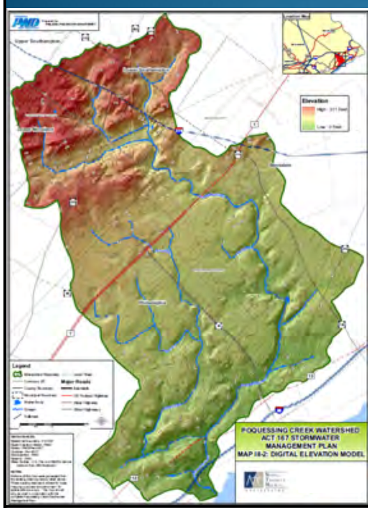
Stormwater & Flooding: Connecting the Drops



Water Resource Center

Southwestern Pennsylvania Commission

Paul A. DeBarry, PE, PH, GISP, D.WRE
NTM Engineering, Inc.

Newell Tereska & Mackay Engineering

1

Agenda:

- Cause - Effect
- Programs
- Floodplains
- Stormwater
  - Infiltration
  - Volume Control (Water Quality)
  - Stream Bank Erosion
  - Peak Rate Control
- Watershed Assessment & Analysis
- Connecting the Drops

2

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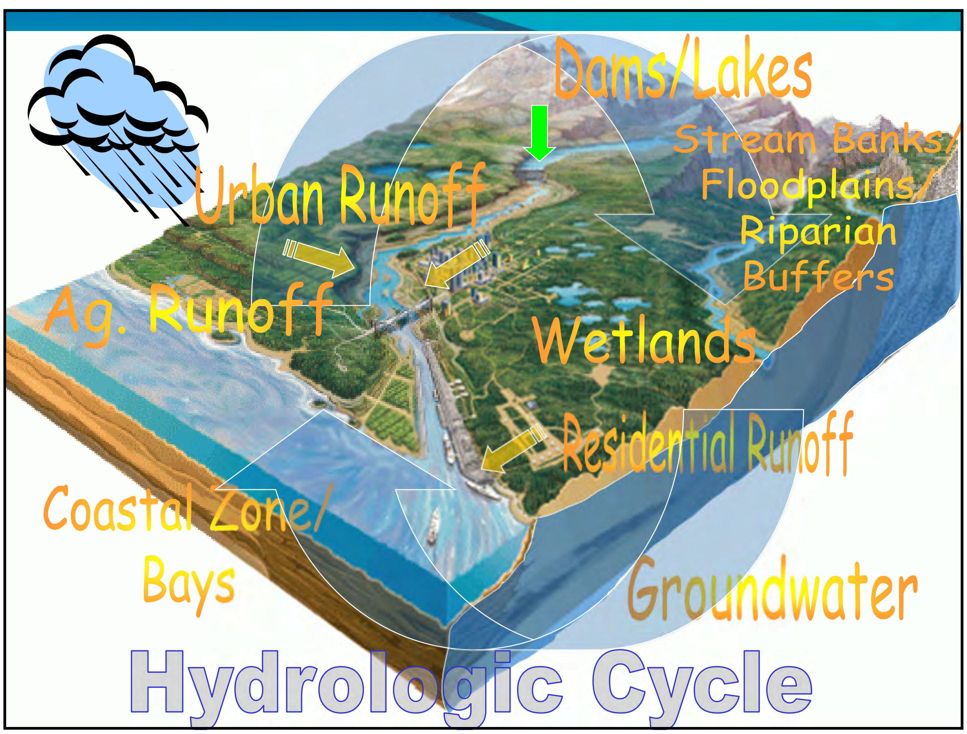
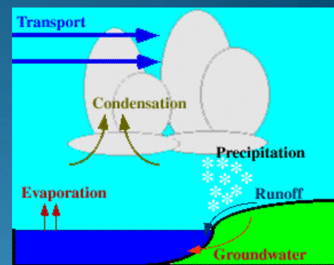
3



4

Hydrologic Balance



P = RO + Re + ET

Where:

P = Precipitation

RO = Surface Runoff

Re = Recharge (Baseflow to streams)

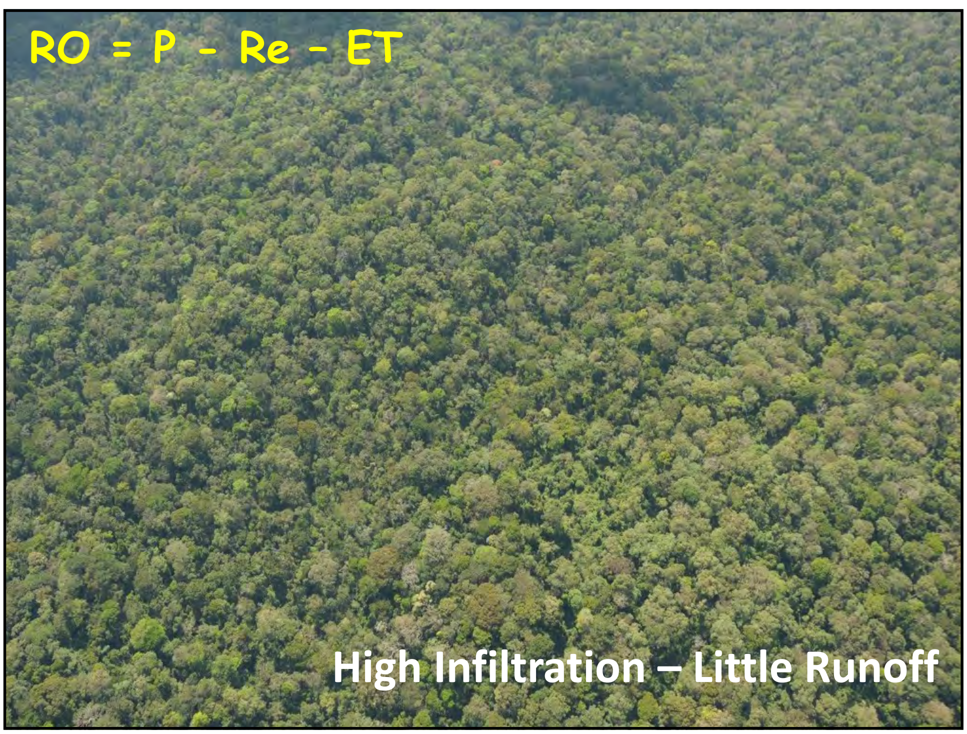
ET = Evapotranspiration

RO = P - Re – ET

Same Equation Whether:

P = .01 in, Trace | 7.5 in/24 hr. 100-yr | or | 45 in/yr. Annual Rainfall

5



6


Some Infiltration – Some Runoff

7


High Runoff – No Infiltration

8


Erosion / Sedimentation Problem Area

9


Water Quality Problem Area

10


Increased and faster runoff
Direct conduits to streams

11


Undersized Storm Sewers

12


Undersized Channels / Culverts
Obstructions

13


Streams & flood-plains in equilibrium
Streams & flood-plains out of balance

14


Past Solution:
Increase channel capacity
Past Solution:
Dikes, levees, floodwalls

15


Levees & Dikes
Limited Capacity &
Limited Lifespan

16

Hurricane Agnes – June, 1972


17

18

Floodplains Flood

19

Agenda:

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20

PA Act 166 – Floodplain Management Act (1978)

(a) Flooding of large areas of land within the Commonwealth causes unnecessary loss of life, destroys private and public property, damages means of livelihood and economic resources; etc.

(b) Extensive expenditures of public funds have been allocated to costly flood control projects…

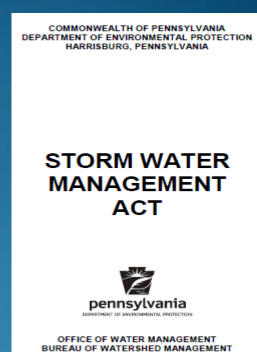
(c) The exclusive use of flood control measures, such as engineering projects, has failed to significantly reduce the human suffering and economic losses caused by recurrent flooding.

(d) A comprehensive and coordinated program of flood plain management, based upon the National Flood Insurance Program, is fundamental to the health, safety, welfare and protection of the people of the Commonwealth.

21

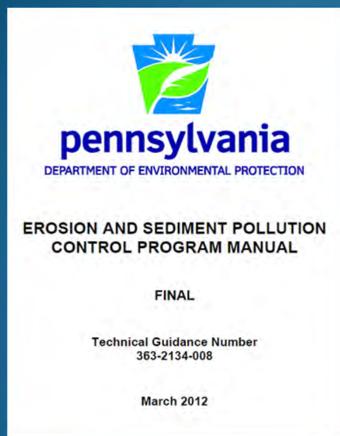
PA Act 167 – Stormwater Management Act (1978)

- In response to the impacts of accelerated stormwater runoff resulting from land development in the state.
- Requires counties to prepare and adopt watershed based stormwater management plans.
- Requires municipalities to adopt and implement ordinances to regulate development consistent with these plans.



22

PA Chapter 102 – E&S


pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

EROSION AND SEDIMENT POLLUTION CONTROL PROGRAM MANUAL

FINAL

Technical Guidance Number
363-2134-008

March 2012

(a) This chapter requires persons proposing or conducting earth disturbance activities to develop, implement and maintain BMPs to minimize the potential for accelerated erosion and sedimentation and to manage post construction stormwater.

(b) The BMPs shall be undertaken to protect, maintain, reclaim and restore water quality and the existing and designated uses of waters of this Commonwealth.

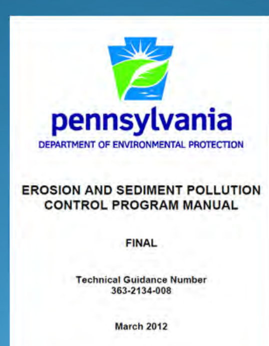
23

Pennsylvania E&S, Stormwater & Floodplain Management Act


COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
HARRISBURG, PENNSYLVANIA

FLOOD PLAIN MANAGEMENT ACT

OFFICE OF WATER MANAGEMENT
BUREAU OF WATERSHED MANAGEMENT


pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

EROSION AND SEDIMENT POLLUTION CONTROL PROGRAM MANUAL

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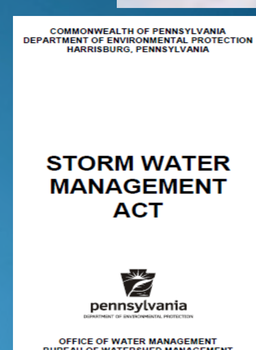

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
HARRISBURG, PENNSYLVANIA

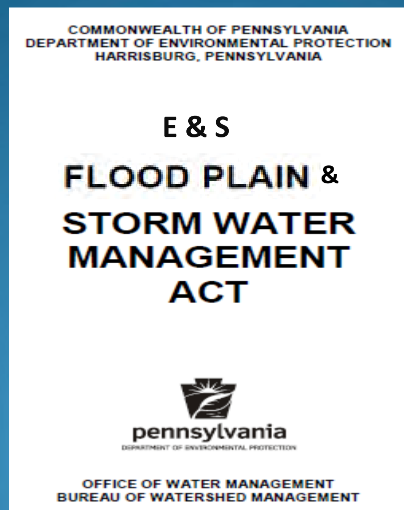
STORM WATER MANAGEMENT ACT

pennsylvania

OFFICE OF WATER MANAGEMENT
BUREAU OF WATERSHED MANAGEMENT

24

Pennsylvania E&S, Stormwater & Floodplain Management Act


COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
HARRISBURG, PENNSYLVANIA

E & S

FLOOD PLAIN &

STORM WATER MANAGEMENT ACT

pennsylvania

DEPARTMENT OF ENVIRONMENTAL PROTECTION

OFFICE OF WATER MANAGEMENT
BUREAU OF WATERSHED MANAGEMENT

25

Updates to Regulations to Coordinate Stormwater, E&S and Flooding

- 2002, attempt to integrate its various stormwater management programs (including MS4 Permits, NPDES Construction Permits, and Act 167) and promote a comprehensive watershed approach to stormwater management, PA DEP finalized a Comprehensive Stormwater Management Policy, DEP Policy No. 392-0300-002.
- 2006 PA BMP Manual
- 2010 New Ch 102 – incorporated PCSM into E&S.
- 2013 Act 68 amended the purposes and powers of Municipal Authorities to include financing working capital; stormwater planning, management and implementation.
- 2021? – New (BMP) PCSM Manual

26

Other Policy / Programs:

- NPDES Program
- TMDL’s
- FEMA FIS
- USACE Projects
- Pa DCNR Rivers Conservation Plans
- Growing Greener
- State Water Plan
- Dam Safety Program
- DRBC, SRBC, etc.

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Agenda:

- Cause - Effect
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28

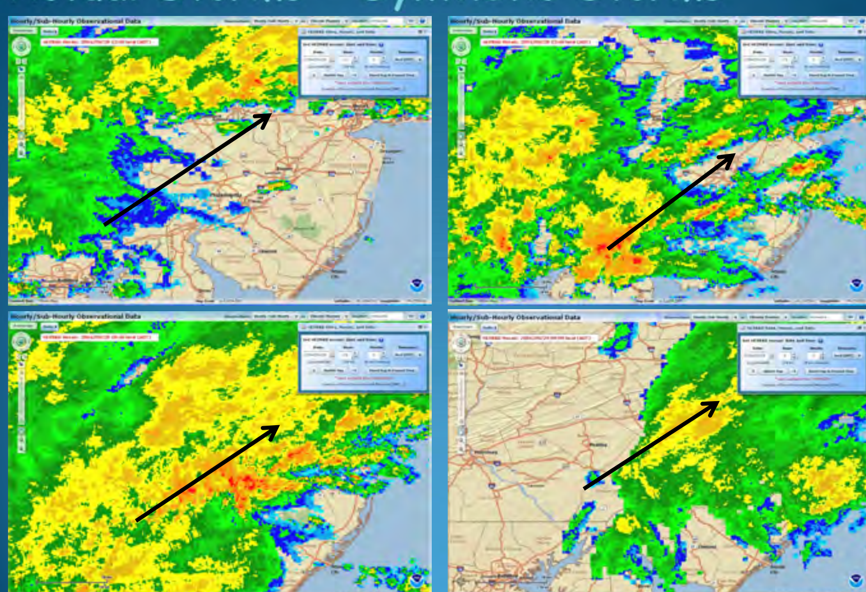
Flooding Caused By:

- High Rainfall Amounts – Can't do to much to control
- Dam Breaks – Dam Safety Program
- Obstructions, Building in the Floodplain – FEMA Flood Insurance Program
- Runoff – Impervious cover – land use & stormwater management

29

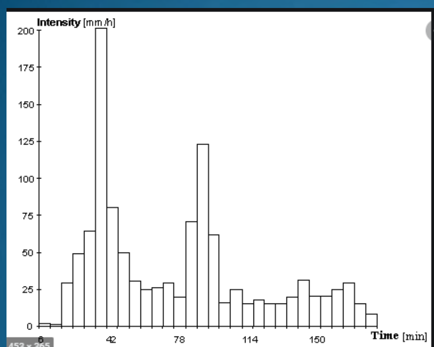
P = Precipitation

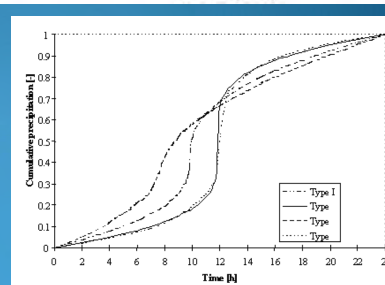
Actual Storms - Synthetic Storms



30

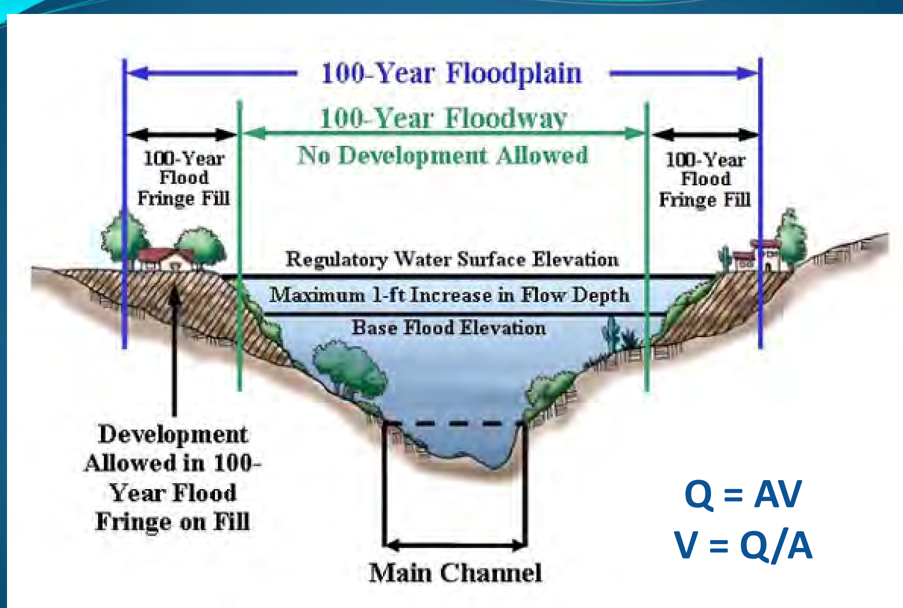
P = Precipitation
Actual Storms – Synthetic Storms





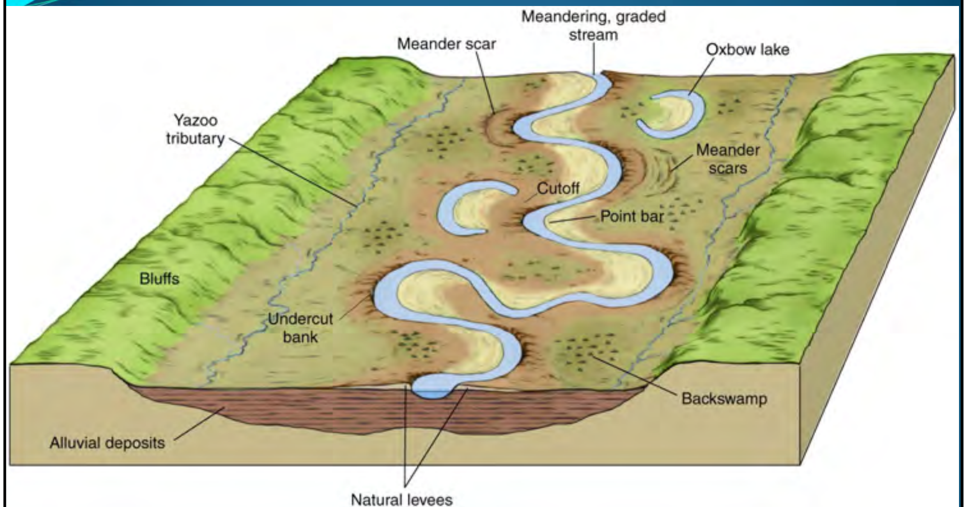
31

Current Regulations Allow Fill in the Flood Fringe



32

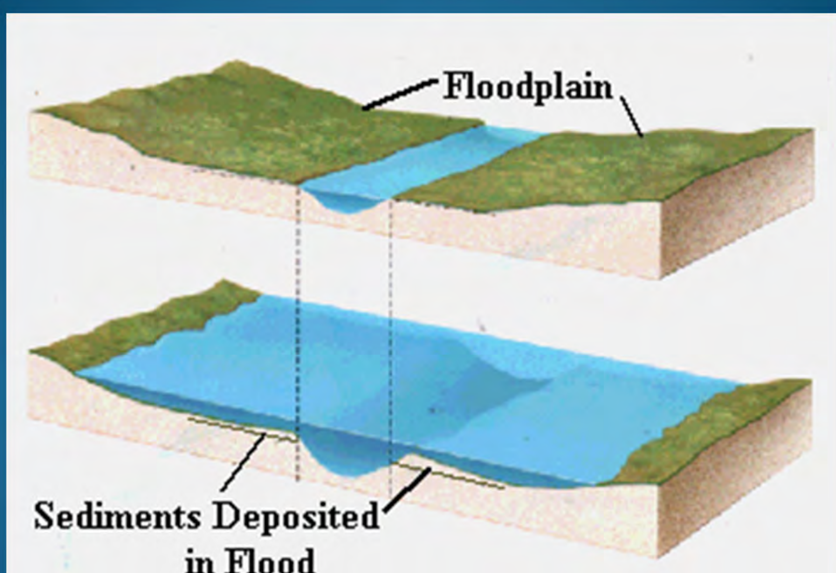
The Flood Fringe Has Many Purposes



- Infiltration
- Sediment Deposition
- Attenuation
- Floodplain Storage

33

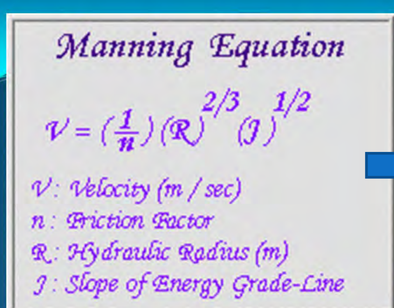
Deposition of Sediment



34

Attenuation

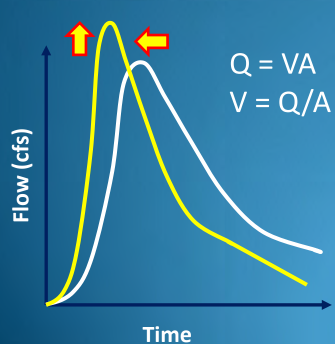
35



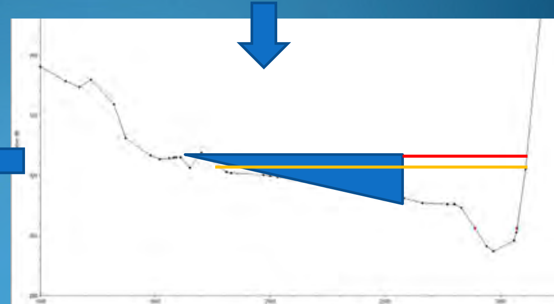
Example 1: Riparian Buffer
n = 0.09 Riparian Forest
n = 0.03 Grass
V = 3 Times Faster on Grass

Example 2: Fill in Floodplain
V = 5 fps Natural Flood Fringe
V = 12 fps Constricted Section

1000' reach of stream – 11 minutes v. 3.7 minutes

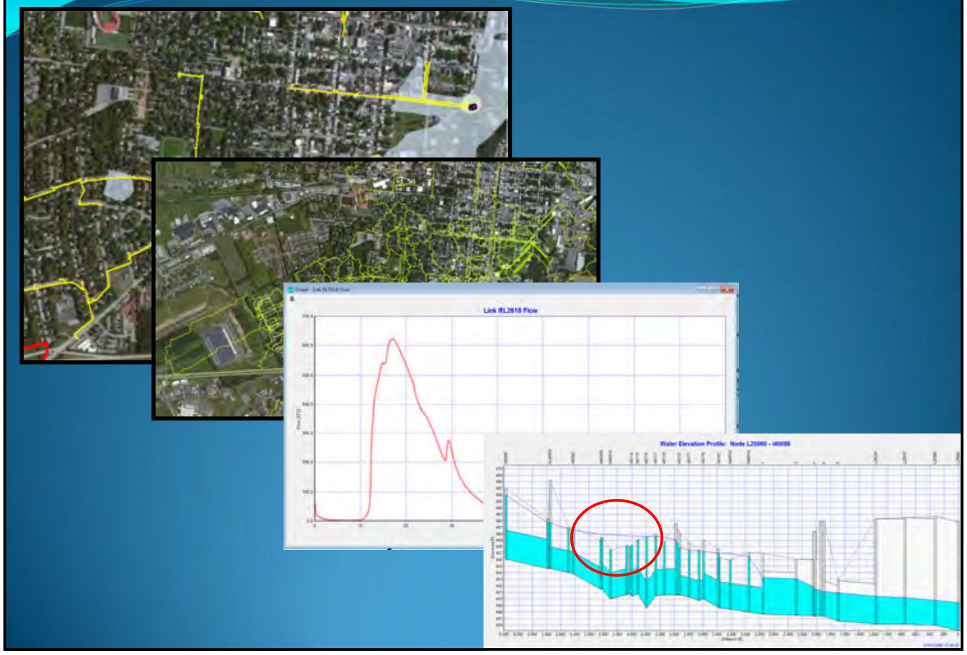


Q = VA
V = Q/A



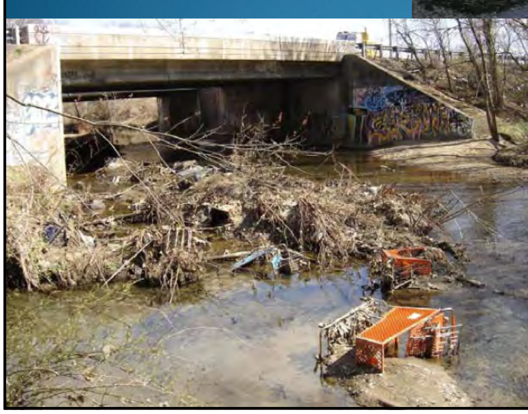
36

Floodplain Backwater Causing Stormwater Problems



37

Problems Caused by Obstructed Flow



38

Obstructions in Floodplain

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Agenda:

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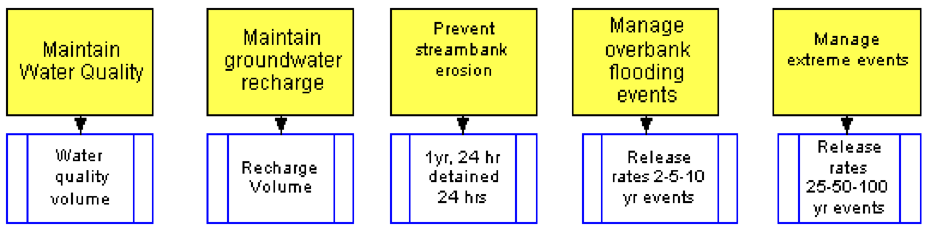
40

Comprehensive Stormwater/Floodplain Management



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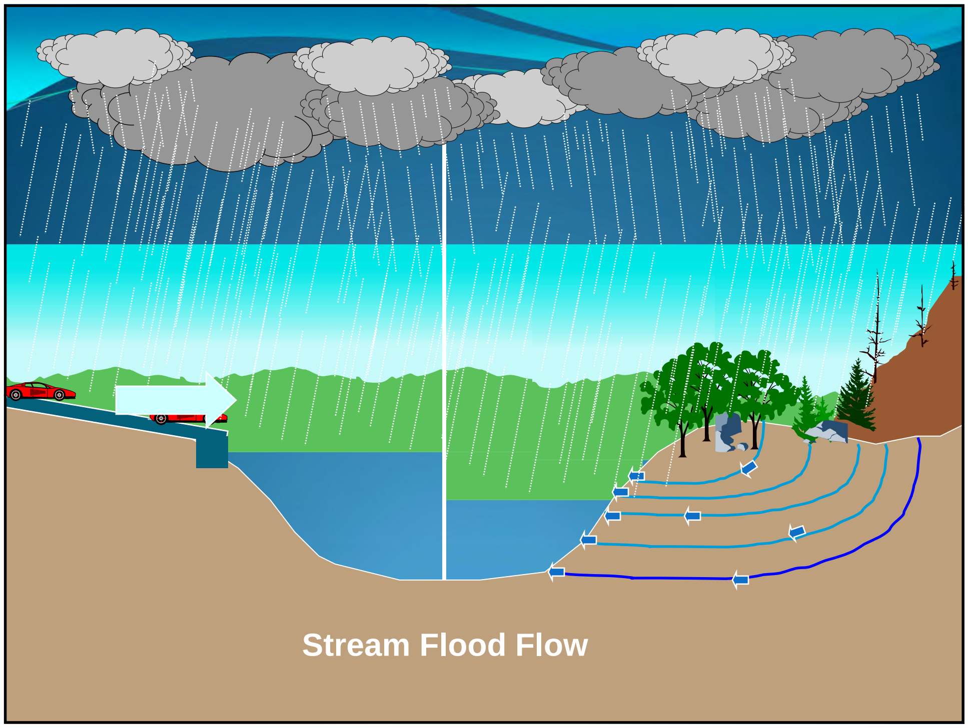
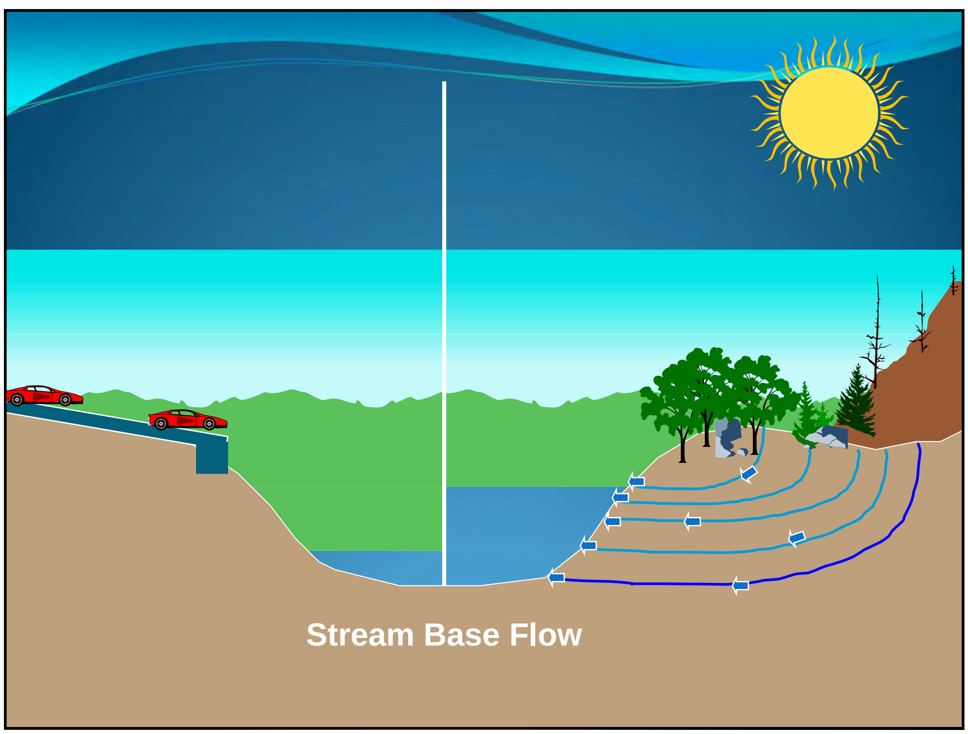
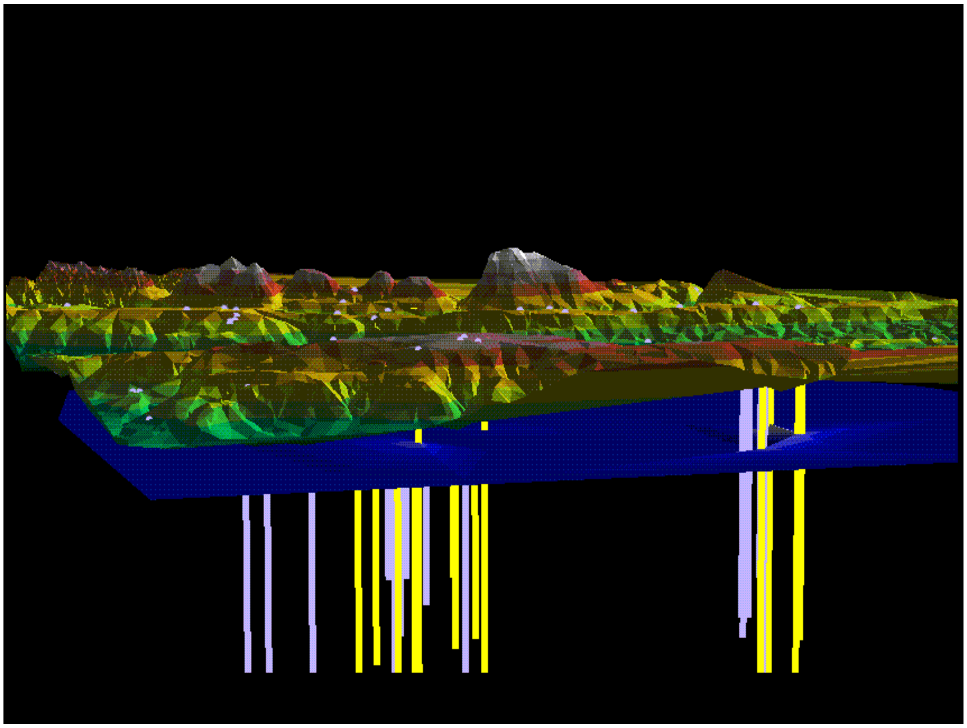
42



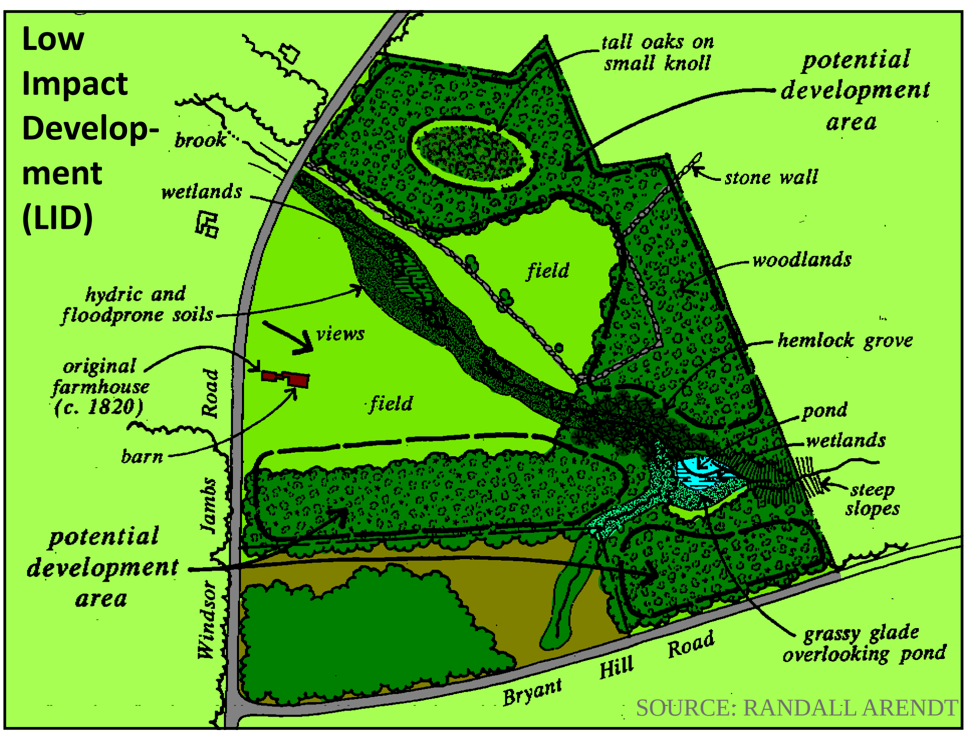
43



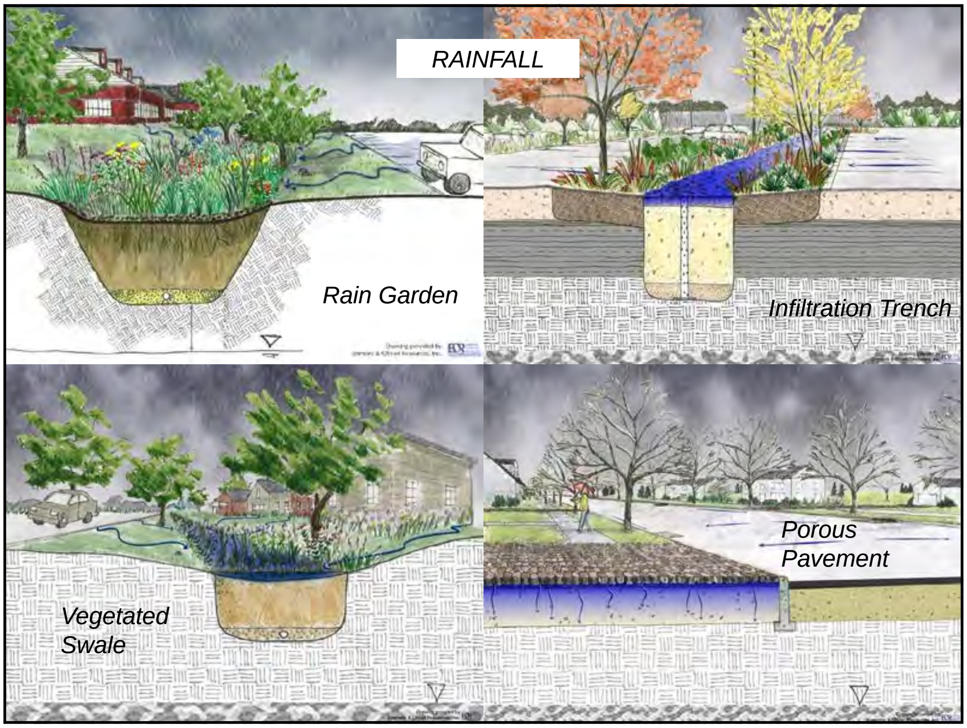
44



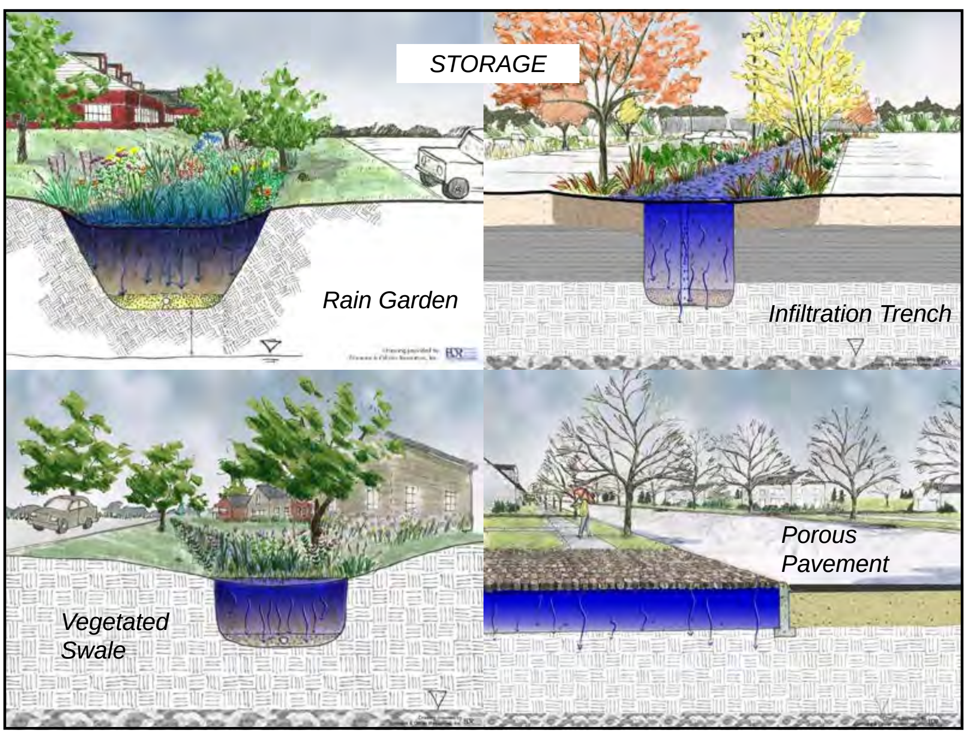
45


Low Impact Develop- ment (LID)
brook
wetlands
tall oaks on small knoll
potential development area
stone wall
field
woodlands
hydric and floodprone soils
views
hemlock grove
original farmhouse (c. 1820)
field
pond
wetlands
barn
steep slopes
Windsor Jambs Road
potential development area
Bryant Hill Road
grassy glade overlooking pond
SOURCE: RANDALL ARENDT

46


RAINFALL
Rain Garden
Infiltration Trench
Vegetated
Swale
Porous
Pavement

47

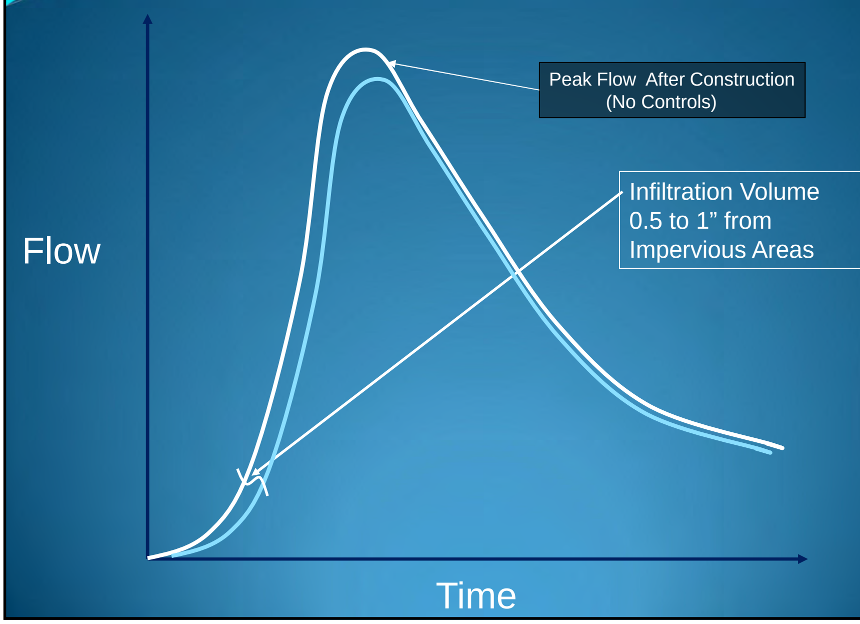

STORAGE
Rain Garden
Infiltration Trench
Vegetated
Swale
Porous
Pavement

48

49

50

Infiltration Volume



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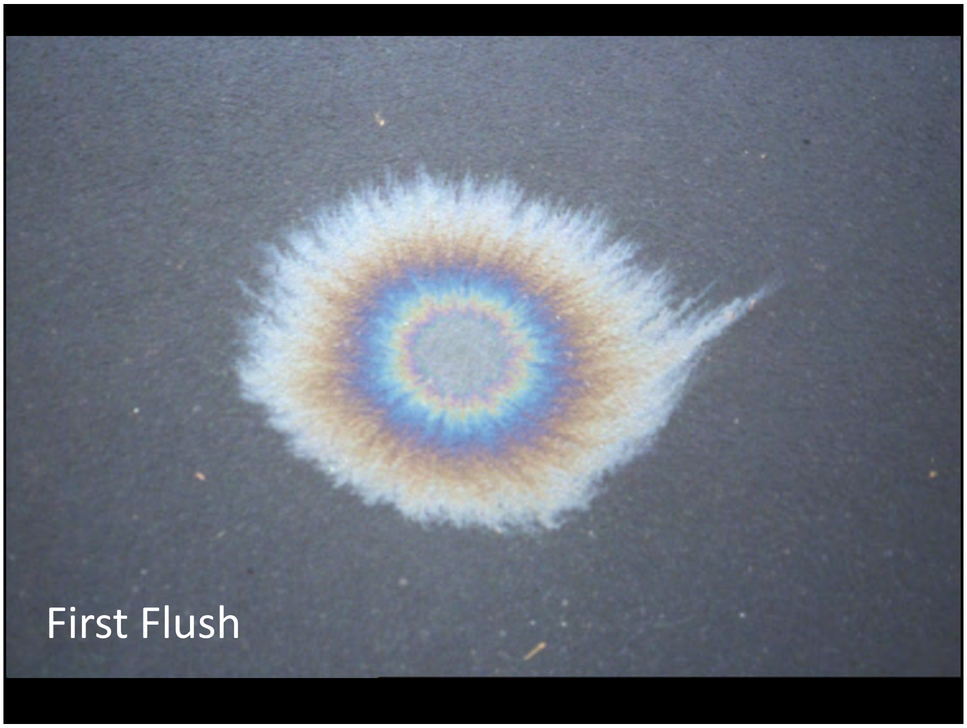
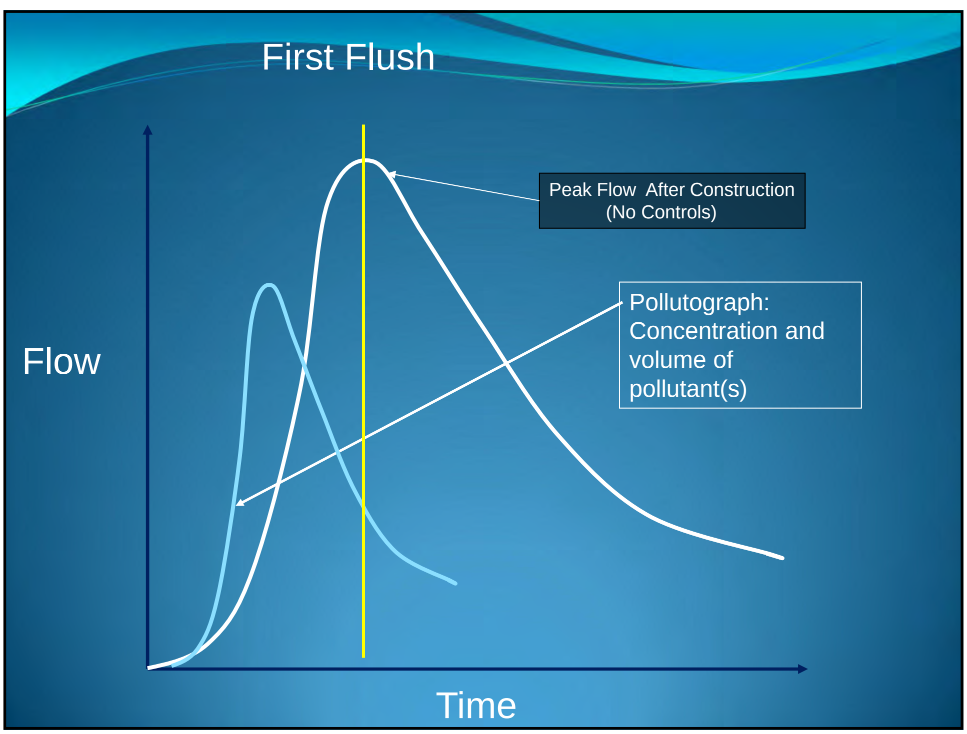
52


First Flush

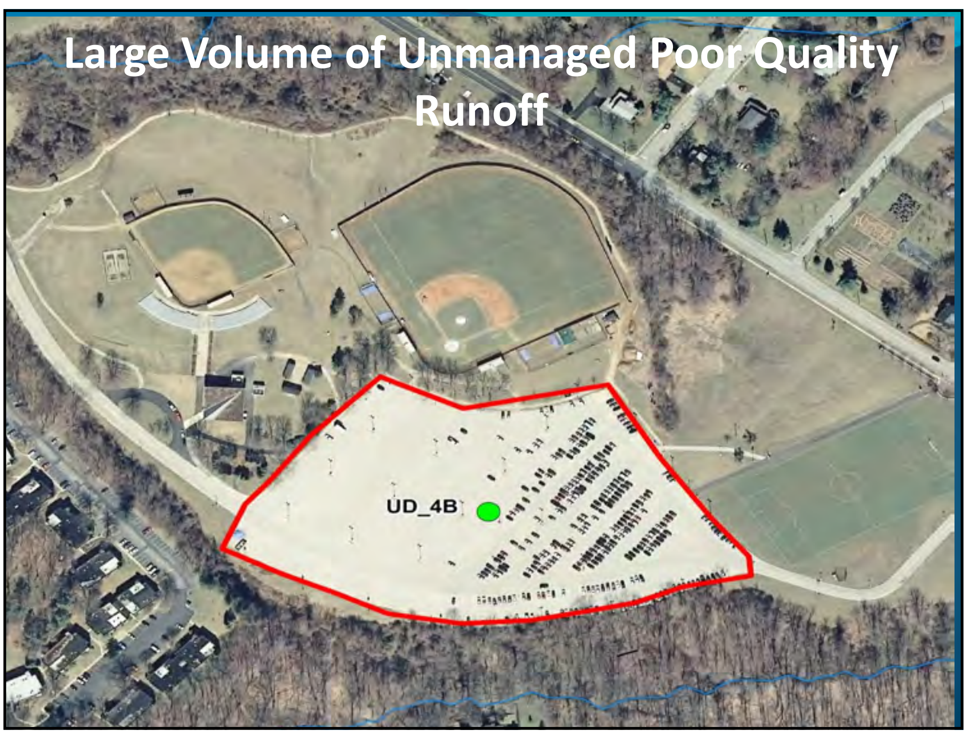
53


First Flush
Peak Flow After Construction (No Controls)
Pollutograph: Concentration and volume of pollutant(s)
Flow
Time

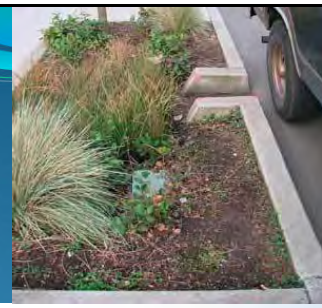
54


Detention Basin – Low Flow Channel

55


Large Volume of Unmanaged Poor Quality Runoff
UD_4B

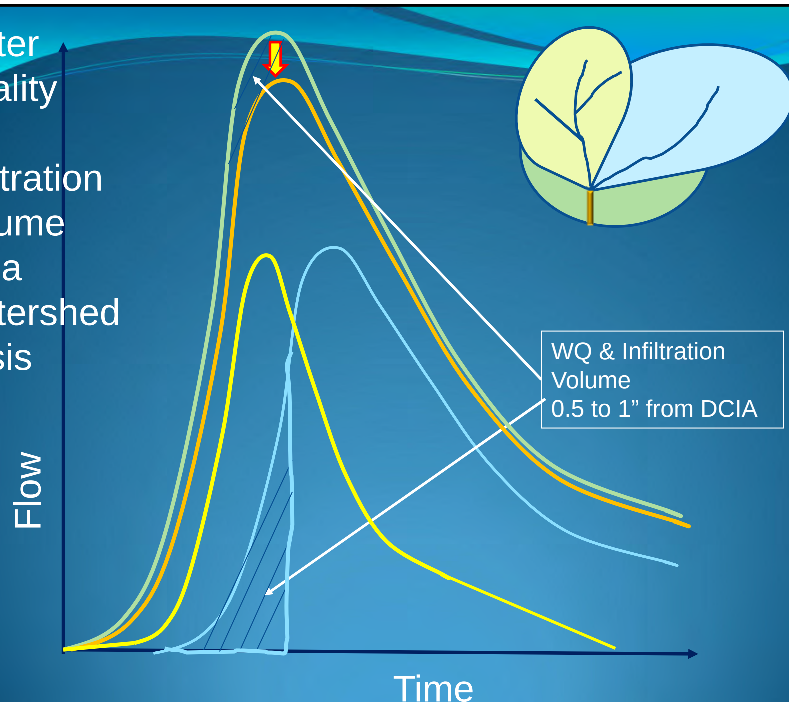
56



Water Quality Volume – Retain or Re-use 1” of Rainfall from DCIA

57

Water Quality & Infiltration Volume On a Watershed Basis



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Agenda:

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- Solutions: Analysis/Tools
- Connecting the Drops

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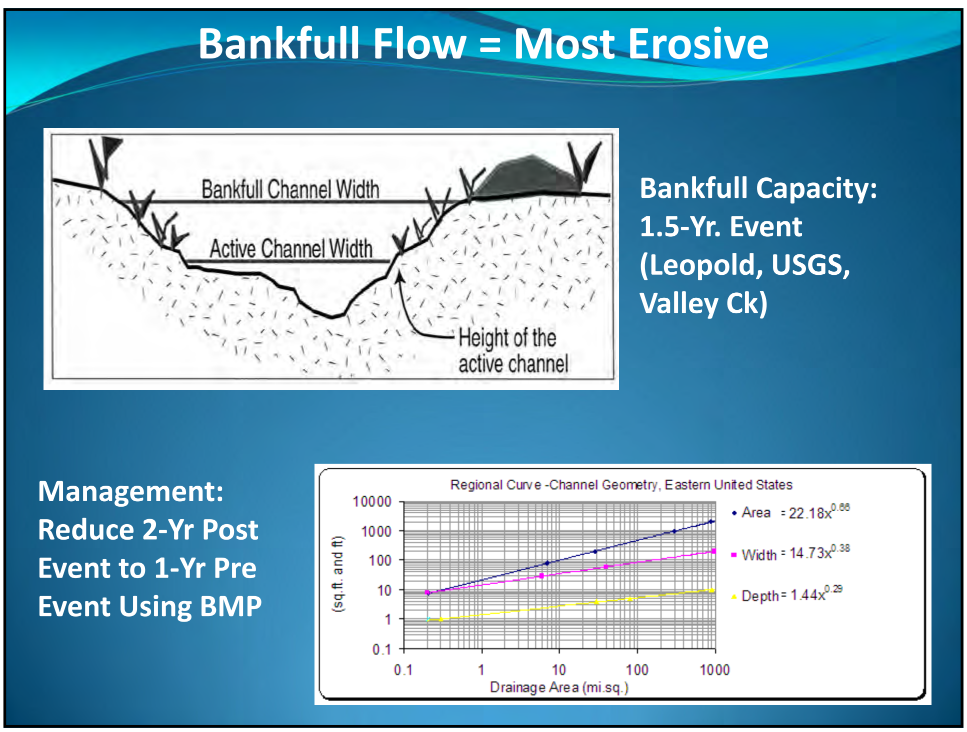
Bridge B420 – Lorrain Run at Fox Rehabilitation Access Road off Stenton Ave. – Whitemarsh Twp.

60

61


Bankfull Flow = Most Erosive
Bankfull Channel Width
Active Channel Width
Height of the active channel
Bankfull Capacity: 1.5-Yr. Event (Leopold, USGS, Valley Ck)
Management: Reduce 2-Yr Post Event to 1-Yr Pre Event Using BMP
Regional Curve -Channel Geometry, Eastern United States
Area = 22.18x^0.66
Width = 14.73x^0.38
Depth = 1.44x^0.29
(sq.ft. and ft)
Drainage Area (mi.sq.)

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63

Agenda:

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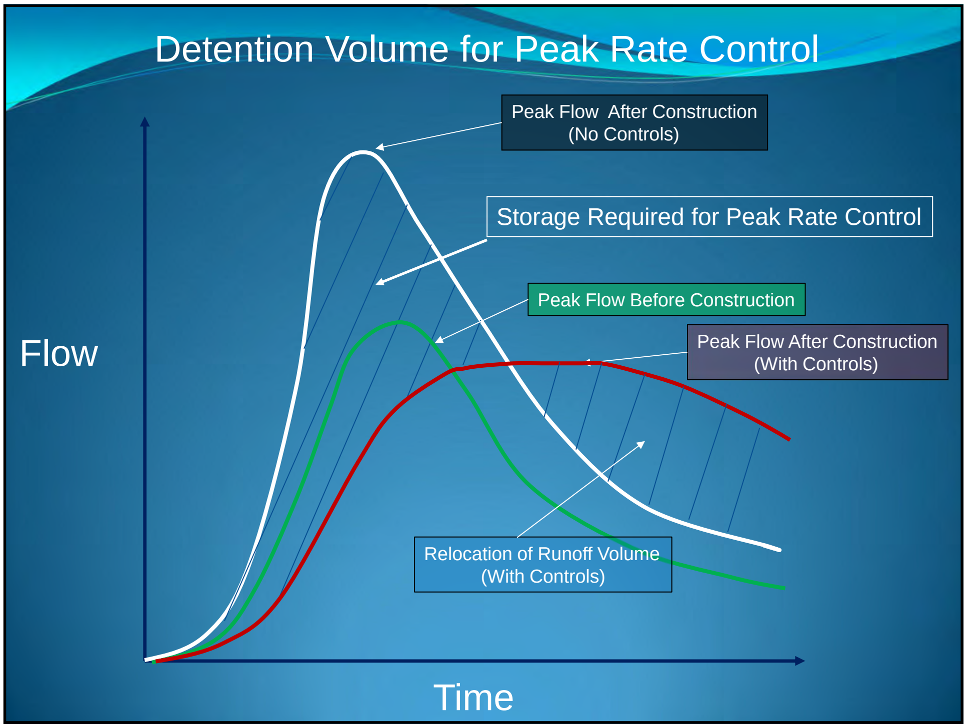
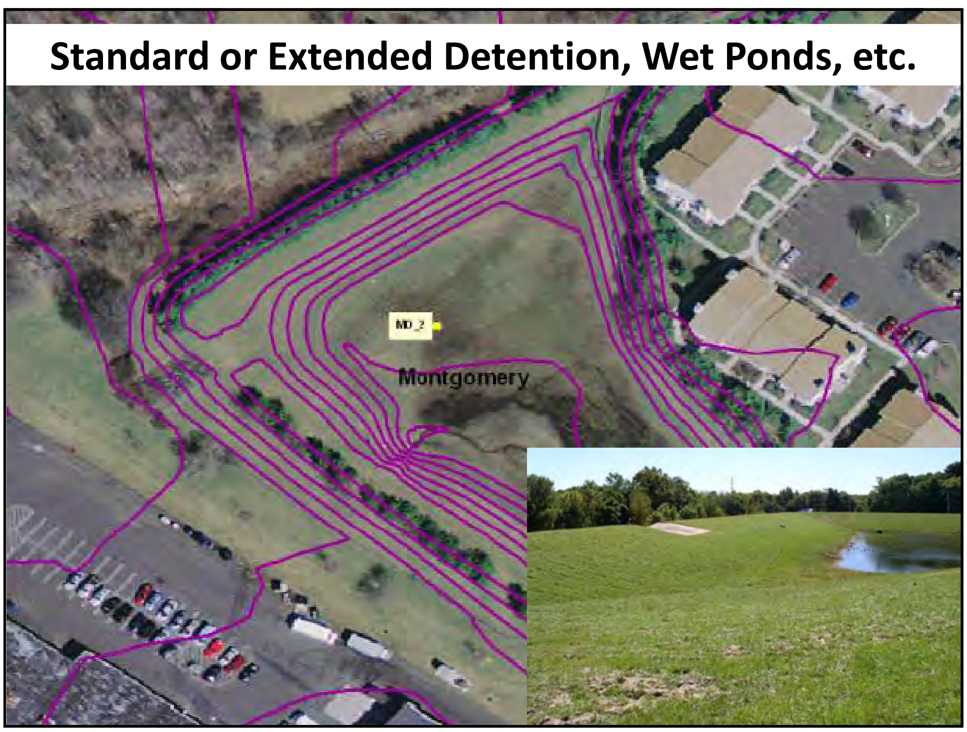
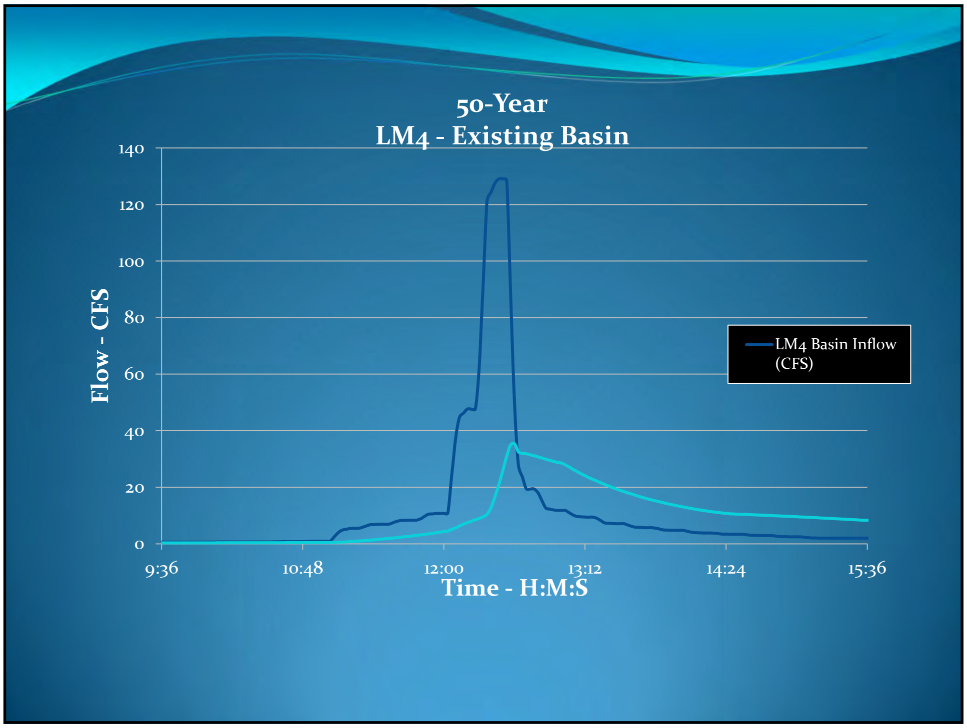

Detention Volume for Peak Rate Control
Peak Flow After Construction
(No Controls)
Storage Required for Peak Rate Control
Peak Flow Before Construction
Peak Flow After Construction
(With Controls)
Flow
Relocation of Runoff Volume
(With Controls)
Time

65

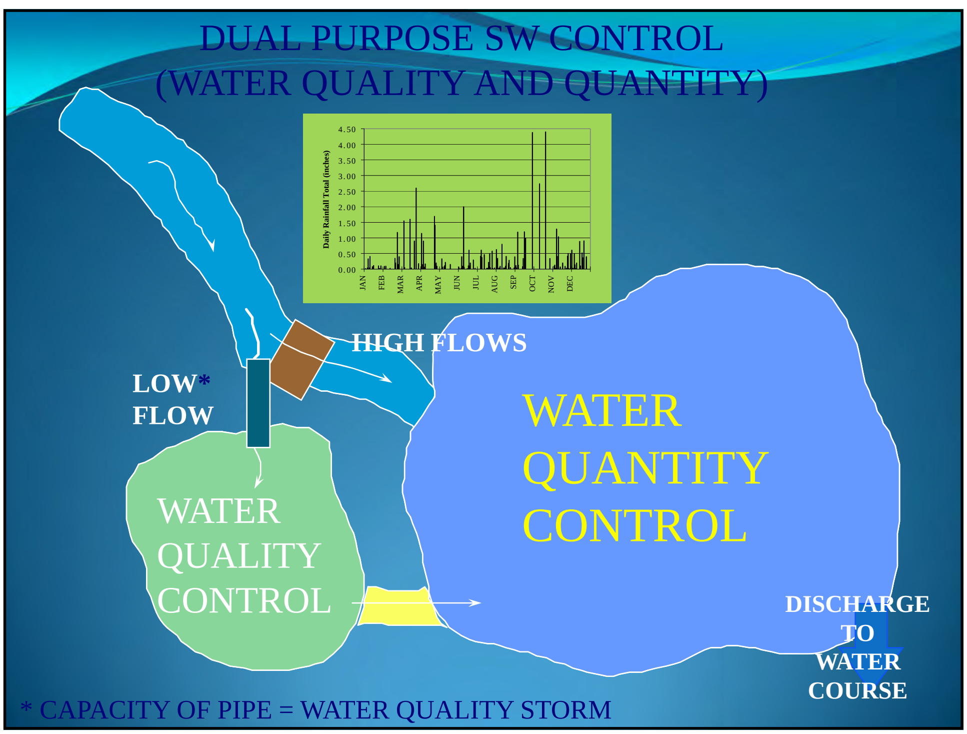

Standard or Extended Detention, Wet Ponds, etc.
Montgomery

66



50-Year
LM4 - Existing Basin
Flow - CFS
140
120
100
80
60
40
20
0
9:36
10:48
12:00
13:12
14:24
15:36
Time - H:M:S
LM4 Basin Inflow (CFS)

67



DUAL PURPOSE SW CONTROL
(WATER QUALITY AND QUANTITY)
HIGH FLOWS
LOW* FLOW
WATER QUANTITY CONTROL
WATER QUALITY CONTROL
DISCHARGE TO WATER COURSE
* CAPACITY OF PIPE = WATER QUALITY STORM

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Agenda:

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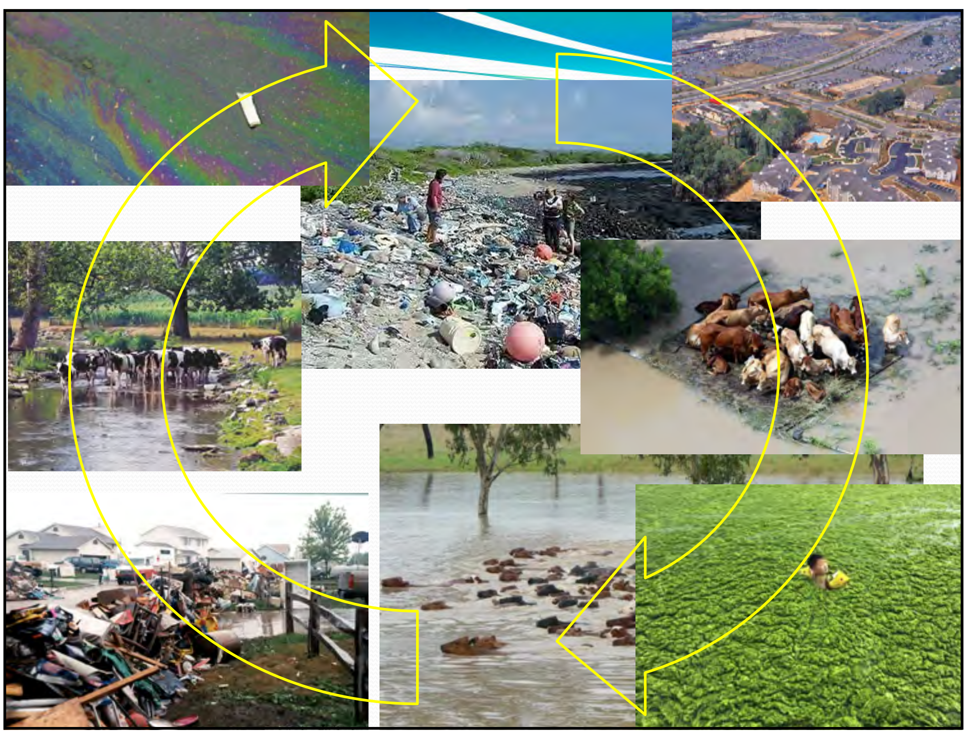

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Solution: Holistic Watershed Approach

Inventory watershed:

- Obstructions
- Problem areas
  - Stormwater (local) (volume/peak)
  - Flooding (regional)
  - Erosion / sedimentation
  - Water quality
- Roads / development
- Flood Insurance Studies data / claims
- Riparian buffers
- Etc.

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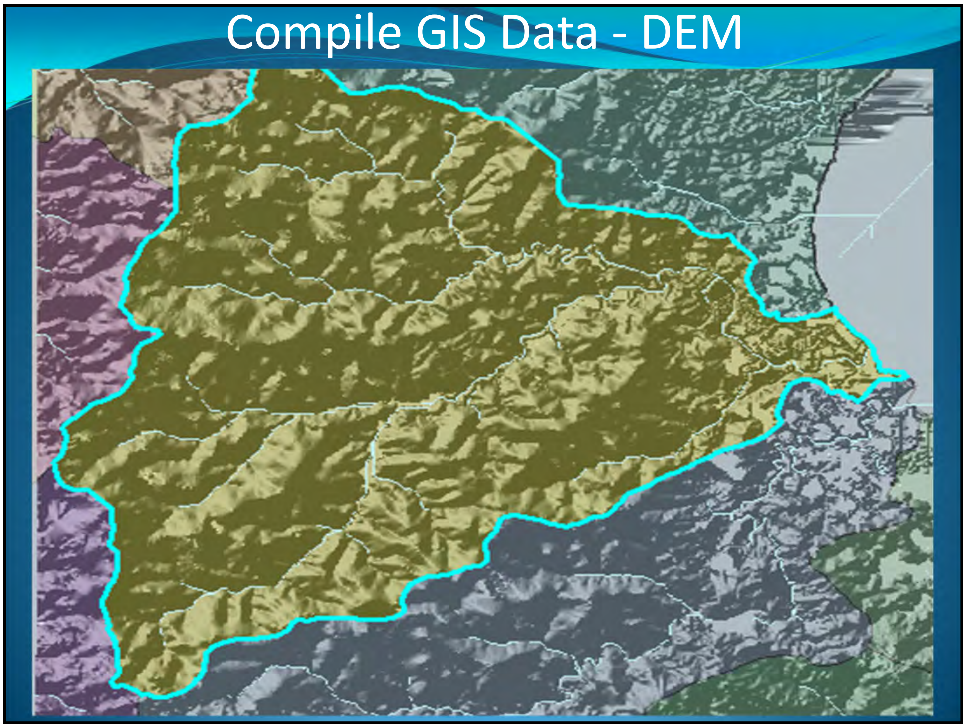
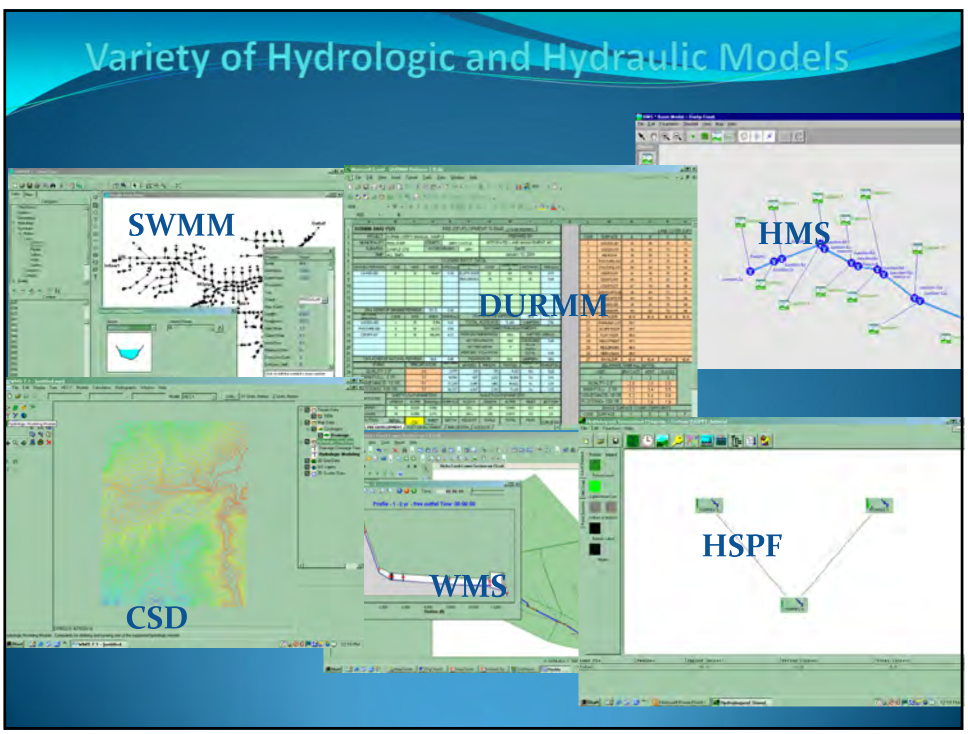
Solution: Holistic Watershed Approach

- Inventory watershed (problem areas (volume/peak/water quality, streambank) , basins, obstructions, etc.)
- Compile GIS data (DEM's, land cover, soils, geology, inventory items)
- Subdivide & model watershed (HEC-HMS, SWMM, etc.)
- From modeling, determine hydrologic response of subwatersheds
- Formulate Plan with management measures and locations – LID, retrofit sites, BMPs
- Implement Plan

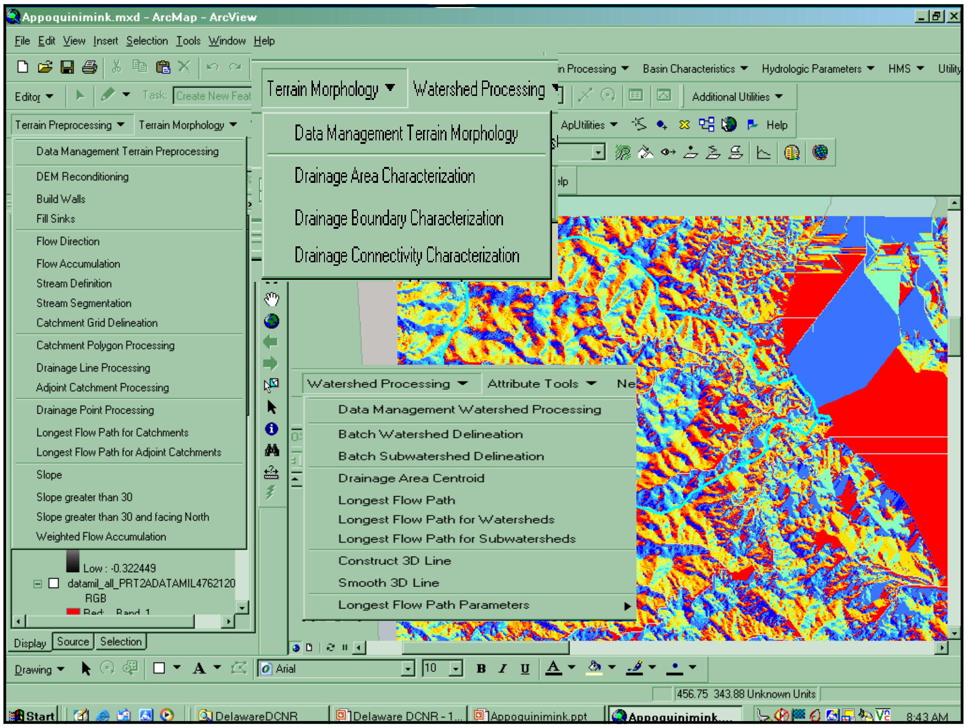
72


Compile GIS Data - DEM

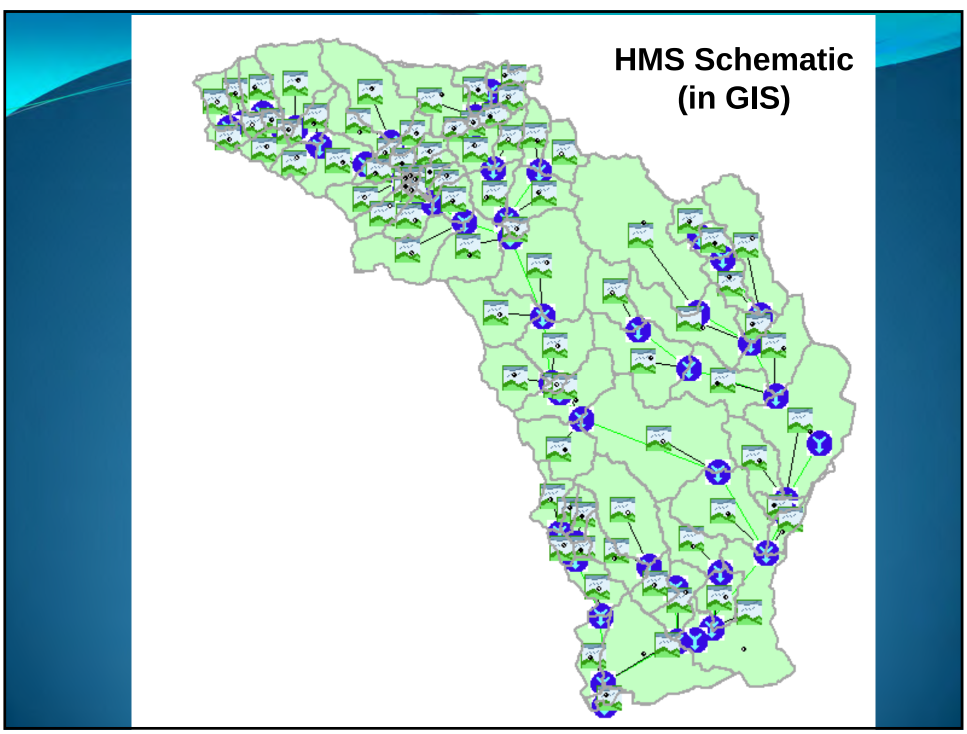
73


Variety of Hydrologic and Hydraulic Models
SWMM
DURMM
HMS
CSD
WMS
HSPF

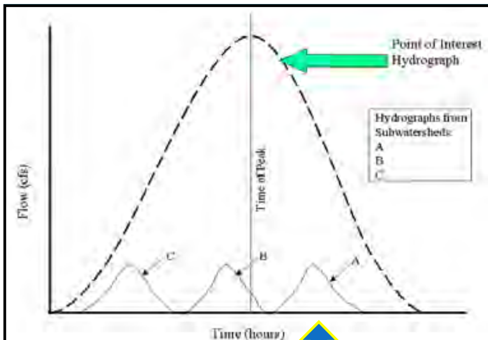
74

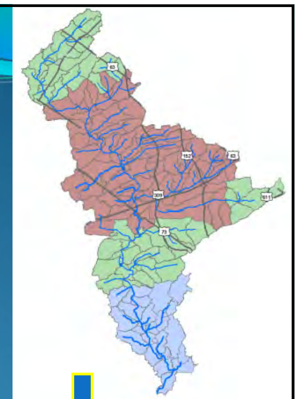

Appoquinimink.mxd - ArcMap - ArcView
File Edit View Insert Selection Tools Window Help
Terrain Morphology
Watershed Processing
Data Management Terrain Morphology
Drainage Area Characterization
Drainage Boundary Characterization
Drainage Connectivity Characterization
Terrain Preprocessing
Data Management Terrain Preprocessing
DEM Reconditioning
Build Walls
Fill Sinks
Flow Direction
Flow Accumulation
Stream Definition
Stream Segmentation
Catchment Grid Delineation
Catchment Polygon Processing
Drainage Line Processing
Adjoint Catchment Processing
Drainage Point Processing
Longest Flow Path for Catchments
Longest Flow Path for Adjoint Catchments
Slope
Slope greater than 30
Slope greater than 30 and facing North
Weighted Flow Accumulation
Attribute Tools
Data Management Watershed Processing
Batch Watershed Delineation
Batch Subwatershed Delineation
Drainage Area Centroid
Longest Flow Path
Longest Flow Path for Watersheds
Longest Flow Path for Subwatersheds
Construct 3D Line
Smooth 3D Line
Longest Flow Path Parameters
Basin Characteristics
Hydrologic Parameters
HMS
Additional Utilities
ApUtilities
Help
Low : -0.322449
datamil_all_PRT2ADATAMIL4762120
RGB
Display Source Selection
Drawing
Arial
456.75 343.88 Unknown Units
Start
DelawareDCNR
Appoquinimink.ppt
8:43 AM

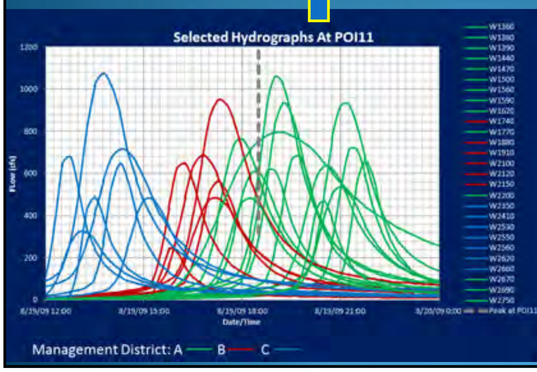
75


HMS Schematic
(in GIS)

76







District	Proposed Condition Design Storm		Existing Condition Design Storm
A	2-year	reduce to	1-year
	5-year		5-year
	10-year		10-year
	25-year		25-year
	50-year		50-year
B	2-year	reduce to	1-year
	5-year		2-year
	10-year		5-year
	25-year		10-year
	50-year		25-year
	100-year		50-year
C*	Conditional Direct Discharge District		

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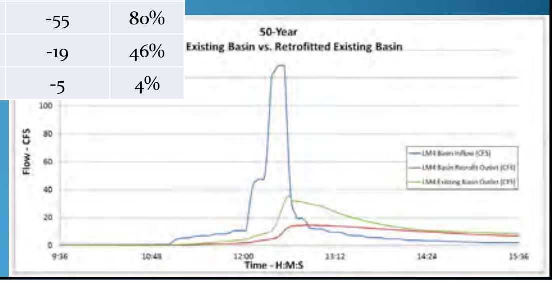
Model Results with Retrofitting

2-Year

Basin	Peak In (CFS)	Existing Peak Out (CFS)	Retrofit Peak Out (CFS)	Difference (CFS)	Reduced By %
LME4	62	10	4	-5	54%
BEE11	83	39	3	-37	93%
BEE40	174	8	1	-8	93%
PHE10	136	46	32	-14	31%

50-Year

Basin	Peak In (CFS)	Existing Peak Out (CFS)	Retrofit Peak Out (CFS)	Difference (CFS)	Reduced By %
LME4	129	35	15	-21	59%
BEE11	178	69	14	-55	80%
BEE40	378	41	22	-19	46%
PHE10	282	130	125	-5	4%



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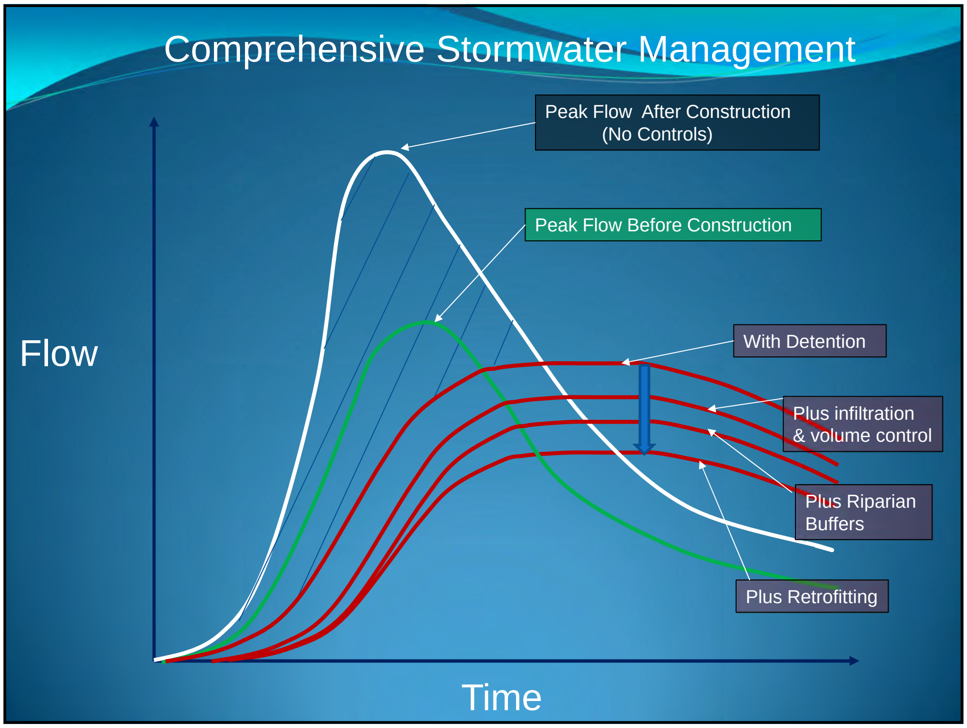
Comprehensive Stormwater Management
Peak Flow After Construction (No Controls)
Peak Flow Before Construction
With Detention
Plus infiltration & volume control
Plus Riparian Buffers
Plus Retrofitting
Flow
Time

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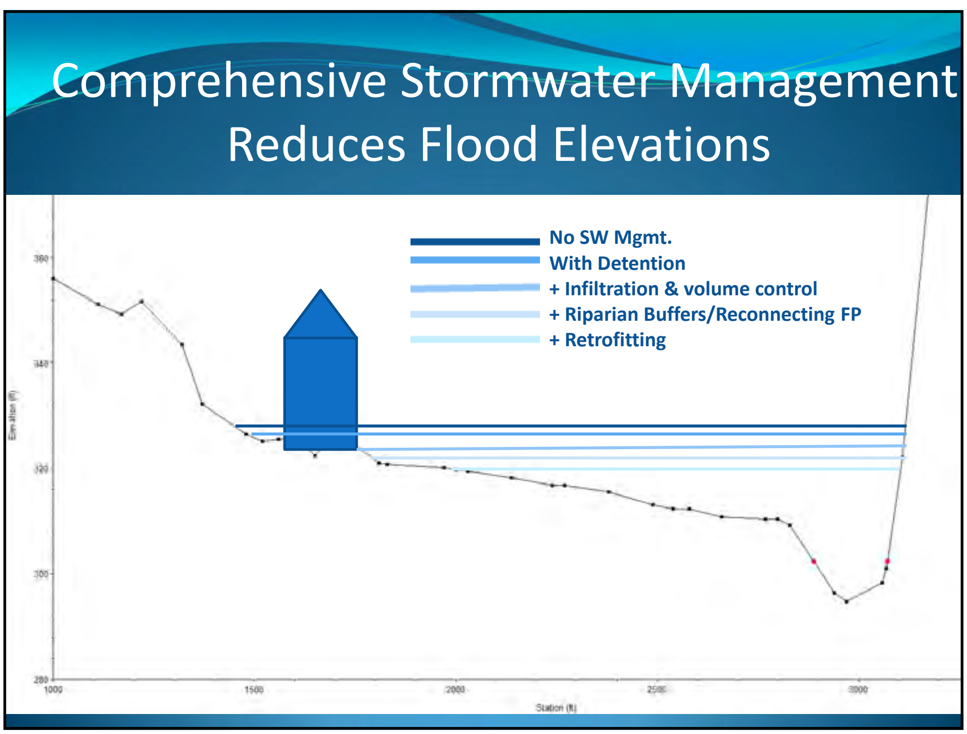
Comprehensive Stormwater Management Reduces Flood Elevations
No SW Mgmt.
With Detention
+ Infiltration & volume control
+ Riparian Buffers/Reconnecting FP
+ Retrofitting

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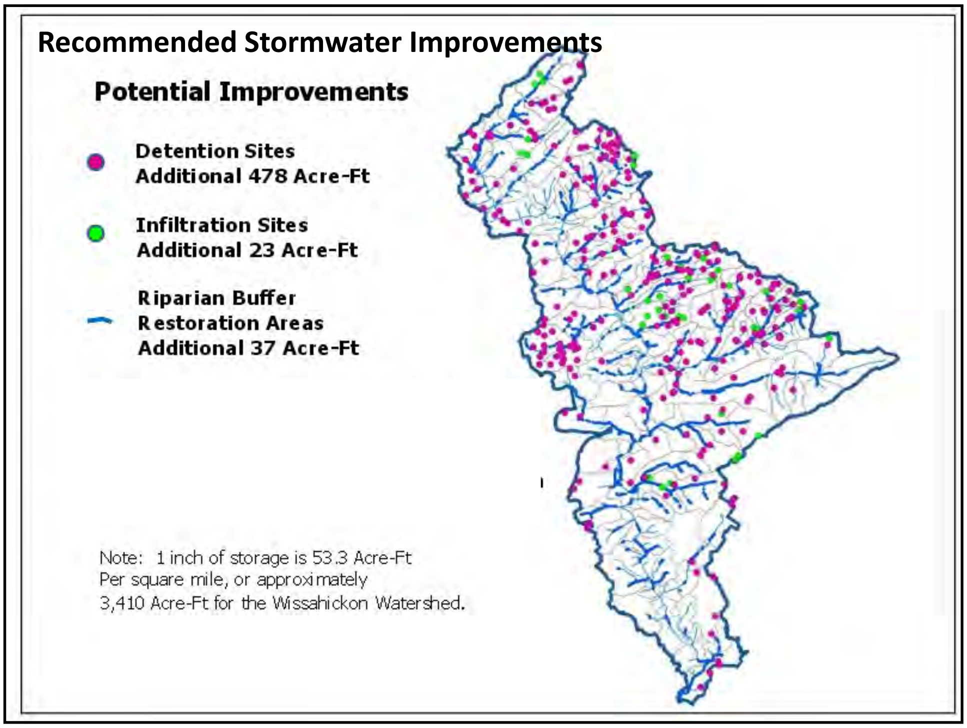
Recommended Stormwater Improvements
Potential Improvements
Detention Sites
Additional 478 Acre-Ft
Infiltration Sites
Additional 23 Acre-Ft
Riparian Buffer
Restoration Areas
Additional 37 Acre-Ft
Note: 1 inch of storage is 53.3 Acre-Ft
Per square mile, or approximately
3,410 Acre-Ft for the Wissahickon Watershed.

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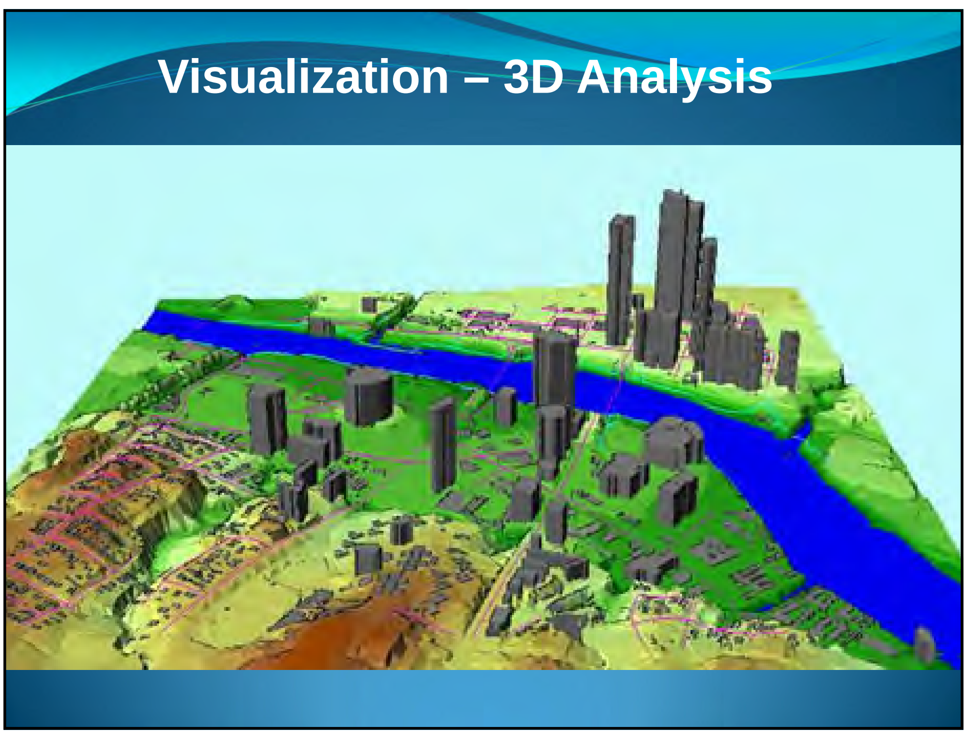
Visualization – 3D Analysis

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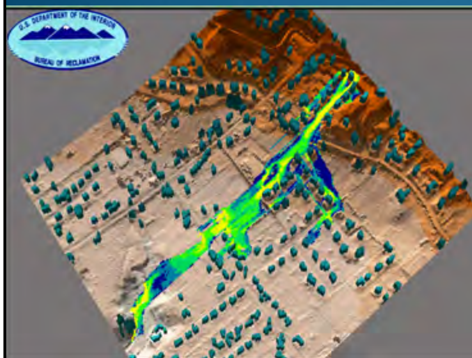
Geographic Information Systems (GIS) with Watershed and Floodplain Modeling



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Agenda:

- Cause - Effect
- Programs
- Floodplains
- Stormwater
    - Infiltration
    - Volume Control (Water Quality)
    - Stream Bank Erosion
    - Peak Rate Control
- Watershed Assessment & Analysis
- Connecting the Drops

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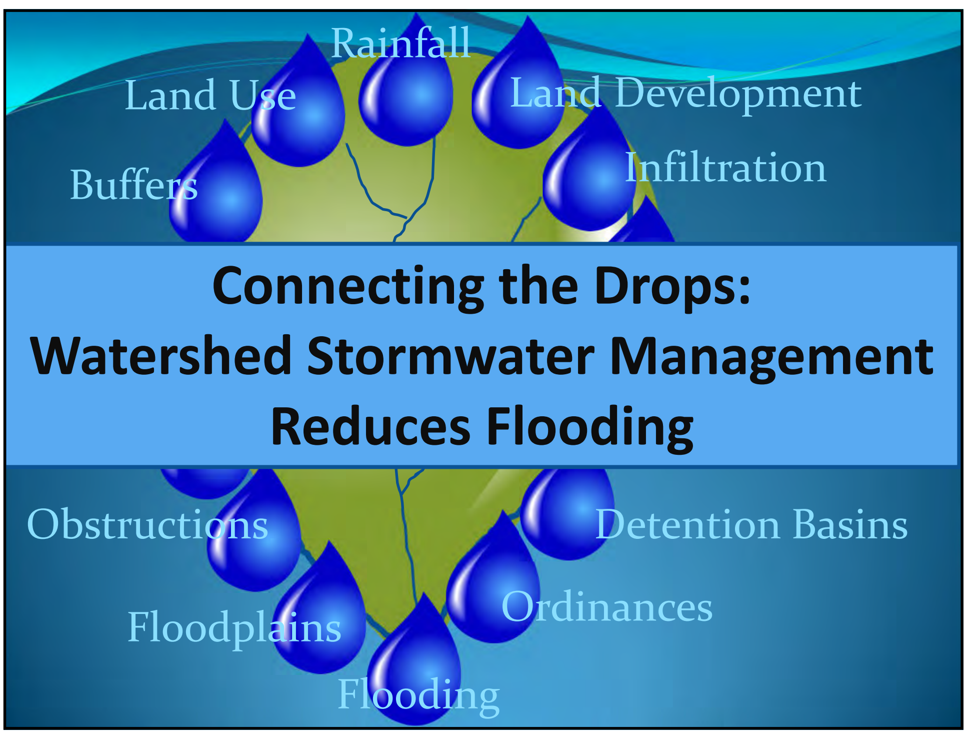

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