SUSTAINABLE SITE DESIGN & WATER RESOURCES MANAGEMENT

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Environmental Consultants

What does this mean in terms of land and water resources?

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SUSTAINABILITY

Sustain the quality and quantity of our natural resources for use by future generations

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GREEN BUILDING COUNCIL

- LEED Program
- Initial focus primarily on buildings
- Energy issues important
- Site issues given greater emphasis recently

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USGBC LEED CRITERIA

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Why are the LEED Site Criteria Important?

- Guidelines for better design.
- Criteria will influence local regulations.
- Civil engineers, Landscape Architects and other site designers have not been a presence in the Green Building movement

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LEED Rating System

Points	5	Innovative Design
	14	Site
	5	Water
	17	Energy
	13	Materials and Resources
	15	Indoor Air
Total	69	Possible

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How does the process begin? Site Selection:

- Urban Redevelopment (1 pt)
- Brownfield Redevelopment (1 pt)
- Alternative Transportation (4 pt)

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Site Planning

Do not locate buildings on:

- Prime Ag (Farmland Trust).
- Lower than 5’ above 100 year flood.
- Within 100’ of wetlands
- Important Habitats

Reduce Disturbance

Reduce Development Footprint

3 Points

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Water Efficient Landscaping

- **Limit Irrigation**
- **Reuse Captured Rainwater**
- **Native Plantings**

2 Points

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Stormwater Management

- **No increase in Rate and Quantity**
- **Reduction in NPS pollutants**
  - **80 % TSS**
  - **40% TP**

2 Points

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Innovative Wastewater

- **Reduce Potable Water Use**
  - **Low flow Fixtures**
  -
- **Treat and Use Greywater**
  - **Toilets**
  - **Landscaping**

1 Point

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Water Use Reduction

- **Reduce Baseline Water Use Calculated for Building**
  - **Plumbing Fixtures**
  - **Dishwashers, Laundry**
  - **Cooling towers/make-up water**

2 Points

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Reduce Heat Islands and Light Pollution

- **Provide shade on 30% of parking lots, plazas, etc.**
- **High reflective or vegetative roof**
- **Eliminate Light Trespass**

3 Points

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LEEDS SITE CREDITS

- SITE SELECTION – 1 to 4 points
- SITE PLANNING – 3 points
- WATER EFFICIENCY – 2 points
- WATER USE REDUCTION- 2 points
- STORMWATER MANAGEMENT – 2 pts.
- INNOVATIVE WASTEWATER – 1 pt.
- HEAT ISLANDS, LIGHT POL. – 3 pts.

Development site selection is usually pre-determined

Design issue is how to fit program on the available land

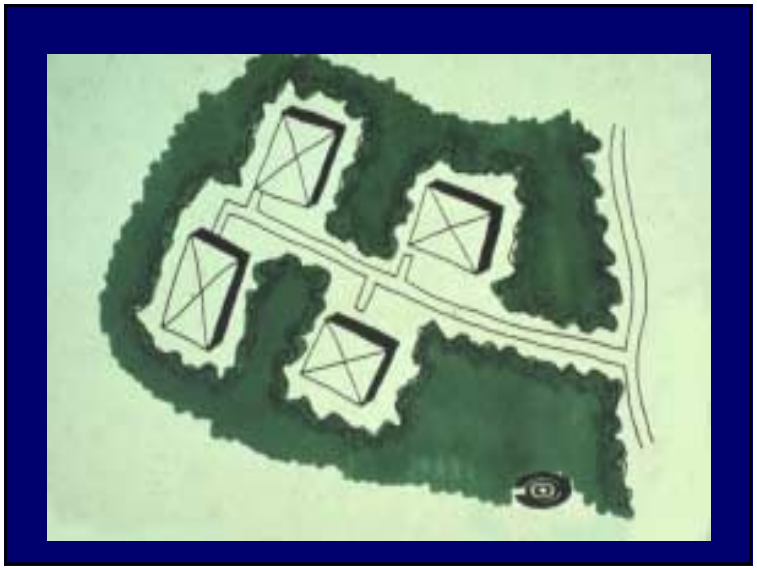
Most of our new development follows the highway system

PRINCIPLES OF SUSTAINABLE SITE DESIGN

- Minimum Disturbance
- Maintain Natural Hydrologic Cycle
- Minimize consumptive water use
- Protect Water Quality

Minimum Disturbance

- Limit removal of existing natural vegetation
- Avoid placing structures in floodplain and sensitive areas
- Keep building and parking envelope as compact as possible
- Maintain riparian buffer along streams and lakes
- Work with natural contours; avoid excessive earthmoving



Save the Trees

THEY ARE THE BEST
MANAGEMENT PRACTICE

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SCHEMATIC SITE PLAN

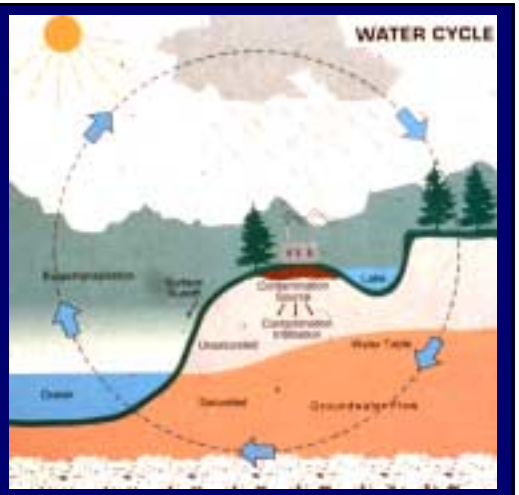
Water Resources Management

- Water Supply
- Wastewater Treatment and Discharge
- Stormwater Management

All three subjects are different expressions of the hydrologic cycle –

They are elements of a single natural system in which we intervene to serve our purposes

Hydrologic Cycle



A Safe and Sufficient Supply of Fresh Water

The primary concern of every settlement made by our species

Wastewater Treatment and Discharge

Generally an afterthought until the past century

Stormwater Management

Only considered during the past thirty years

Stormwater and Wastewater

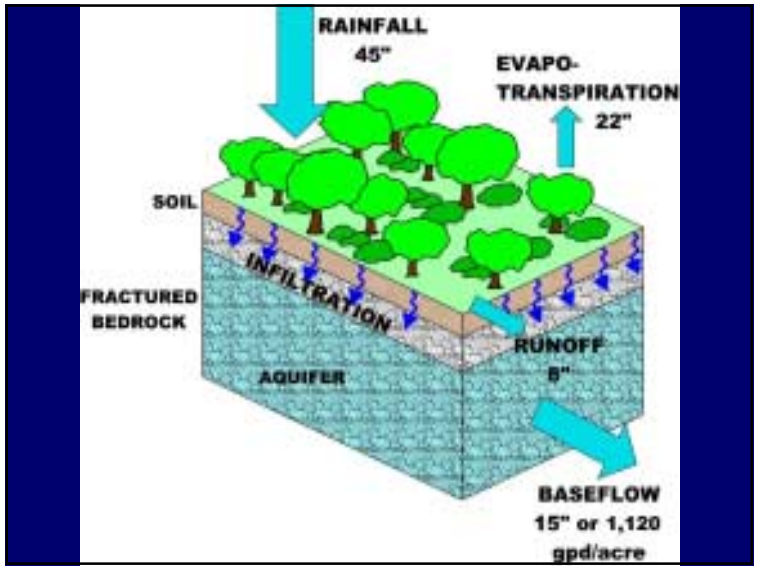
- Both water quality and quantity impacts
- Generally downstream issues
- Flooding impacts
- Non-point source pollution
- Riparian losses

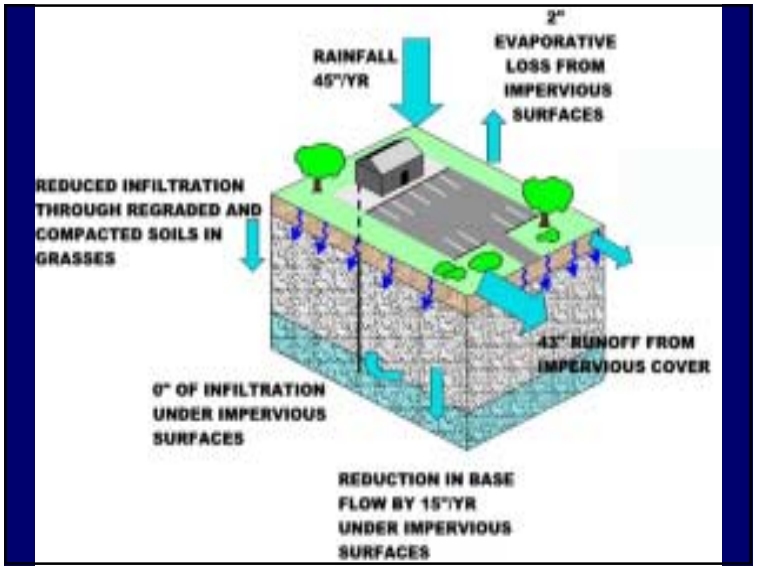
Land Development Alters the Hydrologic Cycle

- Reduces Infiltration
- Increases Direct Runoff
- Increases Pollutants

Maintain Natural Hydrologic Cycle

- No net increase in **volume** of runoff
- Avoid unnecessary impervious surfaces – make pervious if possible
- Maintain recharge of rainfall to groundwater
- Use Best Management Practices (BMPs) such as porous pavement and infiltration beds
- Collect rainwater for plant and garden watering



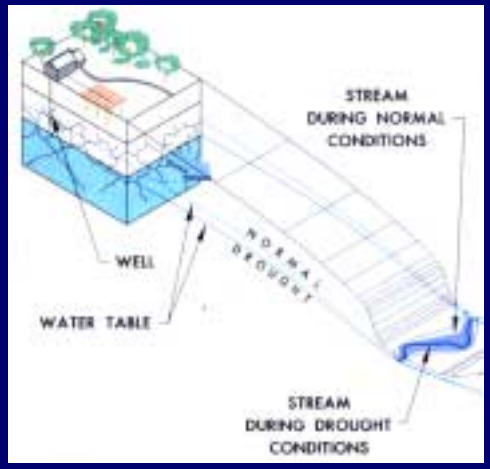


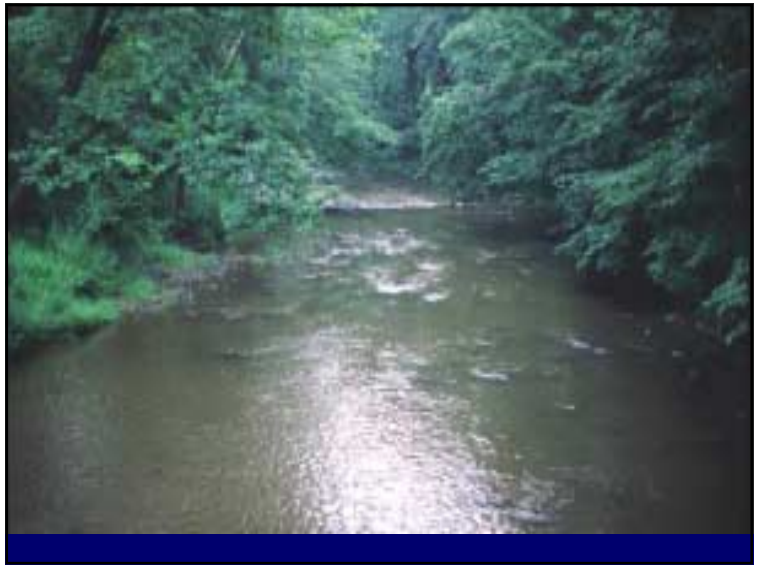
Surface runoff increases by
36” (3 ft) per year

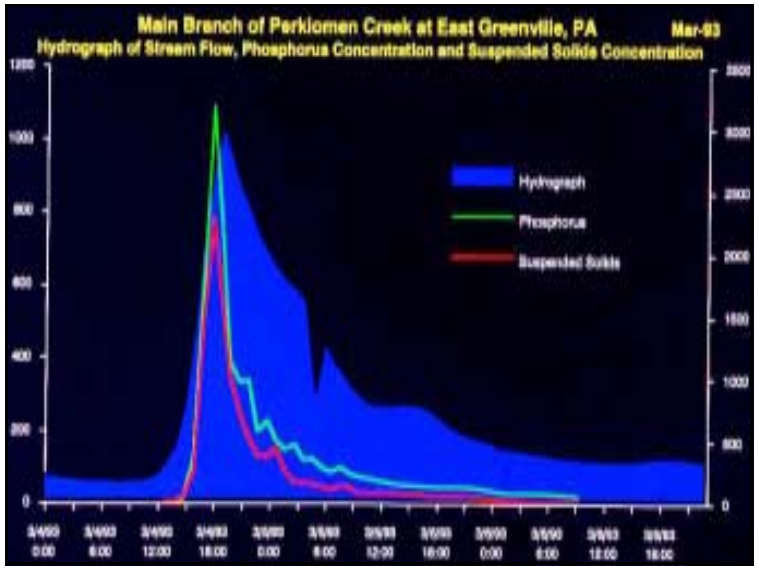
INCREASED RUNOFF

- ET ADDED (PLANTS) – 21” TO 30”/YR
- INFILTRATION PREVENTED – 6” TO 15” /YR

Groundwater Discharge to Surface Streams







Effects of Urbanization on Watershed

- Flash Flooding and Streambank Erosion.
- Diminished Flow During Dry Periods.
- Degraded Water Quality.

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Flood and drought are opposite sides of the same coin

STORMWATER MANAGEMENT

- Water Quantity
- Water Quality
- Rate is minor issue

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"Sustainable" Stormwater Management means Maintaining the Hydrologic Balance that Existed Before Development

- Infiltrating the Net Increase in Volume of Runoff for the 2 Year Storm Event.

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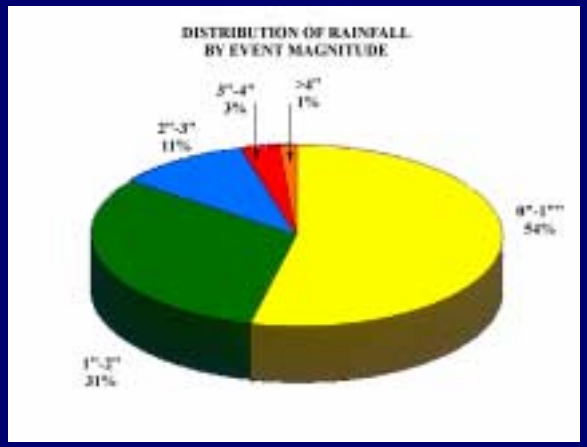

Traditional Stormwater Management

- Control Peak Rate of Runoff after Development to Pre-Development Rate.
- Detention Basins
  - Temporary Storage
  - Sediment Control
- Does Not Address Increase in Volume of Runoff

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Sustainable Site Design and Water Resources Management

Specific design methods and materials

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INFILTRATION BMPS

- Infiltration Beds Beneath Porous Pavement
- Infiltration Trenches, Drains
- Infiltration Swales w/ Vegetation
- Infiltration Berms (sloped areas)

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Porous AC Pavement

- Fully permeable AC mix – 2.5" application
- Uniformly graded stone base reservoir 30"
- Geotextile on bottom to stop soil
- Flat bottom to allow uniform infiltration

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Morris Arboretum
Philadelphia, PA

1984

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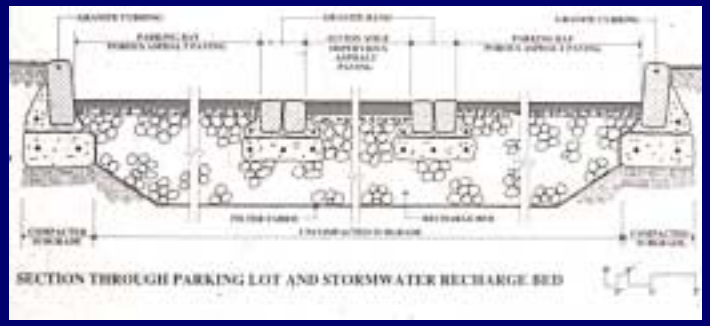

Diagram of infiltration bed at Morris Arboretum

Shared Medical Systems
Malvern, PA

1982

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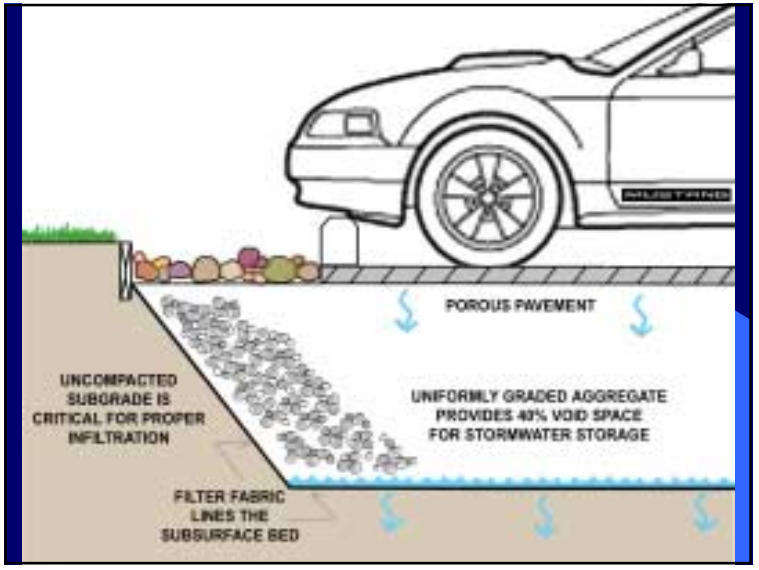
POROUS PAVEMENT
UNCOMPACTED SUBGRADE IS CRITICAL FOR PROPER INFILTRATION
UNIFORMLY GRADED AGGREGATE PROVIDES 40% VOID SPACE FOR STORMWATER STORAGE
FILTER FABRIC LINES THE SUBSURFACE BED

DuPont Barley Mills Office Complex

- Preserve Woodlands
- Porous Pavement w/ Groundwater Recharge
- Reduce Site Disturbance

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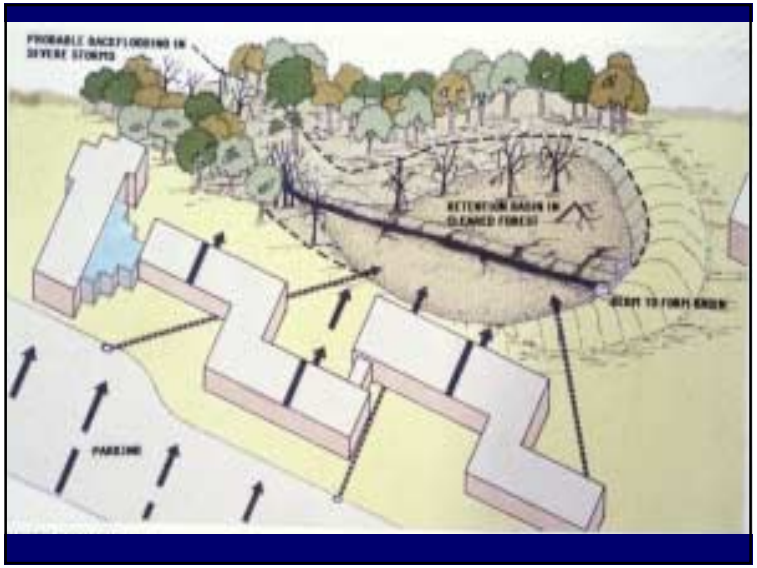
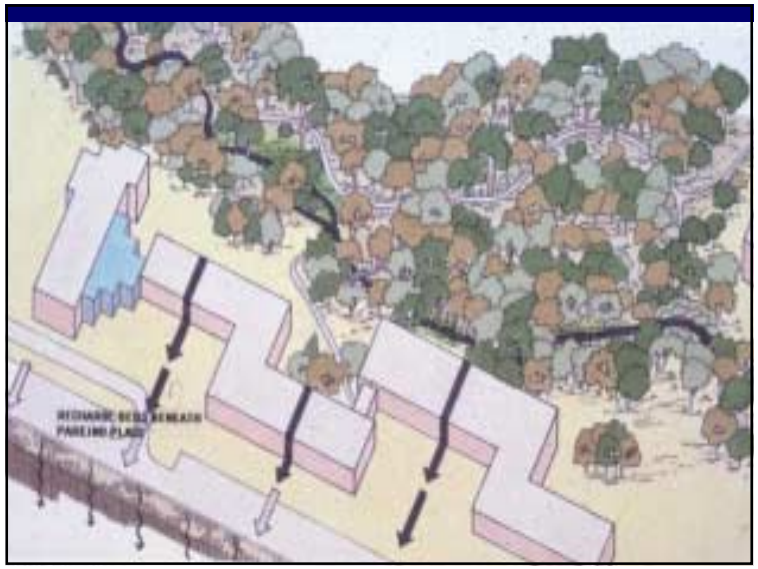
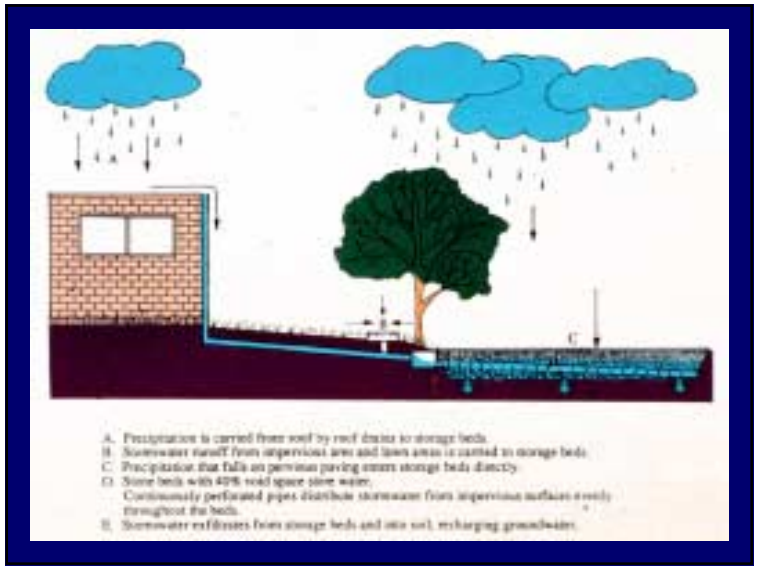
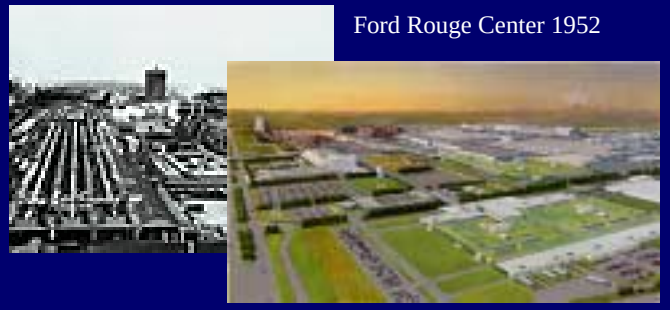






Ford Rouge Center
Dearborn, Michigan

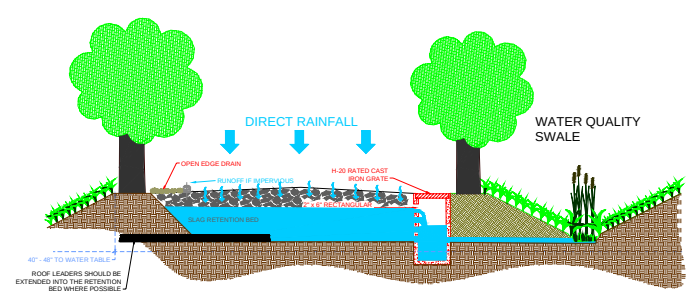


Ford Rouge Center 1952

Ford Motor Company

Artist Richard Rochon's rendering of an aerial view of the Ford Rouge Center that includes the new Ford assembly plant.

Strategy for Water Quality



Ford Motor Company

Ford Motor Company

University of Rhode Island

750 space parking lot
Designed with BETA Engineers

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Environmental Consultants

Flying J Truck Stop
Harrisburg, PA

- Infiltration Below Standard Pavement
- Water Quality Treatment

FLYING J TRUCK STOP

Carlisle, PA

Runoff from parking lot is collected through a trough system that settles out black tire dust and debris

The trough system conveys stormwater to a wetland treatment system

Pollutant laden stormwater is conveyed to this beautiful and functional constructed wetlands, to benefit from phyto-remediation and infiltration.

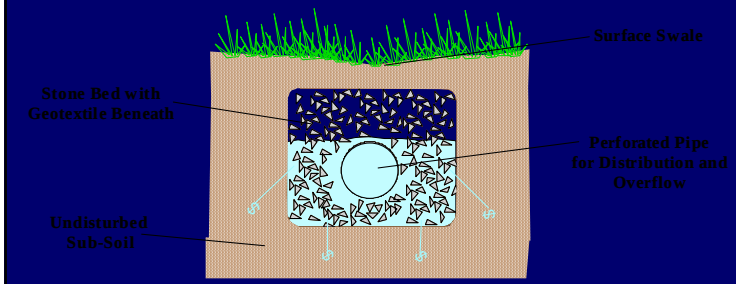
Porous Portland Cement Concrete

- Similar to Porous Bituminous- No Fines
- Developed in Florida

POROUS CONCRETE PARKING LOT

- University of North Carolina, Chapel Hill
- One of two large parking lots – 1,400 cars
- Combination of porous AC and PCC
- Concrete costs four times greater

Infiltration Trench



Infiltration Trench

Infiltration Beds

- Stone Bed Under Soil
- Meadows
- Playfields (soccer, lacrosse)

Infiltration Bed

Rain Gardens & Water Quality Swales

- Integrate Landscape and Stormwater
- Improve Water Quality
- Allow runoff to infiltrate
- Some shallow water during storms

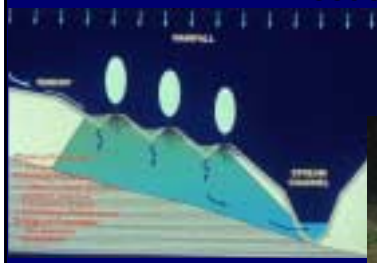
Penn State Visitor Center

Rain Garden

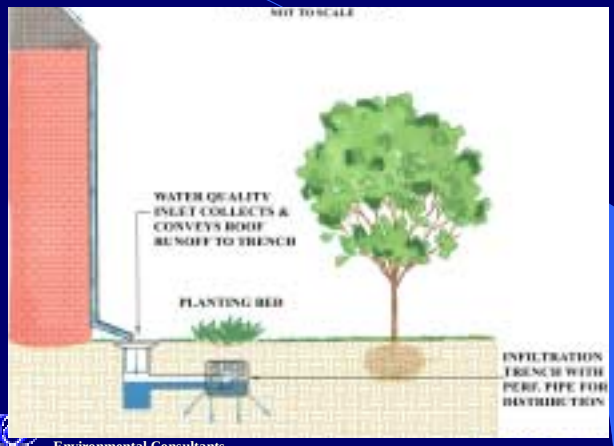
Infiltration Berms

- Simple construction along contour
- Capture runoff behind shallow berm
- Allow runoff to infiltrate
- Very little disturbance

Infiltration of Stormwater Runoff Down A Wooded Hillside



Infiltration Trench Under Planted Area



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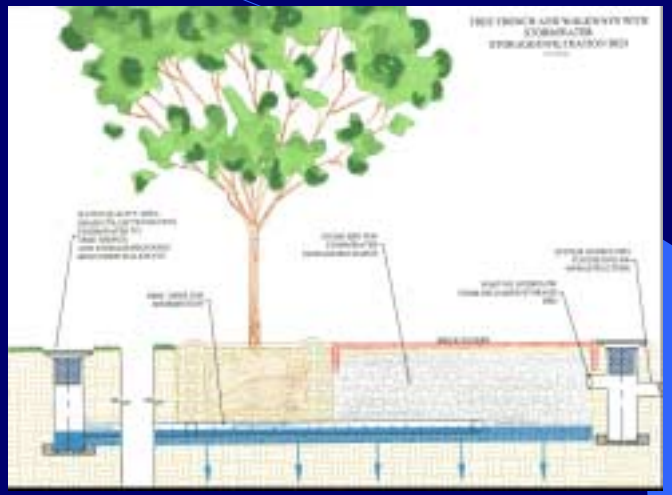
Infiltration Tree Trench



Penn New School
Philadelphia K-8

- Soccer Field underlain by Infiltration Bed
- Porous Asphalt Playfield
- Rain Gardens fed by Roof Leaders
- Urban setting – 43rd and Locust

University of Pennsylvania-Alexander School, Philadelphia, PA

National Cathedral
Washington, DC

Wooded landscape by Olmstead

Stacked Into Cells cells of 25 unit each 2.5 meters tall (8.2 feet)

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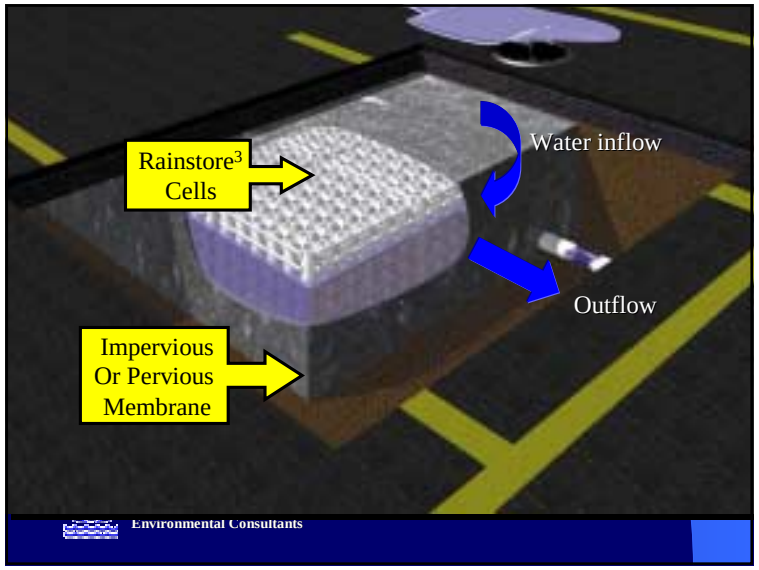

Rainstore3
Cells
Water inflow
Outflow
Impervious
Or Pervious
Membrane
Environmental Consultants

Highly urbanized areas

- Where impervious cover exceeds 70%
- Very limited land surface remaining
- Most open lands contain infrastructure
- Parking is usually structural

Stormwater management must begin …

Up on the roof

Development of Green Roofs

- Original concept in Switzerland – 1970's
- German cities rebuilt after WWII overloaded combined sewer systems
- Cities mandated green roof systems
- All new buildings with roofs up to 21 deg.
- Cheaper than rebuilding sewers

Rooftop systems

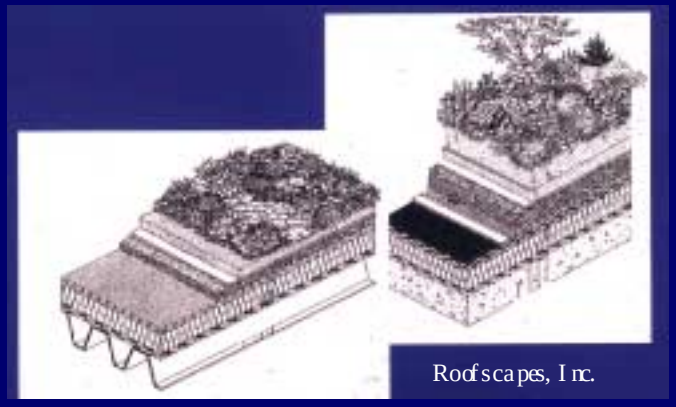
- Store at least ½" of rainfall
- Return to atmosphere as transpiration
- Reduce peak of runoff to ground

Roof meadow™

- site specific design
- light-weight
- un-irrigated and low-maintenance
- durable
- functional

Roofscapes inc.

Vegetated Rooftop System



Runoff Management Using Vegetated Roof Covers

- Reduce total annual runoff volume by 50% or greater
- Immediate runoff is negligible for storms of 0.5 inch or smaller
- Reduce peak runoff to predevelopment levels (2 year event)

(Achievable with an 8 centimeter Roofmeadow™)

Roofscapes inc.

Parking Garage

NEW OFFICE BUILDING

Downtown Munich

Fencing Academy of Philadephia Roofmeadow™

After

Before

Roofscapes inc.

NEW RESIDENTIAL COMMUNITY

Munich Suburb

Current US Design

- UNC Campus – Chapel Hill, NC
- Construction during 2003
- Multi – purpose four story building
- Parking garage, athletic and food service

UNC-CH CAMPUS

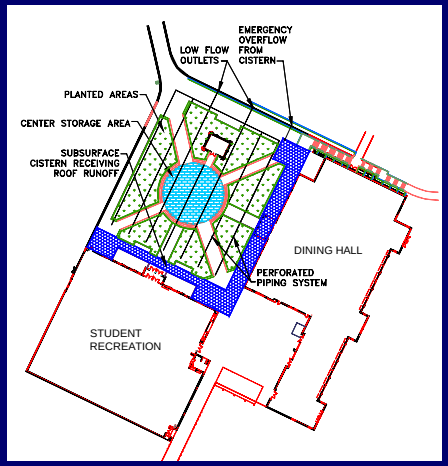
- Central campus is up to 78% impervious
- Little or no room at grade for stormwater
- Many structures not suited for green roofs
- Mechanical equipment placed on roofs

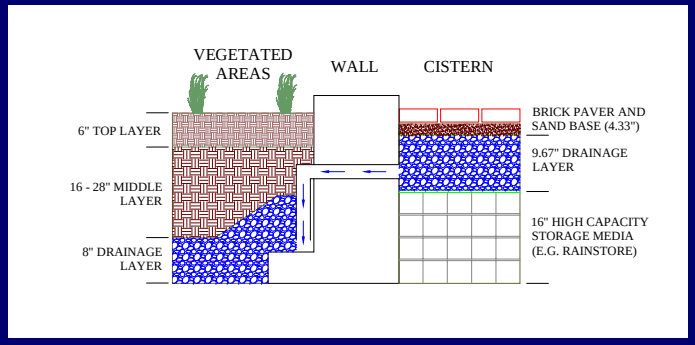
Ram's Head

Green Roof Plaza

- Plaza and Buildings located on top of Parking Garage
- Stormwater held on roof under plaza in Rainstore.
- Irrigation of plaza from stored stormwater.
- Low maintenance plantings.

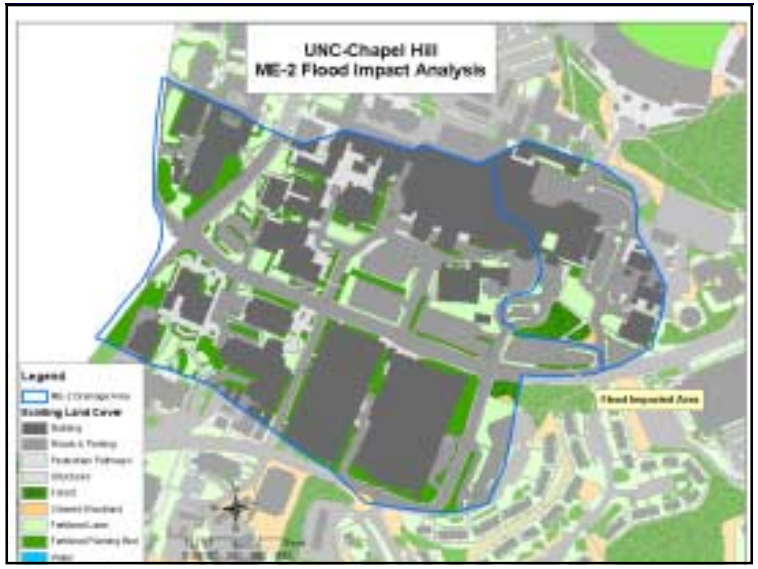
Ramshead Site Plan





Parking Garage Roofs

- Top decks underutilized – very hot summer
- Rain also limits roof use – 45 inches/year
- Greatest source of night illumination
- No mechanical equipment



Two Hospital Garages

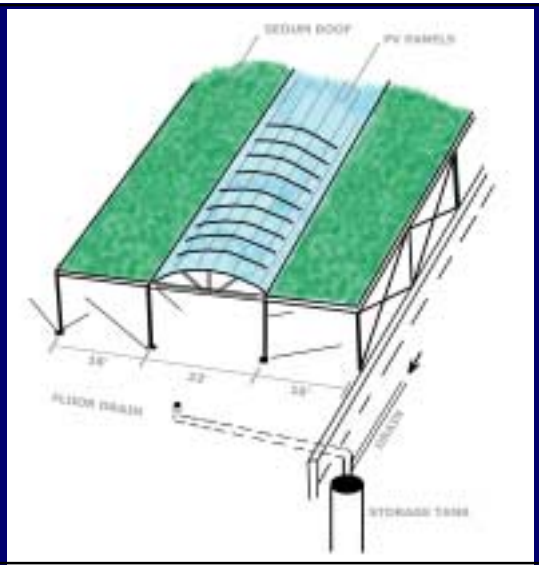
- Total footprint – 6.7 acres, or 291,800 SF
- 18% of impervious surface in ME-2
- 100% capture is 87,500 CF, or 17% of volume
- Annual Runoff – 1,094,250 CF
- 8.2 Million Gallons per year runoff
- Total capture will reduce all runoff
- Reduction by 17% will eliminate current flooding down stream

Existing roof drainage system

- Collects rainfall and discharges to sewers
- Creates flooding downstream
- No opportunity to reduce volume
- No means of preventing pollution

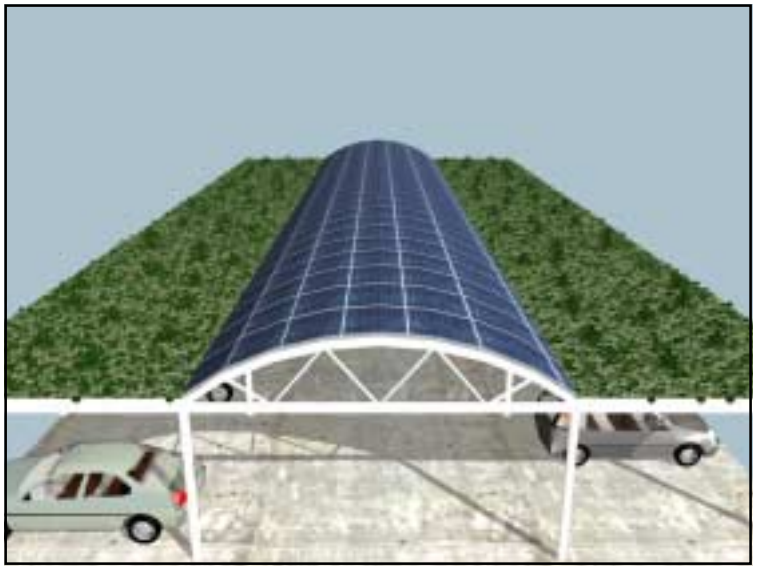
German Auto Canopy

Simple wood/metal frame structure with plastic/metal support base and 2” growing layer



GREEN SOLAR CANOPY

Parking Garage Rooftop Design



Green solar canopy
GSC

- Lightweight aluminum frame
- Green roof over car bays
- Transparent PV panels over driveway
- Roof system includes storage layer – 2”
- Sedum on 2” growing layer
- Skylight framing system
- Internal lighting with no exterior lights

Green Solar Canopy

- Reduces stormwater volume (70% to 100%)
- Provides Significant Evapo-transpiration - ET
- Reduces Carbon Dioxide - CO_2
- Prevents NPS pollution
- Captures solar energy (10 watts/SF)
- Greatly reduces dark sky illumination
- Protects rooftop parking from weather
- Can include rain capture for reuse

INTEGRATES

- Vegetative roof systems- Roofscapes
- Stormwater management – Cahill Assoc.
- Solar energy – Solar Design Associates
- Lightweight skylight framing – Conservatek
- Photovoltaic Panels – RWE Schott Solar

OLD GREEN ROOF

- OSLO, NORWAY
- Approx. 350 years old
- Primarily for insulation
- Wooden box frame

The End

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Potential Reuse

- Landscape irrigation – 1”/week, 20 weeks
- Chiller makeup – summer demand, clean
- Grey water use in flushing systems
- Slow release to sewer as base flow

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Runoff Capture and Reuse

- Elevated storage best for irrigation
- Vertical tanks with downspouts
- Residential rainbarrels
- Grey water requires repressurization
- Quality must be assured

Learning to live within the tolerance limits of the natural system

GROWING GREENER

LIVING BLUE