Redesigning Delhi's Green with Water

January, 2015

Landscape & Environment Planning Department
Delhi Development Authority

Structure of the Presentation

A. Problems pertaining to Stormwater and Wastewater of the City
B. Causes of the Problems
C. Solution: Management of Water in Delhi's Green Spaces

The Problem Scenario

When River Yamuna Overflows…

When the drains of the City overflows…

When the drains of the City overflows…

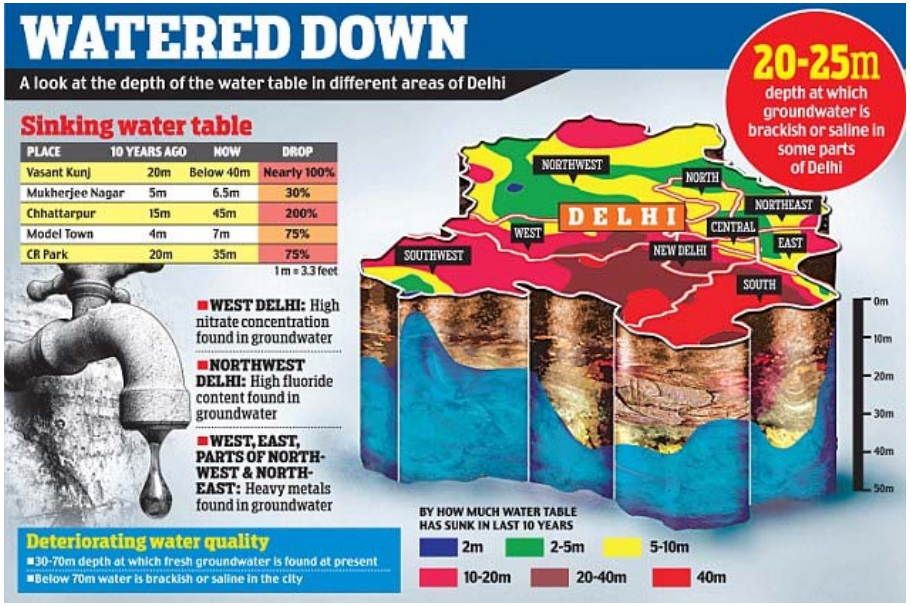
" *India stands first amongst the top ten countries where groundwater abstraction is high. Delhi figures in the list of five states (*Rajasthan, Gujarat, Punjab, Haryana and Delhi) *which suffer from declining ground water levels*."

Source: Managing Water under Uncertainty and Risk, The United Nations World Water Development Report 4, Volume 1

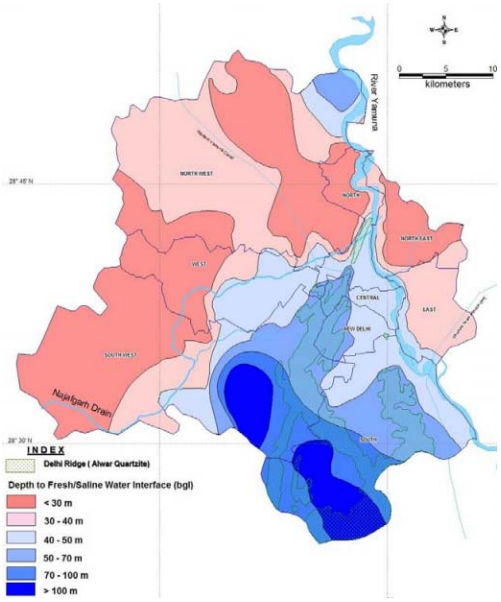
Year	Ground Water Level in major areas of Delhi (in mtrs bgl)	Lowest Ground Water Level (in mtrs bgl)
1977	6	23
1983	10	26
1995	10-20	35
2009		67.73

Source: http://www.rainwaterharvesting.org/index_files/water_level_fluct.htm and CGWB reports.

Over-exploitation of ground water sources has increased the gap in demand and supply of drinking water in NCT-Delhi.



Source: http://www.dailymail.co.uk/indiahome/indianews/article-2288607/Delhis-great-water-fall-Capital-fears-riots-water-shortages-groundwater-level-hits-dangerous-low.html



Depth to Fresh/Saline Interface, NCTD
Source: CGWB, Year Book, 2007-08

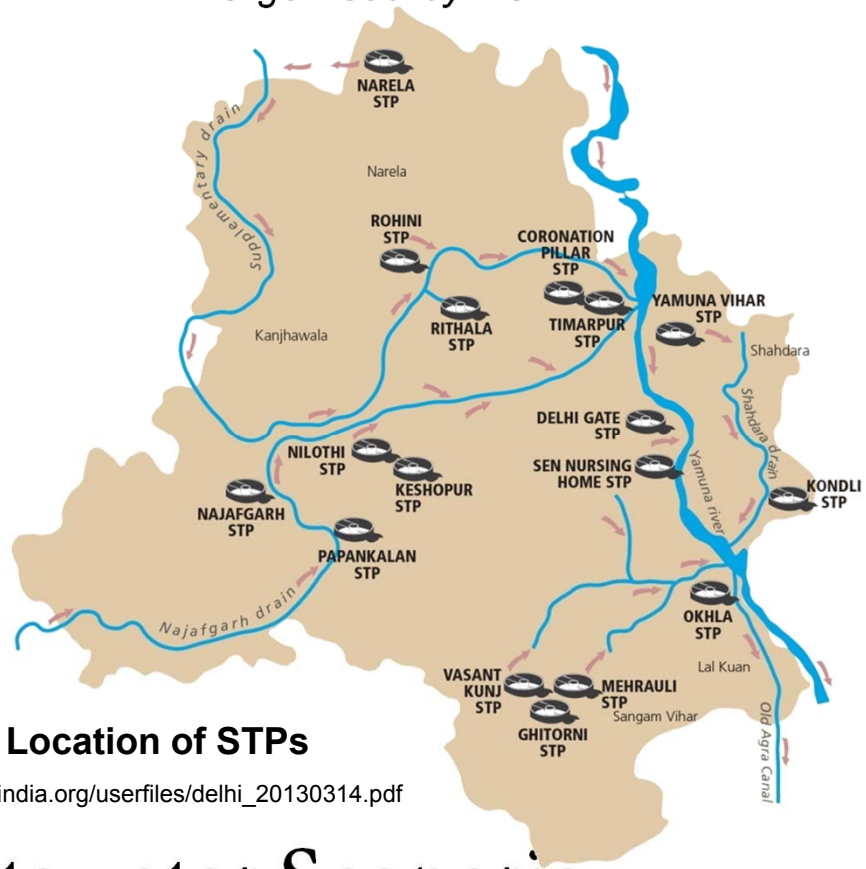
Lower rainfall as well as decrease of water percolation in the soil causes decrease in dilution of saline water.

Ground Water Depletion

	Volume (MGD)
Existing Capacity of STPs	512.4
Proposed Capacity of STPs by 2011	805.4
Projected Waste Generation by 2021	1840

Source: MPD 2021

Monetary cost of treatment of wastewater of Delhi is very high- *As highlighted in a recent workshop organised by DJB*



Location of STPs

http://www.cseindia.org/userfiles/delhi_20130314.pdf

Sewerage treatment Plant in Delhi

Disposal In River Yamuna

Broken Sewerage Pipes

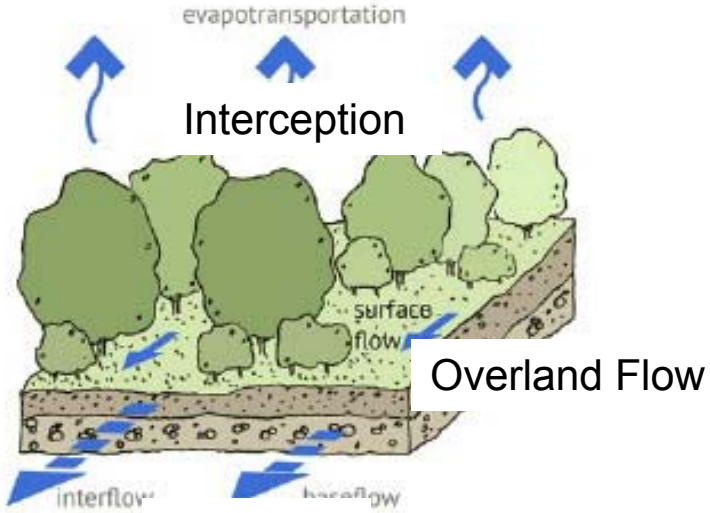
Wastewater Scenario

- Existing Capacity of STPs : 512.4 MGD
- Proposed Capacity of STPs by 2011 : 805.4 MGD
- Projected Waste Generation by 2021: 1840 MGD
- In a recent workshop organised by DJB it was highlighted that monetary cost of treatment of wastewater of Delhi is very high.

Wastewater Scenario in the City

The Cause of the Problem

Pre-development



Rainfall

1. Interception

20-30 %

2. Infiltration

60 %

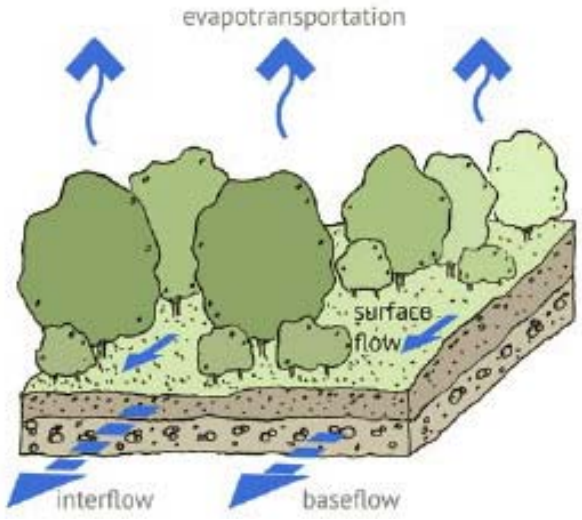
3. Overland-Flow

10-20%

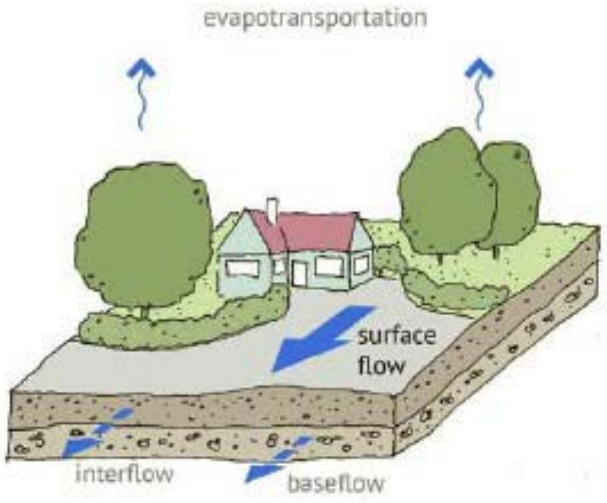
1. Increase in the run-off volume

- Rainfall is disposed off into three ways:
  - Interception
  - Infiltration
  - Overland Flow

Pre-development



Post-development



Rainfall

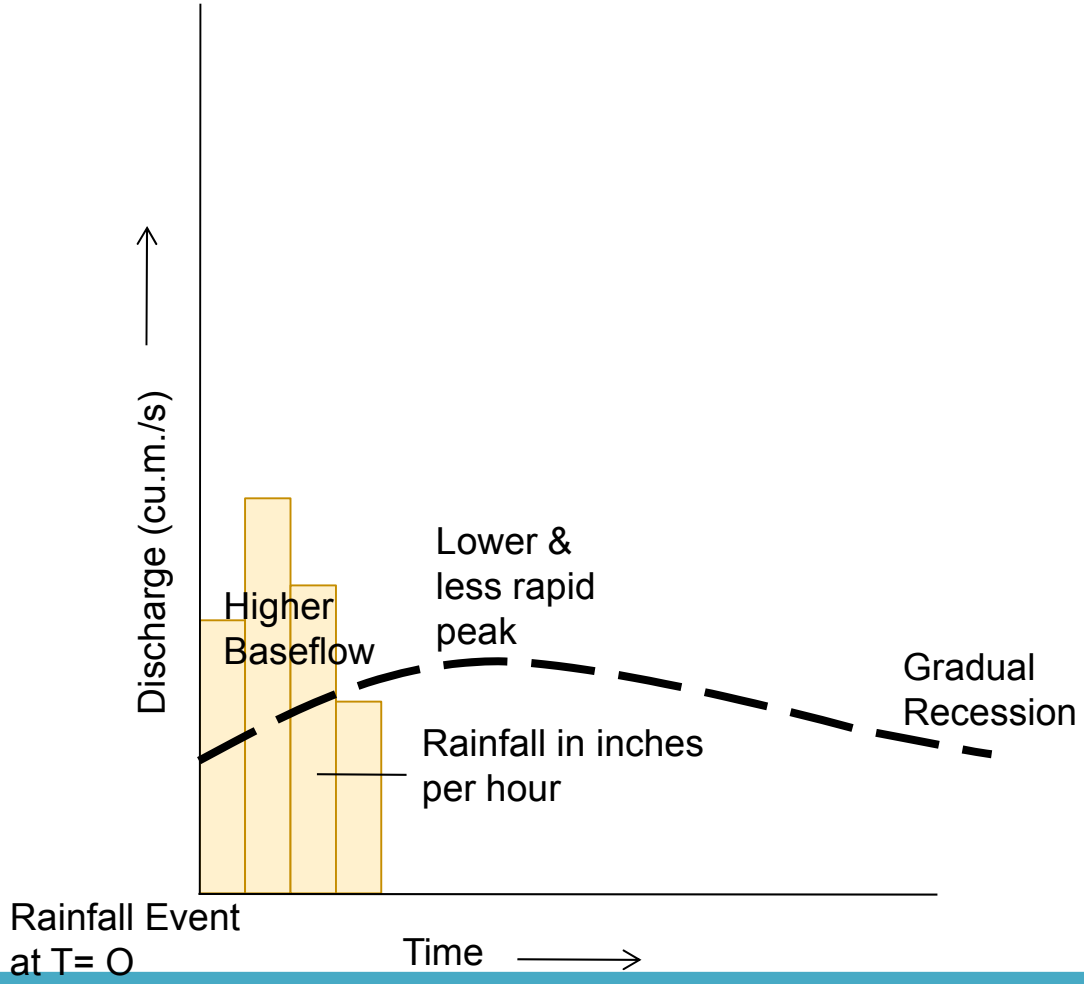
1. Interception
   - 20-30 %
   - 10-20%
2. Infiltration
   - 60 %
   - 10-20%
3. Overland Flow
   - 10-20%
   - 60-80 %

1. Increase in the run-off volume

- Rainfall is disposed off into three ways:
  - Interception
  - Infiltration
  - Overland Flow
- Development of the land changes the coefficient of run-off drastically.

In Delhi, Urban Extension is yet to be developed completely

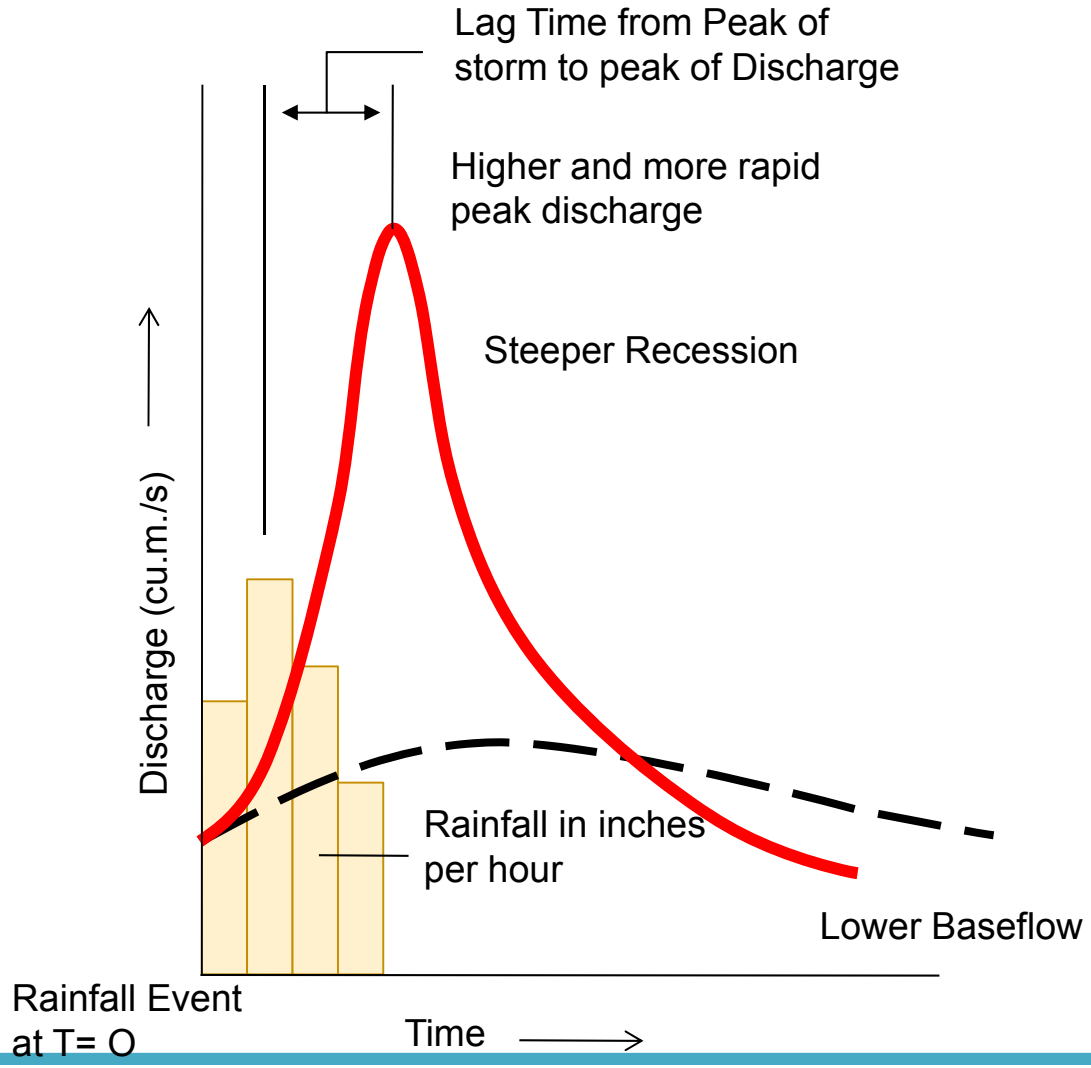
<u>Pre-development</u> – For a particular rainfall event, the hydrograph shows higher baseflow, lower and less rapid peaks, and gradual recession.



1. ***Increase in the run-off volume***
2. ***Faster Systems***

Pre-development – For a particular rainfall event, the hydrograph shows higher baseflow, lower and less rapid peaks, and gradual recession.

Post-development – For the same event, the hydrograph shows higher and more rapid peaks, steeper recession and lower baseflow.

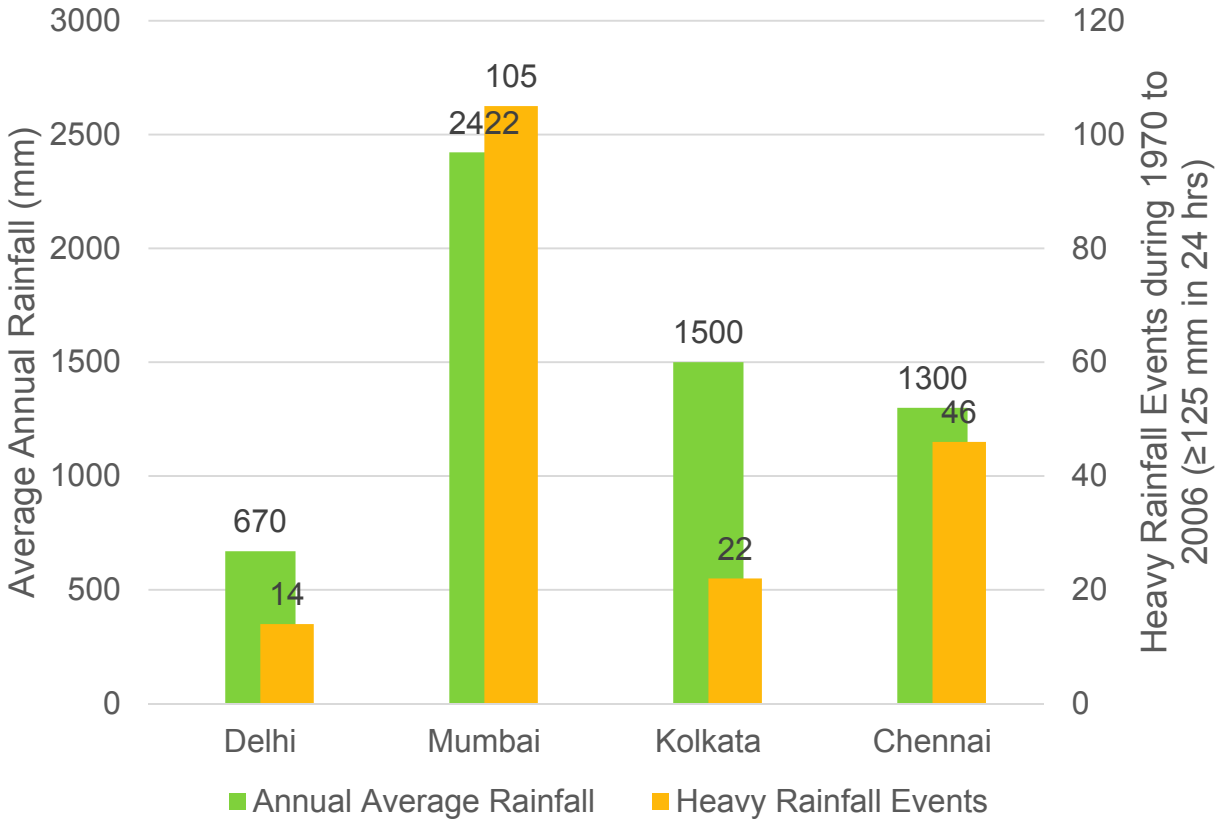


1. ***Increase in the run-off volume***
2. ***Faster Systems***

- The larger volume of runoff demands a more efficient (faster) stormwater removal system.
- Cities are designed with stormsewers.
- This reduce concentration time – 10 fold.
- More water gets to streams much faster and the result is a dramatic increase in magnitude and frequency of peak discharges in these streams

In Delhi, the River Zone and drains are already under a lot of development pressure, reducing its carrying capacity.

- Delhi receives lesser intensity of rainfall than all other metropolitan cities in India. Though the mortality rate is lowest, Airport of Delhi got flooded in just three hours of rainfall (117mm) in 2013.



1. ***Increase in the run-off volume***
2. ***Faster Systems***
3. ***Change in Intensity of Rainfall***

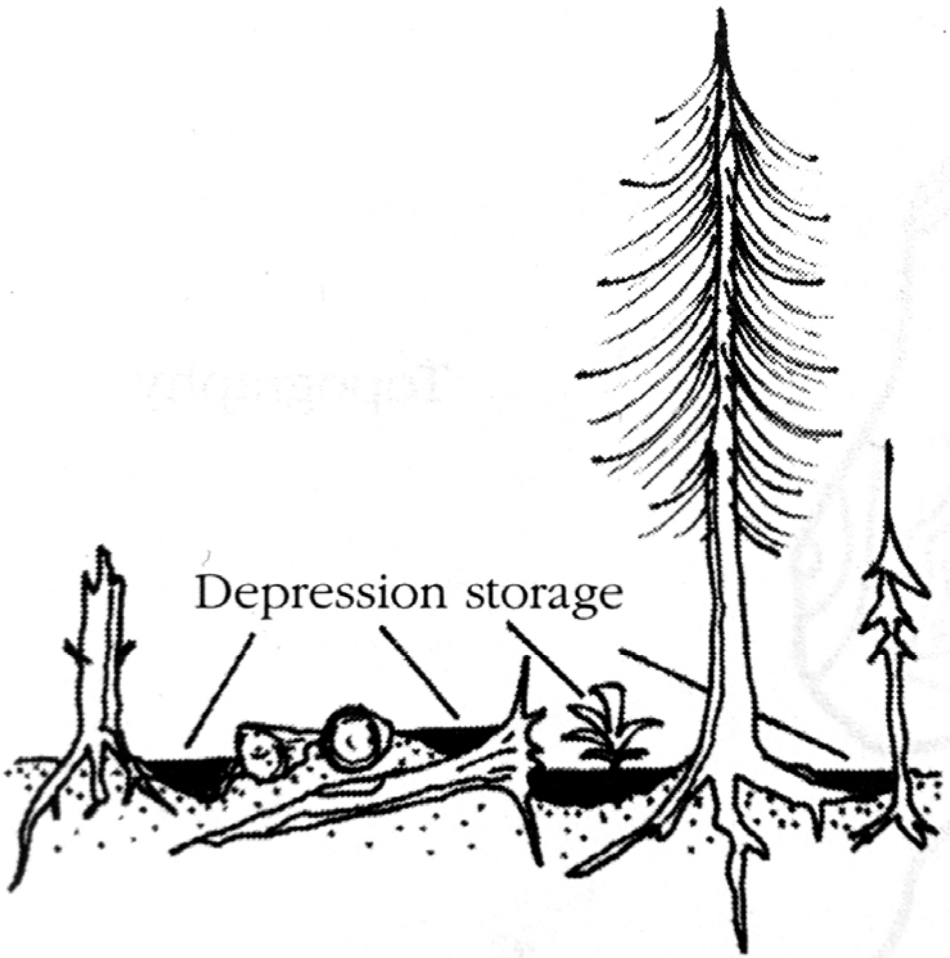
- An unprecedented water amounting to 8.07 lakh cusecs was released during Uttrakhand floods of 2013, which increased water levels in River Yamuna way above danger mark. Fortunately, Delhi did not receive simultaneous rainfall during this time, which could have easily flooded low lying areas.

- Intensity of rainfall is likely to increase as an outcome of Global Warming and Urban Growth.

"*Himalayan Glaciers are receding at faster rates than any other part of the world as a result of gloral warming. Gangotri Glacier is receding three times faster in past three decades. It would cause catastrophic floods initially followed by droughts*".
Source: Climate Change, the Himalayan Mountains, and ICIMOD
Sustainable Mountain Development Vol.53, Winter 2007

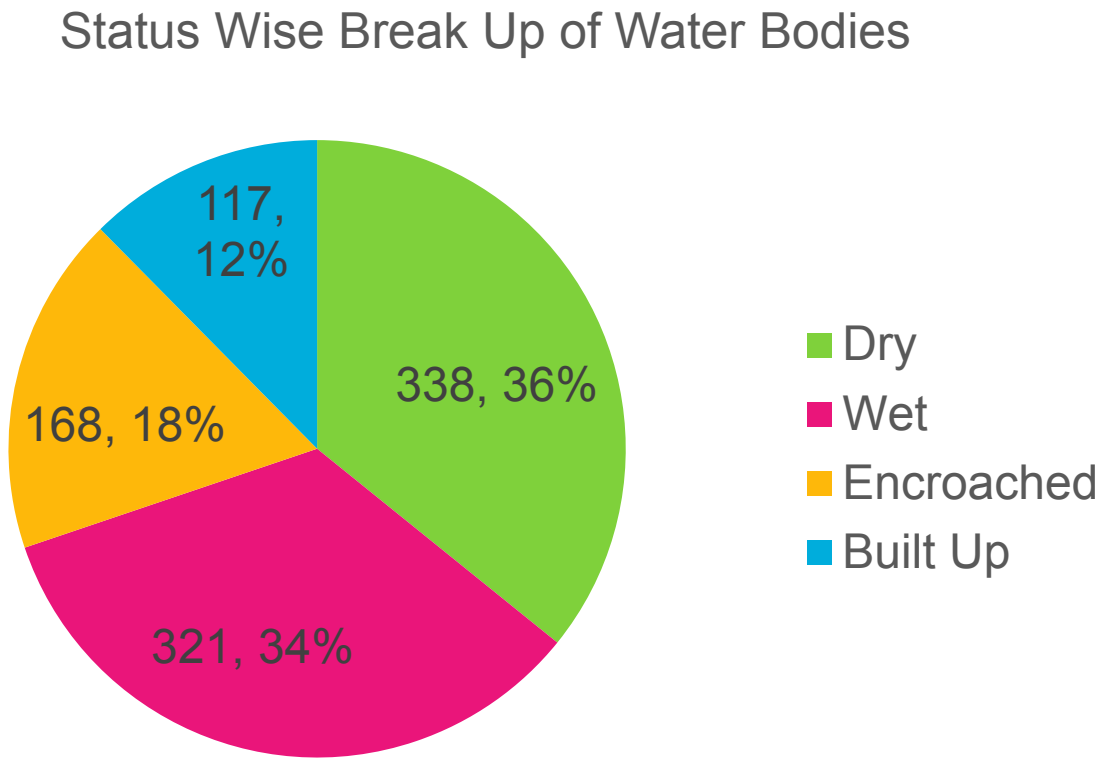
1. ***Increase in the run-off volume***
2. ***Faster Systems***
3. ***Change in Intensity of Rainfall***

Delhi would be witnessing worse flooding in the near future.



1. ***Increase in the run-off volume***
2. ***Faster Systems***
3. ***Change in Intensity of Rainfall***
4. ***Loss of Depression Storage/water bodies***

- Depression Storage retains the rainwater and overland flow in low spots in the microtopogaphy.
- An entire rainstorm can be held in these storages.
- After Development, land is graded smoothly for providing efficient drainage to such activities

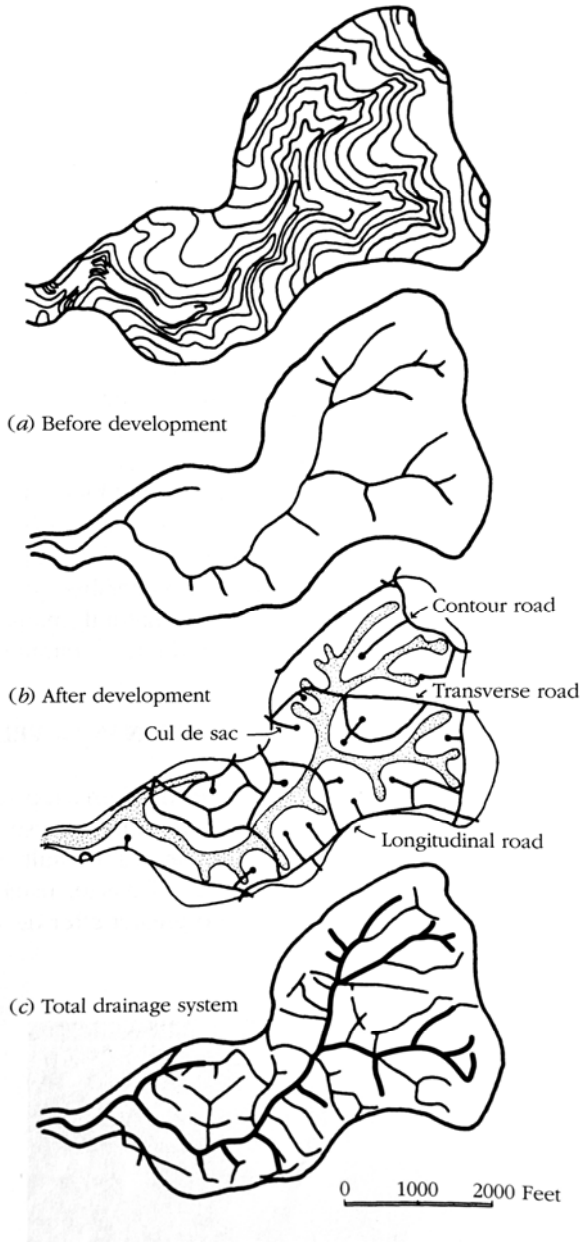


Source: Water Bodies in NCT of Delhi - Status, Problems and Rejuvenation
Delhi Parks and Garden Society

Many water bodies and depression storages which are non-engineered and natural systems of storing stormwater have been lost to development pressures

1. ***Increase in the run-off volume***
2. ***Faster Systems***
3. ***Change in Intensity of Rainfall***
4. ***Loss of Depression Storage/water bodies***

- Depression Storage retains the rainwater and overland flow in low spots in the microtopogaphy.
- An entire rainstorm can be held in these storages.
- After Development, land is graded smoothly for providing efficient drainage to such activities
- Lost of water bodies have added to this issue.



Topography

Natural drainage network

Road system

Composite drainage network (natural channels plus stormdrains)

Example: Austin, Texas

- The pattern of natural channels & roads (with stormdrains) before & after development
- Roads with curbs, gutters, & stormsewers are grafted onto the natural system of stream channels, more than doubling the drainage density.
- The increase in drainage density drives up both the magnitude & frequency of stormflows.

Delhi designed with same type of drainage network along roads also increase the magnitude and frequency of stormflows during monsoons.

1. ***Increase in the run-off volume***
2. ***Faster Systems***
3. ***Change in Intensity of Rainfall***
4. ***Loss of Depression Storage/water bodies***
5. ***Effective Impervious Cover***

- Roads are designed with paralleling drains to carry stormwater.
- These are further connected to streams
- As road network intensifies, drainage density also increases which drives up magnitude and frequency of stormflows.

- **All these development practices, which were initiated to provide efficient drainage, rather eliminates the natural mitigating effects of a landscape on overland flow.**

- **Hence, conventional drainage systems designed in cities, as in Delhi also, intensify the problem.**
  ??

- **Attempts are then made to strengthen the conventional drainage network which have its own financial, land and practical limitations.**

1. ***Increase in the run-off volume***
2. ***Faster Systems***
3. ***Change in Intensity of Rainfall***
4. ***Loss of Depression Storage/water bodies***
5. ***Effective Impervious Cover***

Conclusions

- **All these development practices, which were initiated to provide efficient drainage, rather eliminates the natural mitigating effects of a landscape on overland flow.**

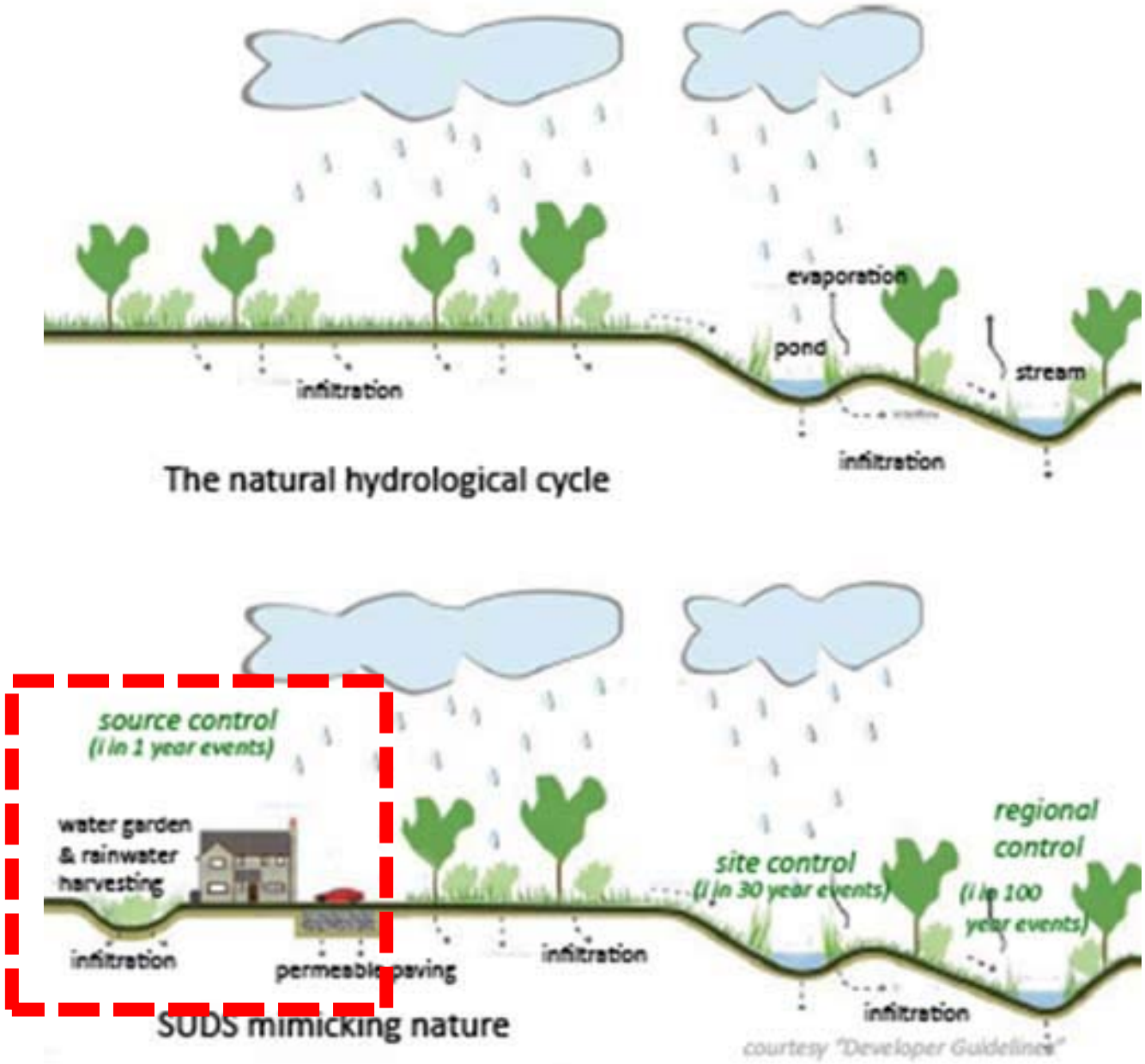
- **Hence, conventional drainage systems designed in cities, as in Delhi also, intensify the problem.**

- **Attempts are then made to strengthen the conventional drainage network which have its own financial, land and practical limitations.**

1. ***Increase in the run-off volume***
2. ***Faster Systems***
3. ***Change in Intensity of Rainfall***

The Solution…

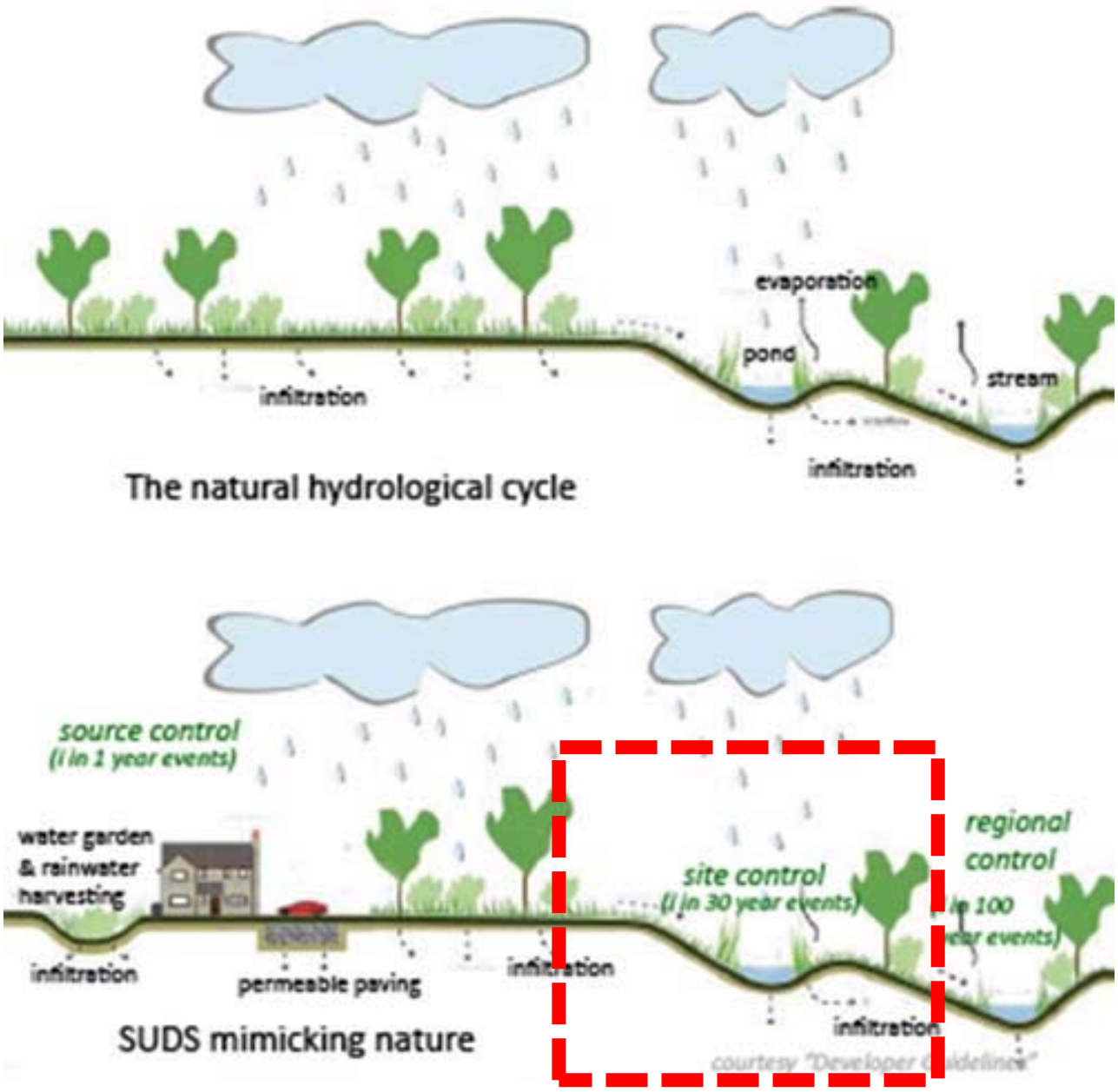
1. Plan the development so that it *produces little or no increase* in stormwater discharge (by using pervious pavements, etc.)



Mimic the Natural Hydrological Cycle

1. Plan the development so that it *produces little or no increase* in stormwater discharge (by using pervious pavements, etc.)

2. *Return* excess water to the ground, where it would have gone before development (by using infiltration trenches, etc.)

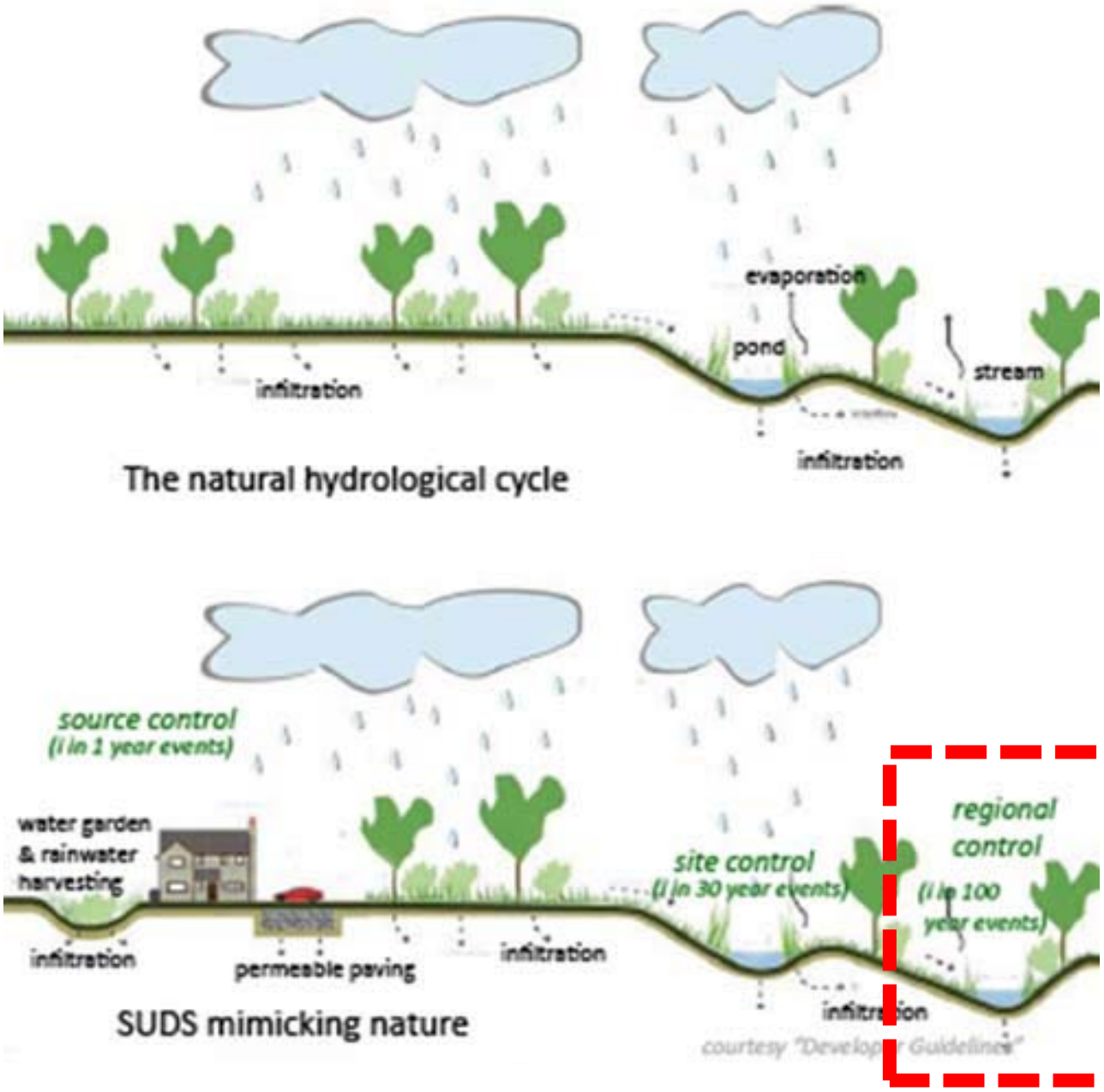


Mimic the Natural Hydrological Cycle

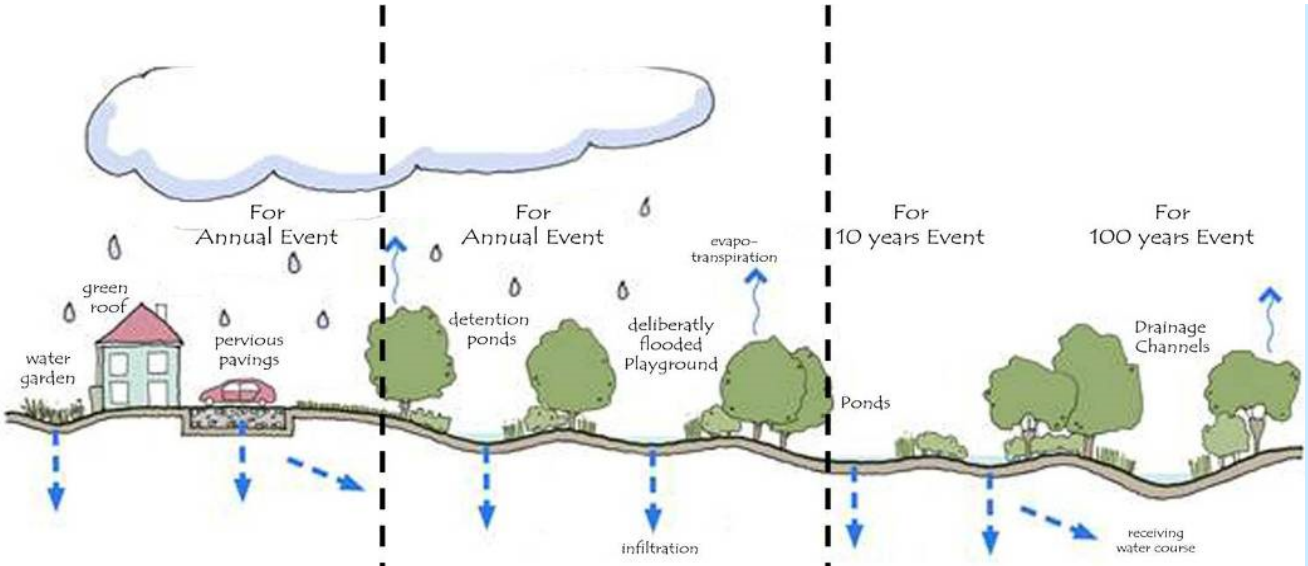
1. Plan the development so that it *produces little or no increase* in stormwater discharge (by using pervious pavements, etc.)

2. *Return* excess water to the ground, where it would have gone before development (by using infiltration trenches, etc.)

3. *Store* the excess water on or near the site, releasing it slowly over a period of time beyond the duration of the runoff event. (by using detention basisn, etc.)



Mimic the Natural Hydrological Cycle



Source Control

Control of runoff at or very near its source (e.g. Soakways, other infiltration methods, green roofs, pervious pavements).

Site Control

Management of water in a local area (e.g. Routing water from building roofs, and car parks to large soakways, infiltration or detention basin).

Regional Control

Management of run-off from several sites (e.g.balancing pond or wetland).

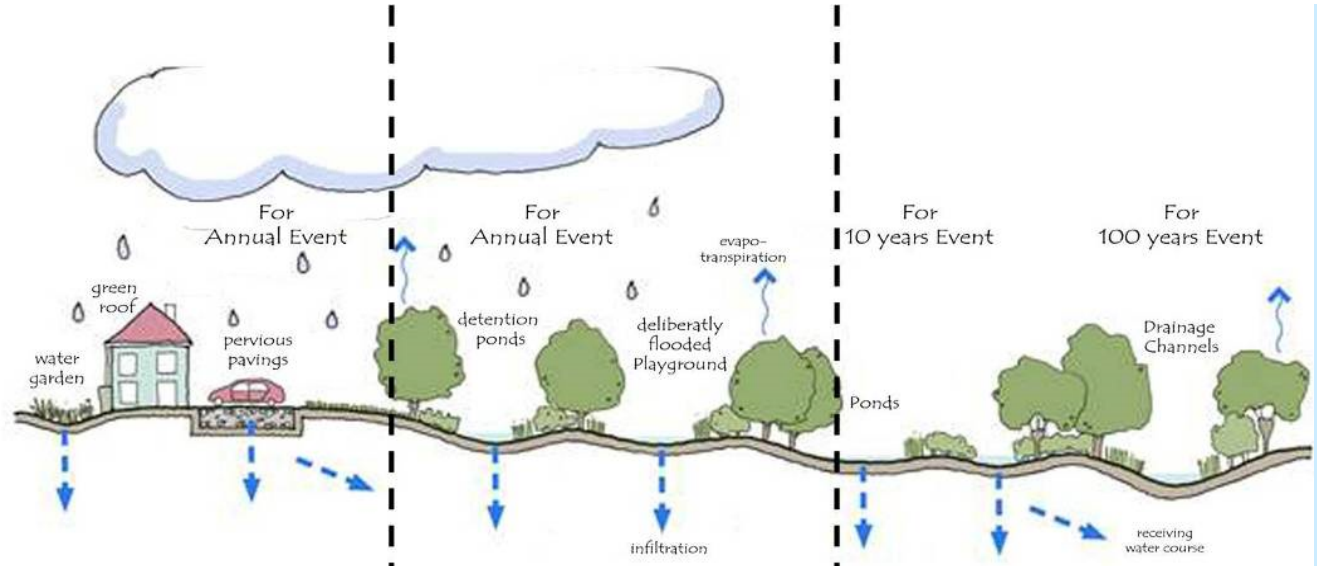
a) Source Control:

- For control of runoff at or very near its source
- For annual storm events
- Largely at building level – designed for Zero run-off discharge.
- E.g. Pervious Pavements, green roofs

Delhi: Larger buildings in developed areas, & all buildings & roads in urban extension areas should be designed on zero-run off discharge which reduces the post-development runoff volume to pre-development run-off.

Sustainable Urban Drainage Systems, SUDS

Stormwater Management Train



Source Control

Control of runoff at or very near its source (e.g. Soakways, other infiltration methods, green roofs, pervious pavements).

Site Control

Management of water in a local area (e.g. Routing water from building roofs, and car parks to large soakways, infiltration or detention basin).

Regional Control

Management of run-off from several sites (e.g.balancing pond or wetland).

a) **Source Control:**

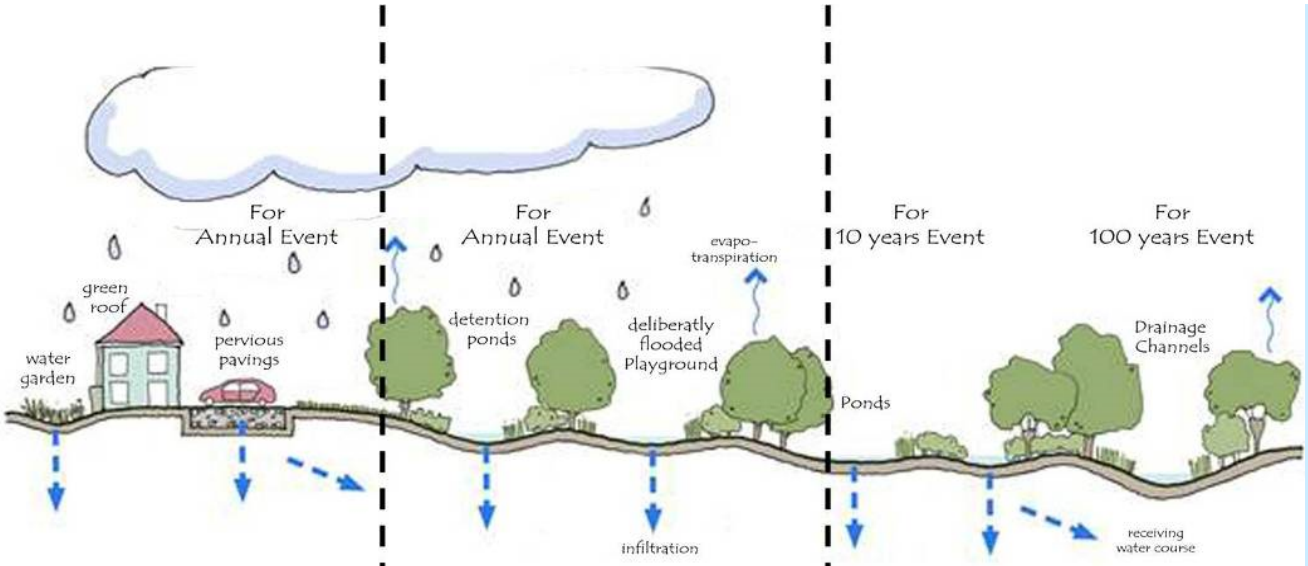
b) **Site Control:**

- Management of water in a local area
- For annual storm / 10 year storm events
- At nearby parks, traffic islands, etc.
- E.g. Infiltration basins, Detention Basins

Delhi: Storm water from roadside drains can be diverted to and stored in Community Parks, Neighborhood Parks, incidental greens and traffic islands.

Sustainable Urban Drainage Systems, SUDS

Stormwater Management Train



Source Control

Control of runoff at or very near its source (e.g. Soakways, other infiltration methods, green roofs, pervious pavements).

Site Control

Management of water in a local area (e.g. Routing water from building roofs, and car parks to large soakways, infiltration or detention basin).

Regional Control

Management of run-off from several sites (e.g.balancing pond or wetland).

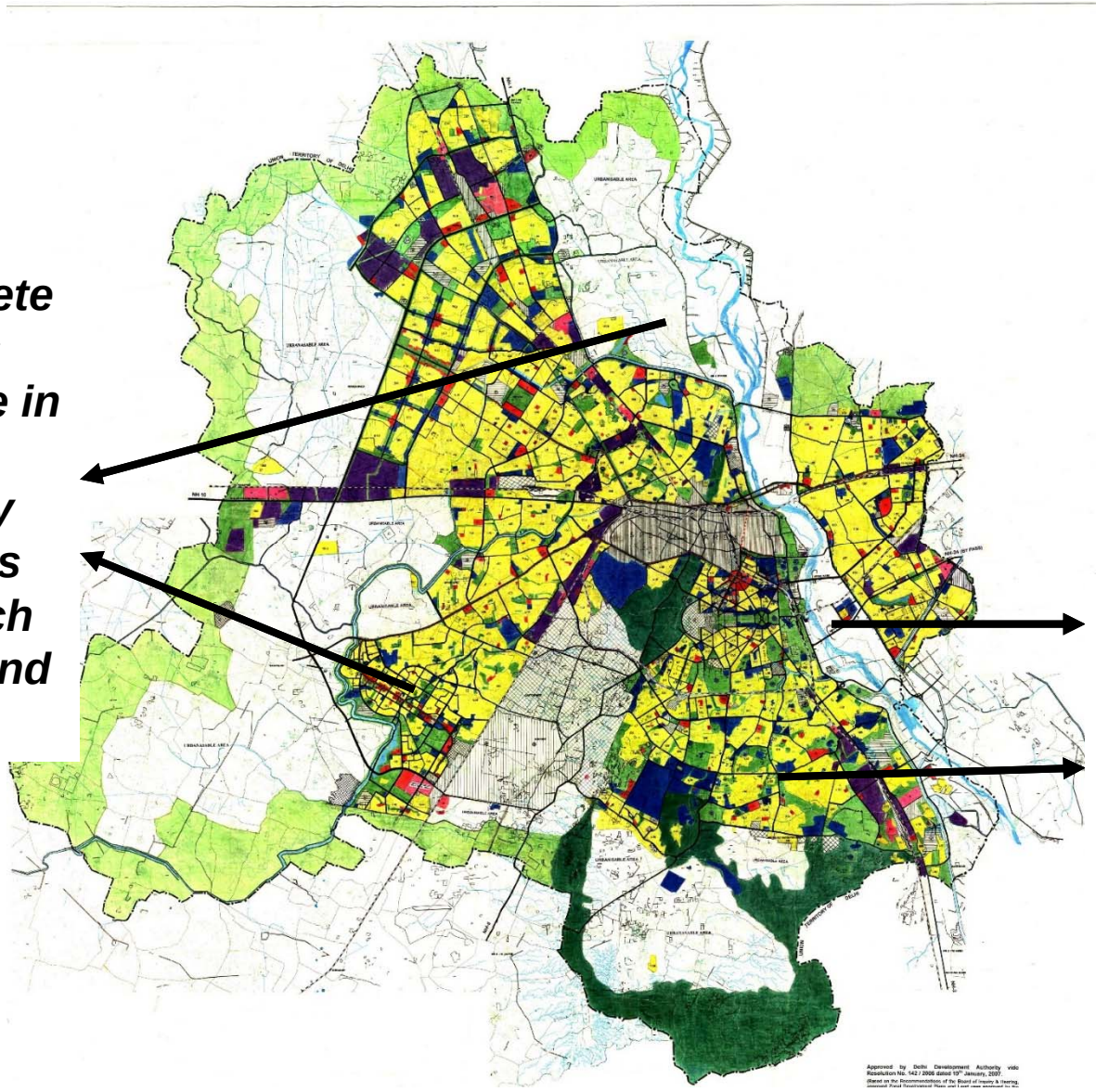
a) **Source Control:**
b) **Site Control:**
c) **Regional Control:**
   - Management of run-off from several sites
   - For larger/100 year storm events
   - Larger Parks, Floodplains, Stream corridors.
   - E.g. Wetlands, balancing ponds

Delhi: Larger Parks like District Park and above can be used for the same.
Along the banks of the major drains, e.g. Supplementary Drain, smaller basins could be created. On the floodplains, store water through basins, ponds, wetlands.

Sustainable Urban Drainage Systems, SUDS

Stormwater Management Train

Detention/Retention basins can be made in areas where soil is clayey or flooding is an issue such as Dwarka and North Delhi



Infiltration basins can be made in areas where ground water is depleting at higher rate & soil is pervious. Such as South Delhi and Zone O

Tentative location of these Basins in Delhi

Source Control

Pervious Surfaces
Green Roofs
Living Walls
Bioretention Areas
Filter Strips
Swales

Site Control

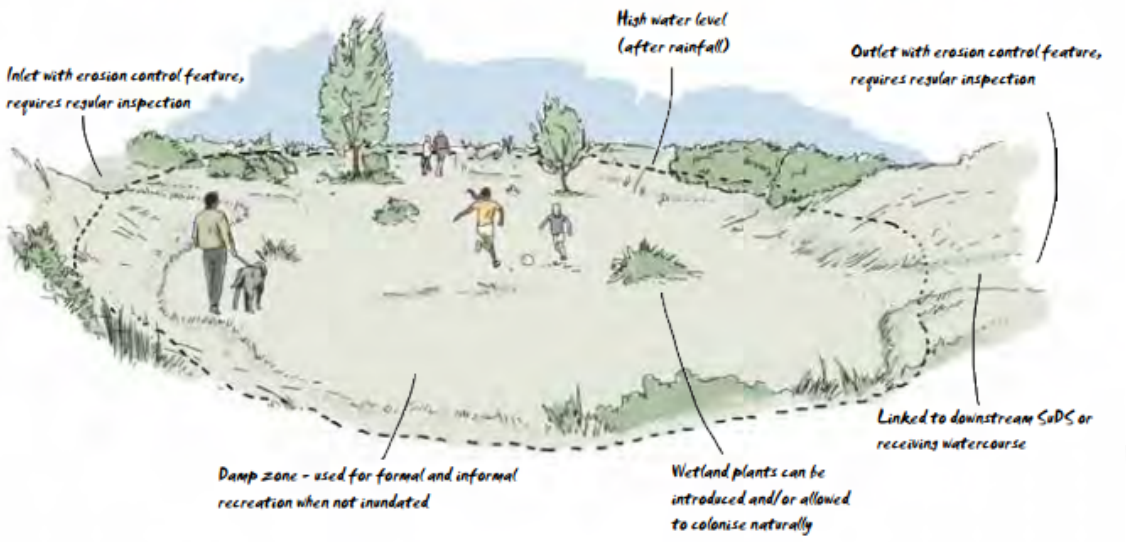
Infiltration Basins
Detention Basins

Regional Control

Retention Basins
Contructed Wetlands
Balancing Ponds
Wetlands

Types of SUDS

Figure 12 Detention basin showing multi-functional use of space.



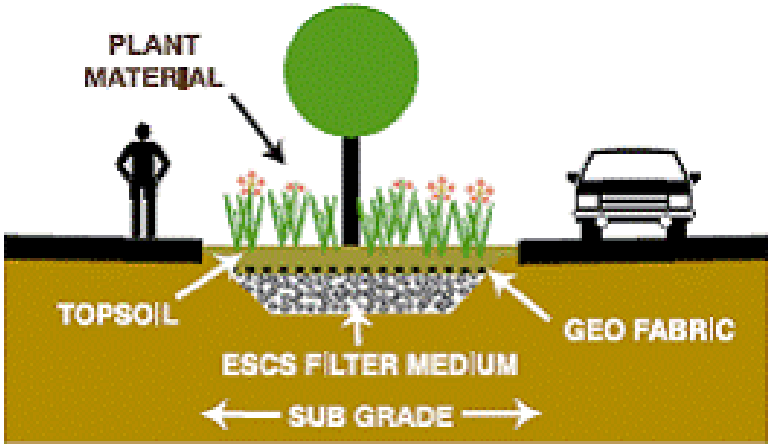
Detention basin

- An open basin built by excavating below ground or constructing above-ground berms or embankments.
- Temporarily stores storm water runoff and slowly releases it through a designed outlet.

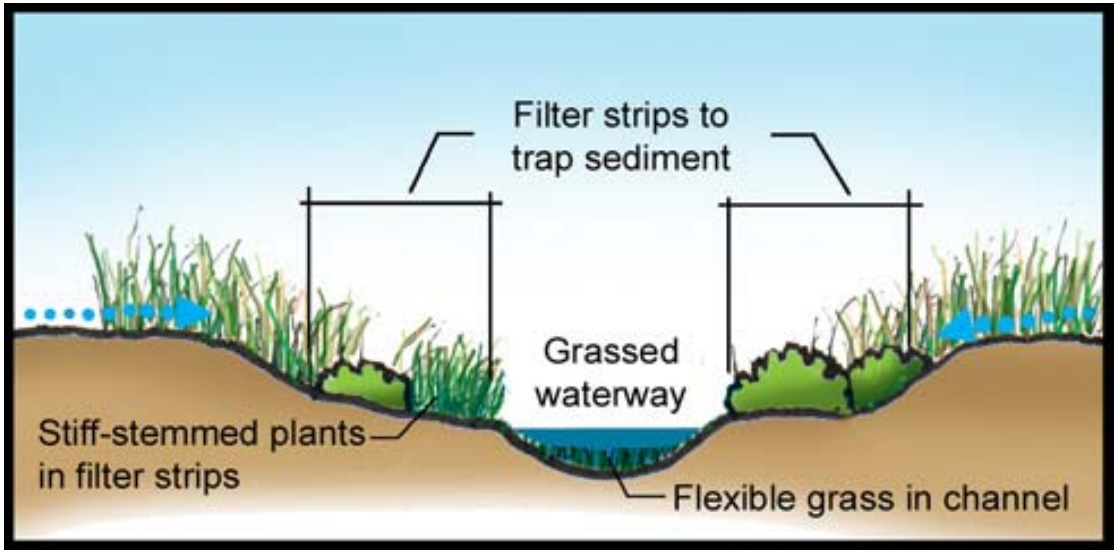
- An artificial lake with vegetation around the perimeter, and includes a permanent pool of water in its design
- Wet ponds are frequently used for water quality improvement, groun dwater recharge, flood protection, aesthetic improvement.

Retention Basin

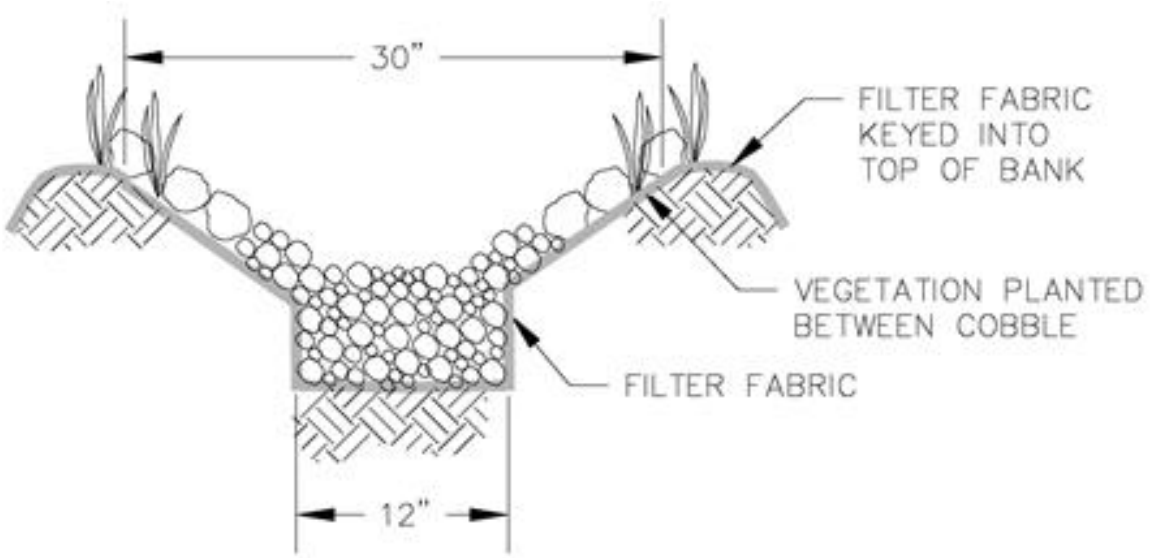
Filter Strips



Cross Section of Filter Strip



- These are wide, gently sloping areas of grass or other dense vegetation that treat runoff from adjacent impermeable areas
- Can be designed along Roads (in green buffers), parking lots and along drains.



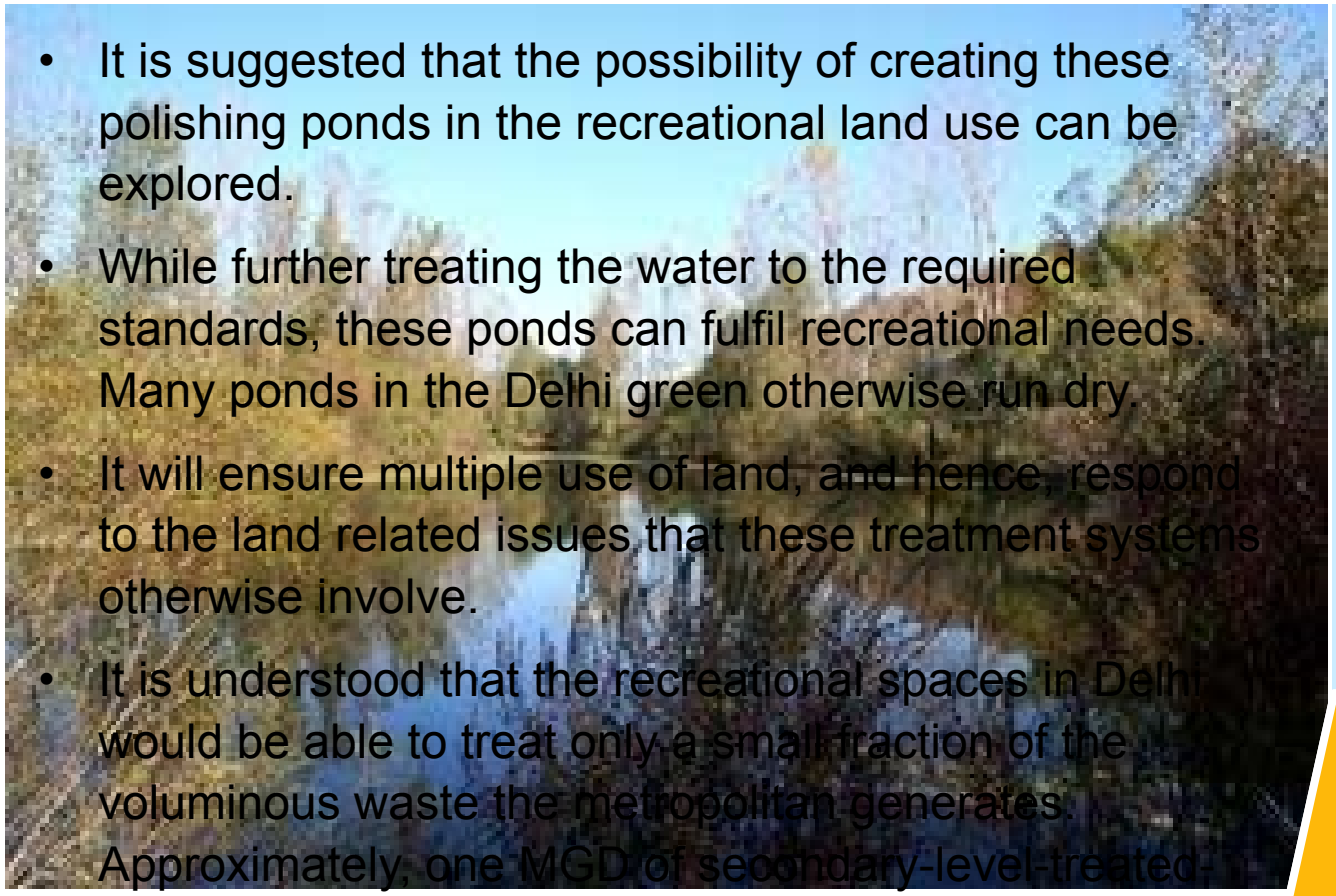
- Swales are broad, shallow channels covered by grass or other suitable vegetation.
- They are designed to convey and/or store runoff, and can infiltrate the water into the ground (if ground conditions allow).
- Can be designed along roads (in Green buffers), parking lots and along drains.

Swales

- Maturation Ponds / Polishing Ponds / Enhancement Ponds: Constructed wetlands which provide advanced treatment to wastewater that has been pre-treated to secondary levels, and also provide other benefits such as wildlife habitat, research laboratories, or recreational uses

- Ecological treatment of sewage water (through constructed wetlands) is a cost effective option which also require lesser maintenance, offer good performance, provide natural appearance, and several other ecological benefits.
- However, they require large land area and hence are considered to be inappropriate for metropolitan cities where land is expensive and development pressures on land are usually very high.

Wastewater Treatment: Polishing Ponds

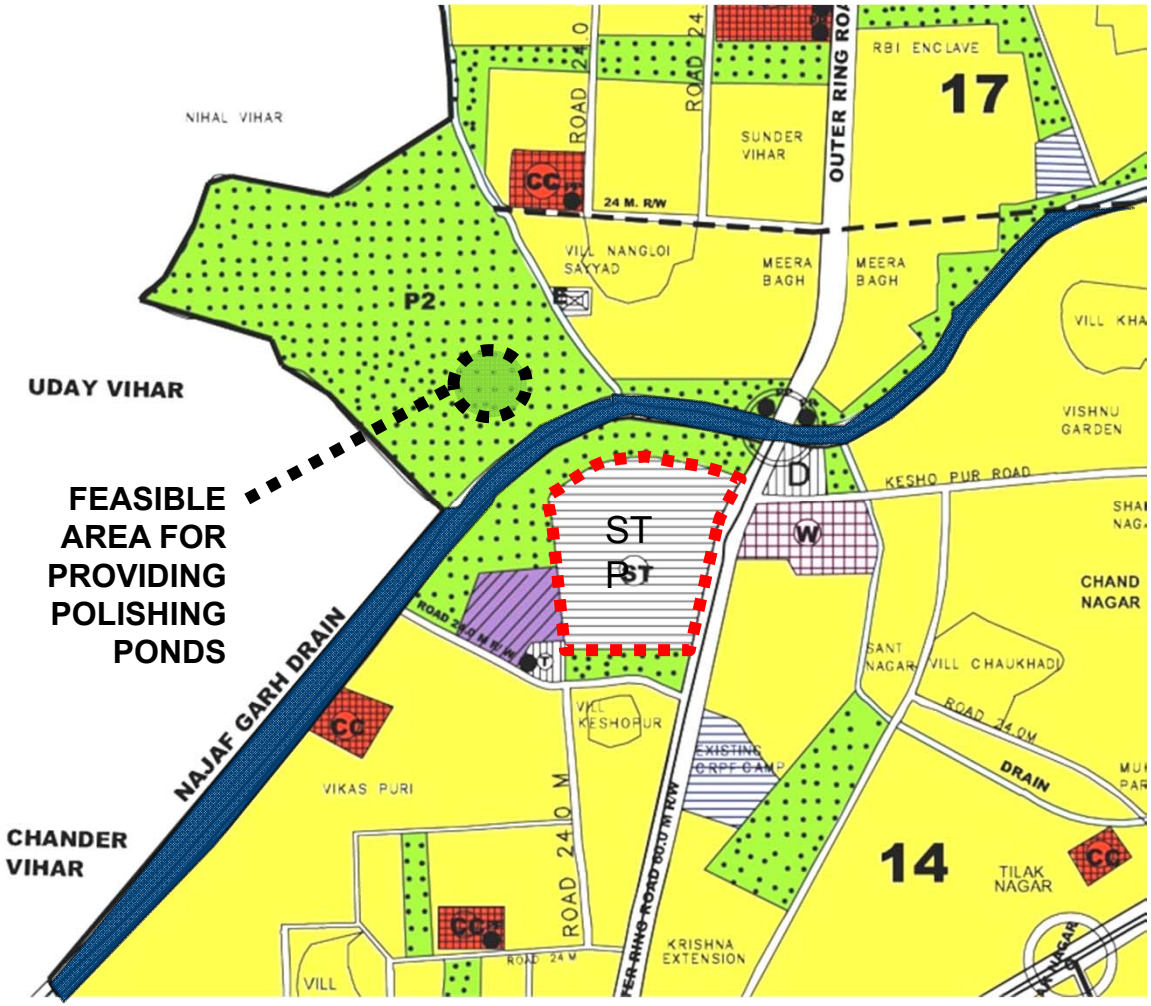


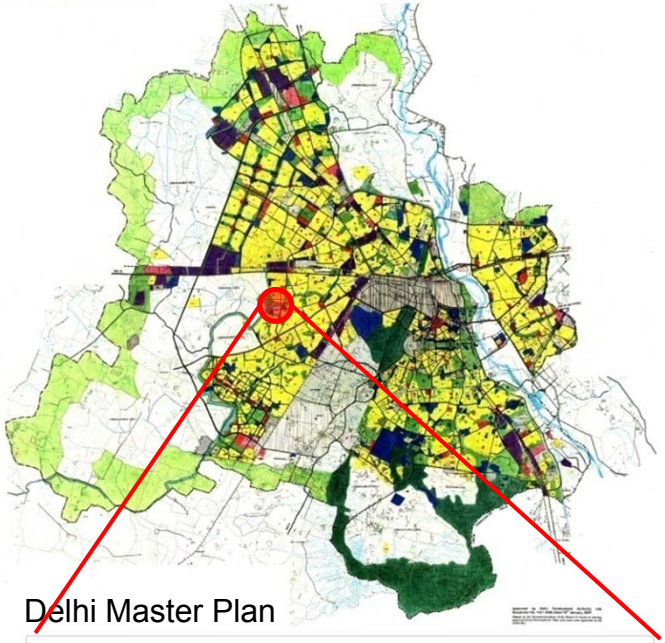
- It is suggested that the possibility of creating these polishing ponds in the recreational land use can be explored.
- While further treating the water to the required standards, these ponds can fulfil recreational needs. Many ponds in the Delhi green otherwise run dry.
- It will ensure multiple use of land, and hence, respond to the land related issues that these treatment systems otherwise involve.
- It is understood that the recreational spaces in Delhi would be able to treat only a small fraction of the voluminous waste the metropolitan generates. Approximately, one MGD of secondary-level-treated waste water might require 1 to 3 Ha of land.
- In a recent workshop organised by DJB it was highlighted that monetary cost of treatment of wastewater of Delhi is very high. Involving polishing ponds to provide tertiary level treatment of water in recreational parks might provide some relief to this monetary issue, though small.

- Maturation Ponds / Polishing Ponds / Enhancement Ponds: Constructed wetlands which provide advanced treatment to wastewater that has been pre-treated to secondary levels, and also provide other benefits such as wildlife habitat, research laboratories, or recreational uses

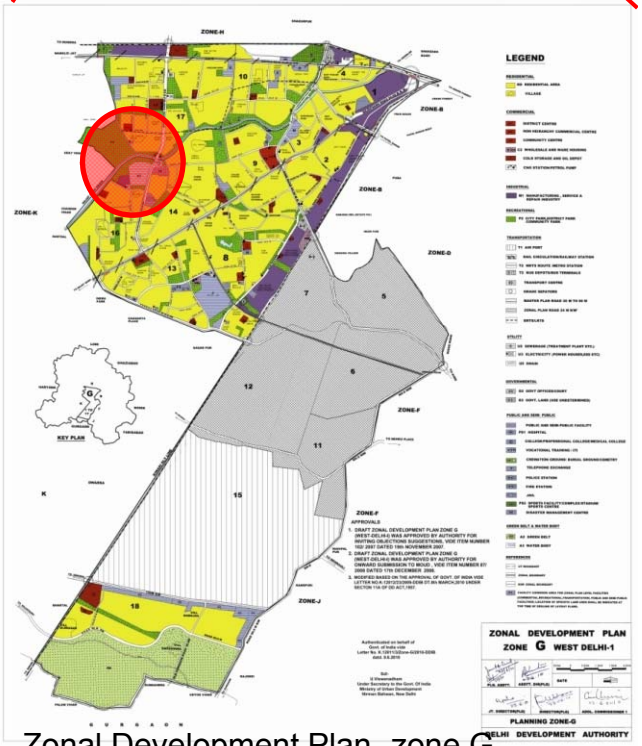
Larger parks (district parks and city parks) which are nearer to the STPs, can be designed with polishing ponds/maturation ponds/enhancement ponds which takes treated water from the nearby STP

Wastewater Treatment: Polishing Ponds





Delhi Master Plan

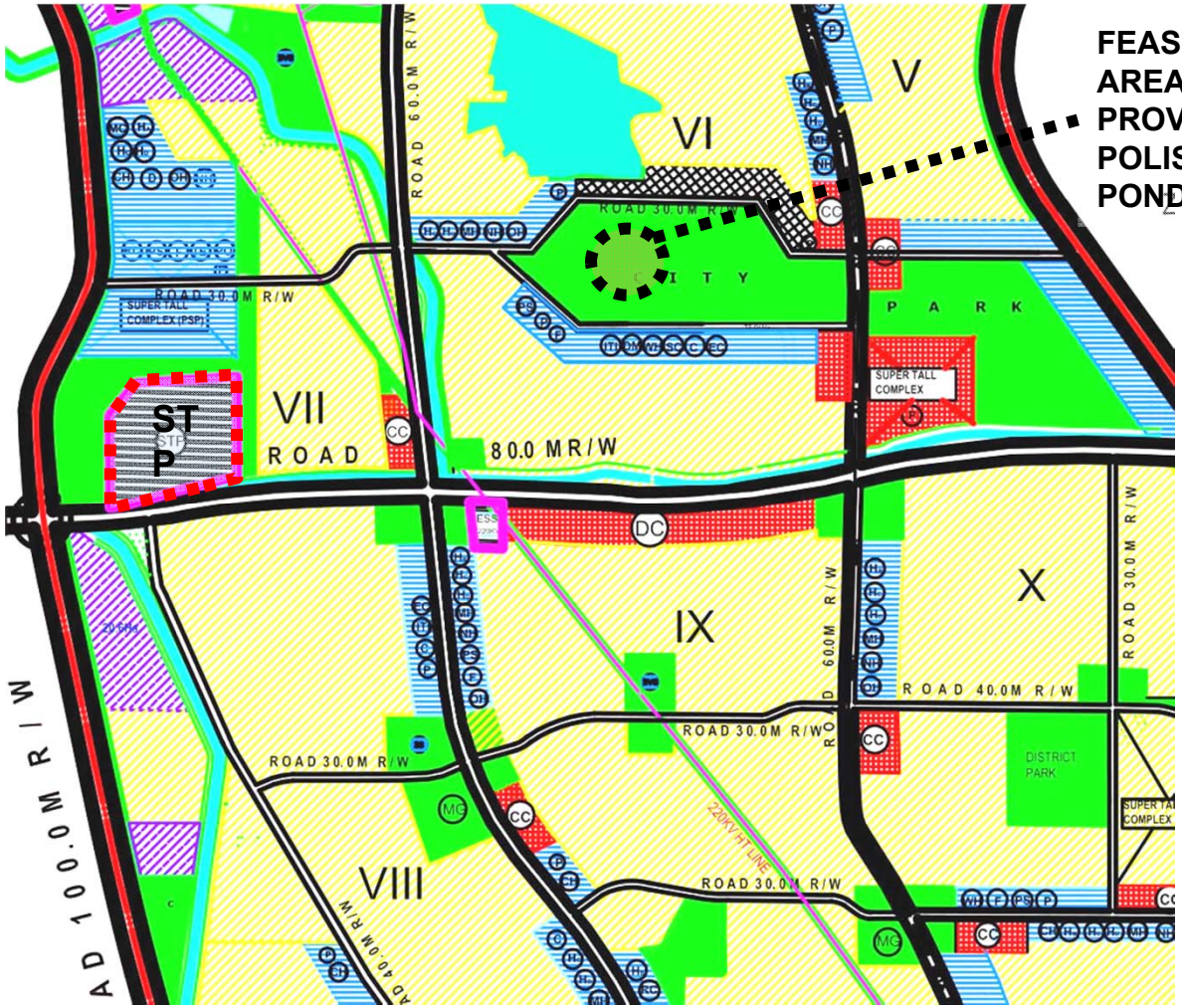


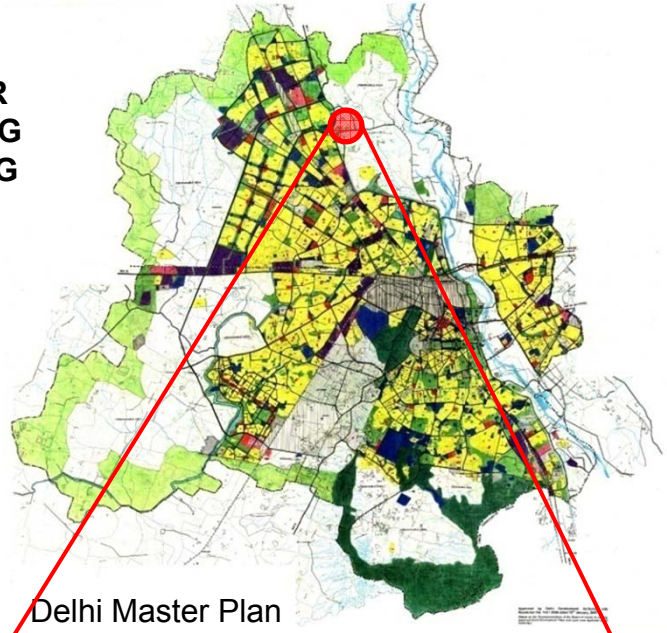
Zonal Development Plan- zone G

Feasible area for providing polishing ponds near STP Keshopur :

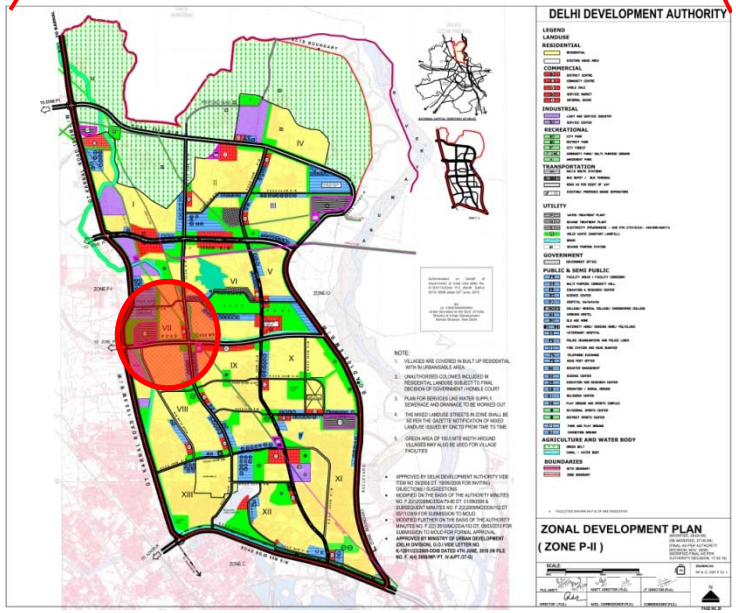
- Green area at Mango Orchard, Nangloi

Tentative Examples





Delhi Master Plan

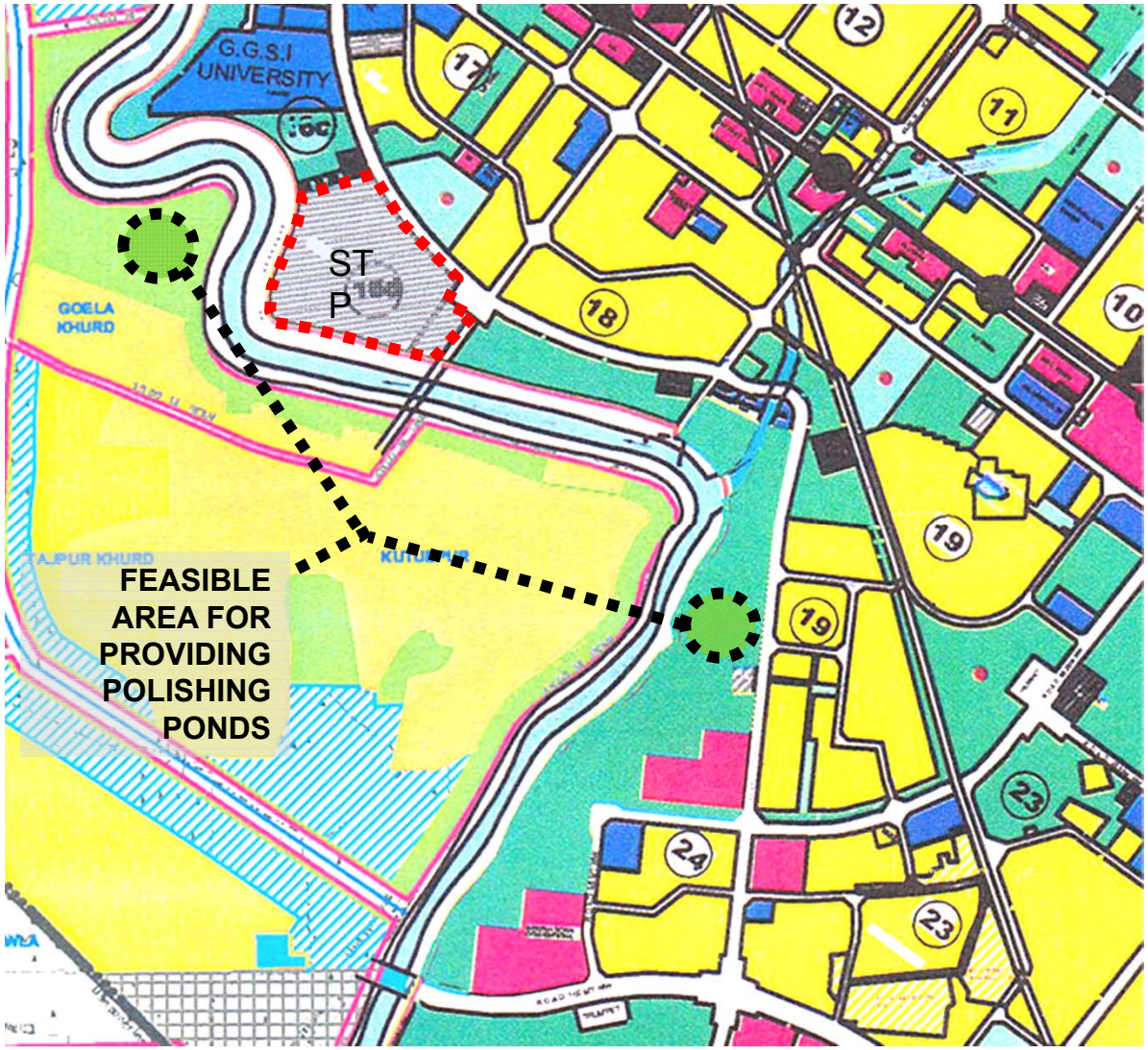


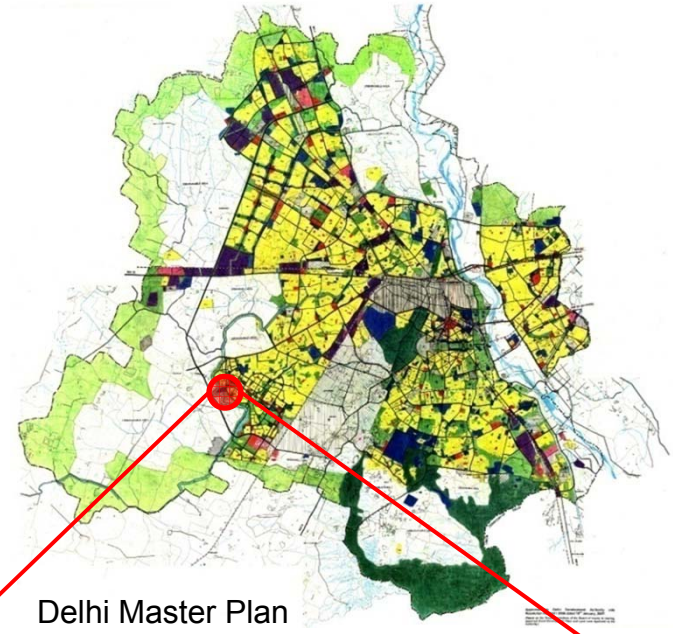
Zonal Development Plan- Zone P-II

Feasible area for providing polishing ponds near STP Narela:

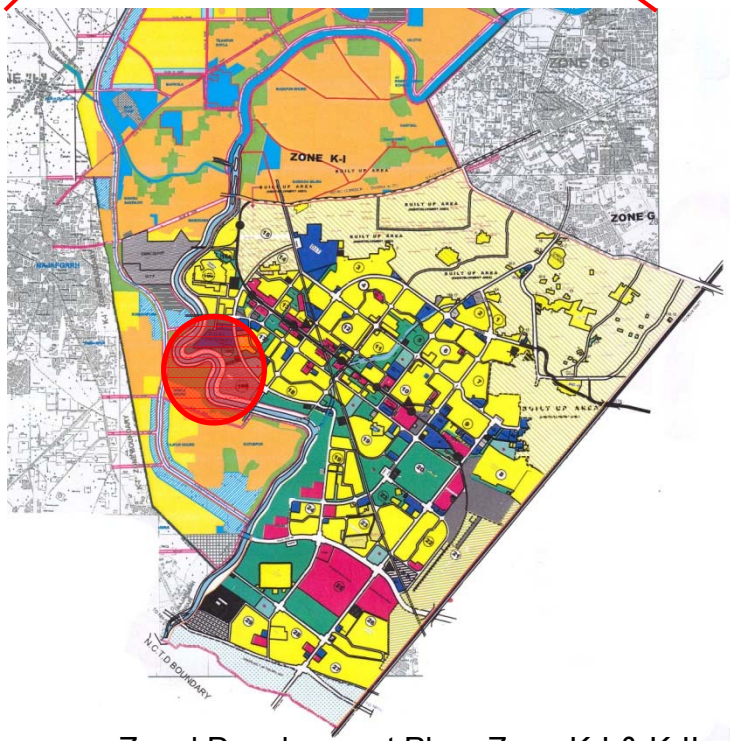
- City Park of the Zone

Tentative Examples





Delhi Master Plan



Zonal Development Plan- Zone K-I & K-II

Feasible area for providing polishing ponds near STP Papankalan:

- Green area Across the STP in Zone K-I

- Green belt along Najafgarh Drain

Tentative Examples

International Case Examples

- Based on **principles of Low Impact Development** with an extensive system of managing their storm water, wherein buildings require permits from different Bureaus. These have:
- Storm water hierarchical system which dictates the kind of storm water management system a property needs to follow (with respect to infiltration, detention & discharge).
- **All buildings above 50 sq.m. require permits.**
- Roads are supposed to cater their own waste water
- Shared properties to manage excess of storm water discharged.
- The city has a elaborate **storm water manual** which specifies the facilities to be designed to achieve the goal & **the entire procedure of taking storm water management permits.**

Restored buffer in an urban setting

Bioretention areas filter polluted road run-off, provide urban wildlife habitat and reduce local flooding

A cistern intercepting downpipe on large residential building discharging via a pipe into the raingarden

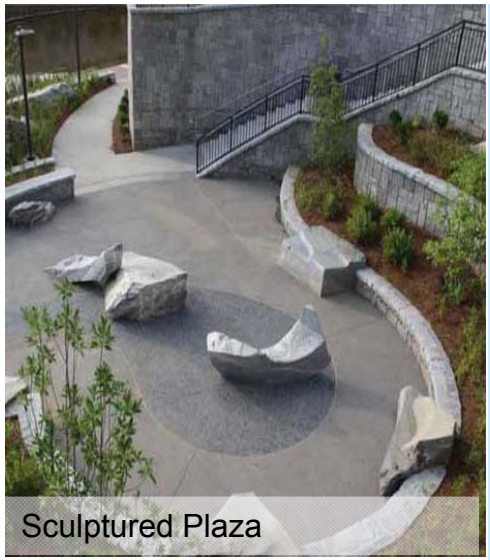
The lake is aesthetically pleasing, but functions as a storm water detention pond to ease capacity problems in the overall 800 acre drainage basin, while reducing the peak flow of the Highland Avenue combined sewer trunk to which it discharges.

At the pond's edge is a roomy amphitheatre cushioned with Bermuda grass. An aerator fountain keeps the detention pond from stagnating.

- Case Study: Atlanta's Historic Fourth Ward Park
- Area: 17-acre
- Flood protection and stormwater overflow solutions are disguised through artistic park features "celebrating" water.

Detention Basins

Splash pad, produce light mists small directional water streams to reduce and control water flow



Sculptured Plaza

Skate Park,

Distinct artistic features on sides of pond to facilitate flow of storm water, curved stones serve as nonconventional seating.

Play ground with rubber safety surfacing

Detention Basins

- Case Study: Atlanta's Historic Fourth Ward Park
- Area: 17-acre
- Flood protection and stormwater overflow solutions are disguised through artistic park features "celebrating" water.
- Additional park amenities: flowing walkways and a city greensward; a splash pad and playground; a recirculating stream and wildflower meadows; a multipurpose recreation field and Atlanta's first skate park.

Detention Culverts and Surface drainage System Freiburg, Germany

Completed portion of Brays Bayou Arthur Storey Park Storm Water detention Basin, near W. Sam Houston Tollway

Soccer Field placed at bottom of Detention Basin Rosewood Park, Georgetown, Washington

Redfern Park, Minto, Australia

Santa Barbara Golf Course Detention System

Detention Basins

Integrated retention ponds.

Rainwater managed above ground by a relatively simple network of channels, retention basins, ponds & waterfalls.

Creatively design storm water collection system

A small Retention pond tucked into one of the green spaces within the housing development

- Case Study: Bo01, Malmo, Western Harbor. : An ecologically sustainable welfare society
- Area- 25 hectares
- 600 housing units for about 1000 residents.
- All the residential units designed as part of a single integrated system of water and resource management.
- The rainwater is managed above ground by a relatively simple network of channels, retention basins, ponds & waterfalls.

Retention Pond

Retention Ponds at Augustenborg, Malmo

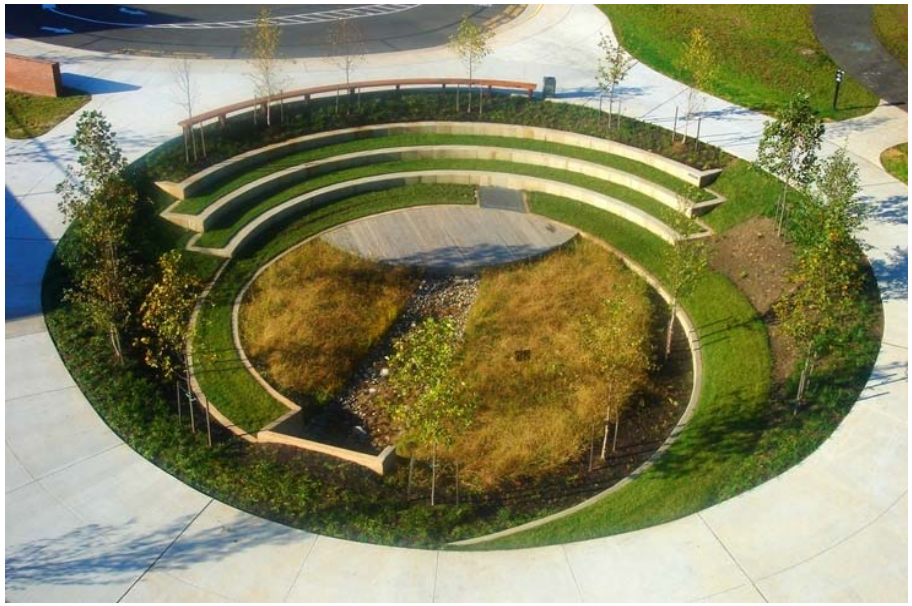
Retention Pond against the buildings in Tewkesbury, England (University of Abertay)

Milton Keynes – a retention pond featuring recently-managed reedbed. Photo: John Day (rspb)

Retention Pond

Stormwater Management Roundabout

Bioswale

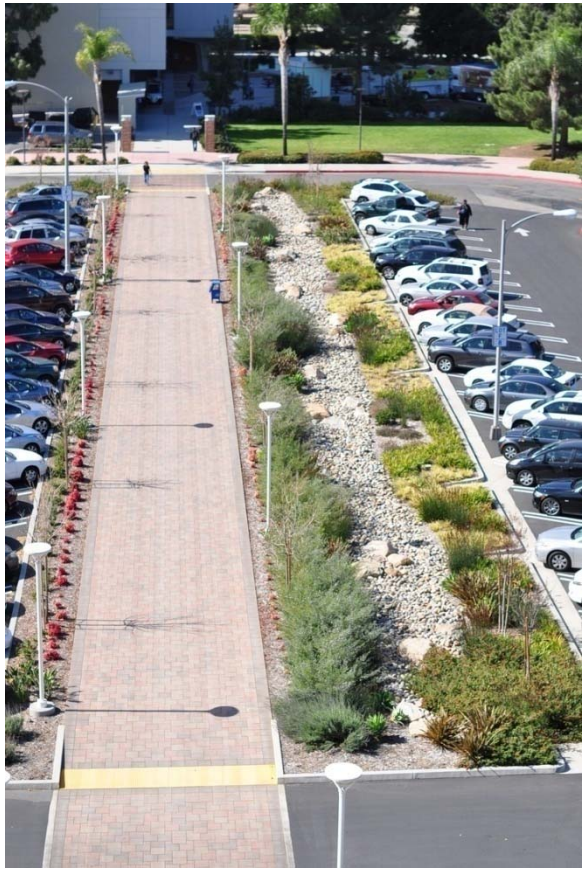


Bioswale Amphitheatre in a School

Bioswale Parking Lot

Application of SUDS in various Parts of City Areas

Natural drainage system in Portland.
(Bioswale style)



Bioswale Parking lot

Stormwater Planter

Application of SUDS in various Parts of City Areas

Rain gardens and constructed wetlands at Bishan-Ang Mo Kio Park

Downspout Art

Green Wall

Application of SUDS in various Parts of City Areas

Phases 2 & 3

Fish Hatchery Water Polishing Constructed Wetland

The alluvial fan inspired wetland will consist of terraced pools, gently descending the slope.

The dam-impacted Columbia River is being restored with side-channels for fish rearing, restored riparian and shrub-steppe habitat, and mesic swales that collect and direct vital water resources on this seasonally-dry site.

- Case Study: Beebe Springs Natural Area
- Site Area: 200 acre
- A multi-phased project to preserve and restore riparian and shrub steppe habitat on a property formerly in orchard.
- The design concept for the wetland mimics the alluvial fans that occur naturally at the site.
- Design solutions are creating a sustainable site that offers recreational, natural, and cultural opportunities.
- The benefits of the project include :
  - New habitat
  - Exhibit art objects
  - Education & research

Polishing Ponds

Thank You