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IMPLEMENTING LOW IMPACT DEVELOPMENT IN CHINA

2018 TRIECA Conference

Toronto, Canada

March 21, 2018

Steven Trinkaus

- Invited presenter on LID & water quality issues in Taiwan, South Korea & China
- Consultant to Pusan National University, Land & Housing Institute, Korean Water & HECOREA, LLC in South Korea and Shenzhen University in China for LID
- Licensed Professional Engineer (CT)
- Over 37 years in the Land Development Field with 17 years applying LID

LOW IMPACT SUSTAINABLE LISD DEVELOPMENT TRINKAUS ENGINEERING

Stormwater in China

- Major cities in China are experiencing rapid urban development over the past 10 years,
- Development projects consist of large roadways and massive apartment complexes to house people moving from the country to the cities for employment

Stormwater in China

- Urban drainage systems all drain to major river systems via structural conveyance systems,
- The rivers systems have huge watershed areas which causes significant water surface increases for even small rainfall events (2.5 cm/24 hrs)

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Stormwater in China

- Increases in water surface of the rivers block the outflow pipes from the urban drainage system with the result being significant flooding of the urban areas,
- In addition to the urban flooding issues, there is no water quality treatment of the urban runoff

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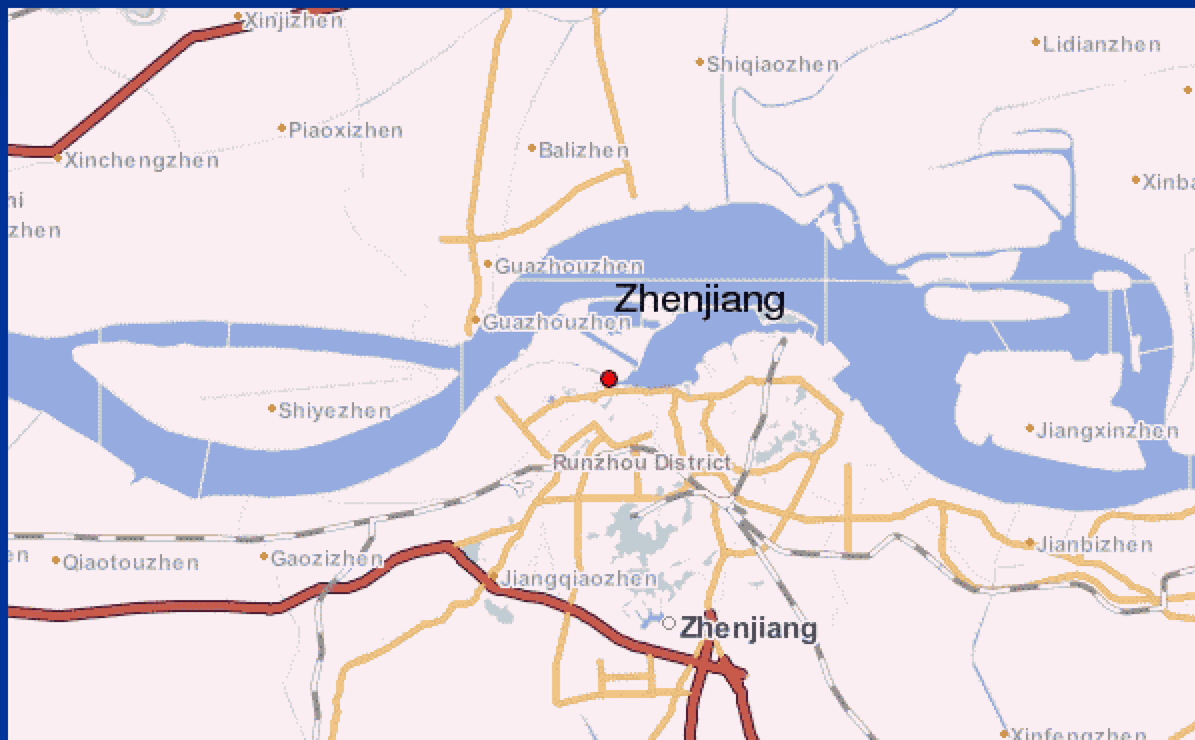
Zhenjiang, China on the Yangtze River



Urban Development in Zhenjiang, China

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China Sponge City Plan

- The Ministry of Housing and Urban-Rural Development issued Technical Guidelines for Construction Technology of Sponge City – The Establishment of Low Impact Development Storm Water Systems in 2014,
- Central Finance Agency will also provide financial support for pilot cities at early stage,

China Sponge City Plan

- The Chinese government designated 16 cities in China for the implementation of Sponge City – LID concepts,
- Government will provide funding in amounts up to $ 50 M per city per year to design and implement LID retrofits to address urban stormwater

2015 First Sino US Sponge City & LID Technology Practice Conference – May 2015

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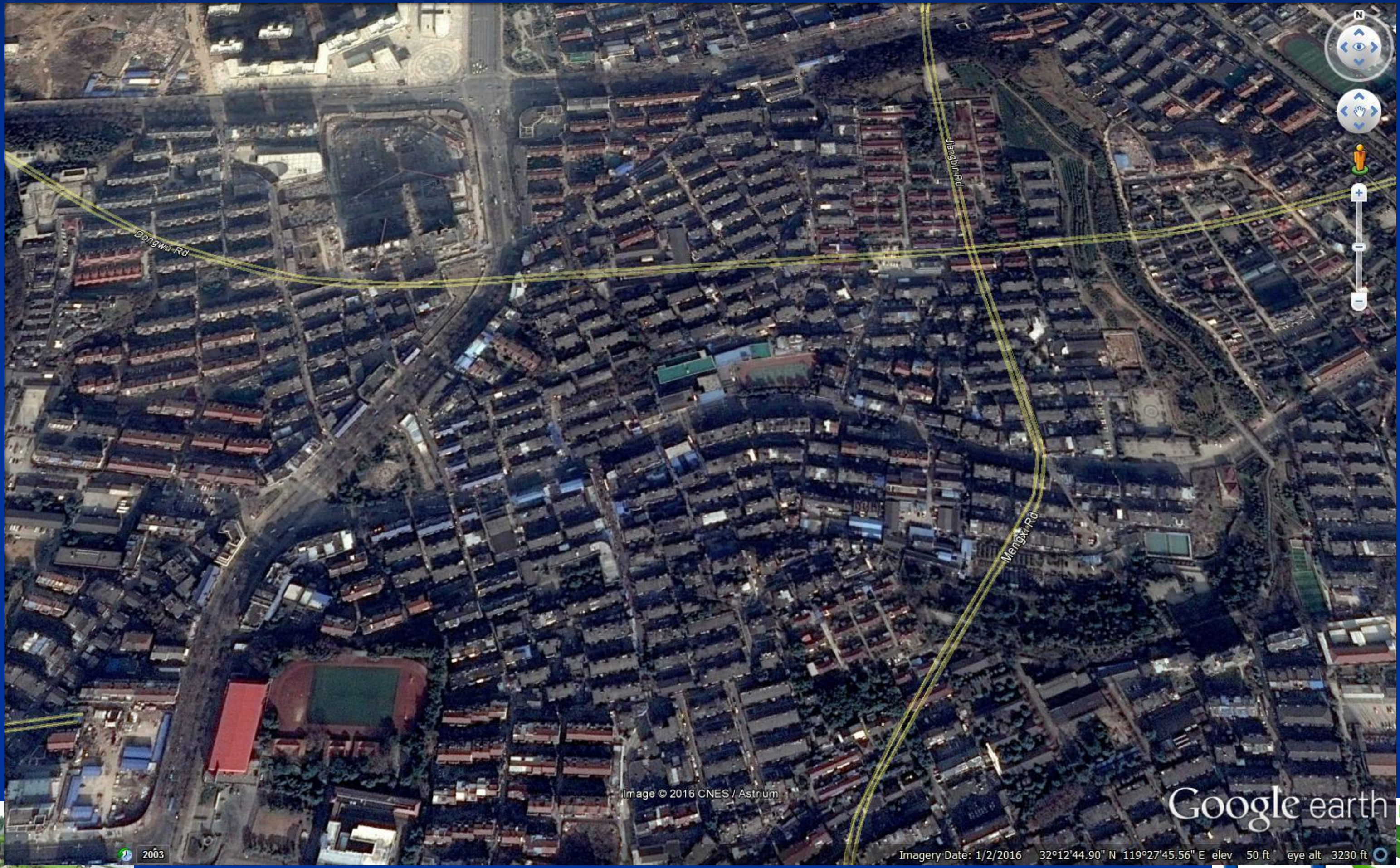
City Expansion Plan with LID

Typical Residential Development Zhenjiang, China



Typical Residential Development Zhenjiang, China

Lots of directly impervious area
Reliance on structural drainage systems

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Typical Residential Development Zhenjiang, China

- Open cell pavers with topsoil are filled to top which makes growing grass next to impossible,
- Soil was also very compacted due to movement of vehicles so no infiltration would occur
- All roof drains, sidewalks, driveways and parking areas were directly connected to conventional storm water management system

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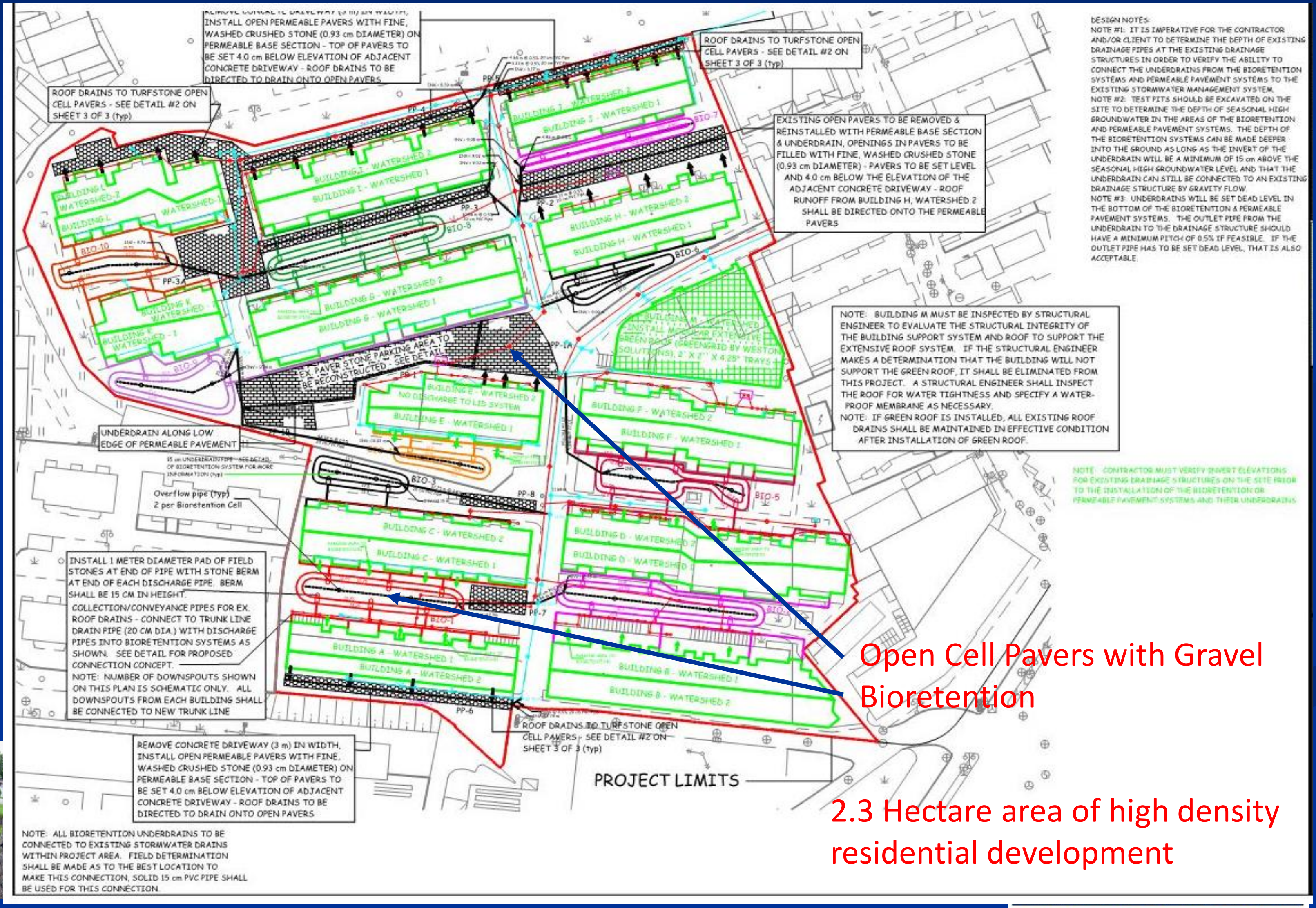
LISD Retrofit Design
Zhenjiang, China

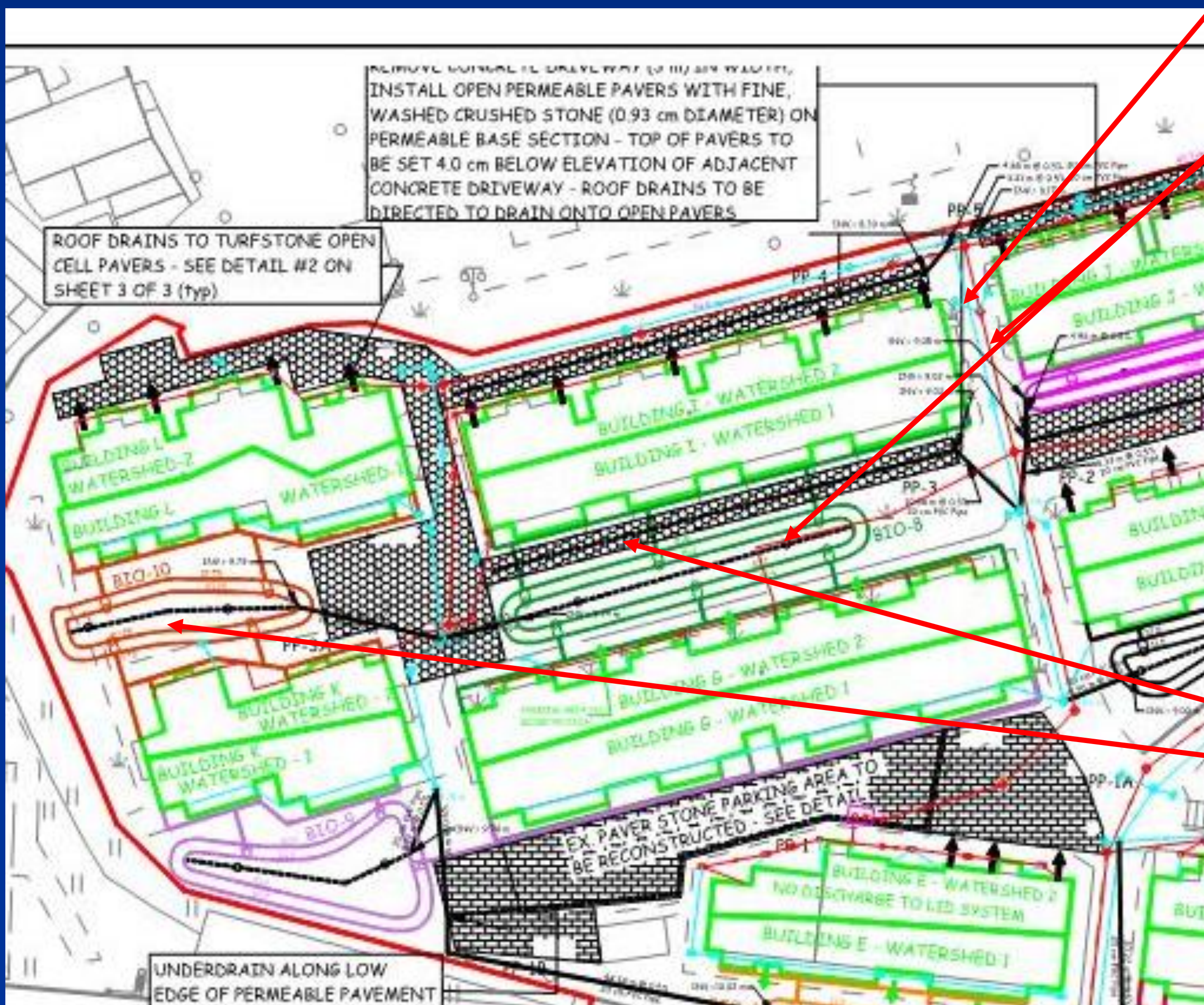


Open Cell Pavers with Gravel

Bioretention

2.3 Hectare area of high density residential development

LISD Retrofit Design
Zhenjiang, China



Ex. Sanitary Sewer
Ex. Stormwater system
Elevated underdrains in both paver and bioretention systems
Elevations of existing stormwater systems dictated the depth of the bioretention cells

Open Cell Pavers with Gravel
Bioretention

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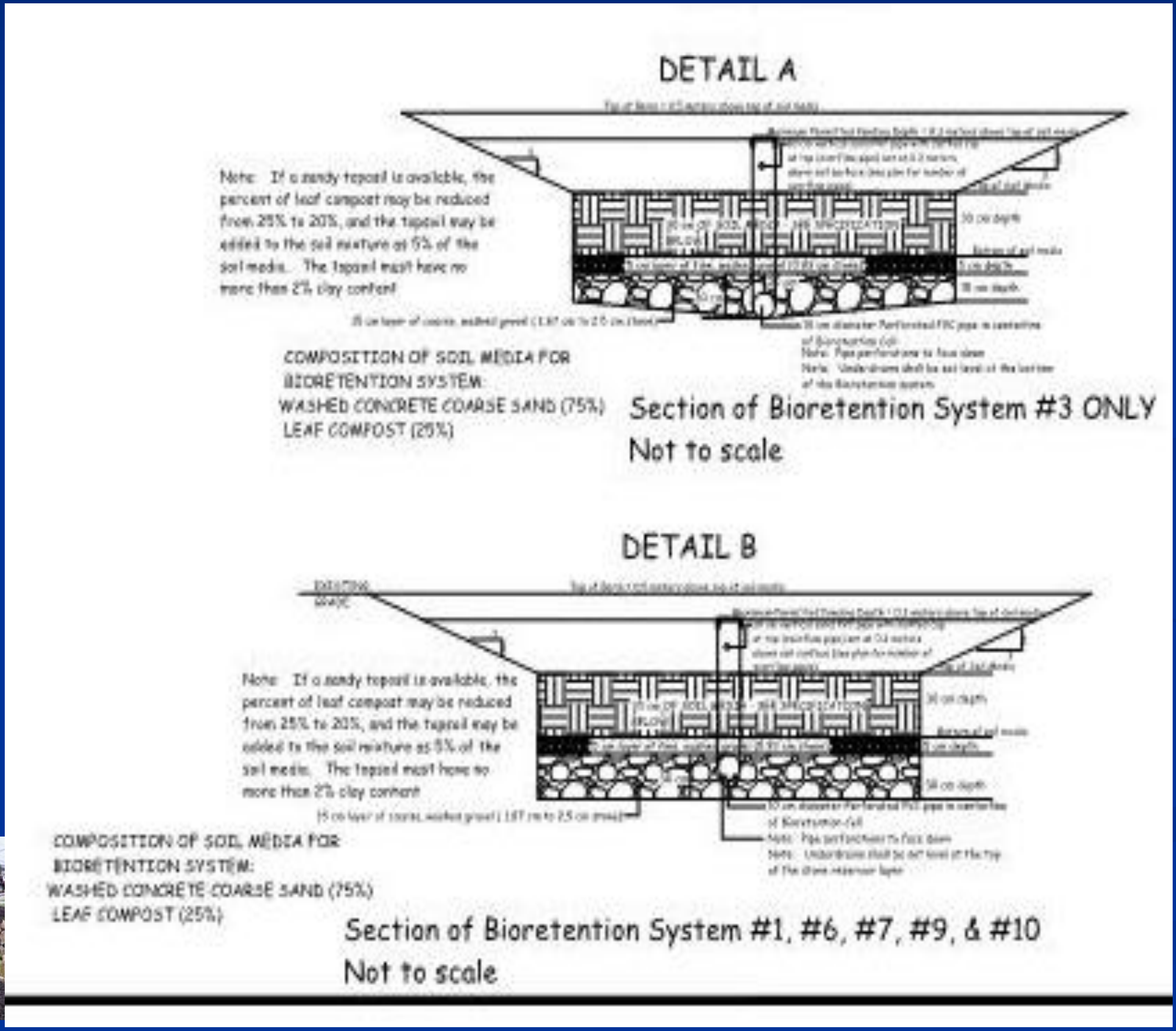
LISD Retrofit Design Zhenjiang, China



Bioretention Design:

- WQV – 65mm rainfall
- No overtopping for 150 mm rainfall
- System above retaining wall D ID NOT have elevated underdrain
- Infiltration rates – 0.25 cm/hr

LOW IMPACT SUSTAINABLE LISD DEVELOPMENT TRINKAUS ENGINEERING

Summary for Pond 3P: Bioretention-1

```
Inflow Area =      0.0784 ha,100.00% Impervious, Inflow Depth >   59 mm   for 65mm event
Inflow      =    0.0192 m³/s @  11.96 hrs, Volume=          0.046 Ml
Outflow     =    0.0098 m³/s @  12.06 hrs, Volume=          0.036 Ml, Atten= 49%, Lag= 6.1 min
Discarded   =    0.0003 m³/s @  12.00 hrs, Volume=          0.006 Ml
Primary     =    0.0096 m³/s @  12.06 hrs, Volume=          0.030 Ml
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 13.310 m @ 12.06 hrs   Surf.Area= 364.8 m²   Storage= 19.7 m³

Plug-Flow detention time= 143.8 min calculated for 0.036 Ml (78% of inflow)
Center-of-Mass det. time= 61.4 min (818.4 - 757.0)

Volume	Invert	Avail.Storage	Storage Description
#1	12.850 m	14.6 m³	**Reservoir (Prismatic)** Listed below (Recalc)
#2	13.150 m	2.4 m³	**Pea gravel layer (Prismatic)** Listed below (Recalc)
#3	13.200 m	7.3 m³	**Soil Media (Prismatic)** Listed below (Recalc)
#4	13.500 m	81.3 m³	**Surface Storage (Prismatic)** Listed below (Recalc)
		105.6 m³	Total Available Storage

Reservoir

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
12.850	121.6	0.0	0.0	0.0
13.150	121.6	40.0	14.6	14.6

Pea Gravel

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.150	121.6	0.0	0.0	0.0
13.200	121.6	40.0	2.4	2.4

Soil Media

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.200	121.6	0.0	0.0	0.0
13.500	121.6	20.0	7.3	7.3

Surface Storage

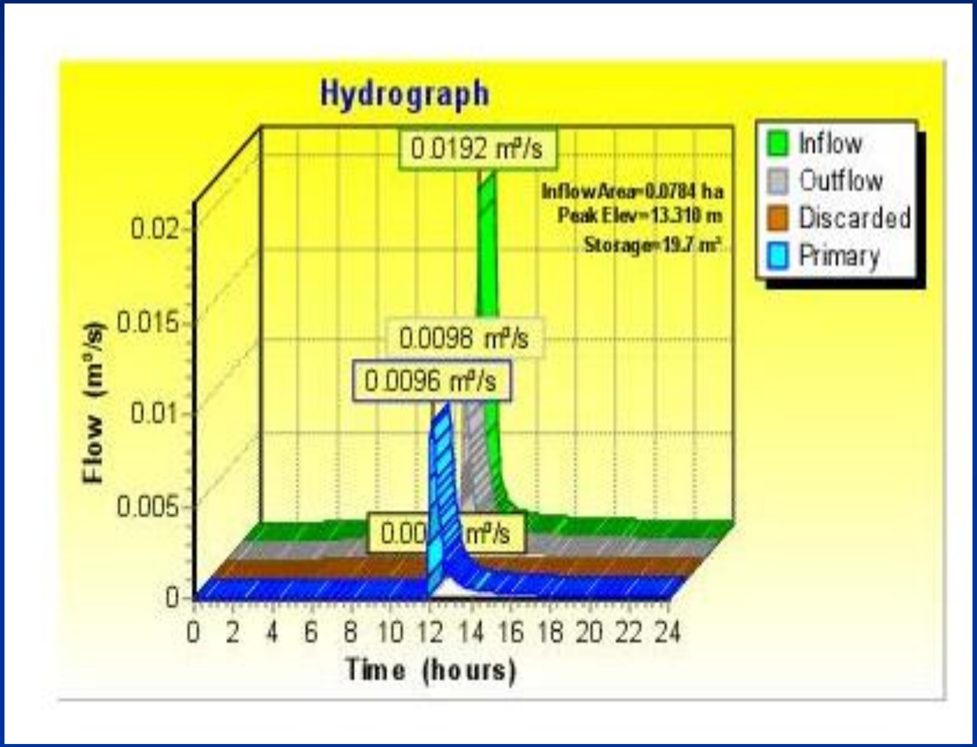
Elevation (meters)	Surf.Area (sq-meters)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.500	121.6	0.0	0.0
14.000	203.7	81.3	81.3

Device	Routing	Invert	Outlet Devices
#1	Discarded	12.850 m	**2.50 mm/hr Exfiltration over Surface area**
#2	Primary	13.050 m	**100 mm Vert. Orifice/Grate** C= 0.600
#3	Primary	13.800 m	**100 mm Horiz. Orifice/Grate** X 2 rows C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.0003 m³/s @ 12.00 hrs HW=13.272 m (Free Discharge)
└1=**Exfiltration** (Exfiltration Controls 0.0003 m³/s)

Primary OutFlow Max=0.0095 m³/s @ 12.06 hrs HW=13.306 m (Free Discharge)
├2=**Orifice/Grate** (Orifice Controls 0.0095 m³/s @ 1.21 m/s)
└3=**Orifice/Grate** (Controls 0.0000 m³/s)

LISD Retrofit Design: Zhenjiang, China – 65 mm/24 hr event



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Summary for Pond 3P: Bioretention-1

```
Inflow Area =      0.0784 ha,100.00% Impervious, Inflow Depth >   144 mm   for  150mm event
Inflow      =   0.0449 m³/s @  11.96 hrs, Volume=          0.113 Ml
Outflow     =   0.0152 m³/s @  12.10 hrs, Volume=          0.102 Ml, Atten= 66%, Lag= 8.2 min
Discarded =     0.0004 m³/s @  12.10 hrs, Volume=          0.008 Ml
Primary     =   0.0149 m³/s @  12.10 hrs, Volume=          0.094 Ml

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 13.607 m @ 12.10 hrs   Surf.Area= 504.0 m²   Storage= 38.3 m³

Plug-Flow detention time= 105.3 min calculated for 0.102 Ml (91% of inflow)
Center-of-Mass det. time= 54.8 min ( 795.5 - 740.7 )
```

Volume	Invert	Avail.Storage	Storage Description
#1	12.850 m	14.6 m³	**Reservoir (Prismatic)** Listed below (Recalc)
#2	13.150 m	2.4 m³	**Pea gravel layer (Prismatic)** Listed below (Recalc)
#3	13.200 m	7.3 m³	**Soil Media (Prismatic)** Listed below (Recalc)
#4	13.500 m	81.3 m³	**Surface Storage (Prismatic)** Listed below (Recalc)
		105.6 m³	Total Available Storage

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
12.850	121.6	0.0	0.0	0.0
13.150	121.6	40.0	14.6	14.6

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.150	121.6	0.0	0.0	0.0
13.200	121.6	40.0	2.4	2.4

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.200	121.6	0.0	0.0	0.0
13.500	121.6	20.0	7.3	7.3

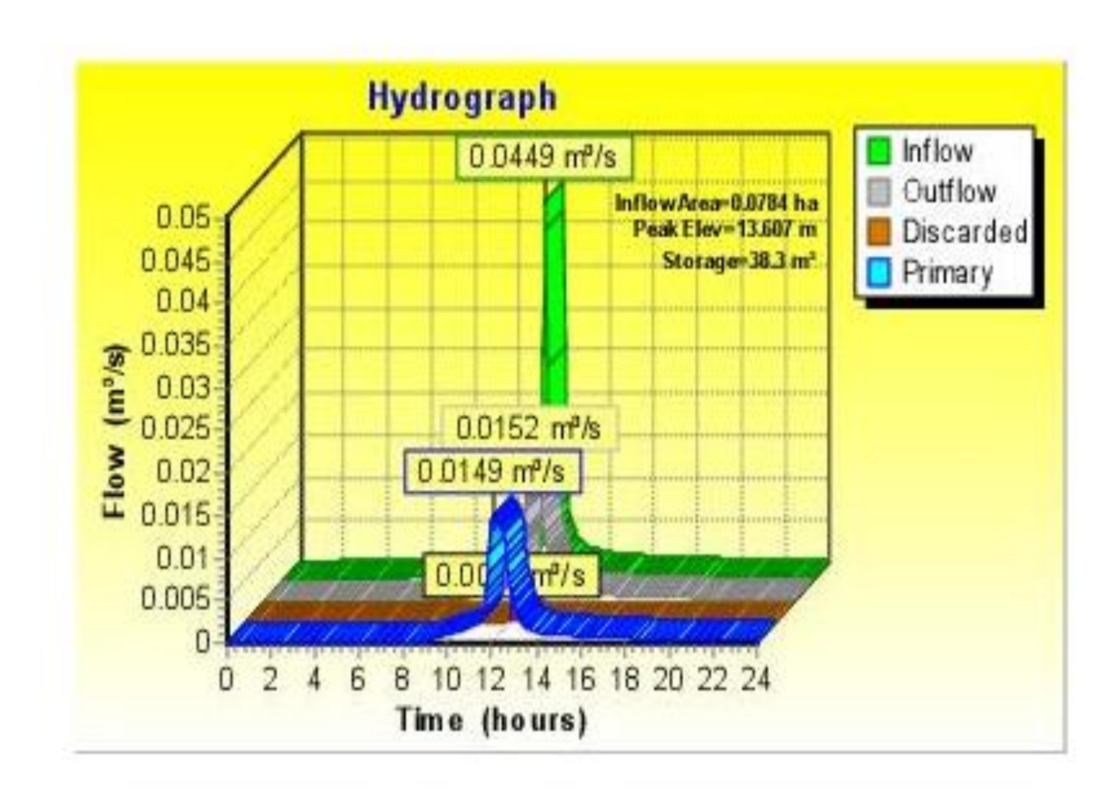
Elevation (meters)	Surf.Area (sq-meters)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.500	121.6	0.0	0.0
14.000	203.7	81.3	81.3

Device	Routing	Invert	Outlet Devices
#1	Discarded	12.850 m	**2.50 mm/hr Exfiltration over Surface area**
#2	Primary	13.050 m	**100 mm Vert. Orifice/Grate** C= 0.600
#3	Primary	13.800 m	**100 mm Horiz. Orifice/Grate** X 2 rows C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.0003 m³/s @ 12.10 hrs HW=13.607 m (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.0003 m³/s)

Primary OutFlow Max=0.0149 m³/s @ 12.10 hrs HW=13.607 m (Free Discharge)
├─**2=Orifice/Grate** (Orifice Controls 0.0149 m³/s @ 1.89 m/s)
└─**3=Orifice/Grate** (Controls 0.0000 m³/s)

LISD Retrofit Design: Zhenjiang, China – 150 mm/24 hr event



Summary for Pond 3P: Bioretention-1

```
Inflow Area =      0.0784 ha,100.00% Impervious, Inflow Depth >   204 mm   for 210mm event
Inflow      =    0.0630 m³/s @  11.96 hrs, Volume=          0.160 Ml
Outflow     =    0.0167 m³/s @  12.12 hrs, Volume=          0.149 Ml, Atten= 73%, Lag= 9.3 min
Discarded   =    0.0004 m³/s @  12.12 hrs, Volume=          0.008 Ml
Primary     =    0.0163 m³/s @  12.12 hrs, Volume=          0.141 Ml

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 13.713 m @ 12.12 hrs   Surf.Area= 521.3 m²   Storage= 53.9 m³

Plug-Flow detention time= 91.5 min calculated for 0.149 Ml (93% of inflow)
Center-of-Mass det. time= 52.5 min ( 788.6 - 736.0 )
```

Volume	Invert	Avail.Storage	Storage Description
#1	12.850 m	14.6 m³	**Reservoir (Prismatic)** Listed below (Recalc)
#2	13.150 m	2.4 m³	**Pea gravel layer (Prismatic)** Listed below (Recalc)
#3	13.200 m	7.3 m³	**Soil Media (Prismatic)** Listed below (Recalc)
#4	13.500 m	81.3 m³	**Surface Storage (Prismatic)** Listed below (Recalc)
		105.6 m³	Total Available Storage

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
12.850	121.6	0.0	0.0	0.0
13.150	121.6	40.0	14.6	14.6

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.150	121.6	0.0	0.0	0.0
13.200	121.6	40.0	2.4	2.4

Elevation (meters)	Surf.Area (sq-meters)	Voids (%)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.200	121.6	0.0	0.0	0.0
13.500	121.6	20.0	7.3	7.3

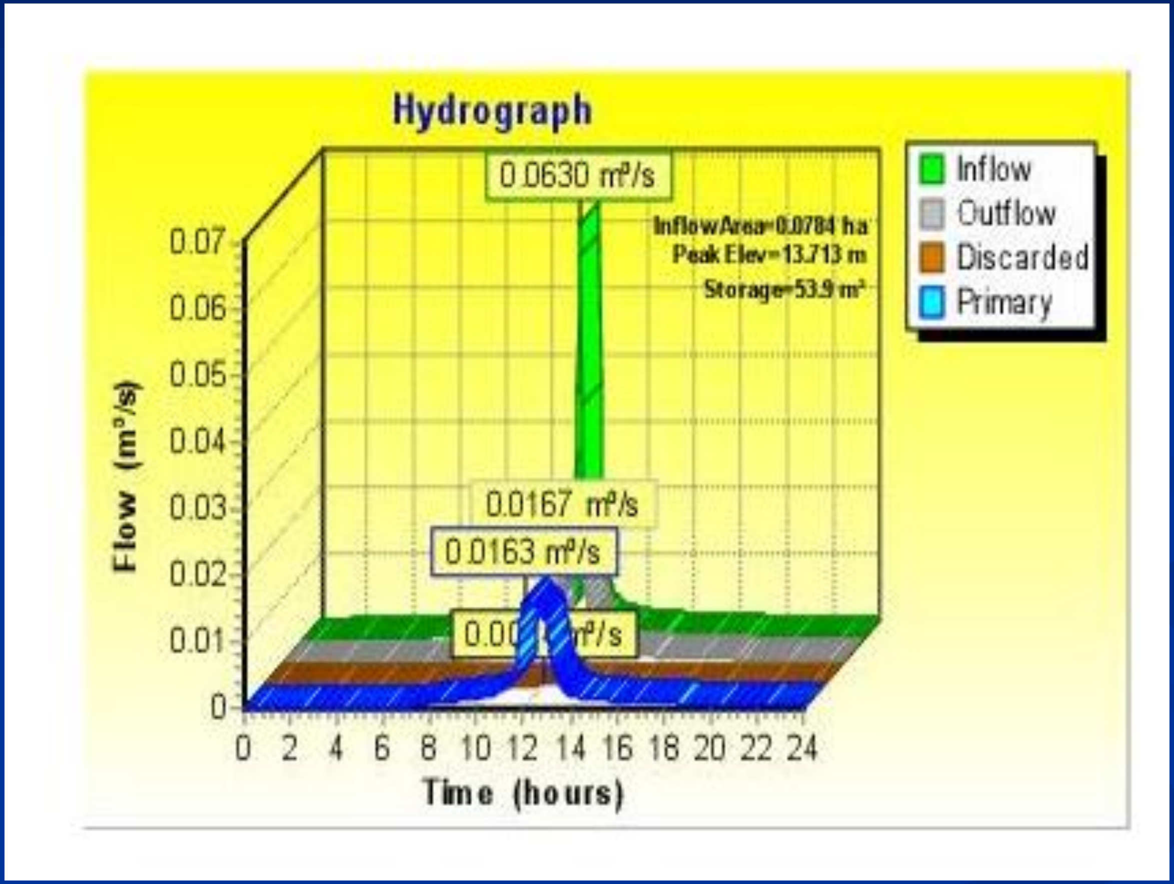
Elevation (meters)	Surf.Area (sq-meters)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
13.500	121.6	0.0	0.0
14.000	203.7	81.3	81.3

Device	Routing	Invert	Outlet Devices
#1	Discarded	12.850 m	**2.50 mm/hr Exfiltration over Surface area**
#2	Primary	13.050 m	**100 mm Vert. Orifice/Grate** C= 0.600
#3	Primary	13.800 m	**100 mm Horiz. Orifice/Grate** X 2 rows C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.0004 m³/s @ 12.12 hrs HW=13.711 m (Free Discharge)
└1=**Exfiltration** (Exfiltration Controls 0.0004 m³/s)

Primary OutFlow Max=0.0163 m³/s @ 12.12 hrs HW=13.711 m (Free Discharge)
├2=**Orifice/Grate** (Orifice Controls 0.0163 m³/s @ 2.08 m/s)
└3=**Orifice/Grate** (Controls 0.0000 m³/s)

LISD Retrofit Design: Zhenjiang, China – 210 mm/24 hr event



Home Village LID facilities Program report

Guangzhou Pearl Water Environment Technology Co., Ltd.

October 21, 2015

小区现状及存在的问题

Existing flow paths and ponding location

小区竖向分析图

Current Status of Residential Areas and Existing Problems - Status Quo Green and Hard

现状绿地与硬地图

Community green area of 6446.6 square meters, the green rate was 26.5%

Current Situation of Residential Areas and Existing Problems - Status of Rain Downspouts

Ex. Gutter Downspouts

Community status quo and existing problems






Current Status of Residential Areas and Problems Existed - Problems of Site Evaluation and Drainage

- The entire district is high in the south and low in the north, with large elevation difference in the north and south, and the elevation difference in some areas reaches 3m.
- The entire community road is more spacious, but due to the parked vehicles on the roadside, resulting in poor traffic.
- Community green better preserved, green rate is high, but the plant is more messy, the landscape effect is poor.
- The terrain is low in the north of the district and flooded in the rainy season.
- Rainfall mixed with rain and rain in residential area is serious (except for 2 #, 10 # and 14 #), and the rain droppipe is relatively old and damaged severely.
- Residential area is basically rain and shunt, but there is some mixed.

Design goals

According to Zhenjiang sponge city construction pilot program requirements, home village LID facilities layout to achieve the following three goals:

Annual runoff total control rate of 85%, corresponding to design rainfall of 42mm.

Drainage waterlogging standards to effectively deal with 30-year rainfall.

Non-point source pollution reduction rate of 60%.

Project Design - Design Principles

- Will be converted into ecological green house parking lot, rain garden and permeable paving combination.
- Make the best use of the green belt beside the road and transform it into concave green space to solve the surface runoff on the road.
- In combination with community requirements, we will try to increase the parking space under the premise of ensuring part of the green space.

Program design - program layout

Program Design - Description

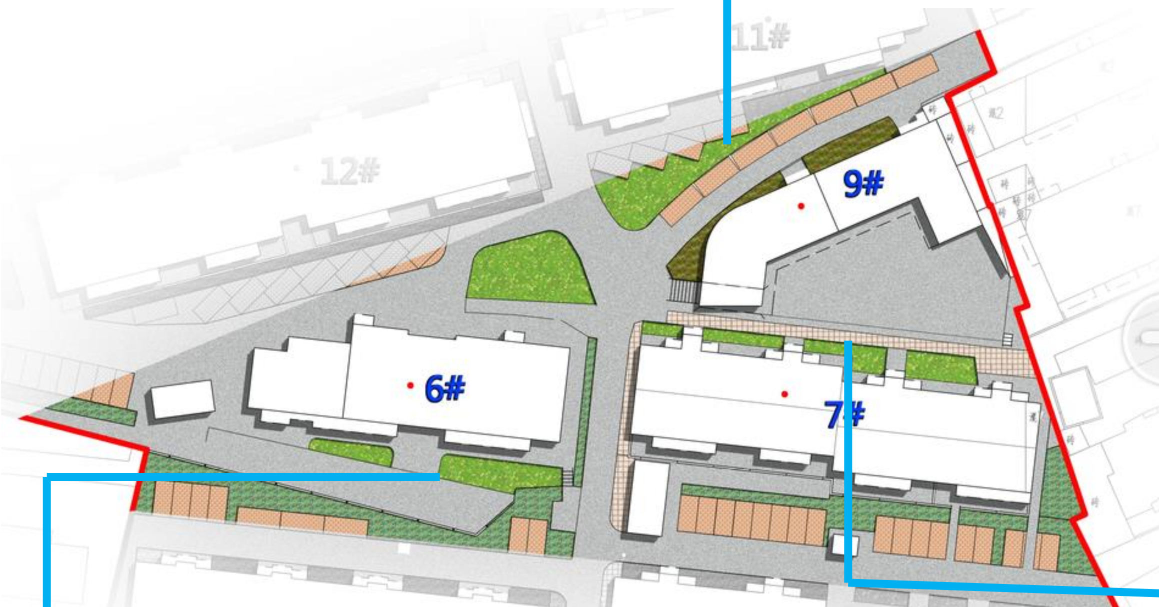
- The status of green land combined with water paving, rain gardens or sunken green spaces into ecological parking.
- The basic status of flower beds transformed into high rain flower beds.
- On the north side of # 10 and 14 #, Zhaizi Road was transformed into a permeable pavement.

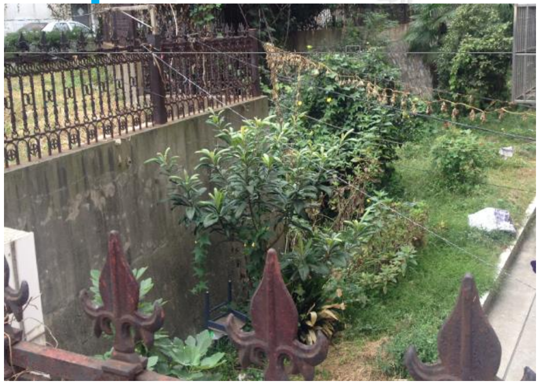
Design

The green land between 2 # and 4 # is transformed into a rainwater garden on the south and a permeable pavement on the north.

4 #, 5 # south of the green area into permeable pavement, combined with rain garden into ecological parking.

Design





6 # green space on the south into a rain garden, 7 # green space on the south side into a permeable paved and recessed green space combination of ecological parking.

The flower bed on the northern side of Building No. 9 has been changed into a high rainwater flower bed, and the green space on the south side of No. 11 has been transformed into a permeable paved garden and rainwater garden.

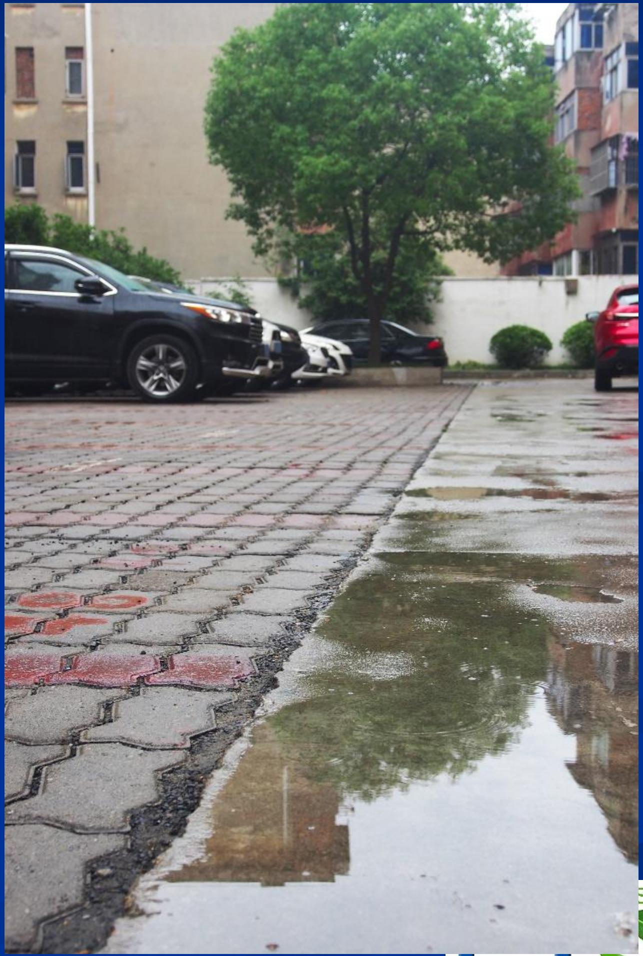
Design

8 #, 10 # south, north of 12 # into a rain garden and water permeable pavement;

13 # South pavement into permeable pavement, green into rain garden;

10 #, 14 # north of the former homestead road into a permeable pavement.

Installed Permeable Paver System for Parking Areas – Zhenjiang, China



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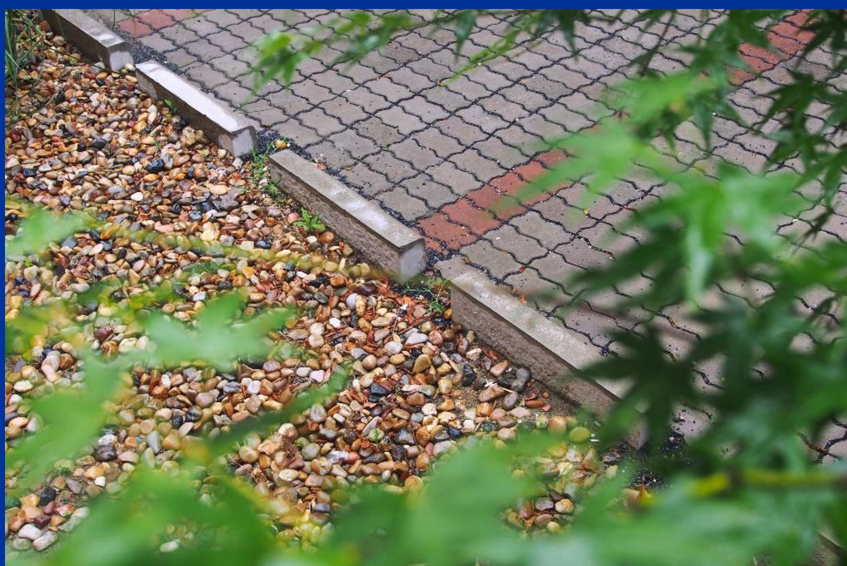
Installed Permeable Paver System for Parking Areas – Zhenjiang, China



LOW IMPACT SUSTAINABLE DEVELOPMENT
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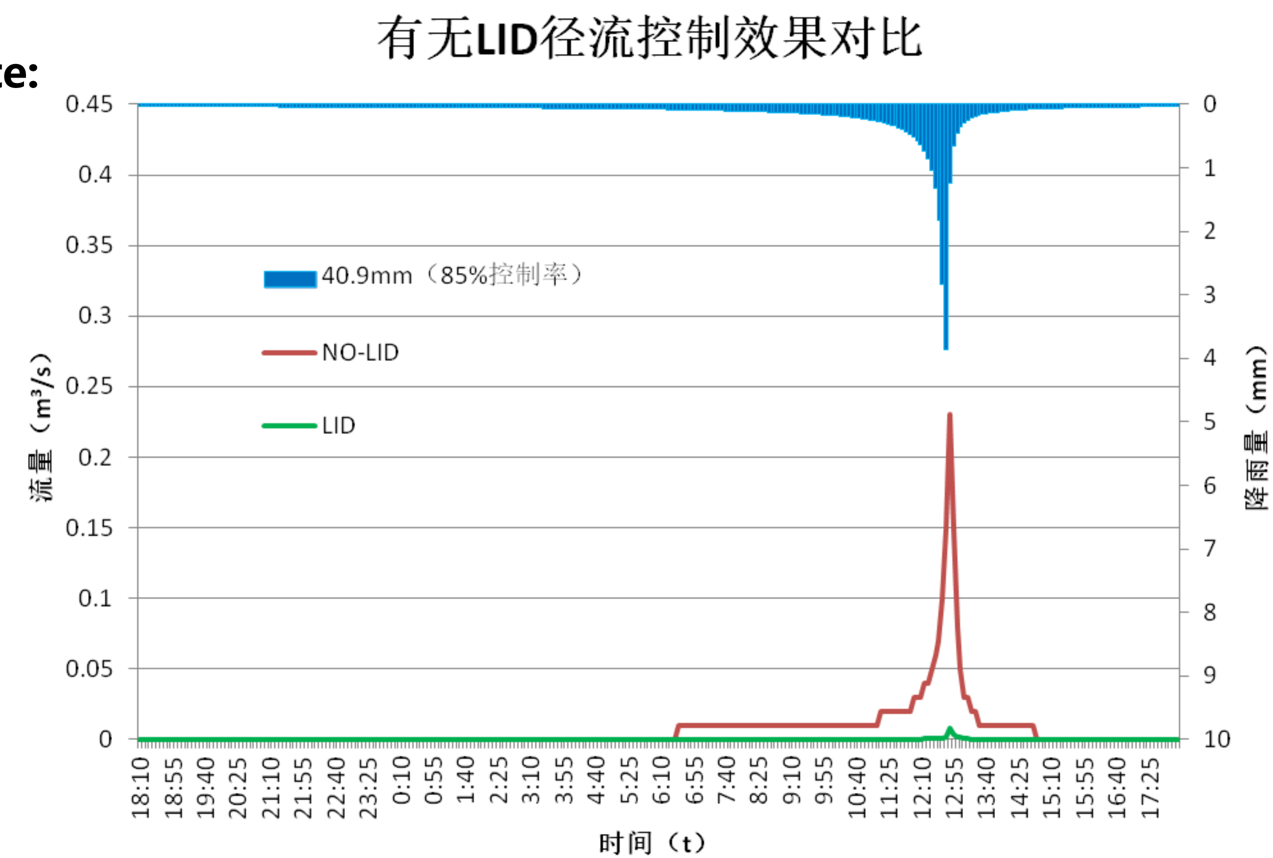
Simulation results analysis

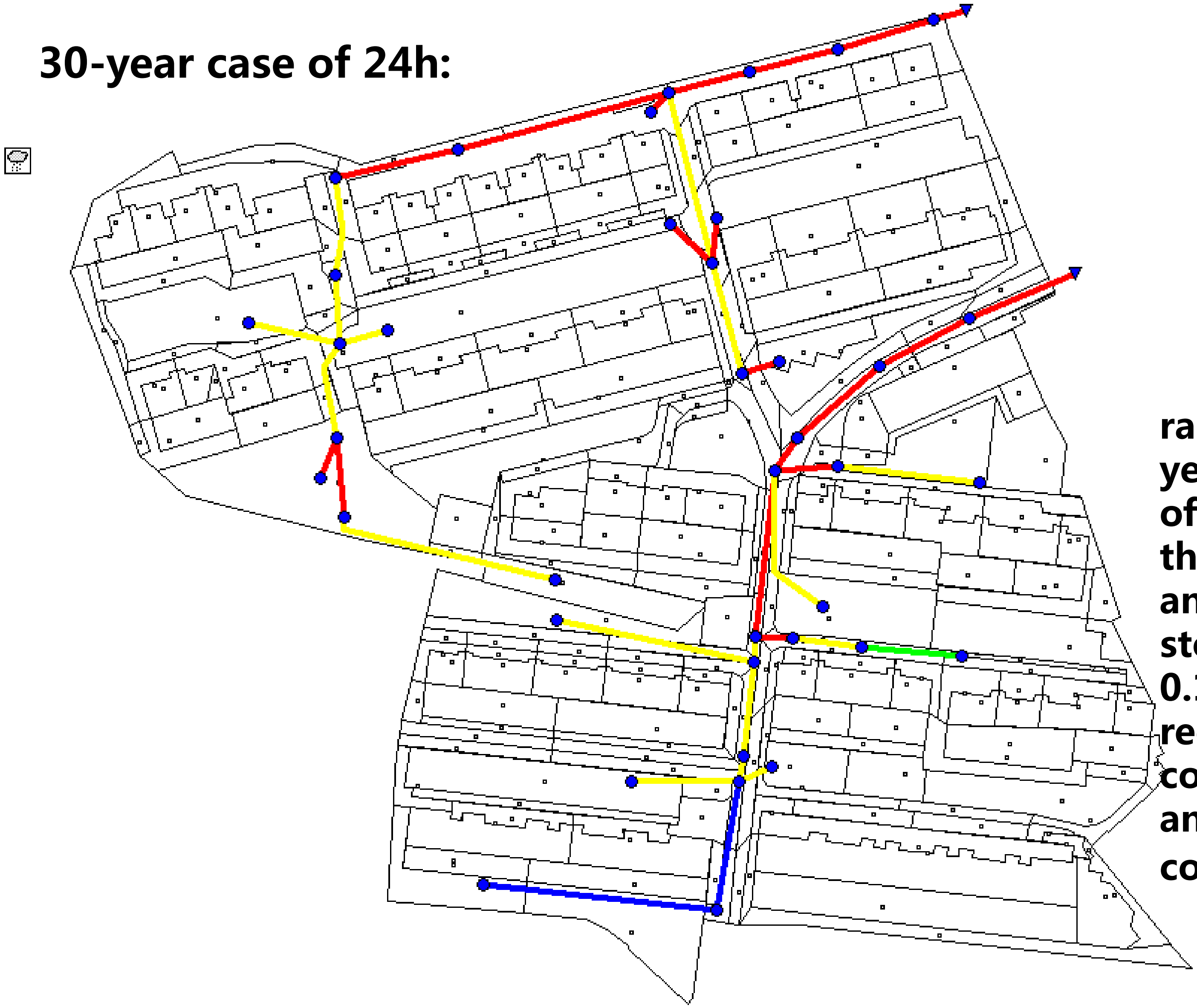
85% Control rate:



In 85% of the annual runoff total control rate of 40.9mm corresponding to the design rainfall, the basic area of LID facilities are not outside the row (need to add 20m³ storage tank) to meet the design requirements.

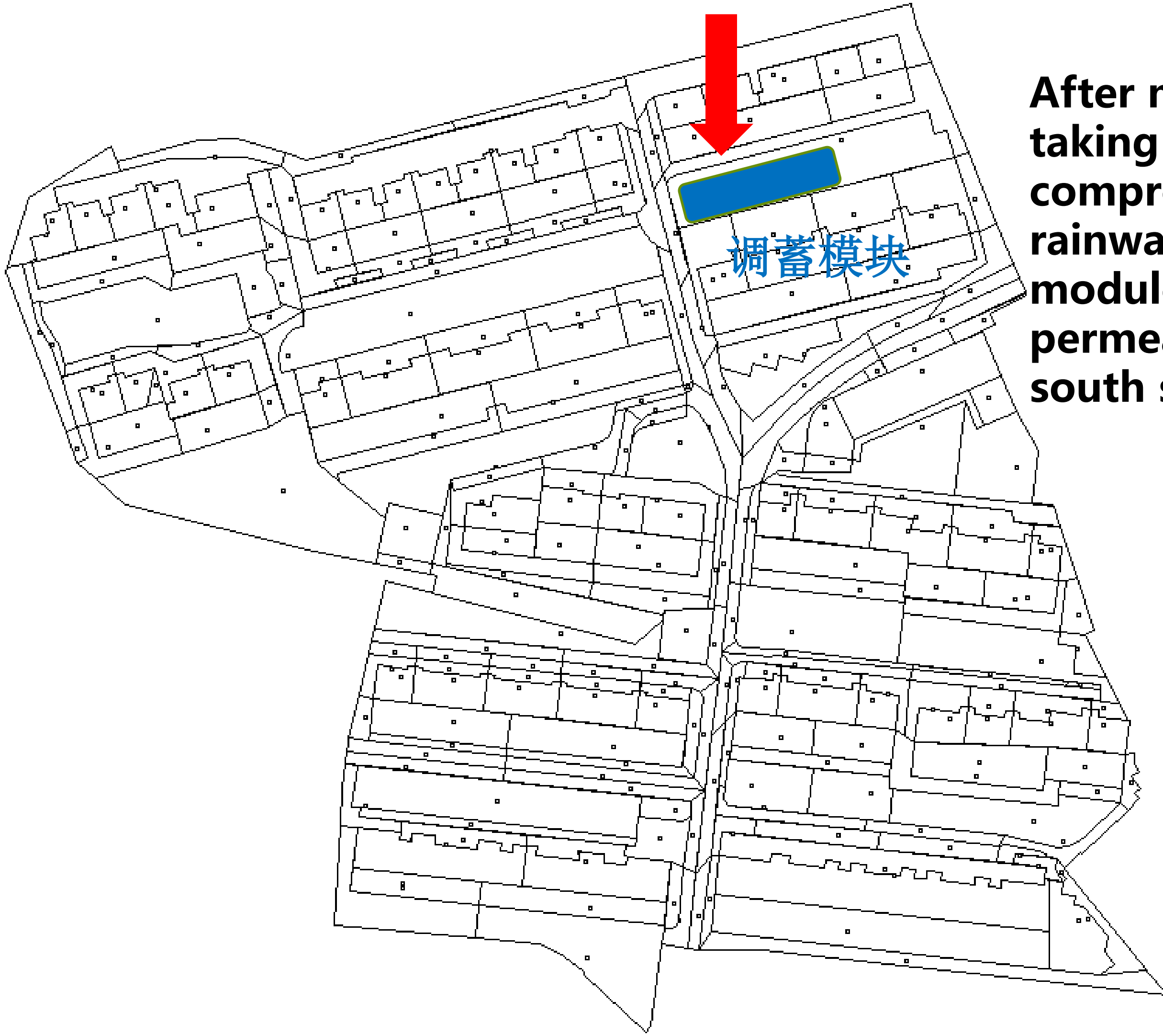
Simulation results analysis

30-year case of 24h:



In case of 24-hour rainfall of 220 mm in 30 years, the overflow time of the pipe network of the district is not 0.5 h and the depth of water storage does not exceed 0.15 m, which meets the requirements of flood control and drainage and can be effectively controlled.

Simulation results analysis



After model simulation and taking into account the comprehensive reuse of rainwater, a 20m³ storage module needs to be laid under permeable pavement on the south side of 13 #.

Contact Information

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