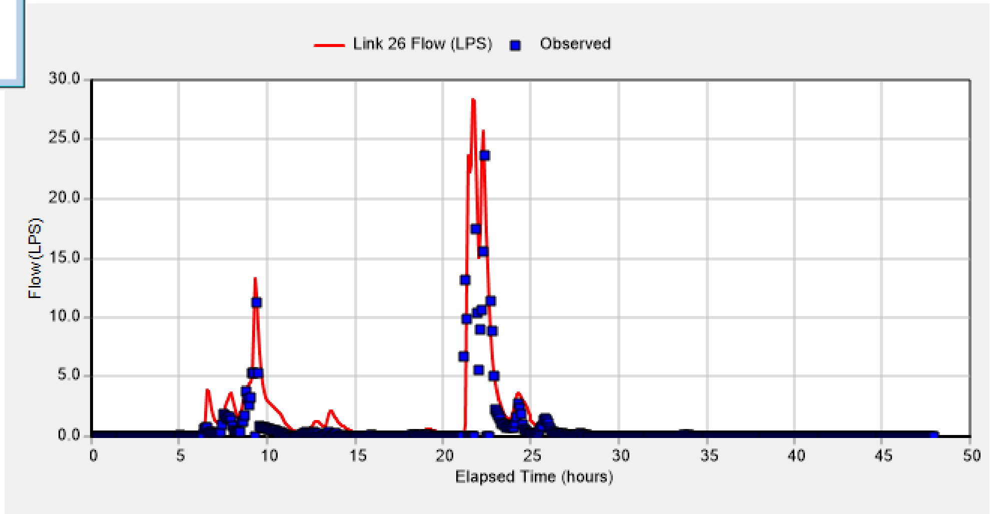
Hydrograph of a sub basin (Event simulation)

Initial Wash - off



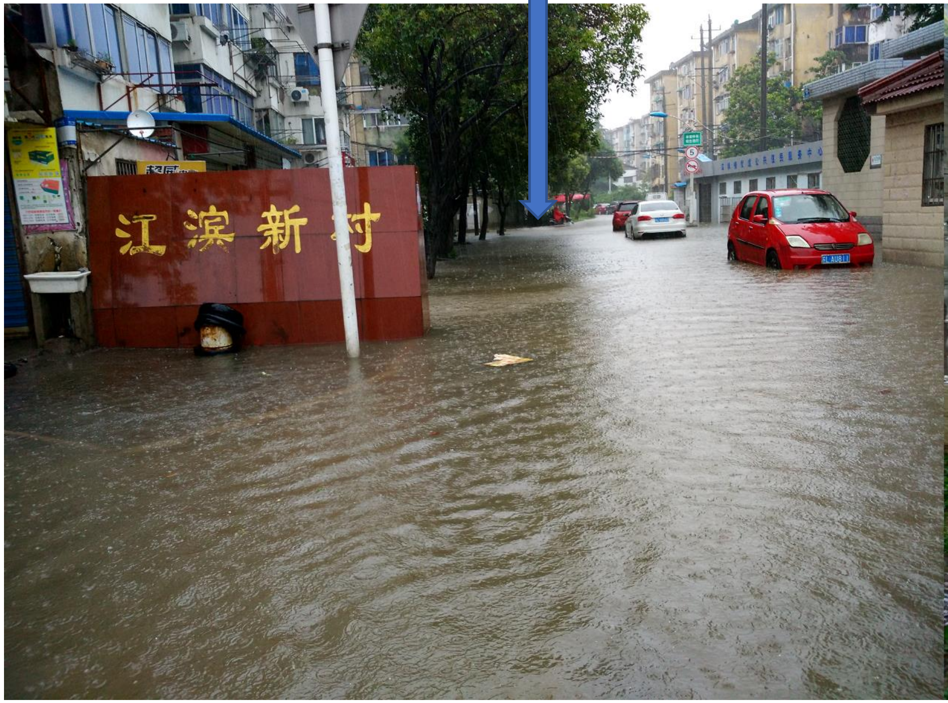


SWMM Calibration to Determine model parameters

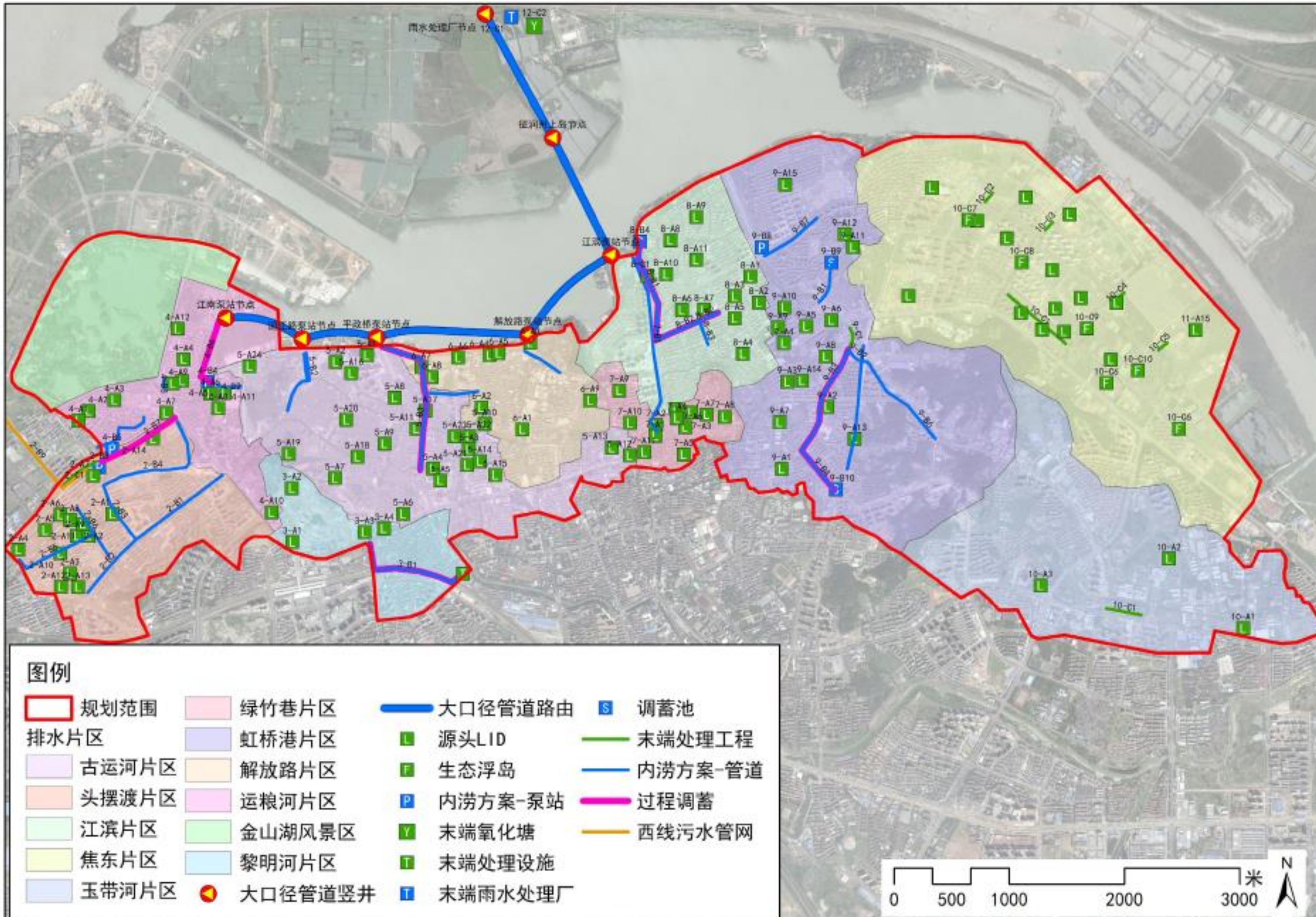


Flood Locations

These communities are well known for flooding every year. These photos were taken on 6/29/2015 before LID construction and retrofit.



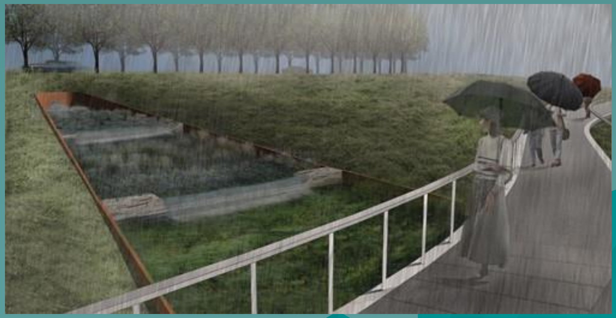
Redraw the City: Green + Grey + Blue Solutions



In my opinion the Sponge City is the redrawing of urban landscape to meet the challenge of climate change, flooding, water shortage, water pollution and water culture. The implementation of the sponge city should be an integrated system of grey and green infrastructures that reduce the runoff and pollution from the source, control the runoff and pollution inline and treat the runoff at the end of the pipe. Rivers and lakes can also be used as water quality channel for pollution removal and establish aquatic habitats





Retrofit Old Neighborhoods Using LID

Basin	boundary	**area (km^2)**	Drainage	Receiving water
Green Valley	南起花山湾新村，西自烈士陵园墓，北至金山湖	**0.79**	CSO	Lake of Golden Mt.
Liberation	北自长江路，南到中山东路，西起古运河东侧，东至第一楼街	**1.22**	separate	Lake of Golden Mt.
Water Front	南自镇江市江南学校，东起虹桥河西侧，北至滨水路	**1.81**	separate	Lake of Golden Mt.






Build a Resilience and Aesthetic Landscape in an Old Ultra Dense Residential Community

There are hundreds of communities within 22 km^2

Cause Study – Second Community of Riverfront Community

This is a high density neighborhood built in 1970s. Most residents are low income retirees. Due to the lack of maintenance, this neighborhood had endured annual flooding, deterioration of aging infrastructure, lack of appropriate sanitary conditions and no parking lot . Young people moved out

Problem 1 - Flooding

Flooding Event in 2015 before the retrofit

Problem 2 – Pavement Damage

For decades there was no maintenance. The pavements in the neighborhood were damaged. Many green spaces were destroyed

Problem 3 – Landscape Sites Became Garbage Dumping Ground

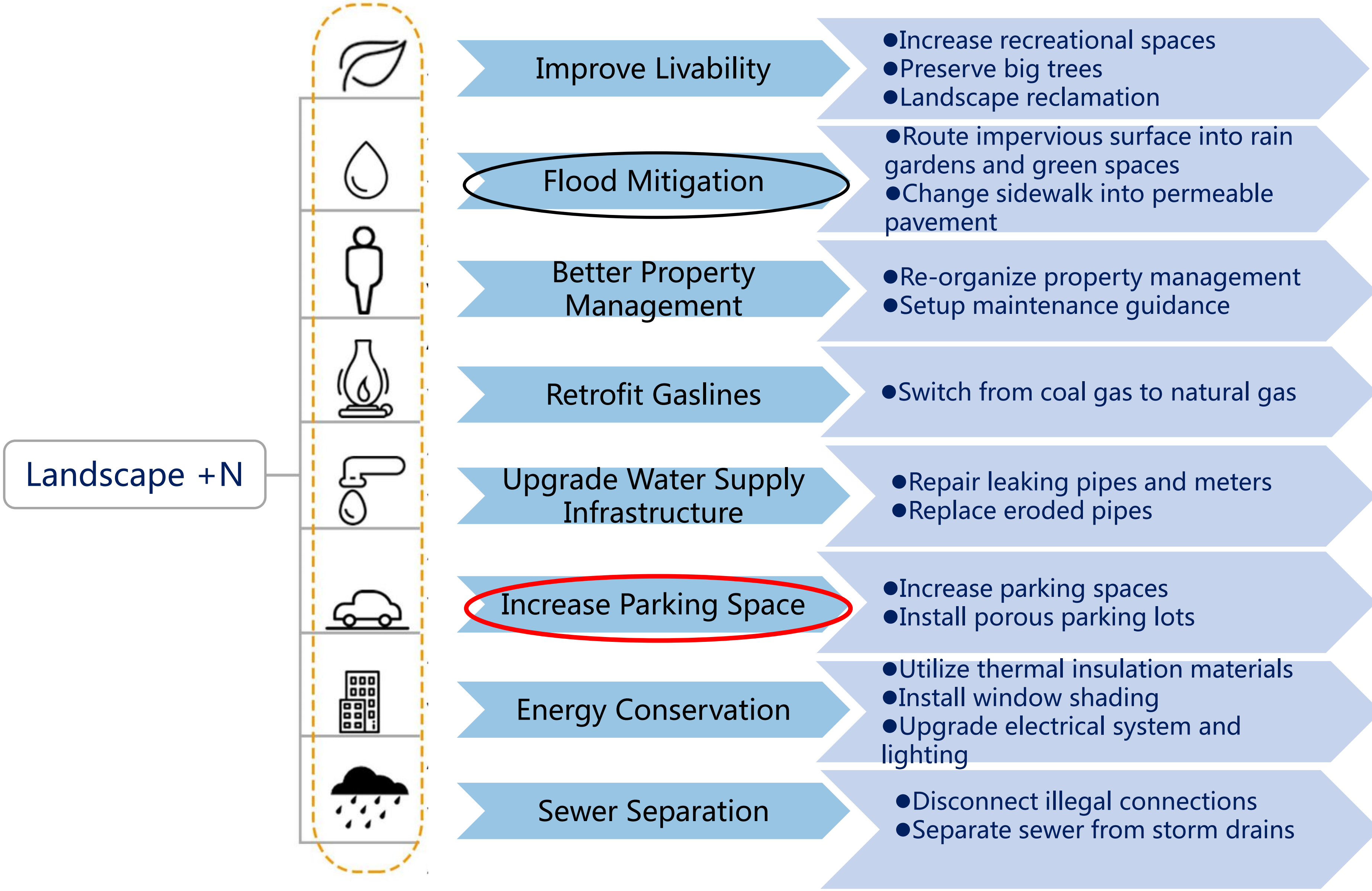
The garbage were dumped into landscape sites

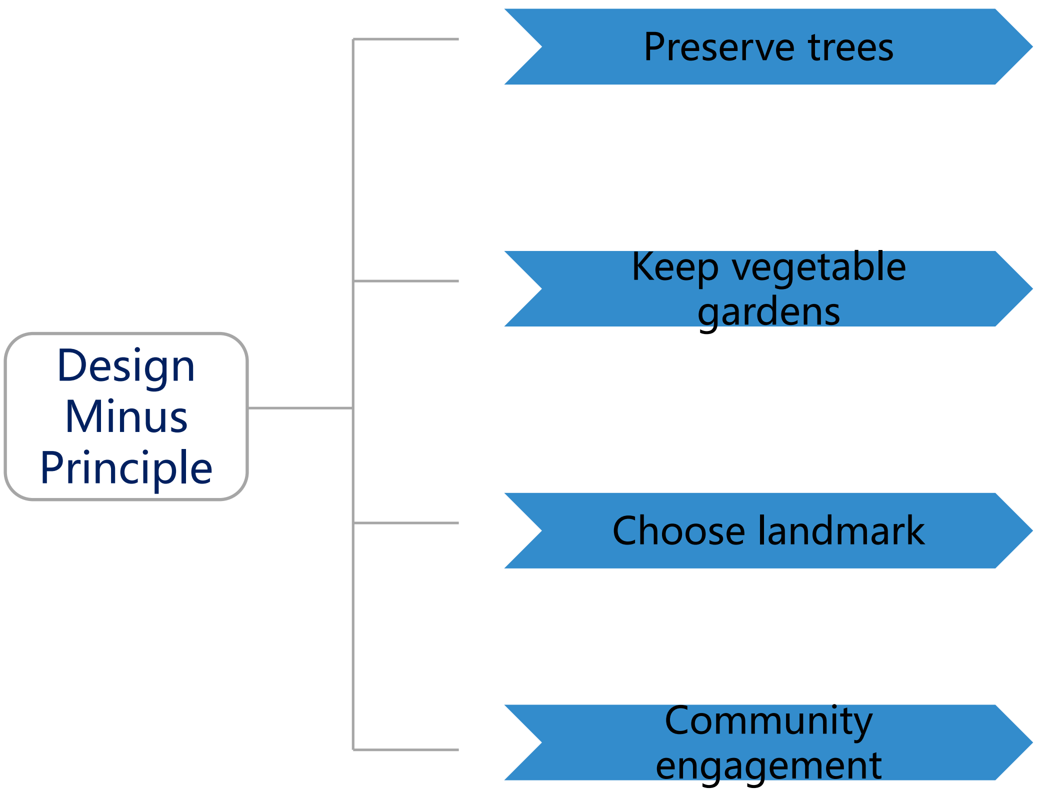
Problem 4 – Lack of Parking Space

Due to lack of parking space some green space became "illegal parking lots"

Problem 5 – Building Surface Deterioration and Lack of Appropriate Infrastructures

Our Approach





Design minus principle is minimizing the landscape intervention because this neighborhood has about 40 years of history. Residents spent most of their life in the neighborhood. Keep their memory is so important in the design work. After the retrofit it is desirable to minimize the maintenance cost, and encourage the residents to maintain their vegetable gardens and fruit trees.

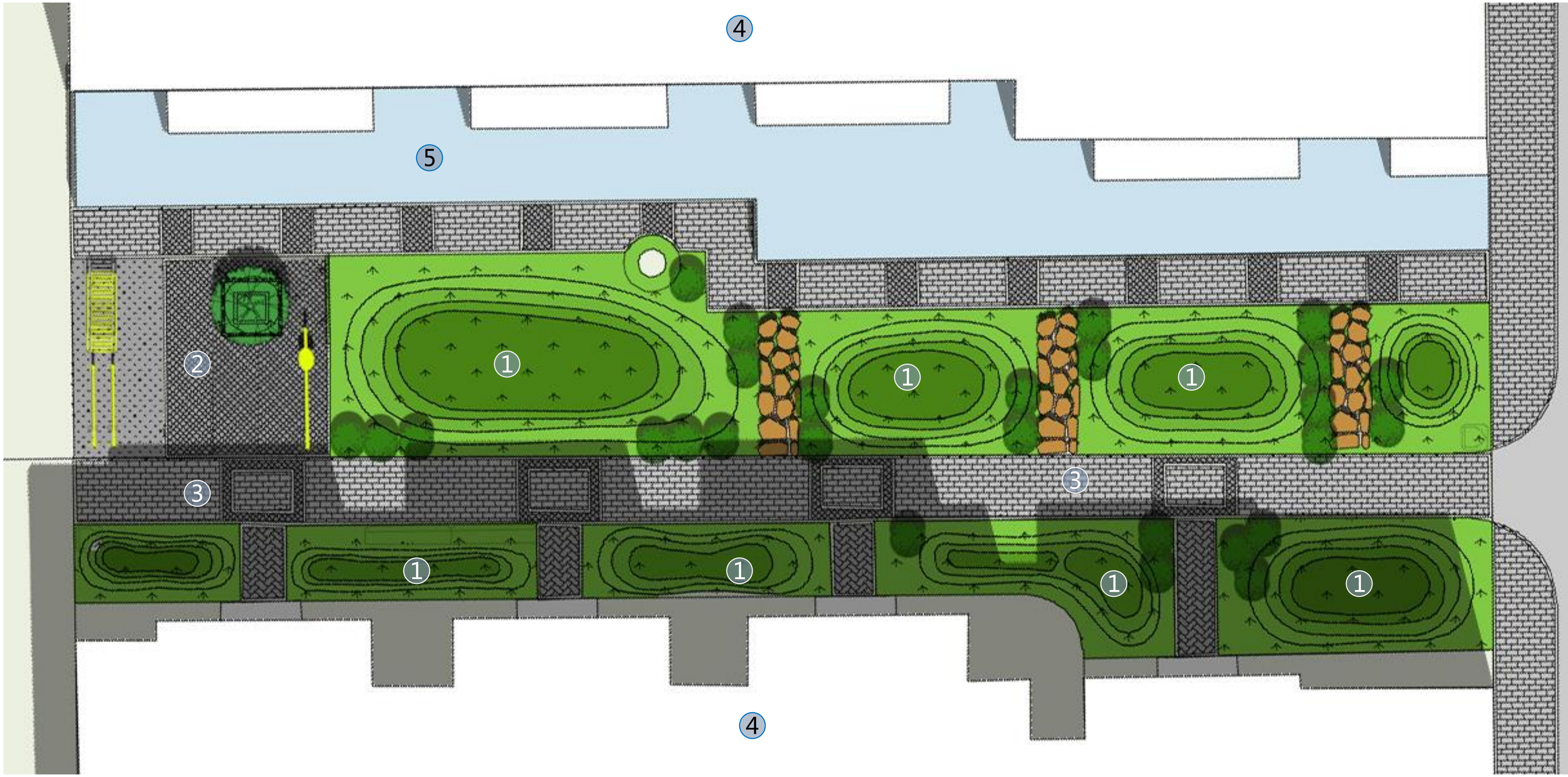
Design Process

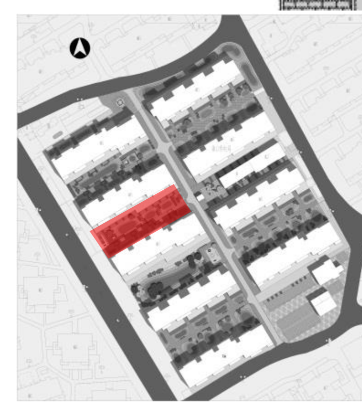
LID design process :

1. Site Investigation
2. Survey drainage network
3. Subcatchment delineation
4. Communication with residents
5. Soil infiltration testing
6. LID layout and modeling
7. Separation
8. Monitoring

Schematic Design: Plan Layout

Section Design





1. Bioretention
2. Recreation space
3. Porous pavement
4. Building
5. Yard

How Green Stormwater Infrastructure Works

Experiments before the construction

Growing Media Test

Plants Selections

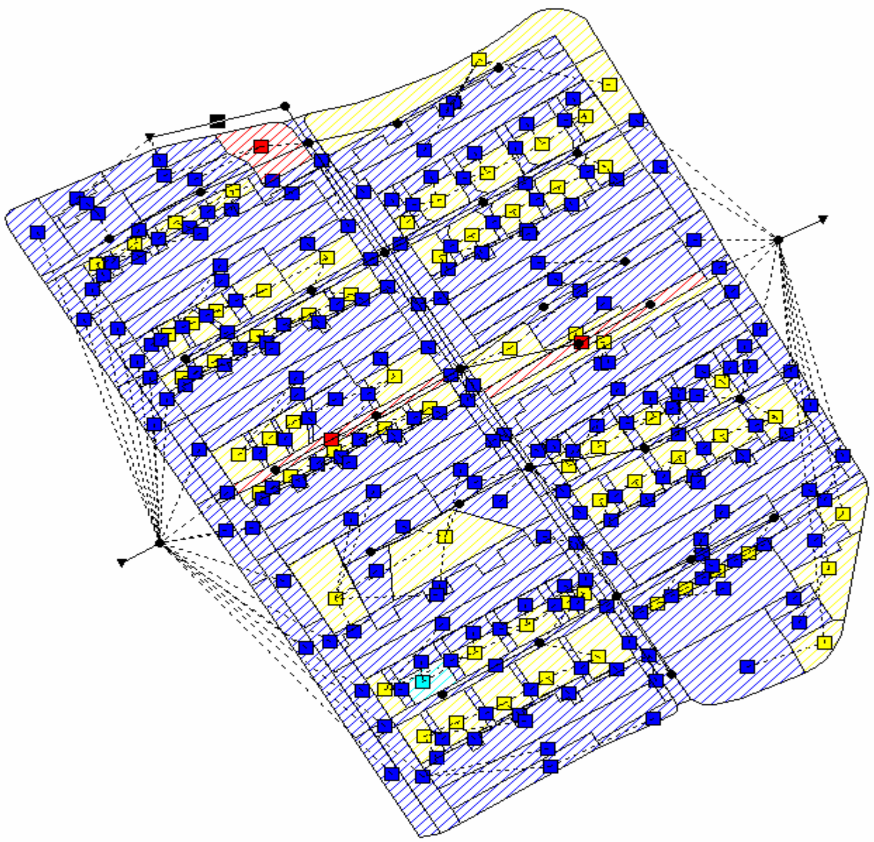
Infiltration Test

Observation of Plant Growth

Site Delineation and Modeling :

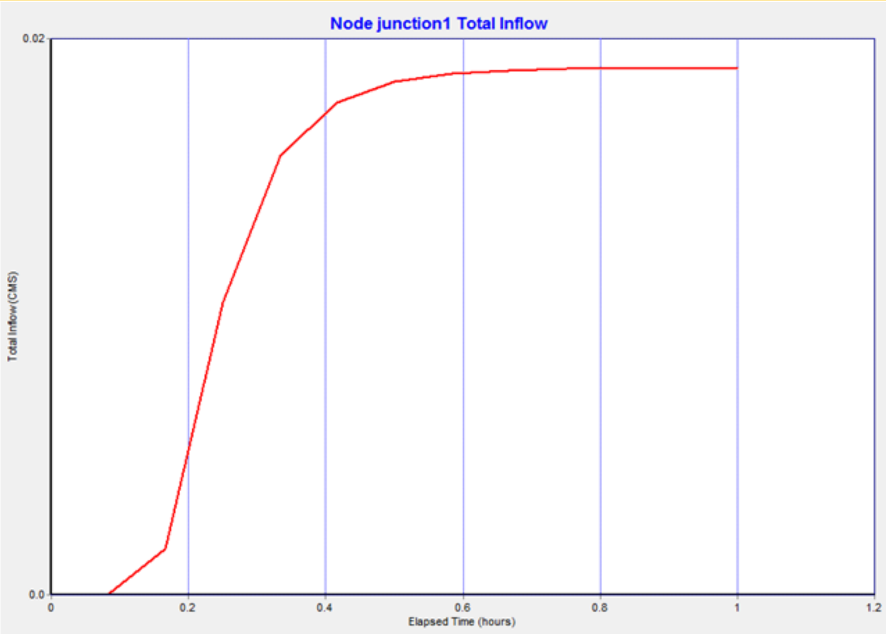
Delineation: Rooftop, Road, Green Space and “Yard”

Model: SWMM

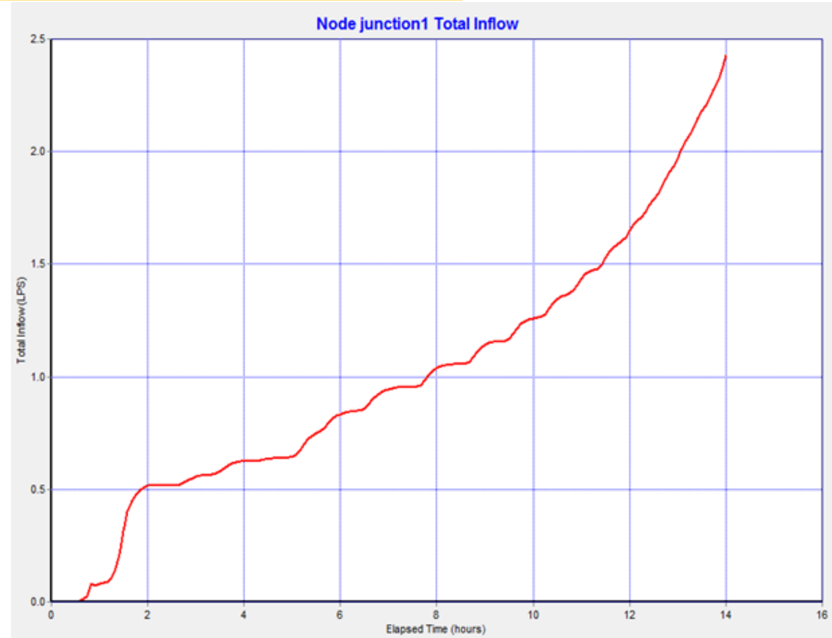


Runoff Quantity Continuity	Volume hectare-m	Depth mm
Initial LID Storage	0.022	11.521
Total Precipitation	0.413	219.979
Evaporation Loss	0.000	0.000
Infiltration Loss	0.052	27.927
Surface Runoff	0.189	100.574
Final Surface Storage	0.193	102.629
Continuity Error (%)	0.160	

30yr-24hr



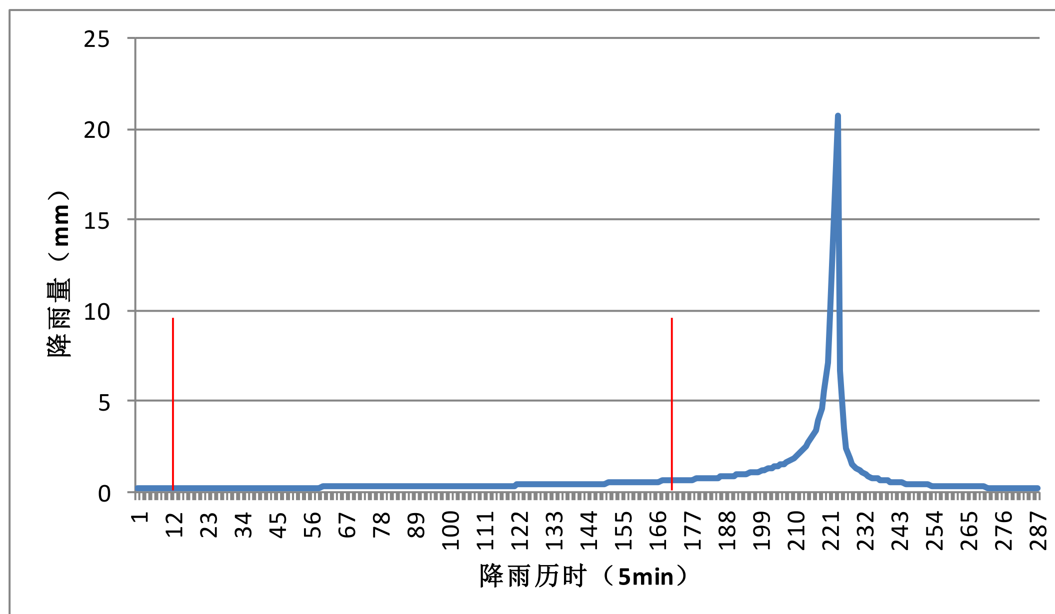
NO-LID（Before）6.2mm rainfall detention

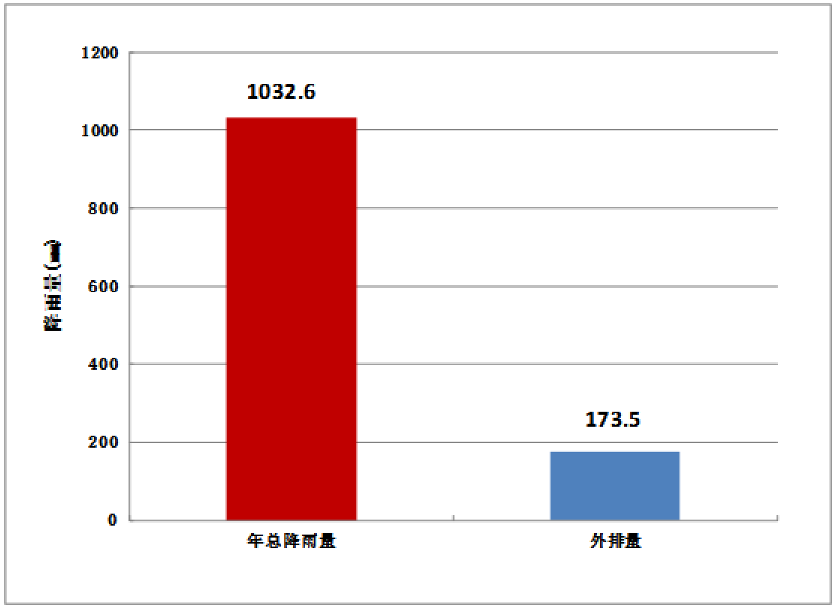


LID（After） 34.6mm rainfall detention

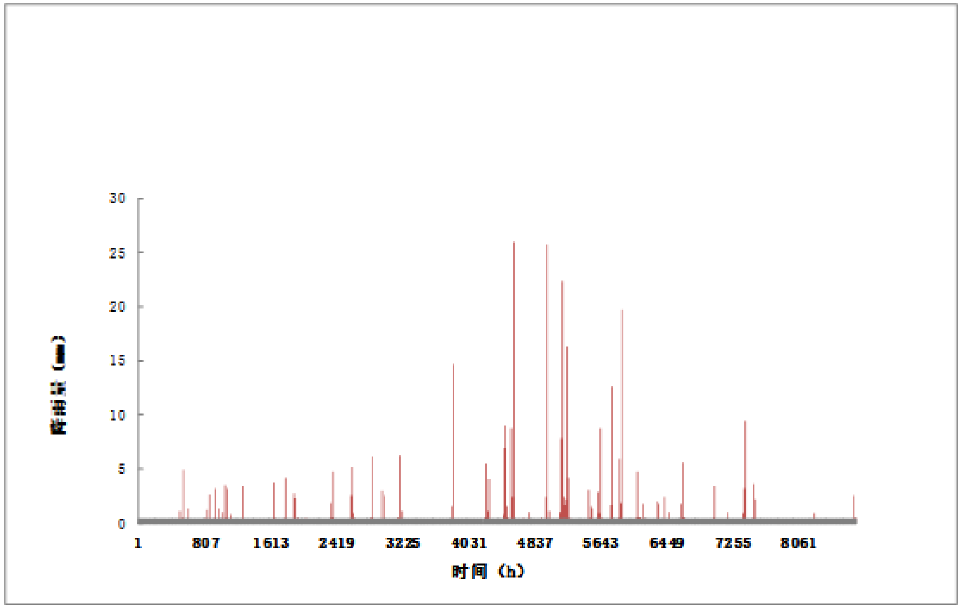
Concluding：

LID can delay 13 hours of discharge at the outfall. (Without LID it is just 1 hour)





Annual rainfall vs discharge



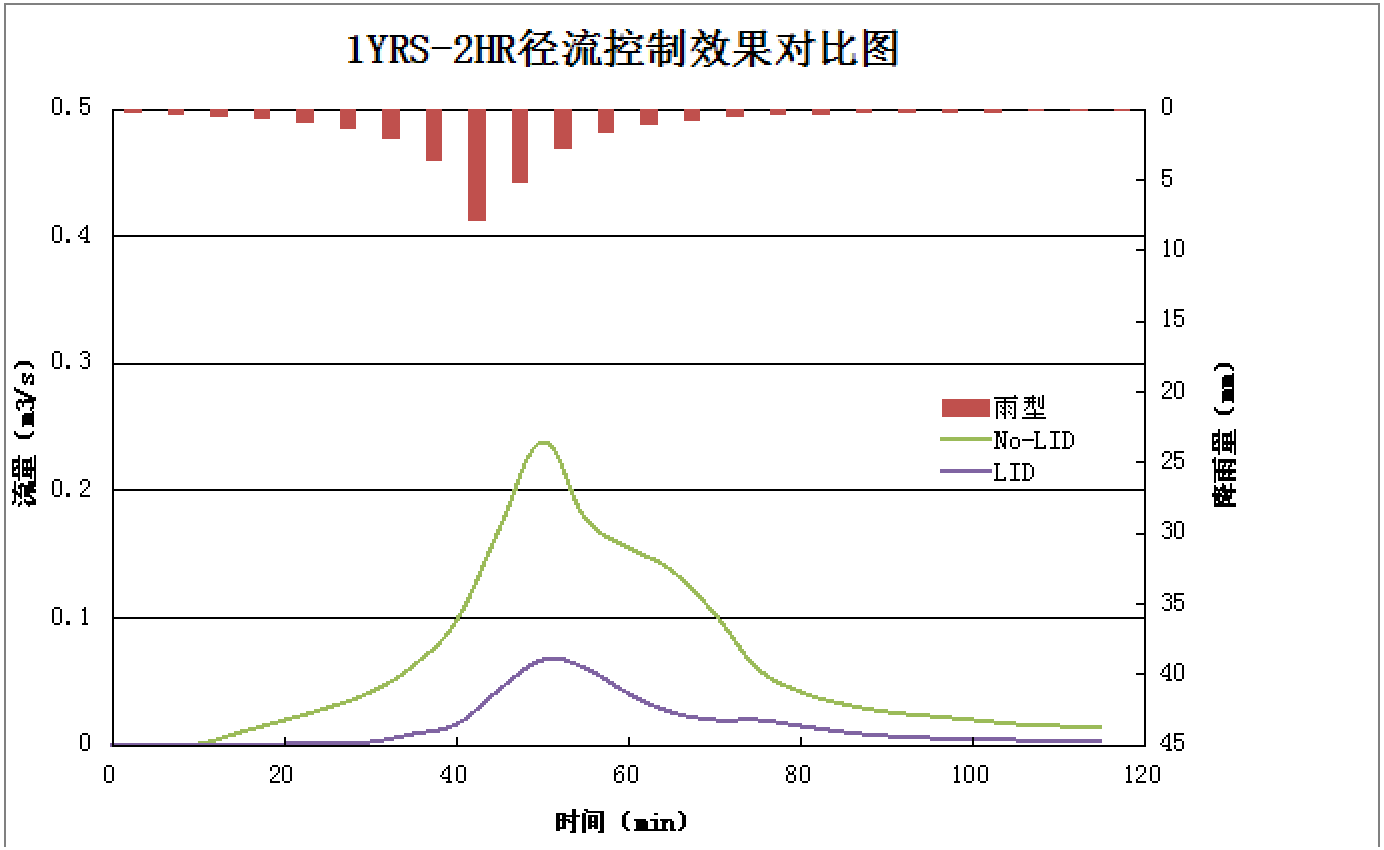
2005 rainfall data（5-min）

Data Analysis：113 events，7 events exceed 34.6mm，6.2%。

Annual rainfall 1032.6mm ，Discharged runoff 173.5mm，16.8%。

注：以上年总降雨量及实测降雨量均参考2005年南京实测数据。

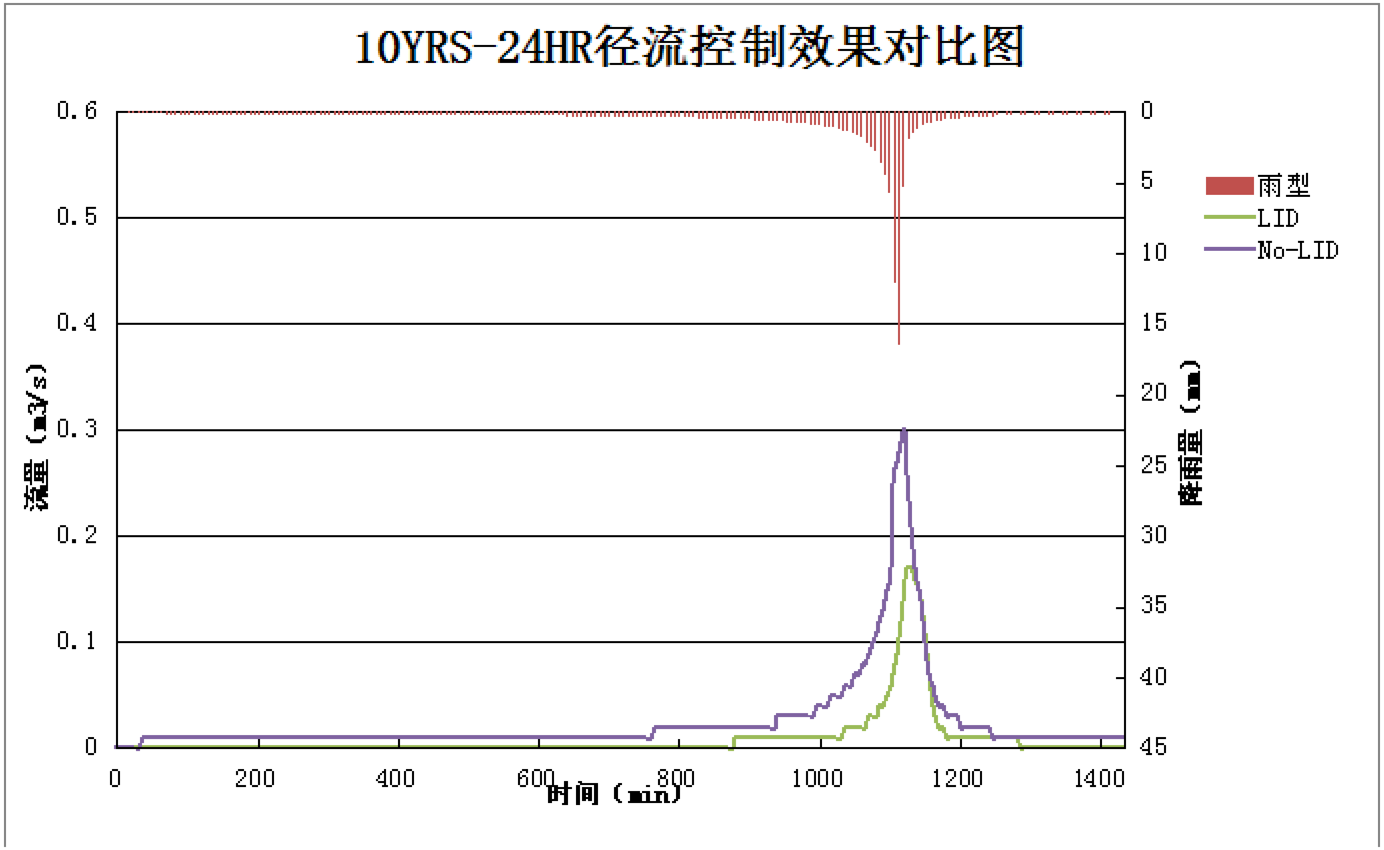
1yr-2h：



	Rainfall（mm）	Peak rainfall（min）	Peak runoff（min）	Runoff Volume（m^3）	Peak runoff（m^3 /s）	Runoff Coefficient
Before	37.5	40	50	598	0.24	0.85
After	37.5	40	50	198	0.07	0.28

72% runoff volume reduction

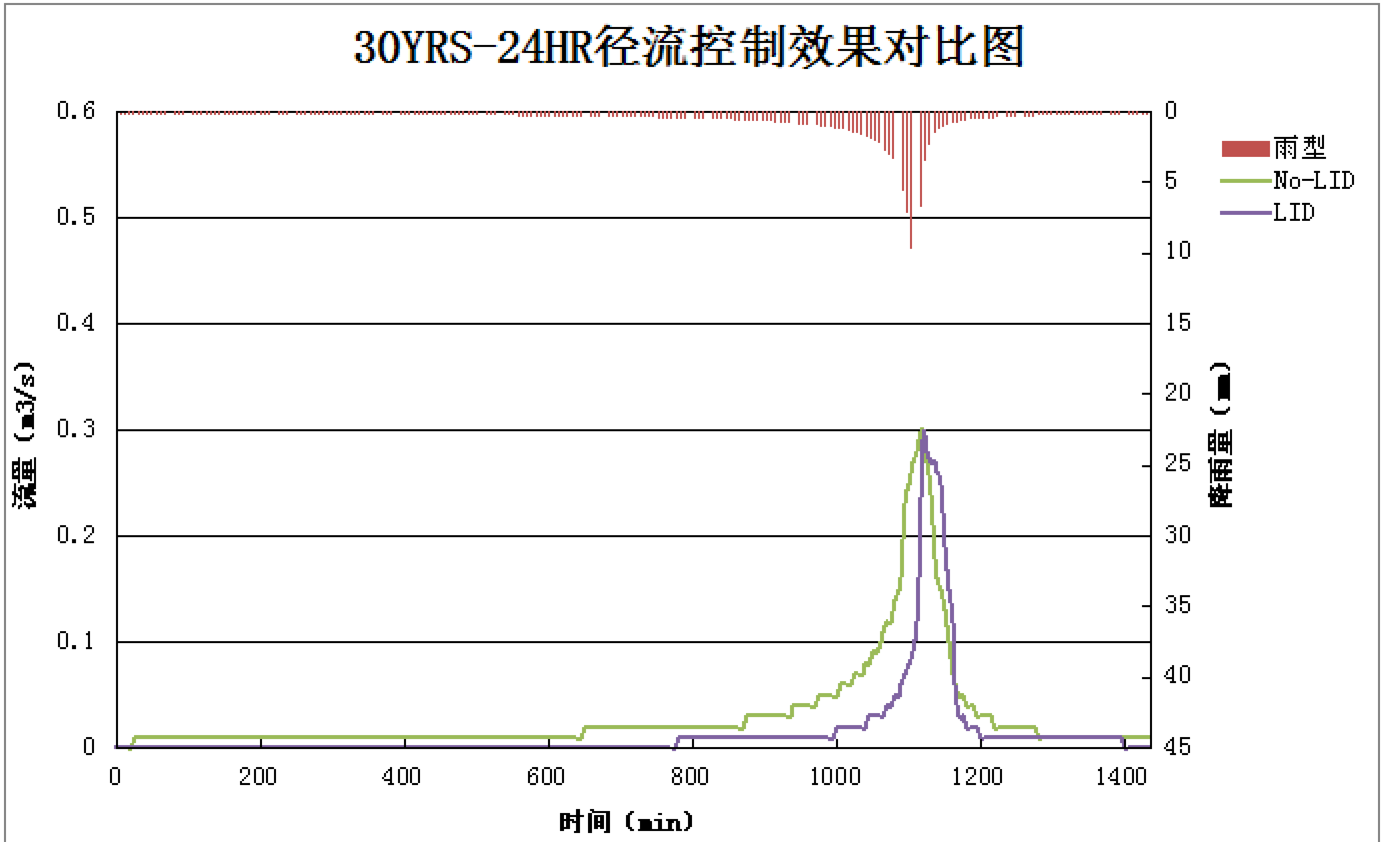
10yr-24h：



	Rainfall（mm）	Rainfall peak（min）	Runoff peak（min）	Runoff Volume（m³）	Runoff peak（m³ /s）	Runoff Coefficient
Before	175. 0	1115	1120	2810	0.30	0.85
After	175. 0	1115	1125	1290	0.17	0.40

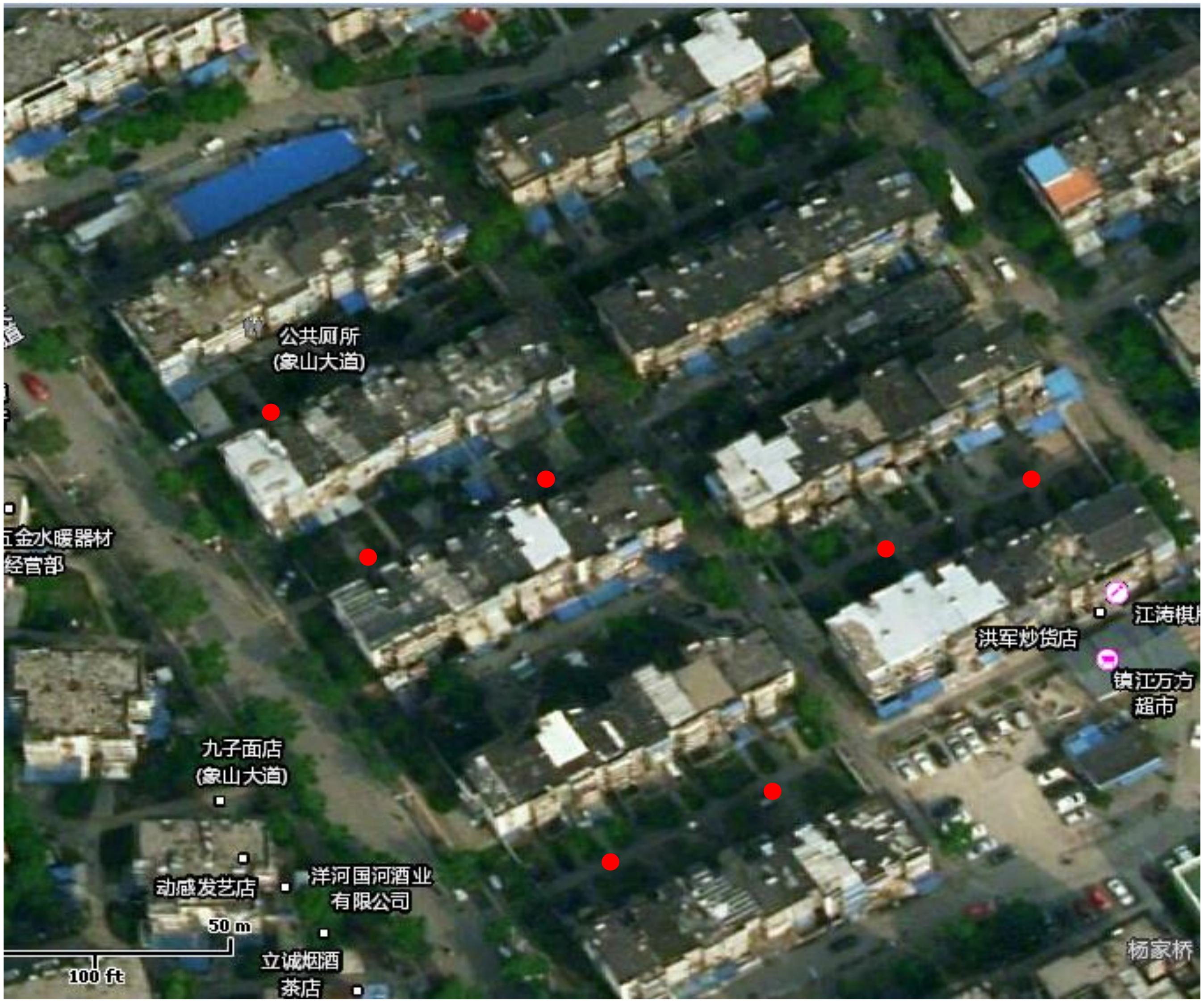
Volume Reduction 54%，Peak Reduction 43%，Peak shifting

30yr-24h：



	Rainfall（mm）	Rainfall peak（min）	Runoff peak（min）	Runoff volume（m^3）	Runoff peak（m^3/s）	Runoff Coefficient
Before	220. 0	1115	1120	3600	0.30	0.87
After	220. 0	1115	1125	1890	0.29	0.46

Runoff volume reduction 47.5%，No significant reduction of peak



There are 24 hot spots before. Flood volume 512m3，14 spots exceed 15cm in depth。

Only 7 hot spots left after. Flood volume 62m3, Only 1 spot exceeds 15cm in depth. Flood time 30min。

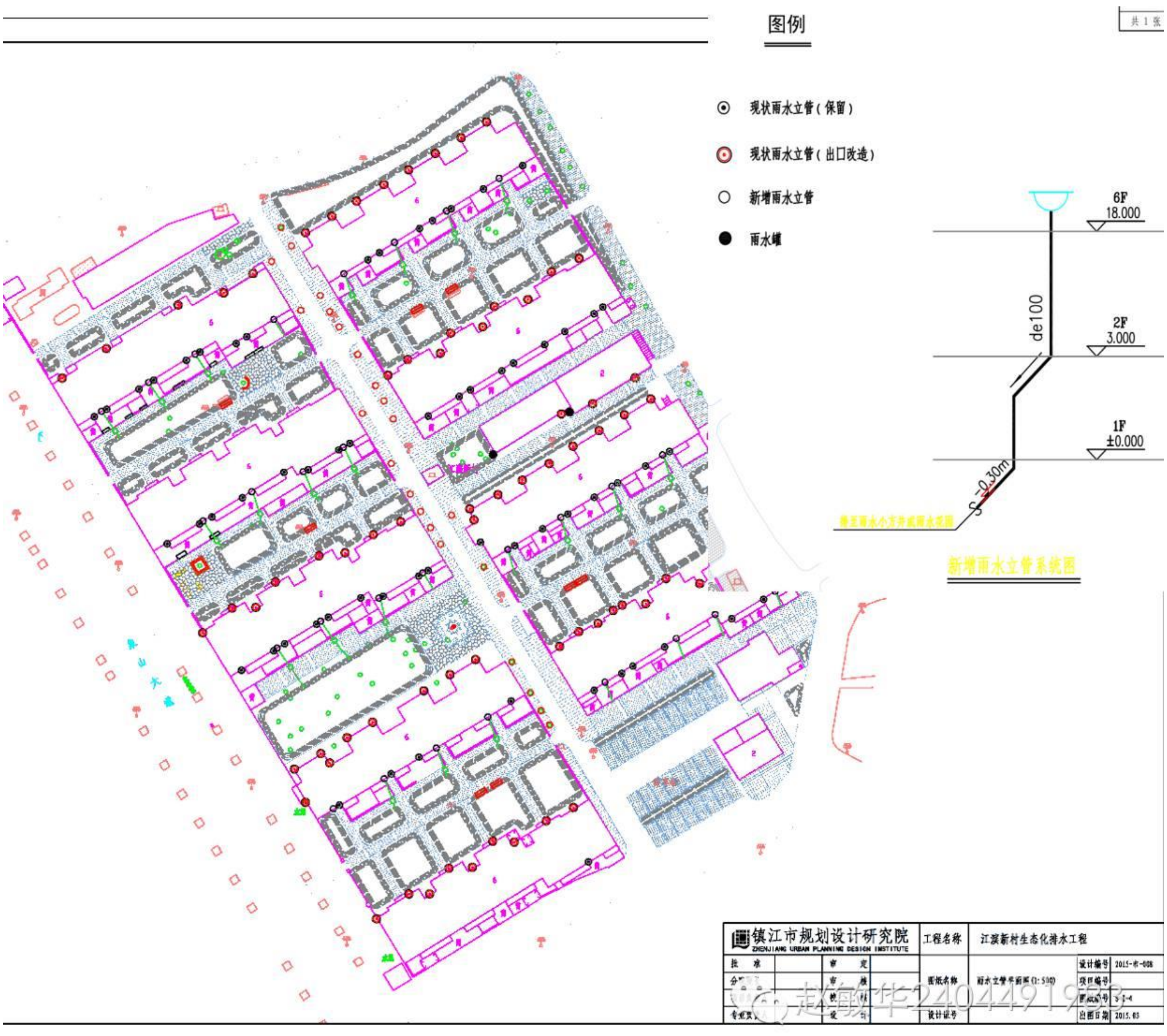
Design Process

Design Discussion

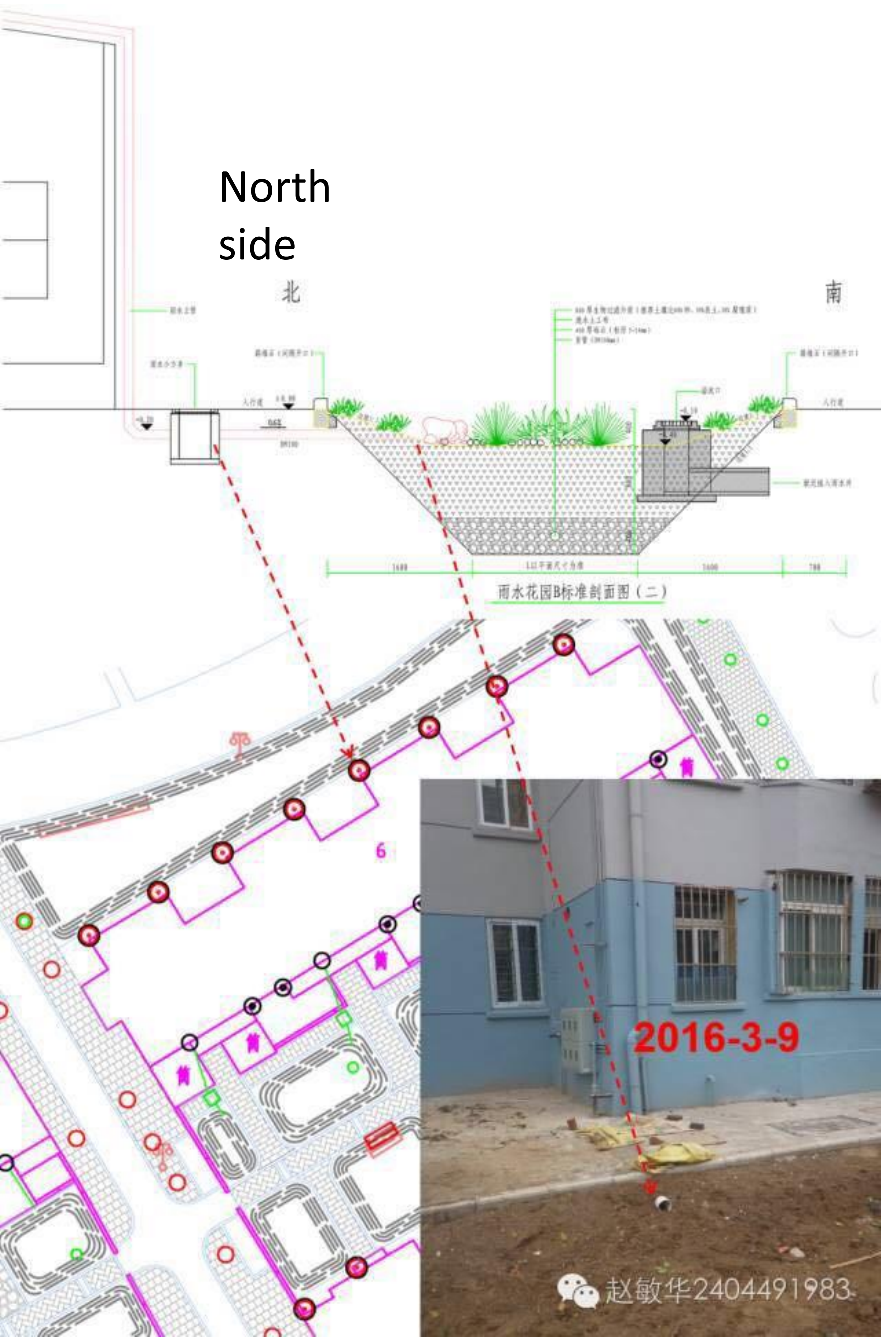
Outreach

Public Comments

Design Process: Disconnection



Engineering Drawings



Northside After Construction

Treatment Train

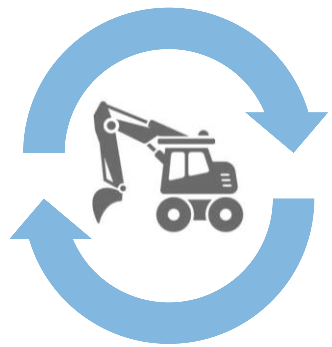
Interlocking Pavement Designed for both Walking and Parking

Construction

Preparation

Escavation

Pipe layout



Gravel

Growth media

Planting

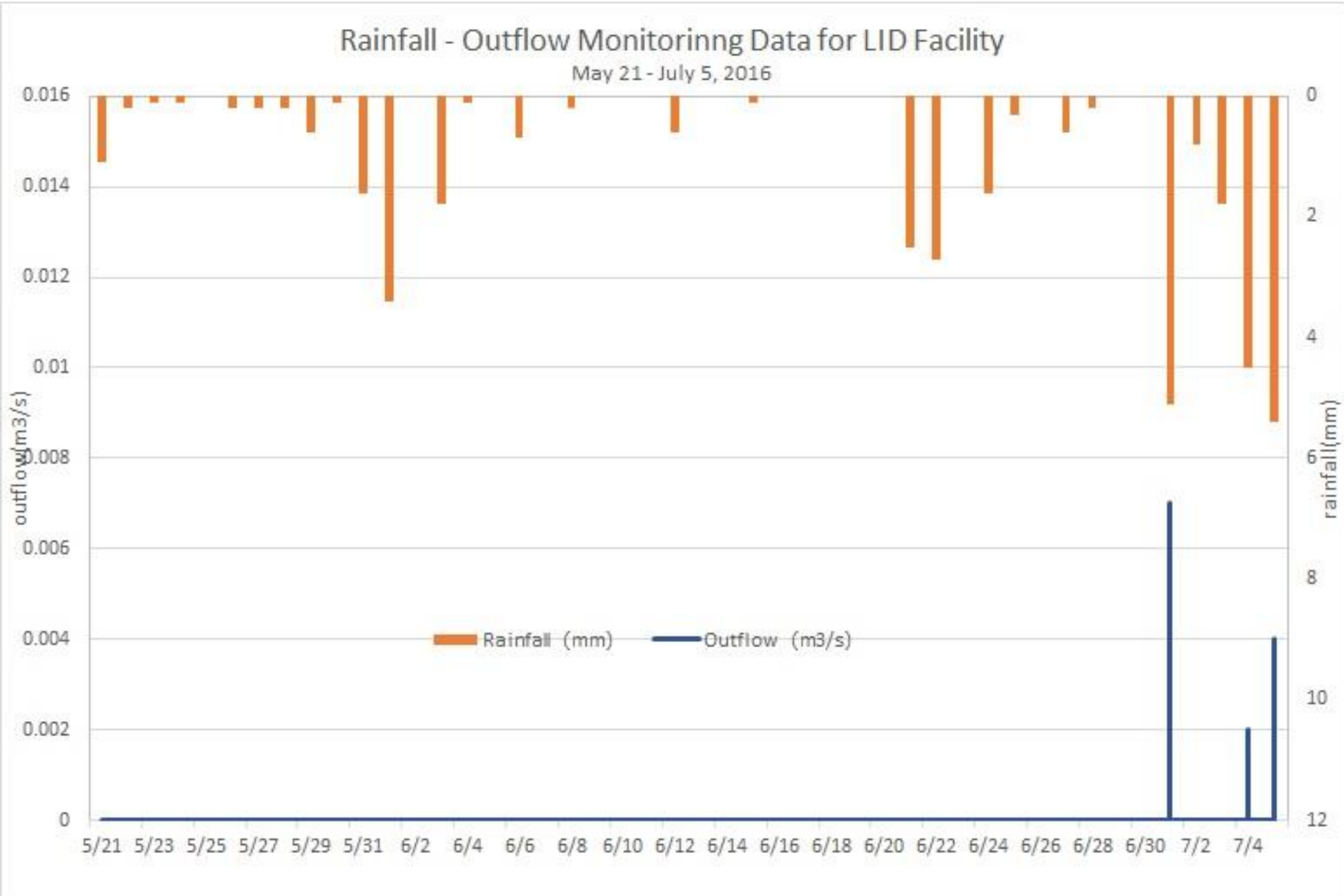
Maintenance

Completion

Post Construction

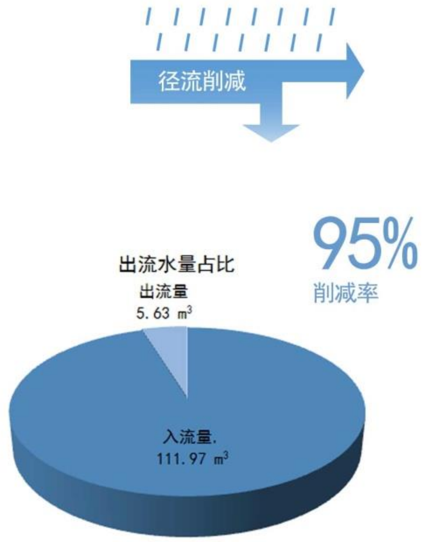
During Heavy Storm

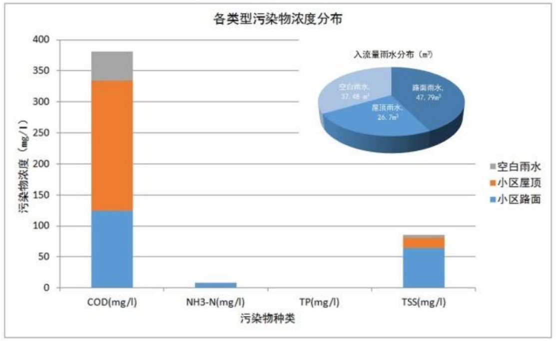
After completion of the project the neighborhood experience two heavy storm events. One is 138 mm rainfall in 2016 and another is 125mm rainfall in 2017.



Rainfall - Outflow Monitorinng Data for LID Facility
May 21 - July 5, 2016
outflow(m3/s)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
rainfall(mm)
0
2
4
6
8
10
12
Rainfall (mm)
Outflow (m3/s)
5/21 5/23 5/25 5/27 5/29 5/31 6/2 6/4 6/6 6/8 6/10 6/12 6/14 6/16 6/18 6/20 6/22 6/24 6/26 6/28 6/30 7/2 7/4

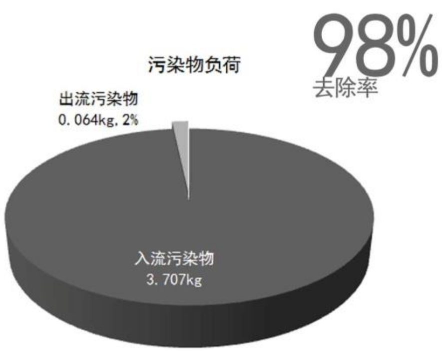
Monitoring Results





下垫面类型	COD (mg/l)	NH_3-N (mg/l)	TP (mg/l)	TSS (mg/l)	入流总水量（m²）
小区路面	125.09	7.57	0.21	64.73	47.79
小区屋顶	209.45	0.26	0.07	16.36	26.7
空白雨水	46.27	0.25	0	4.73	37.48
综合污染浓度	118.82	3.37	0.11	33.11	111.97

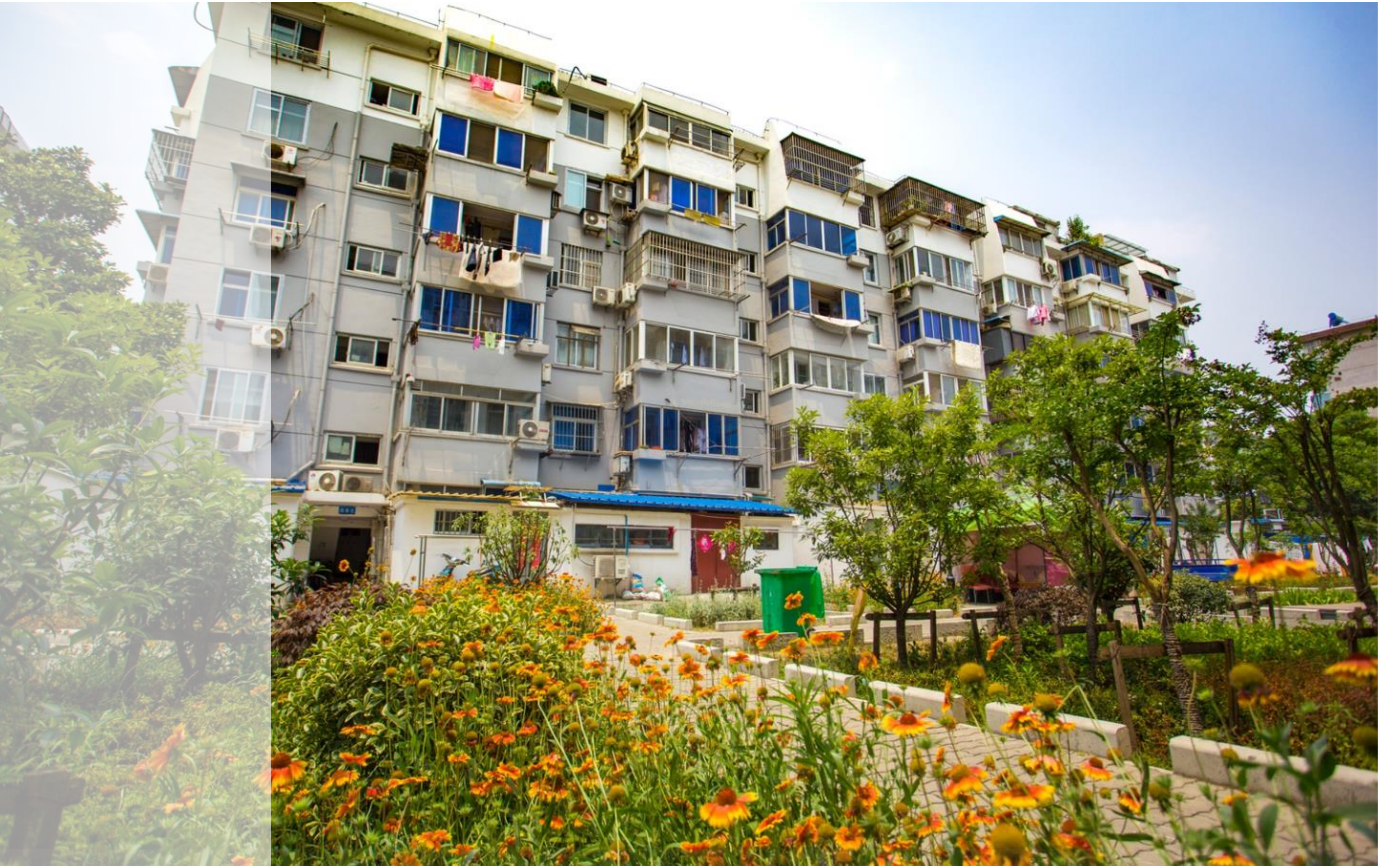
		总污染负荷（kg）	污染去除率（%）
综合污染浓度 (mg/l)	33.11		
总入流量 (m^3)	111.97	3.7073	0.9827
出水水质浓度 (mg/l)	11.36		
总出流量 (m^3)	5.63	0.064	



95% Flow Reduction, and 98% TSS Removal

An Ideal Place for Social Interactions of the Residents

Beautiful Landscape – Reduced Symptoms of Depression and Anxiety

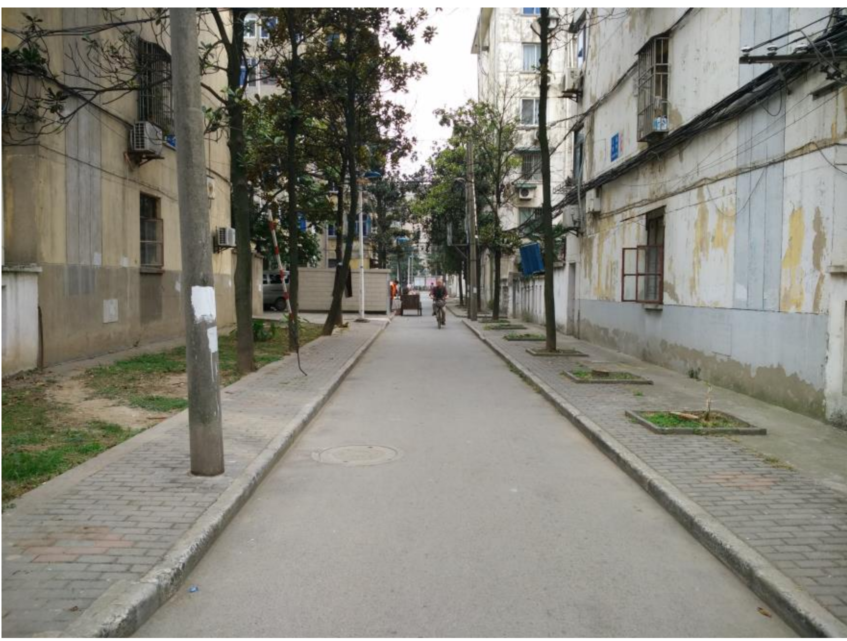


Rain Garden + Porous Access = Improved Personal Safety

Happiness – Yong People bring their Children back

Increase Parking Space

Before the retrofit



After the retrofit

采样日期	取样点	CODCr（mg/L）	BOD（mg/L）	SS（mg/L）	NH3-N（mg/L）	**TN（mg/L）**	TP（mg/L）	pH	色度	浊度（NTU）
2015.5.27（雨后）	江二停车场植草沟（南）	13.6	——	——	0.213	**10.6**	0.128	——	——	1.839
	江二停车场植草沟（北）	13.1	——	——	0.036	**5.98**	0.173	——	——	3.220
2015.6.2（雨后）	江二停车场植草沟（南）	6.3	1.2	——	0.325	**3.32**	0.055	——	——	12.2
	江二停车场植草沟（北）	23.5	0.6	——	0.182	**8.33**	0.065	——	——	6.31

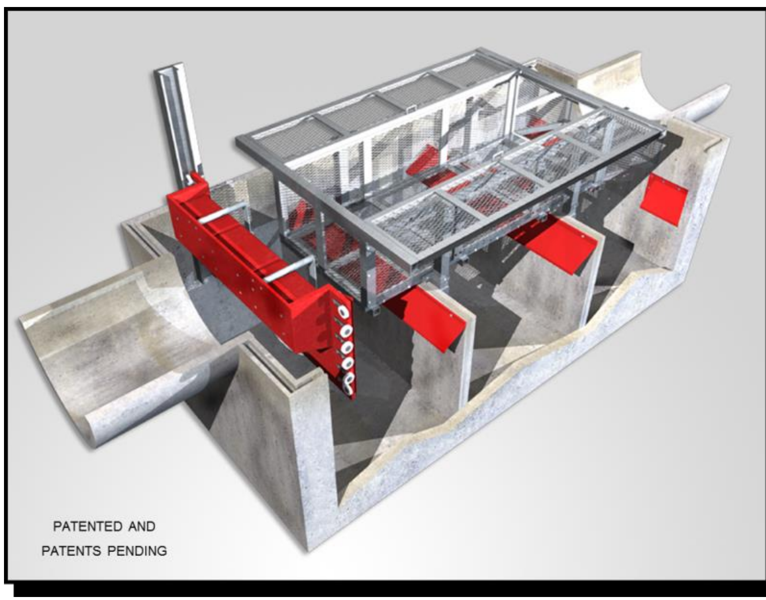
Not very pretty,
but it works

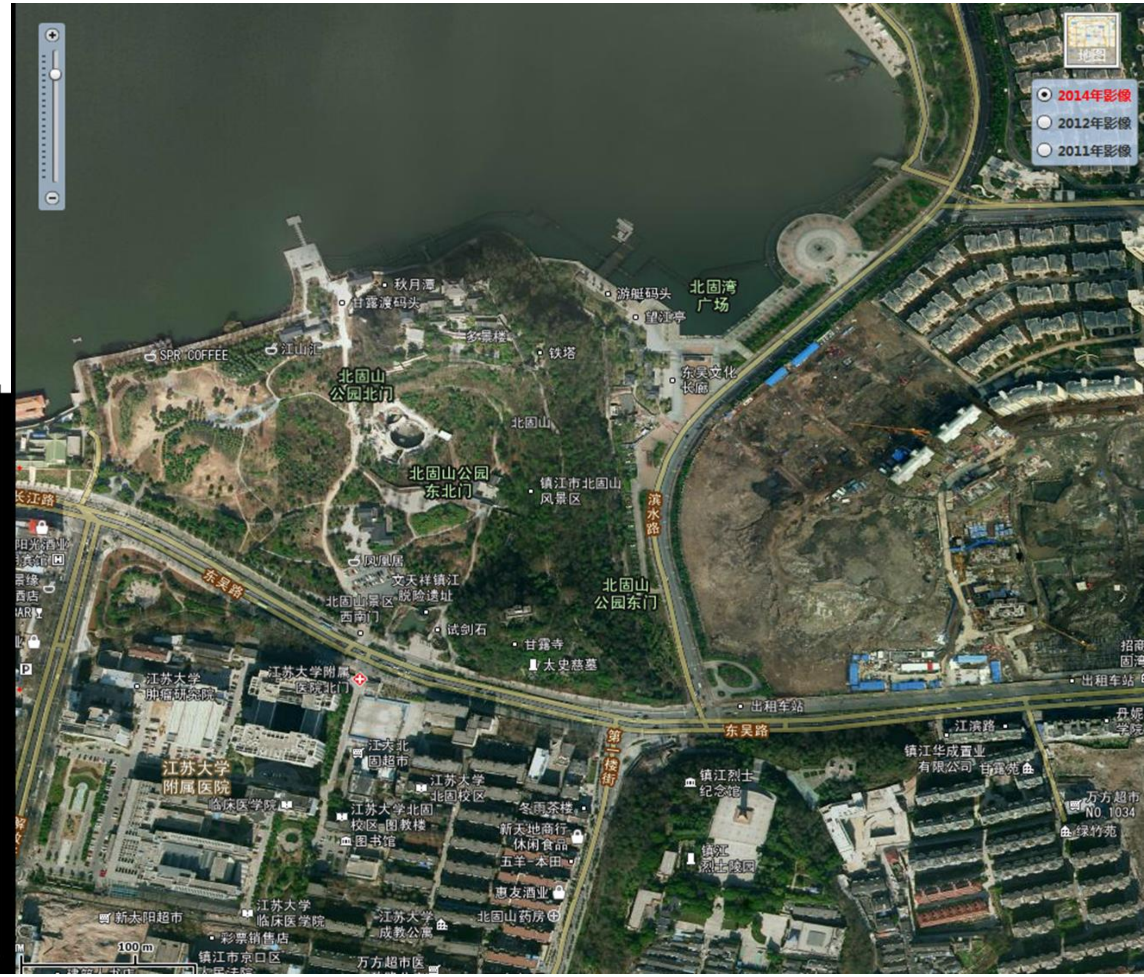
Two Years Later (7/21/2017)

Too dense to retrofit

Green Valley

- Inline Treatment





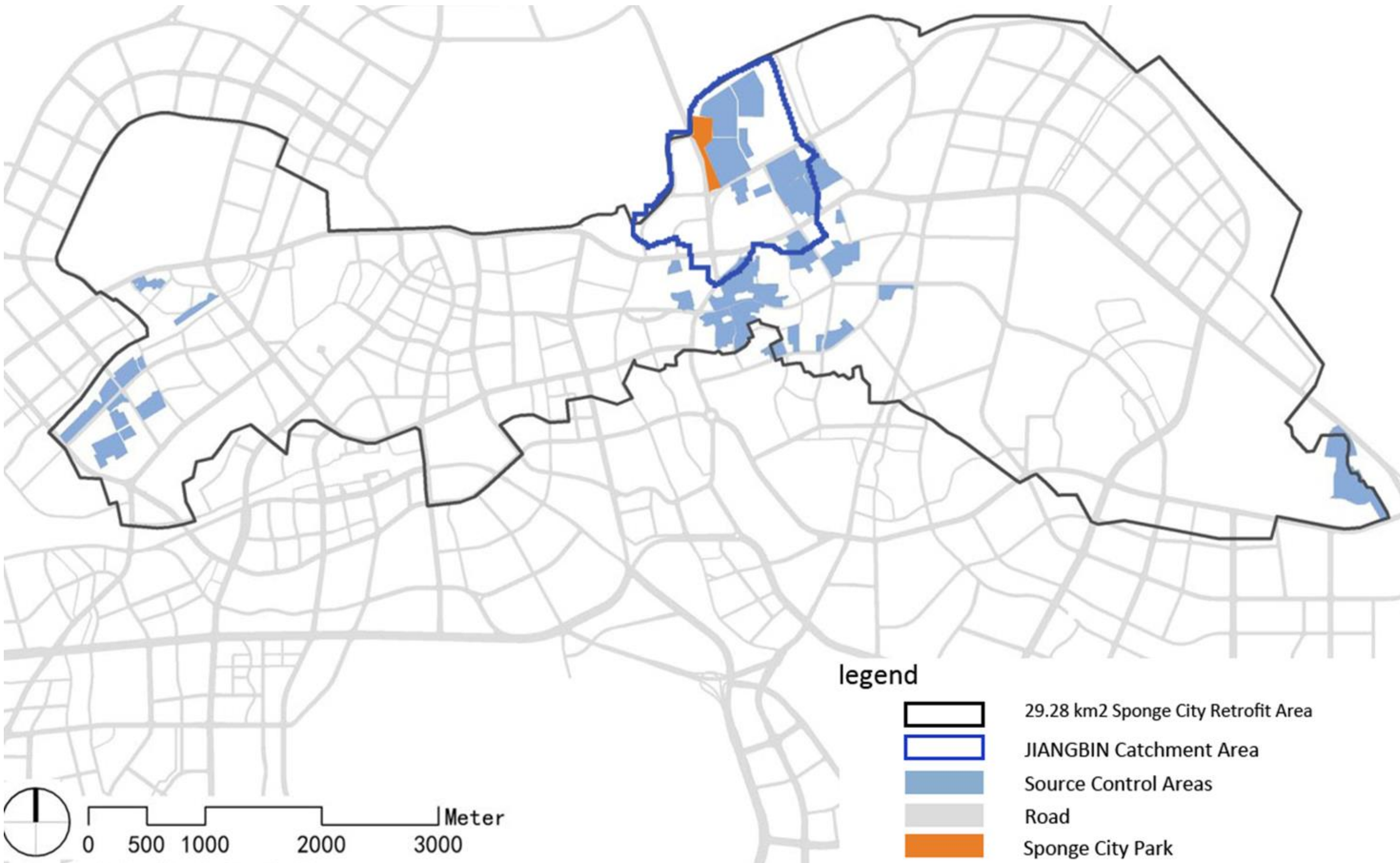
Removal Efficiency

NSBB Model #	Inside Width (feet)	Inside Length (feet)	Baffle Height (1) (inches)	Standard Height (2) (feet)	Sedimentation Area (feet^2)	Recommended Pipe Sizes (inches)	Treatment Flowrate NJDEP PSD 63 micron (3) (cfs)	Treatment Flowrate 100 micron PSD (4) (cfs)	Maximum Treatment Flow Rate (5) (cfs)	Peak Flow Rate (6) (CFS)	Weight of Concrete Vault (lbs)	Weight of Fiberglass Vault (lbs)
2-4-60	2	4	24	5	8	4 - 12	0.44	0.58	1.3	2	8,100	550
3-6-72	3	6	36	6	18	8 - 18	1	1.3	3	5	12,500	875
3-8-72	3	8	36	6	24	8 - 18	1.33	1.73	3.5	6	15,300	980
4-8-84	4	8	36	7	32	12 - 24	1.8	2.31	8	12	22,800	1,250
5-10-84	5	10	36	7	50	12 - 30	2.8	3.61	15	30	31,400	N/A
6-12-84	6	12	36	7	72	18 - 36	4	5.2	24	46	38,100	N/A
6-15-100	6	15	42	8.33	90	18 - 36	5	6.5	24	46	59,800	N/A
7-14-100	7	14	40	8.33	98	24 - 42	5.44	7.07	26	50	59,700	N/A
8-12-84	8	12	36	7	96	24 - 48	5.3	6.93	26	50	68,600	N/A
8-14-100	8	14	40	8.33	112	24 - 54	6.2	8.09	32	60	76,700	N/A
8-16-100	8	16	44	8.33	128	24 - 54	7.1	9.24	40	75	105,400	N/A
9-18-100	9	18	46	8.33	162	30 - 54	9	11.7	40	75	140,200	N/A
10-14-100	10	14	40	8.33	140	36 - 60	7.8	10.1	45	82	103,100	N/A
10-16-125	10	16	46	10.42	160	36 - 60	8.9	11.5	50	90	132,200	N/A
10-20-125	10	20	48	10.42	200	36 - 60	11.1	14.44	55	95	149,800	N/A
12-20-132	12	20	48	11	240	48 - 72	13.3	17.33	66	125	182,400	N/A
12-24-132	12	24	60	11	288	48 - 72	16	20.8	72	135	209,700	N/A

2 CMS

Flow rates based on 67% removal efficiency of NJCAT verified testing for NJDEP particle size distribution with an average of 63 microns.
Fow rates based on 80% removal efficiency of NJCAT verified testing for 100 micron particles.

Sponge City Park for CSO Treatment



PLAN

图例

LEGEND :

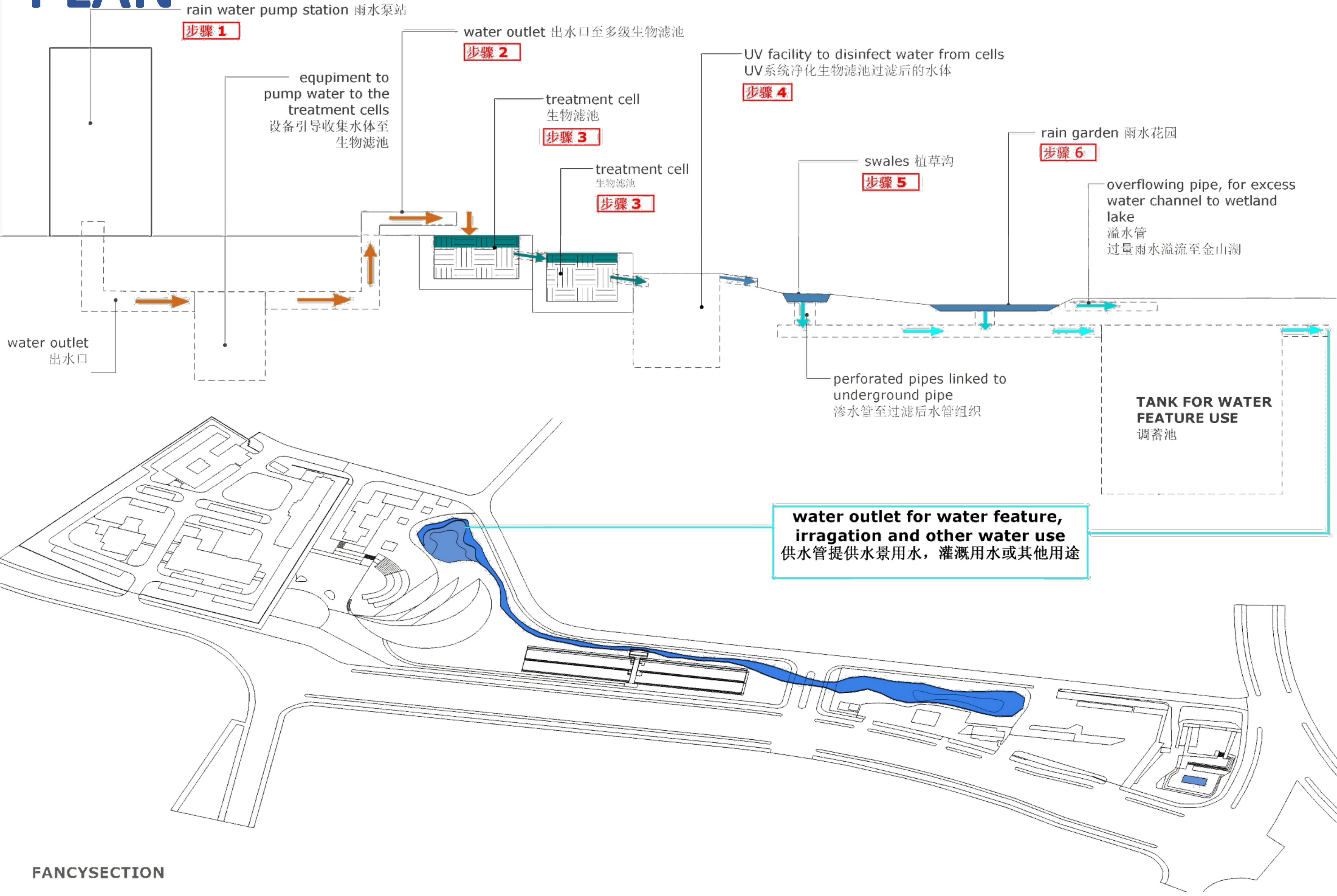
1. 抵达处和开敞广场
   Arrival and Open Plaza
2. 展示中心
   Exhibition Center
3. 休闲区
   Recreation Area
4. 下沉草坪
   Sunken Lawn
5. 湿地与溪流
   Wet Land and Stream
6. 多级生物滤池
   Regional Storm Water Treatment Facilities Building
7. 栈道
   Boardwalk
8. 次入口
   Secondary Entrance
9. 车行通道
   Vehicular Access
10. 雨水庭院
    Rain Garden
11. 屋顶花园
    Roof Garden
12. 空中廊道
    Future Staff Parking
13. 公园
    Public Park
14. 泵站主入口
    Main Entrance Pump Station
15. 次入口
    Secondary Entrance
16. 泵站
    Pump Station
17. 垃圾站
    Rubbish Bin Collection Building
18. 巴士转换站
    Bus Interchange
19. 庭院
    Courtyard
20. 户外健身区
    Outdoor fitness
21. 太极广场
    TI-CHI Plaza

0 10 30 60 100m
SCALE 1:1000

Sponge park renderings

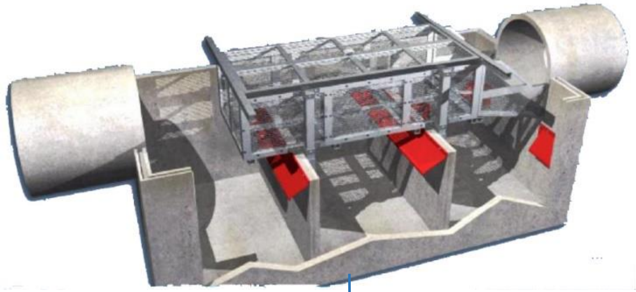
Achievements

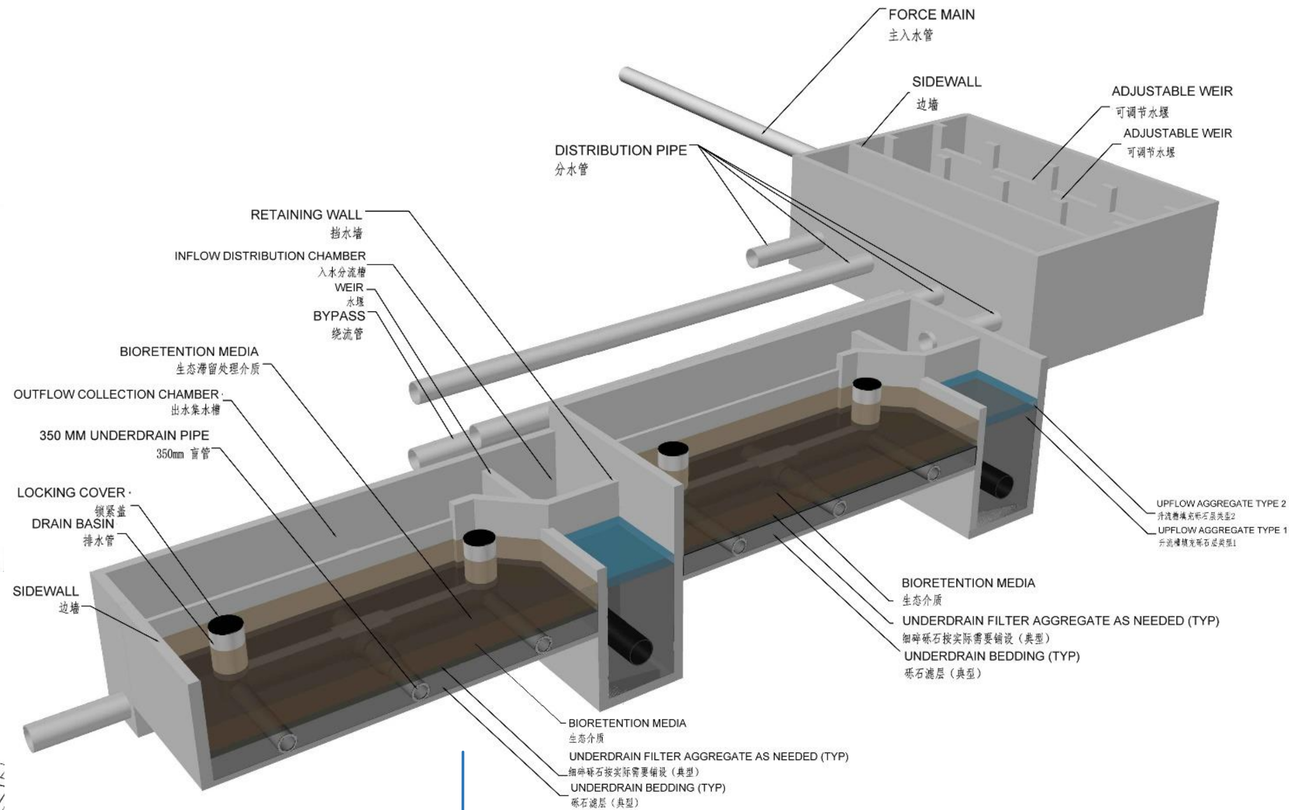
PLAN



FANCYSECTION

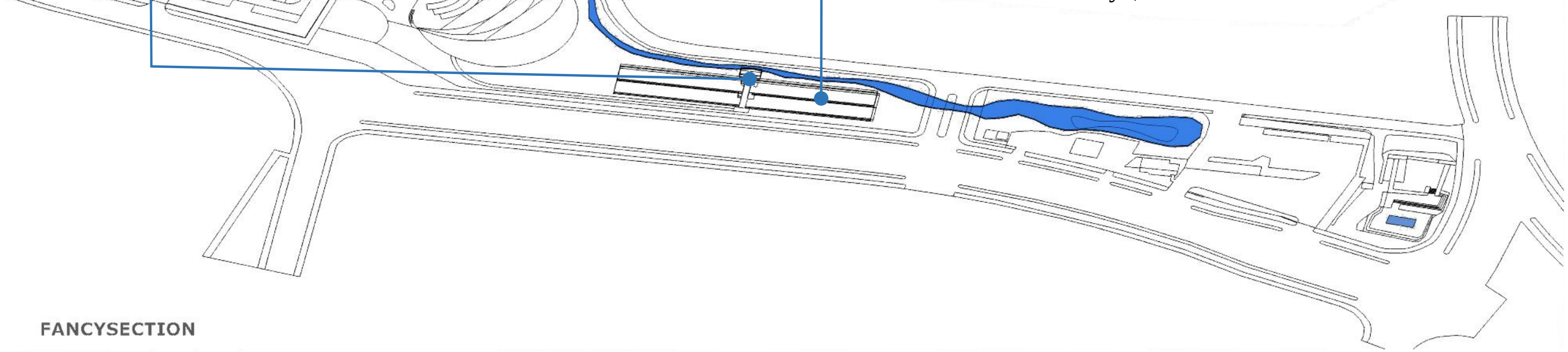
PLAN





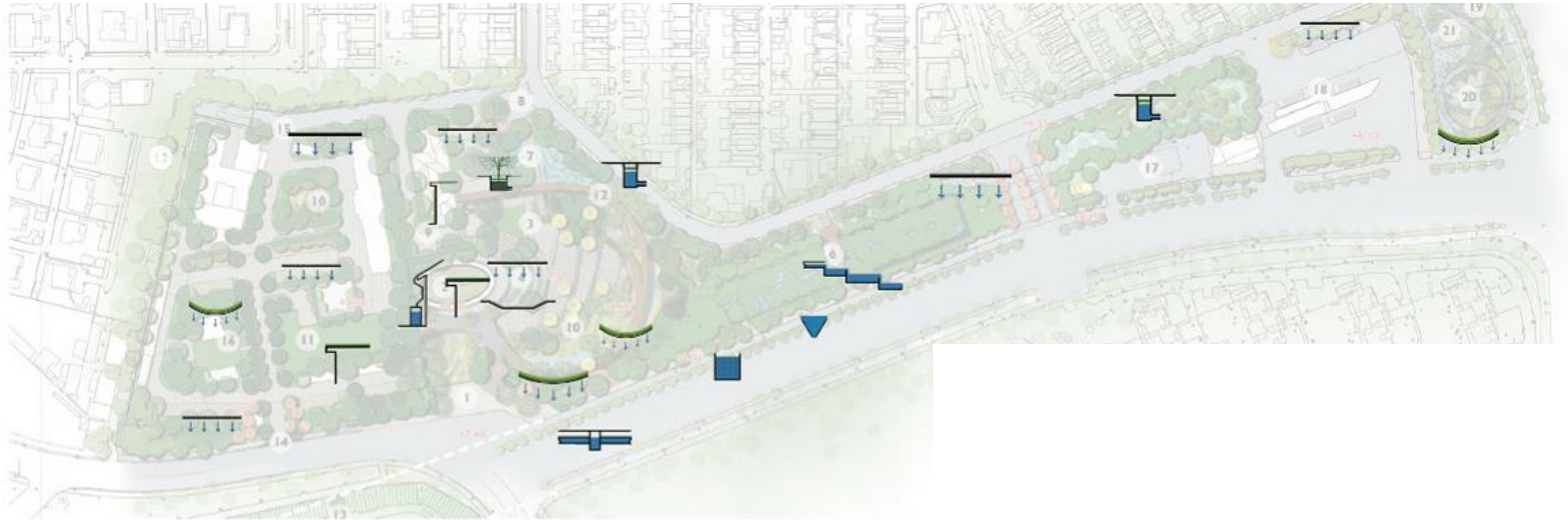
WTS:2400m^2，Capacity:25,000m^3/d，

TSS removal:119.9t/yr，97% removal rate



FANCYSECTION

PLAN

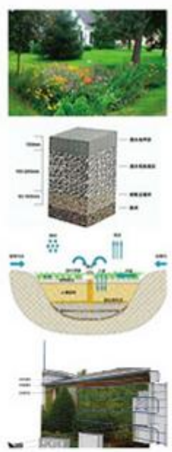


Rain garden

Permeable pavement

Concave square

Vertical greening



Roof greening

Rainwater tank

Storage tank

Ecological planter

Basket filter

Regional green infrastructure

In-line treatment

Infiltration trench

Permeable pavement

swale

EFFECT DISPLAY

EFFECT DISPLAY

EFFECT DISPLAY

EFFECT DISPLAY

EFFECT DISPLAY

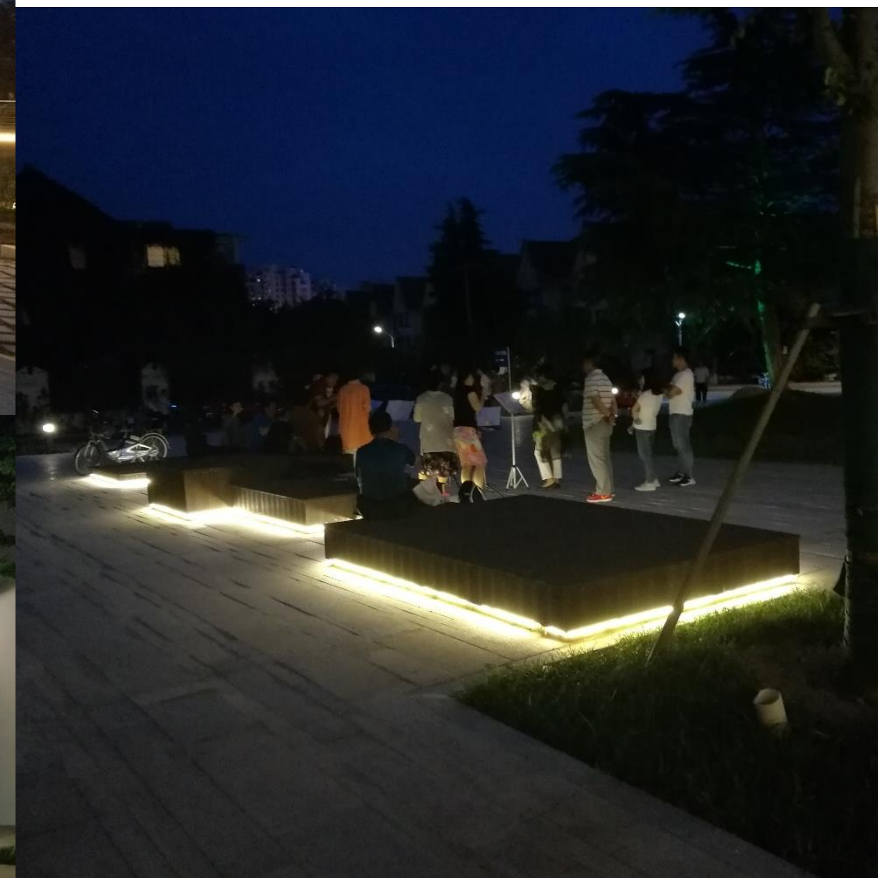
EFFECT DISPLAY

EFFECT DISPLAY

EFFECT DISPLAY

EFFECT DISPLAY

EFFECT DISPLAY



Welcome to Sponge City Park

Resilient (Sponge) Campus
Shenzhen University

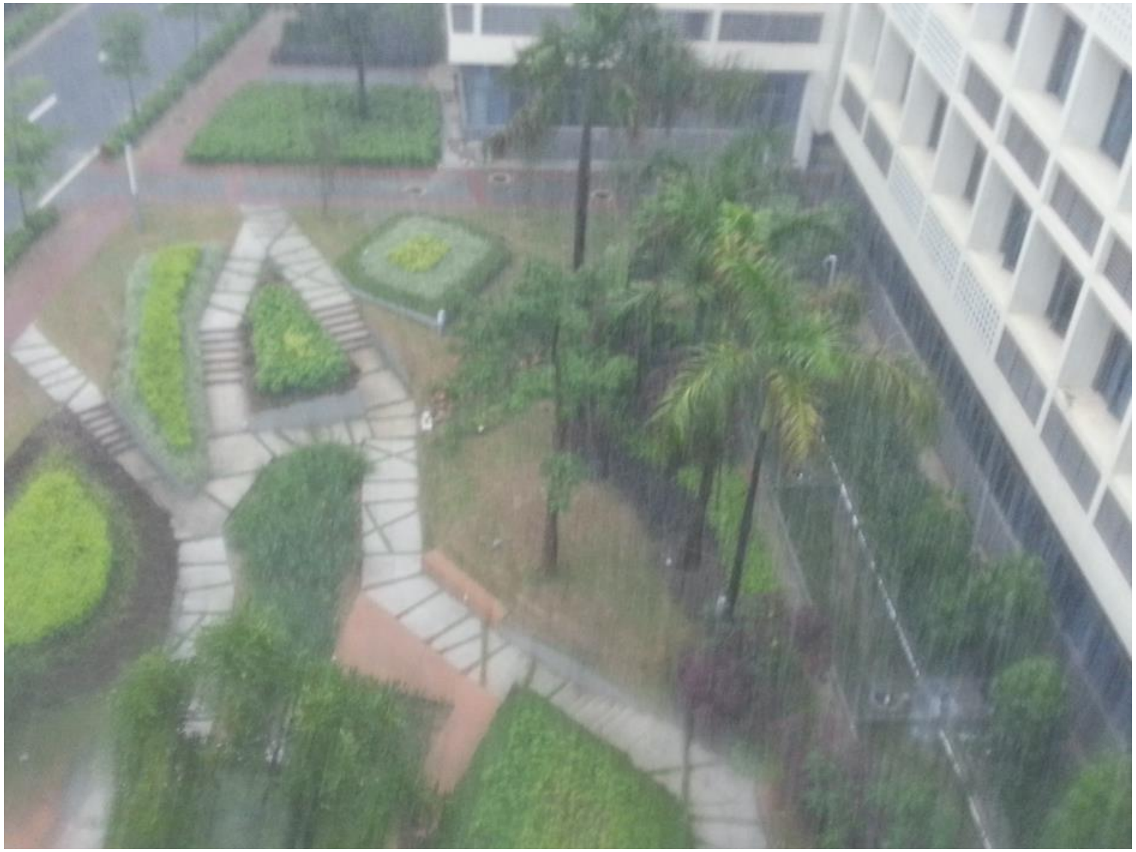
Extreme Storm Event

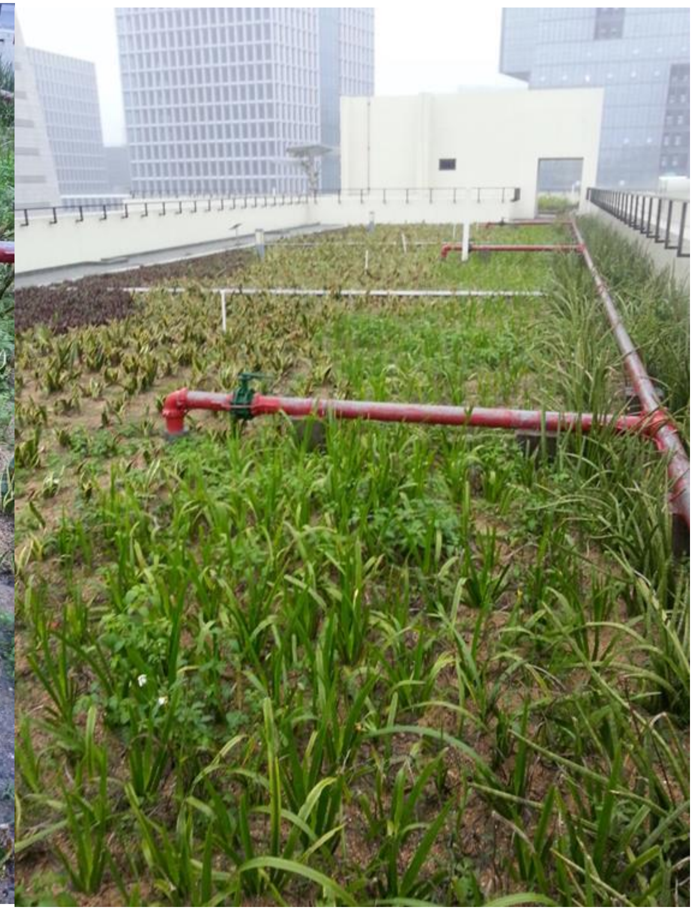
- On May 11, 2014， Average rainfall from 6:00am to 4:00pm ia 177.7mm， max rainfall = 363.8mm， max hourly rainfall =89.3mm

Front street of Shenzhen University South Campus

Next to Civil Engineering Building

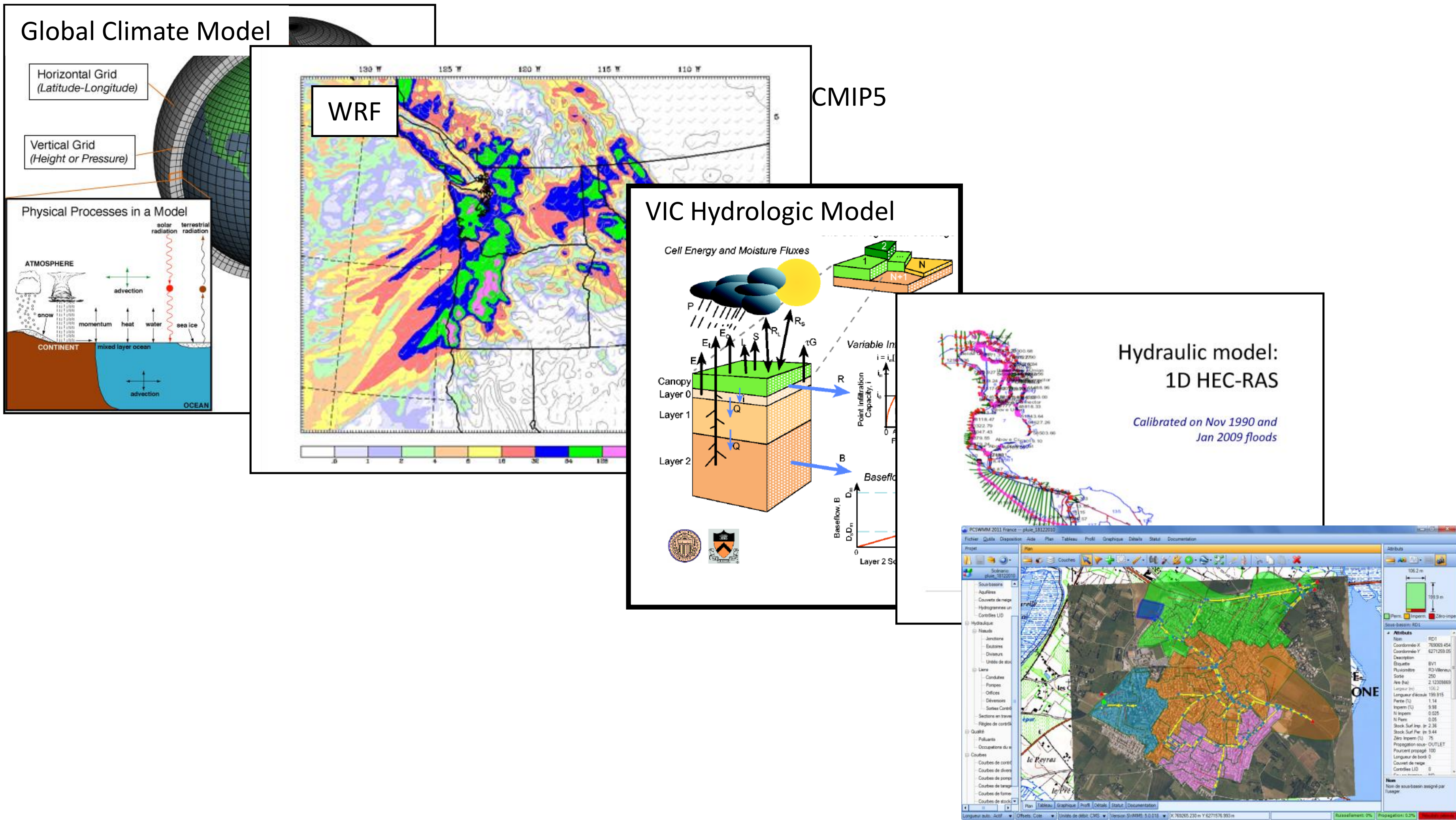
Rainfall outside of Our building








Regional Climate Model Projections of Future Flood Risk: Method

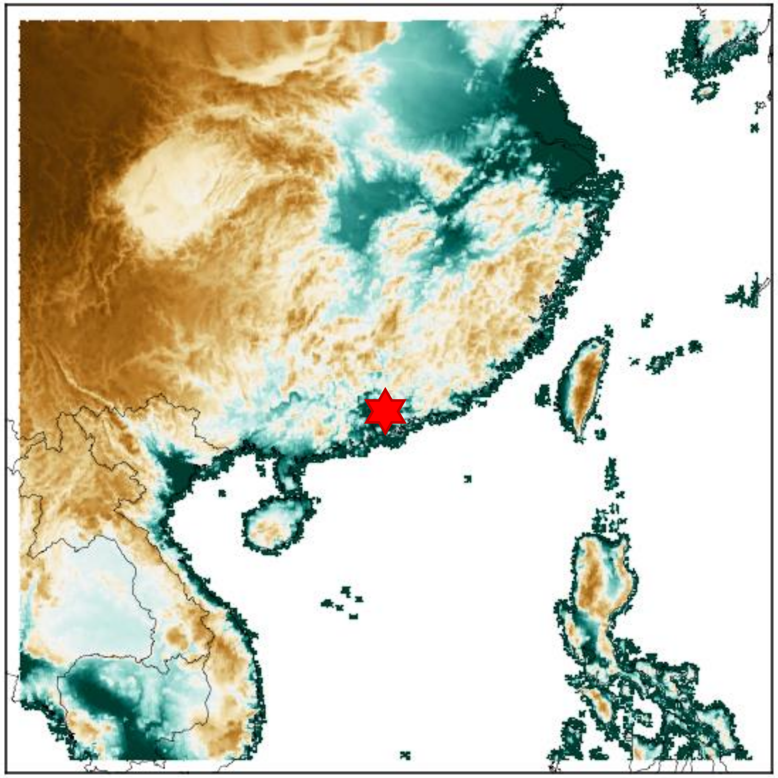


WRF Regional Climate Simulation

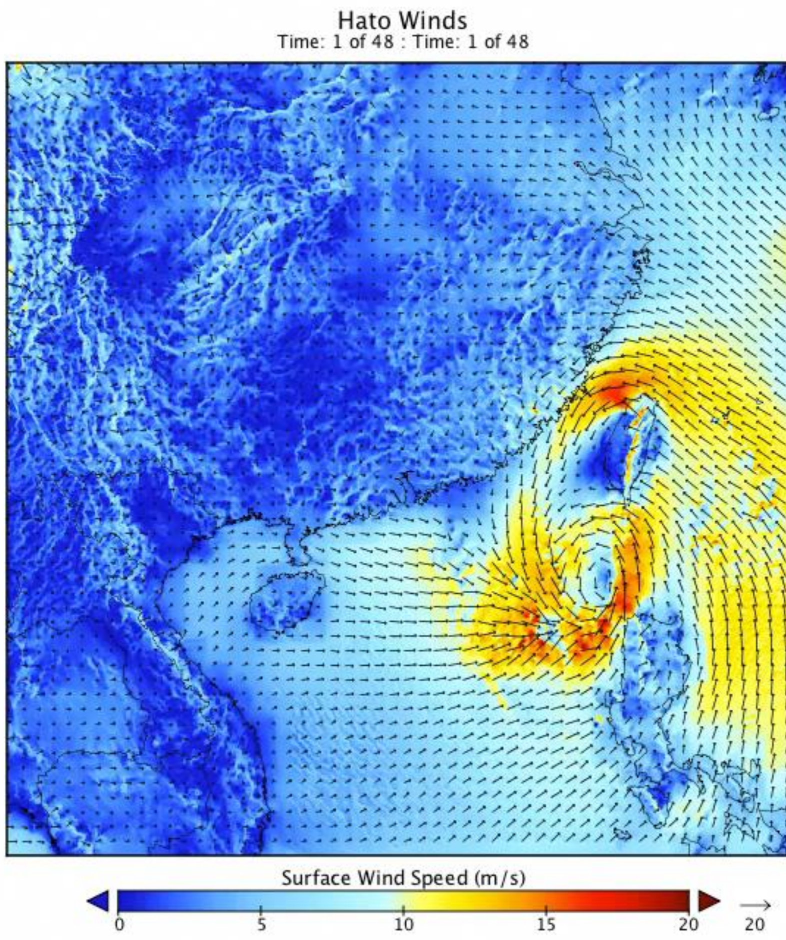
WRF model parameters optimization for Zhuhai

- 4km * 4 km
- PBL: YSU
- Cumulus: None
- Microphysics: Thompson
- Land: Noah
- Radiation: RRTM

WRF Domain



WRF Model Validation1

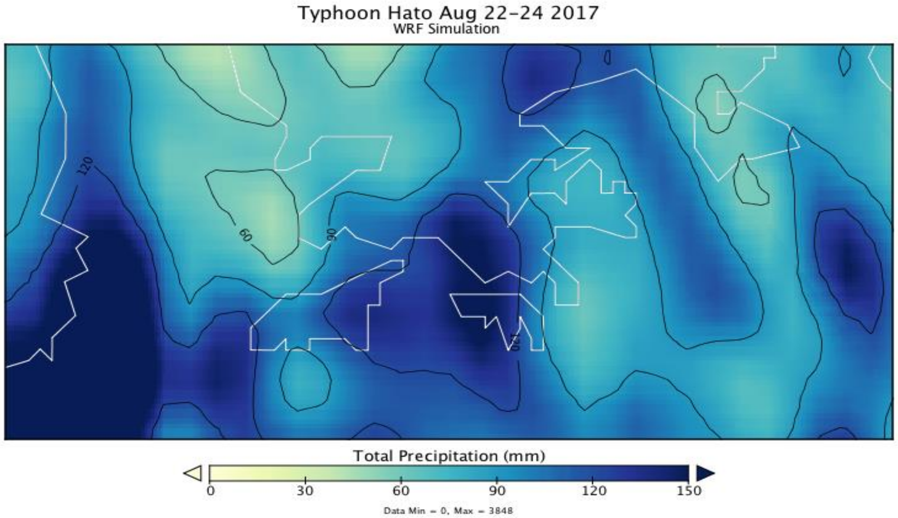


Typhoon *Hato*

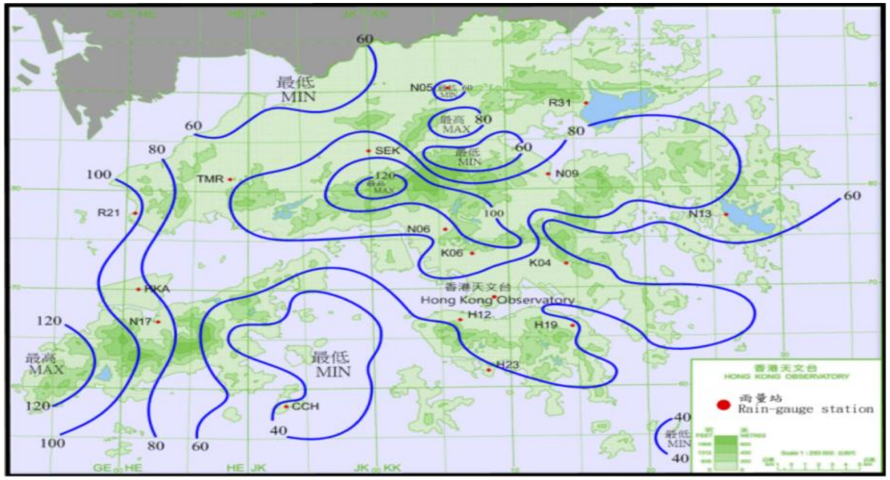
simulated by WRF

3.3 WRF Model Validation2

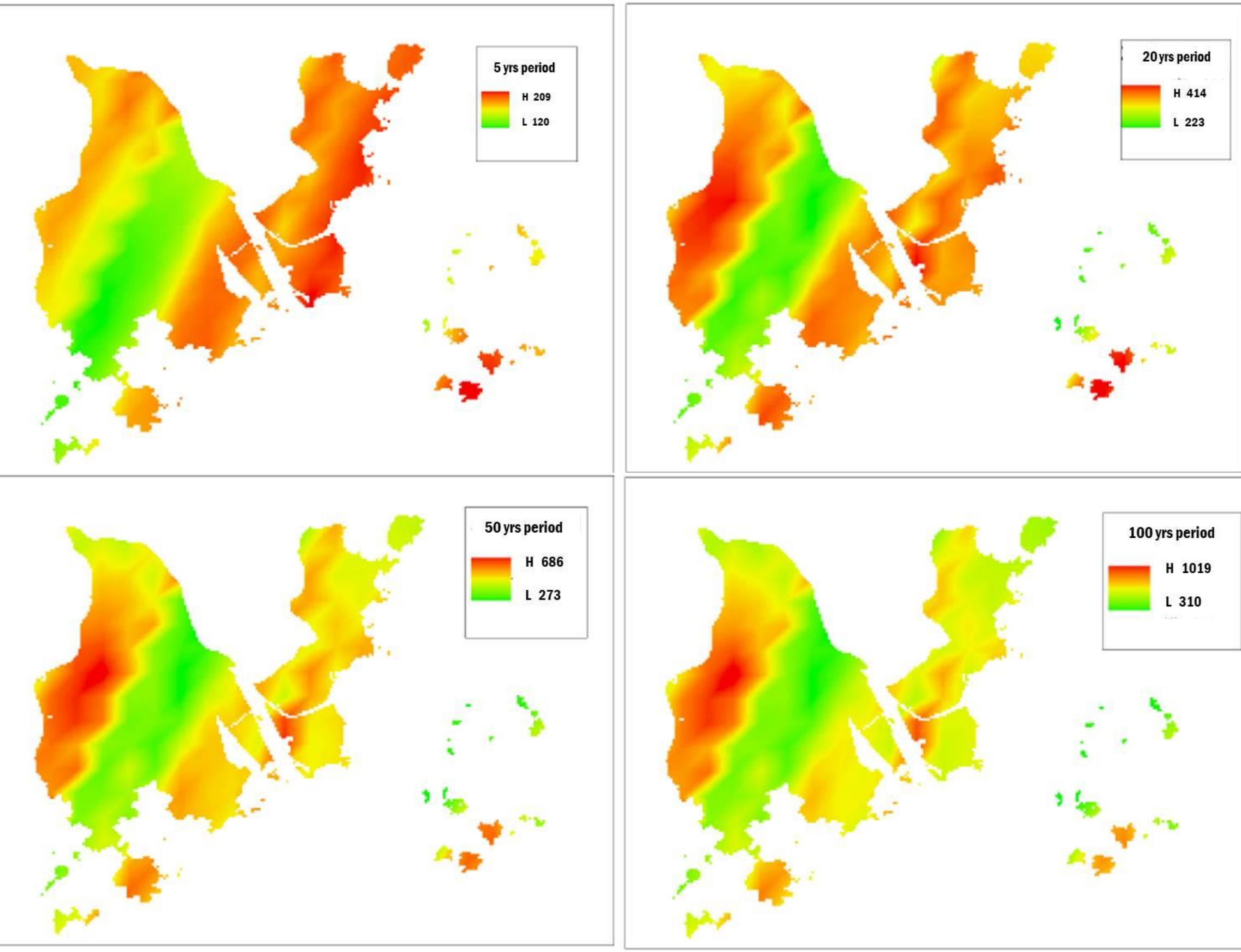
WRF Model ERAint Boundary Conditions



Hong Kong Observatory Rain Gage Data



3.7 Future Extreme Precipitation Trend

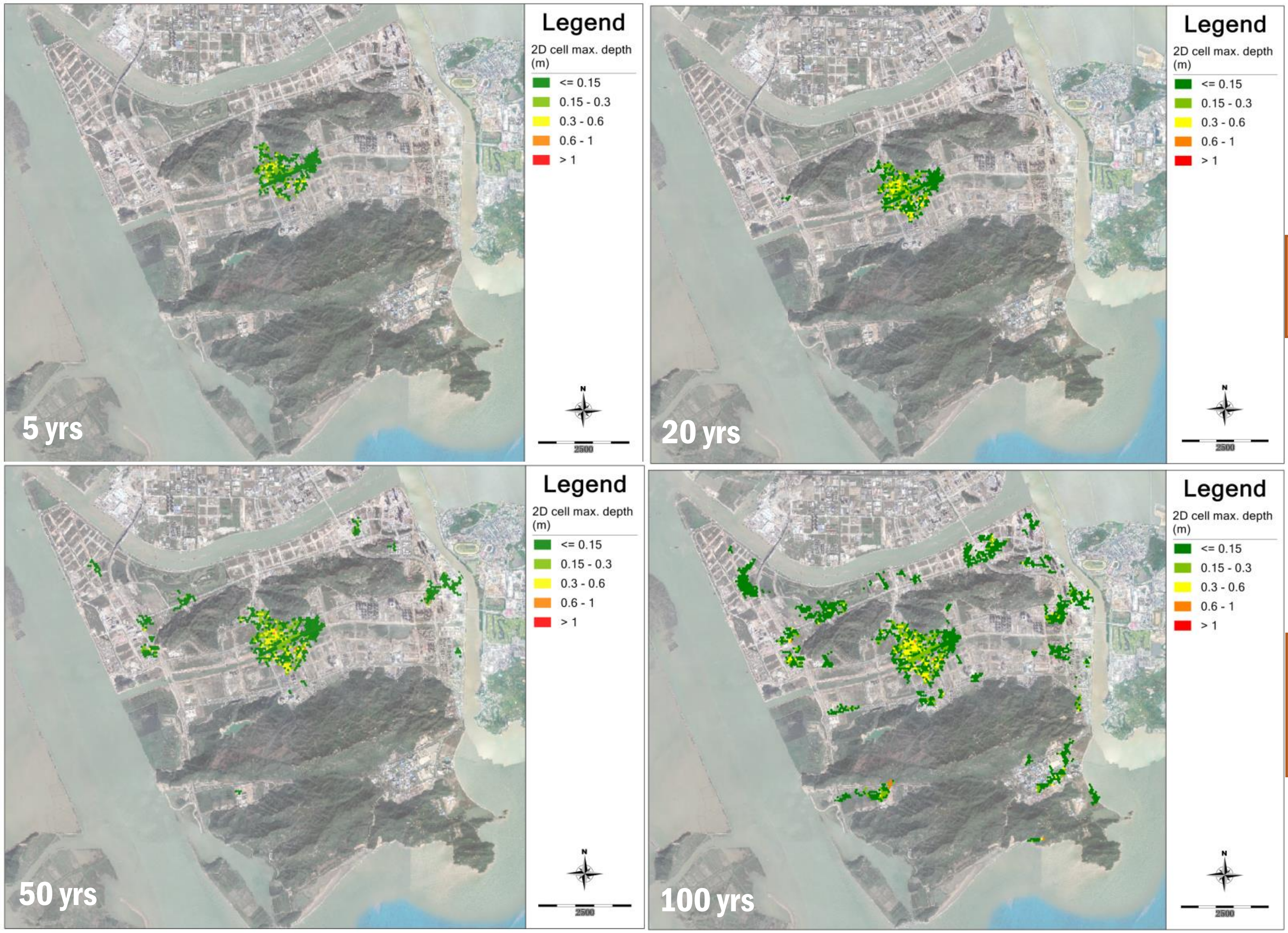


- For different return period, the spatial distribution is similar.
- More rainfall in Xiangzhou and Hengqin District than western part
- An obvious low precipitation zones in the middle of western part, probably related to typhoon.

The 50 yrs return period precipitation is recorded as 479.6mm/24hr, the result from WRF is 509mm/24hr.

In the future,
extreme event will be enhanced,
frequency will be increased.

4.4 Flood Risk Analysis



The areas on both banks of Tianmu River have the highest risk to be flooded in the future due to the local low points

Adjust the ground elevation during the future planning

The areas beside of some roads have middle risk to be flooded in the future due to the local low points and weak pipelines

Adjust the ground elevation or increase the pipeline design criteria during the future planning