Water Quality, Land Protection, and Climate Change – Implications for Drinking Water and Stormwater Managers

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Objectives

- Examine hydrologic responses from land use changes
- Discuss association of contaminants and land use
- Develop and implement preventive and mitigating approaches
- Impacts of climate change (i.e., floods in New England)

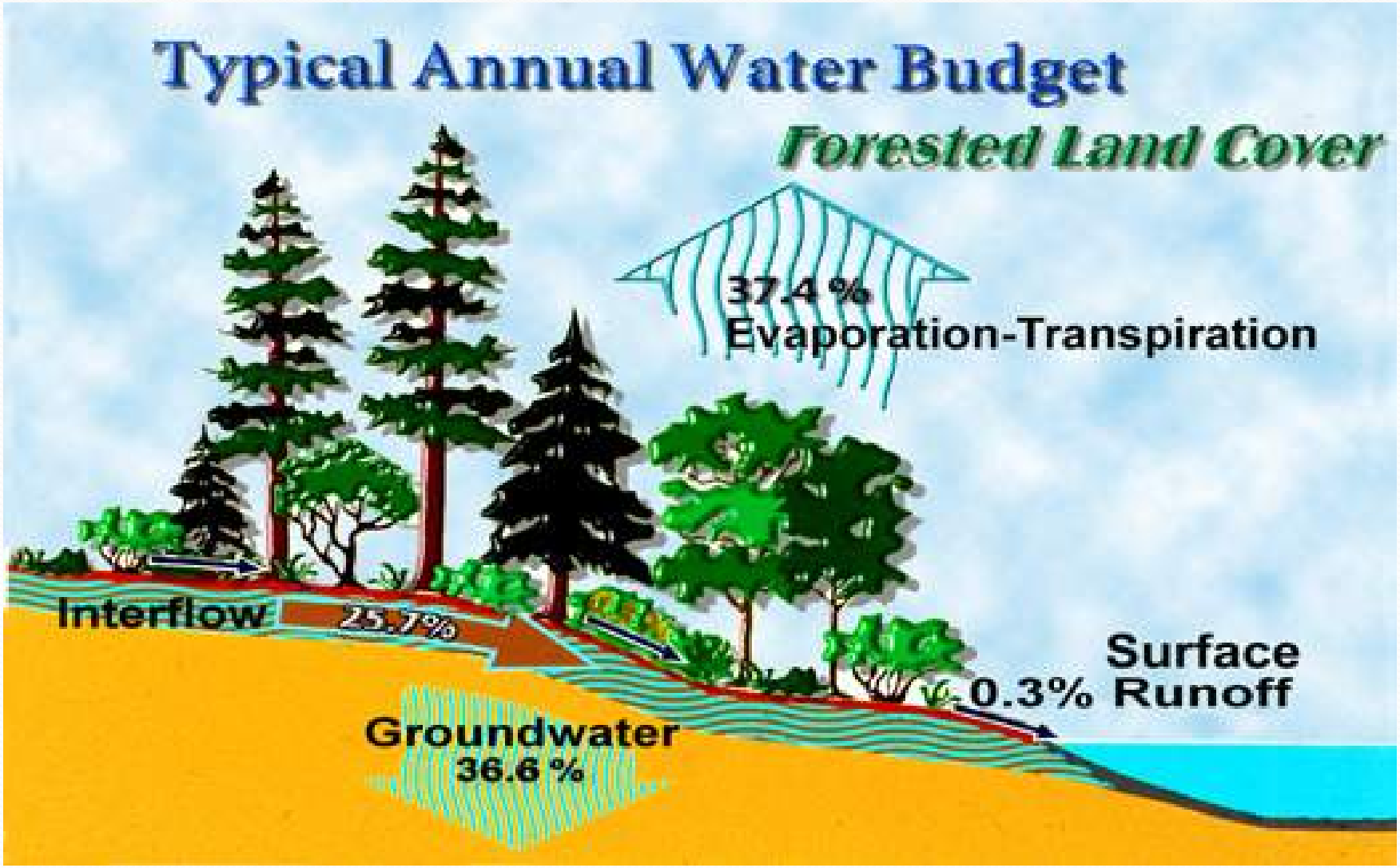
Hydrologic Responses to Land Use Changes (1)

- Evolution of natural hydrologic regimes
  - Climatic conditions
  - Geology and soils
  - Vegetation
  - Event frequency (high and low)
  - Time

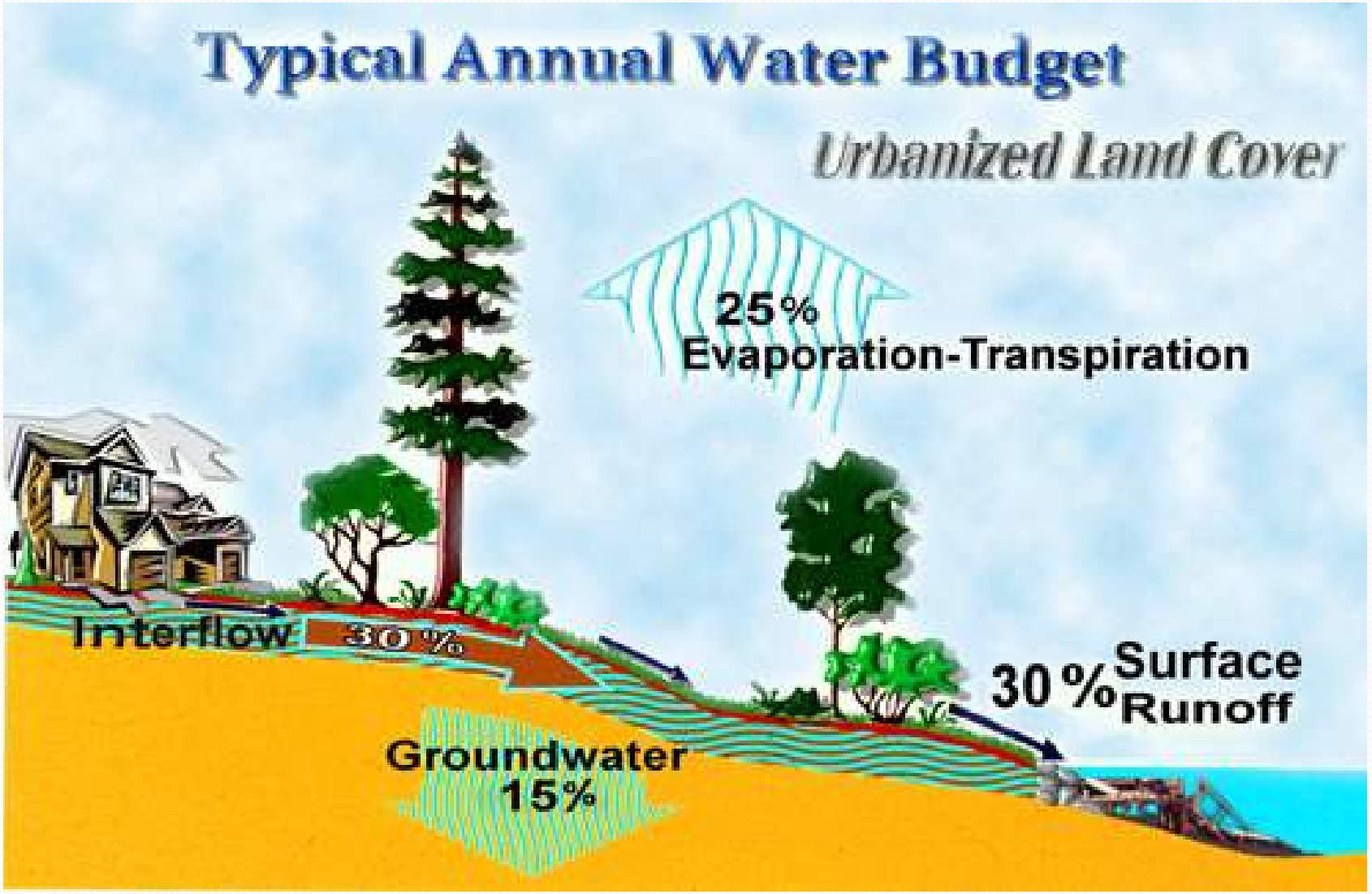
Hydrologic Responses to Land Use Changes (2)

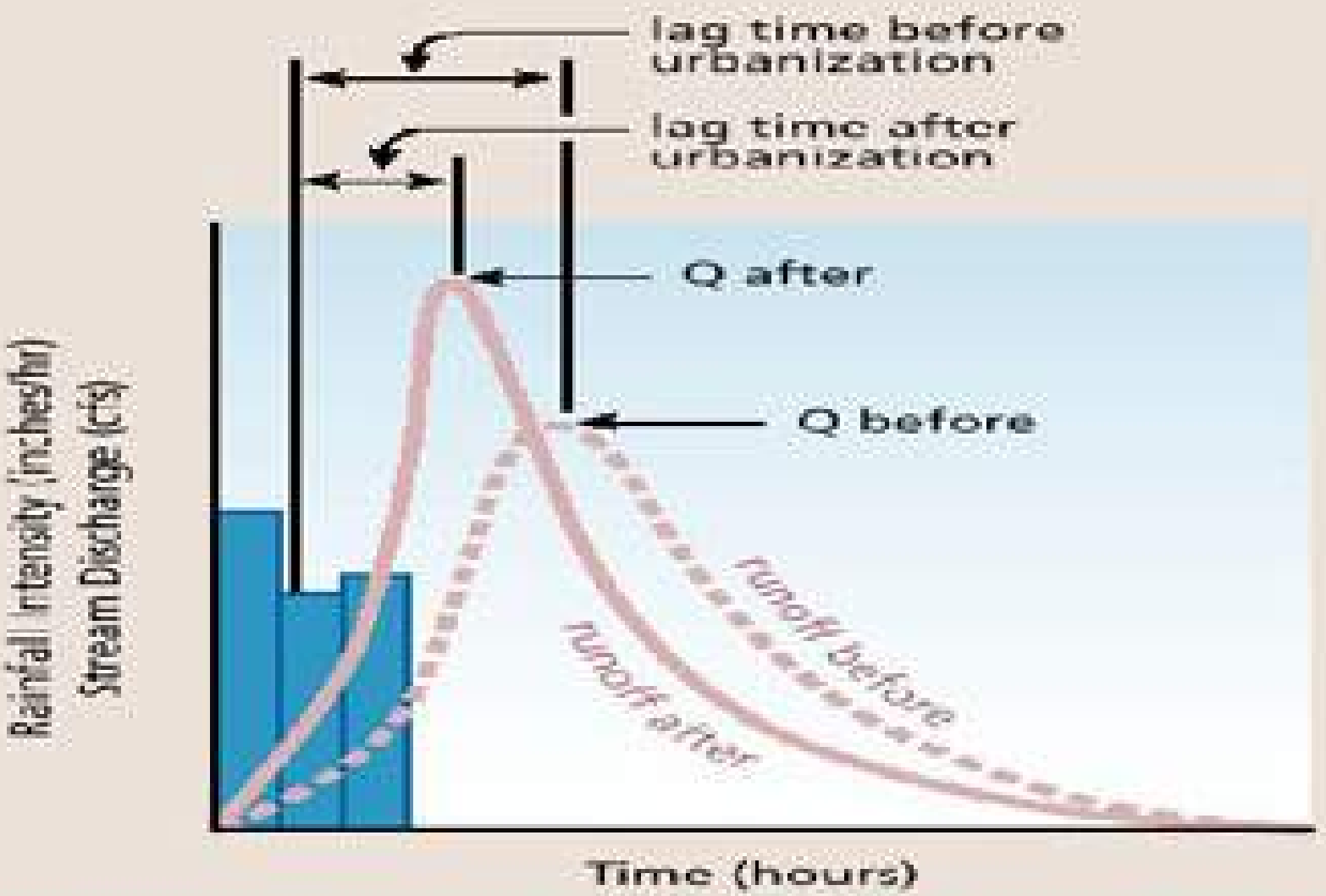
- Hydrologic cycle
  - Precipitation
  - Infiltration and percolation
  - Ground water storage and flow
  - Evapotranspiration
  - Runoff
  - Streamflow
    - Stormflow
    - Interflow
    - Baseflow

Natural Conditions



Developed Conditions

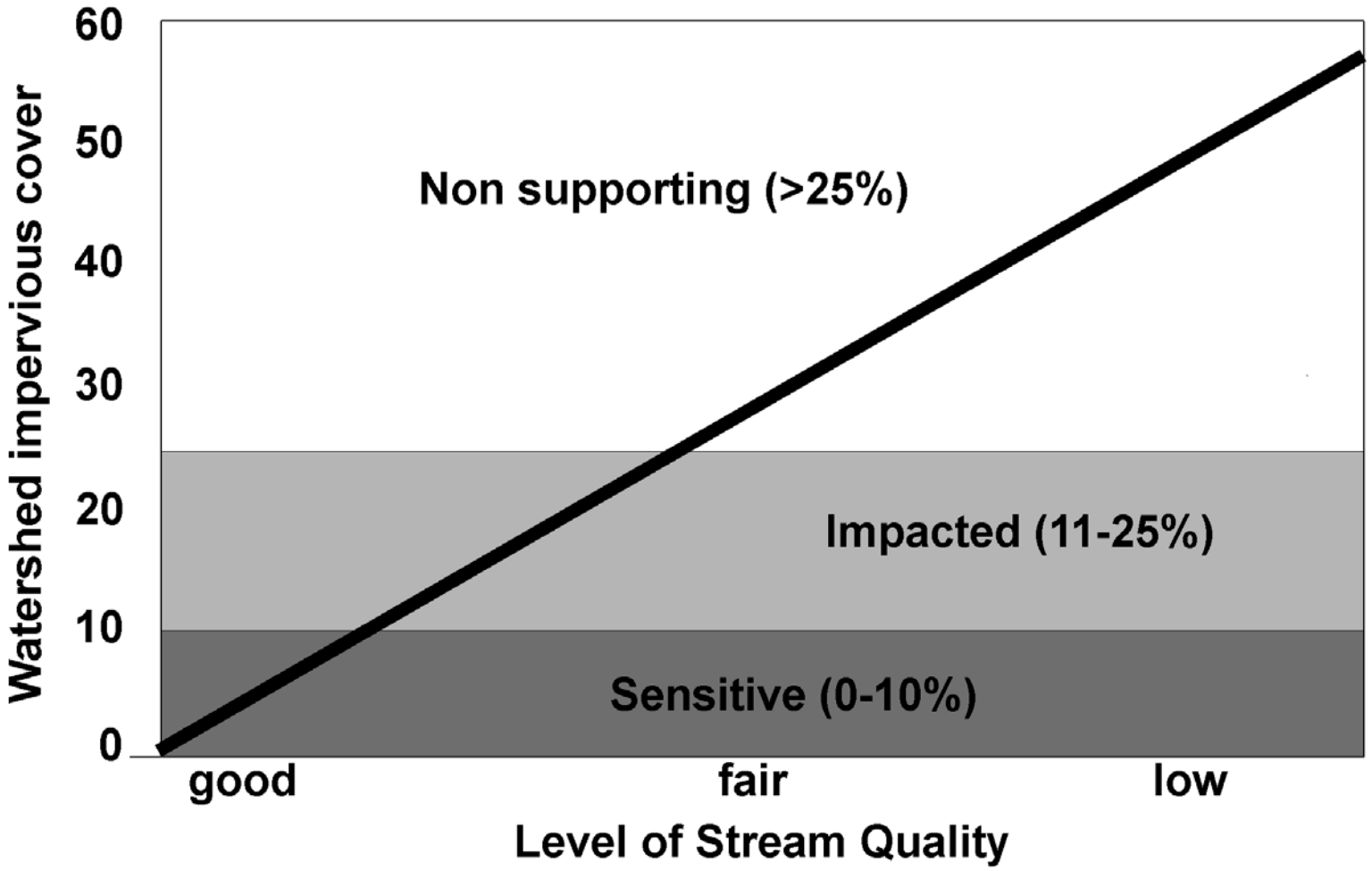




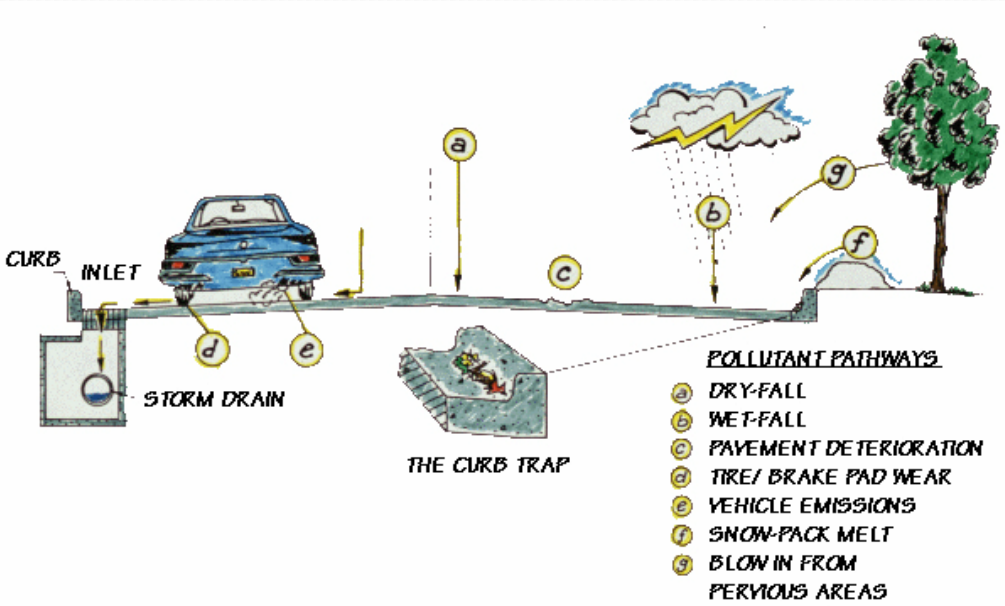
A comparison of hydrographs before and after urbanization (blue bars indicate rainfall rate and timing). The discharge curve is higher and steeper for urban streams than for non-urbanized streams due to faster and greater runoff.

Hydrologic Responses to Land Use Changes

Relationship Between Impervious Cover and Stream Quality



Land Based Contaminants - Stormwater



KEY POLLUTANT DEPOSITION PATHWAYS ON THE STREET SURFACE

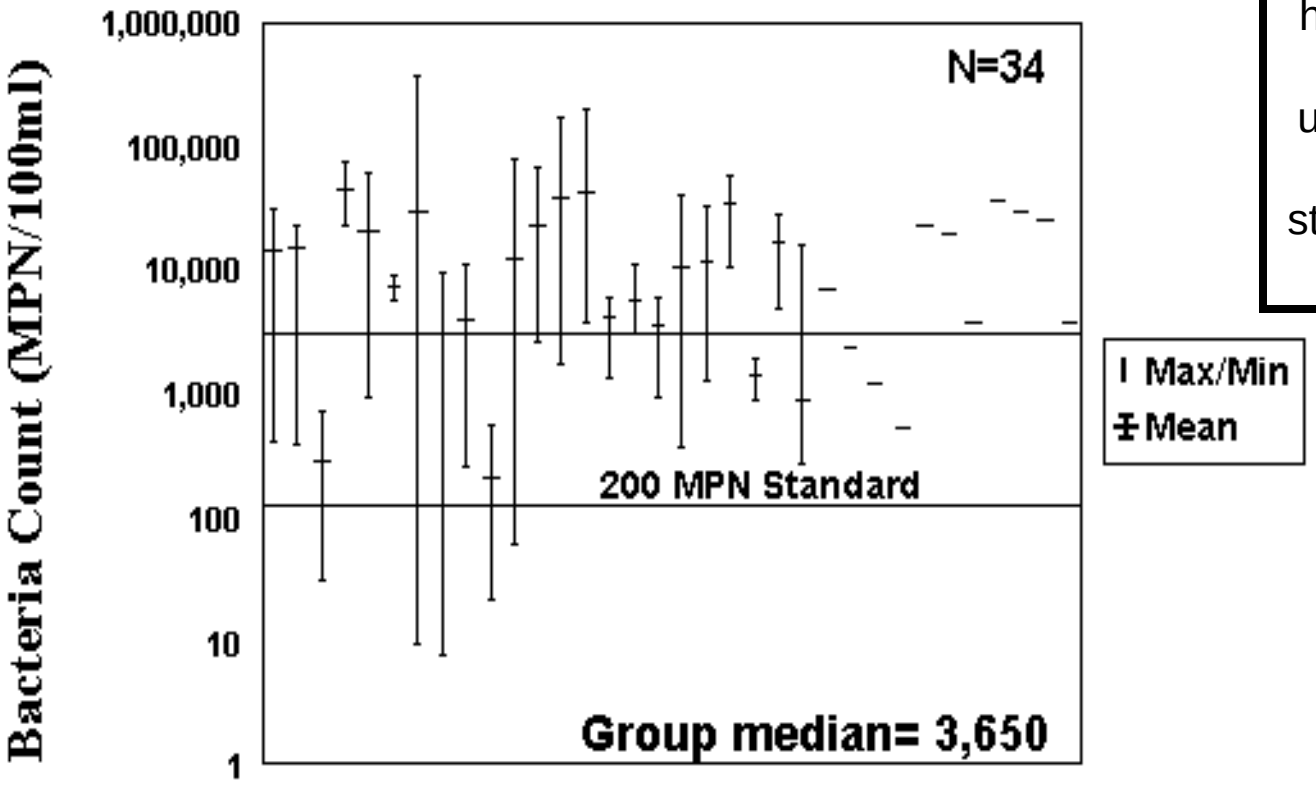
Land Based Contaminants - Stormwater

- Source areas
  - Agricultural practices
  - Auto recycling
  - Commercial parking lots
  - Fleet storage areas
  - Forest harvesting
  - Industrial rooftops
  - Landscaping/nursery
  - Industrial (outdoor storage or unloading)
  - Vehicle service and maintenance
  - Vehicle washing/steam cleaning

Land Based Contaminants - Stormwater

- Typical pollutants
  - Suspended solids/sediments
  - Nutrients (nitrogen and phosphorus)
  - Metals (copper, zinc, lead, and cadmium)
  - Oil and grease
  - Bacteria
  - Pesticides and herbicides
  - Temperature

Fecal Coliform Levels in Urban Stormwater: A National Review



Stormwater runoff levels from 34 small catchments in 13 monitoring studies conducted:
AL, AZ, ID, KY, MD, NC, NH, NY, SD, TN, TX, WA, WI

Studies of fecal coliform levels have found much higher levels in urban stormwater runoff than the standard accepted levels.

Stormwater Management

- Objectives:
  - Manage peak flows
  - Treat water quality (first flush)
  - Reduce severity and frequency of flooding
  - Reduce soil erosion and sedimentation
  - Protect water quality
  - Promote ground water recharge
  - Restore fish and wildlife habitat

Best (Effective) Management Practices

- Structural versus non-structural
- Control versus preventive
- Engineering versus cultural

- Regulatory versus non-regulatory

Best Management Practices

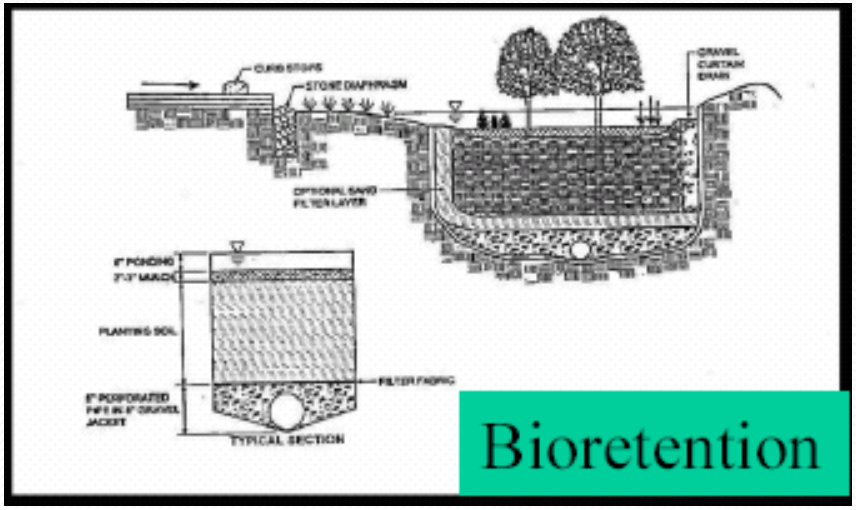
- Structural
  - Grassed swales
  - Infiltration basins
  - Detention basins
  - Media filters
  - Percolation trenches/well
  - Porous pavement
  - Retention ponds
  - Wetland basins
  - Wetland channels/swales
  - Hydrodynamic devices

- Non-structural
  - Source control
  - Education practices
  - Recycling practices
  - Maintenance practices

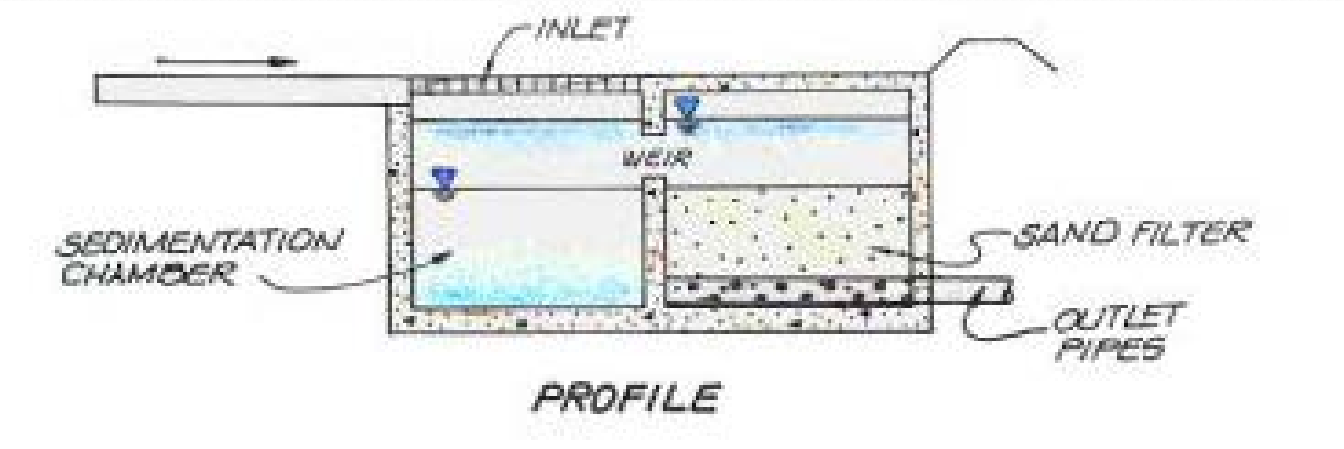
Grassed Swales

Shallow, vegetated ditches
-Reduce speed and volume of runoff
-Allow infiltration and filtration of runoff

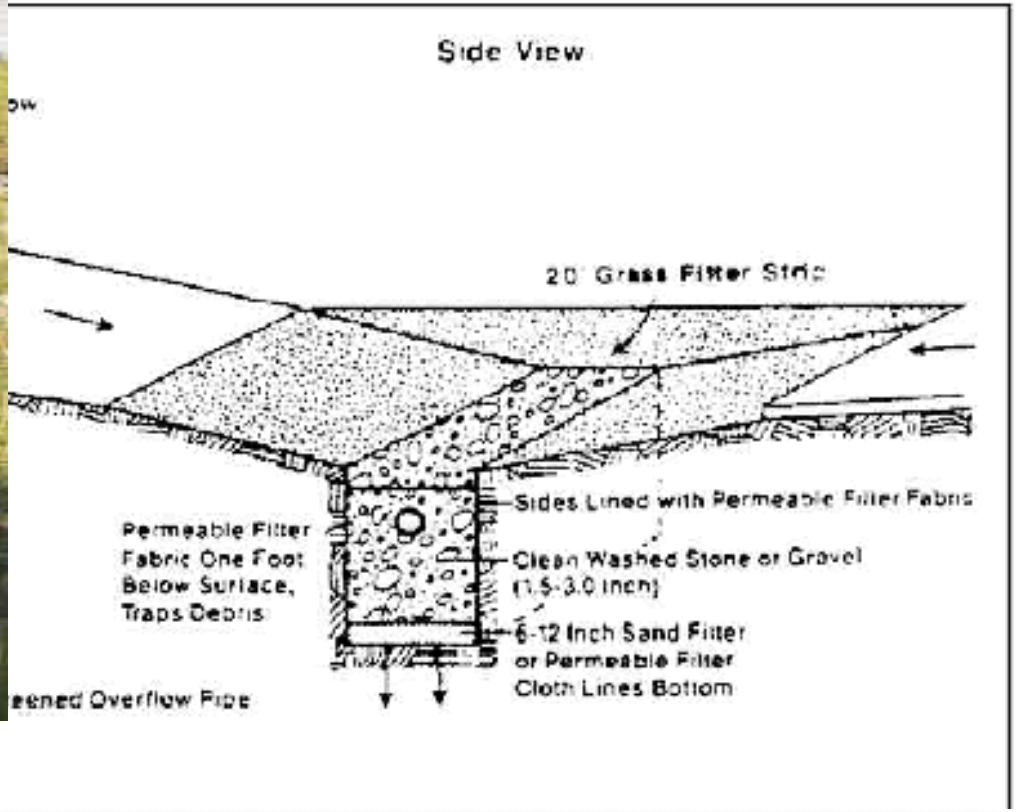
Filtration and Infiltration – Vegetated and Bioretention



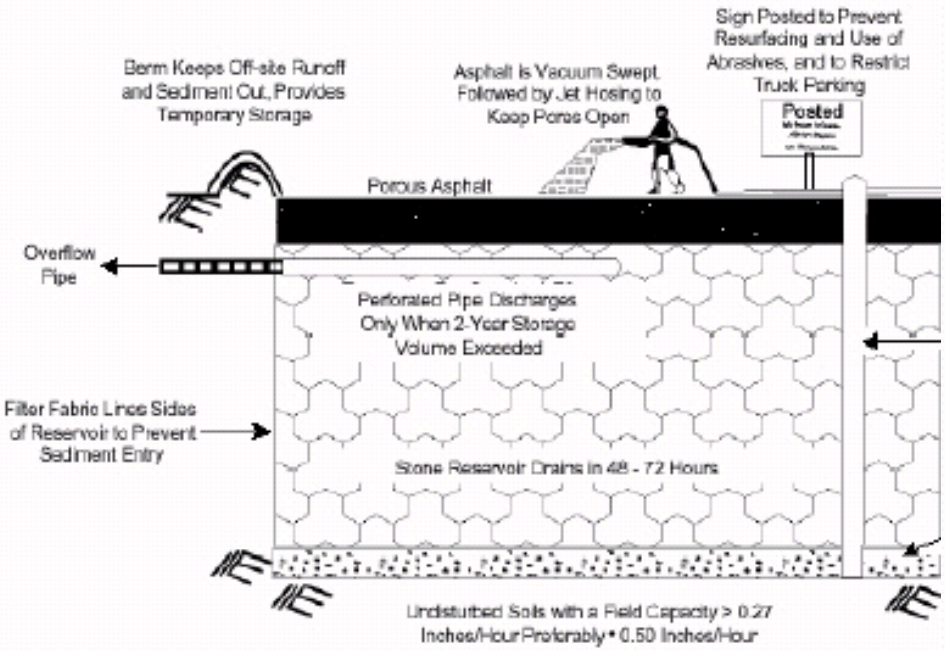
Sand Filter


INLET
WEIR
SEDIMENTATION CHAMBER
SAND FILTER
OUTLET PIPES
PROFILE

Infiltration Trench



Porous Pavement



Wet Pond

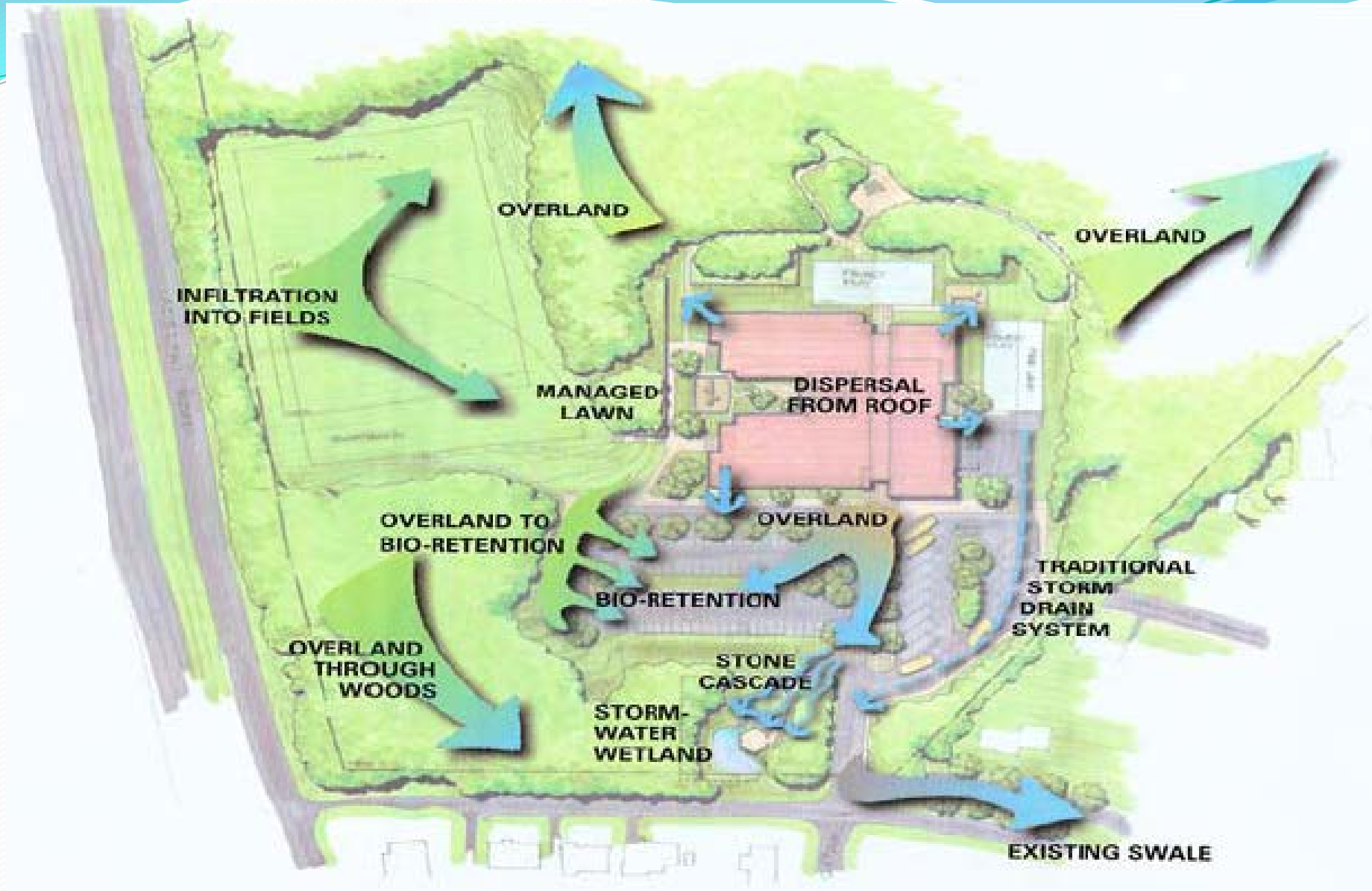
Wetland/Pond System

Office Complex Wetland

Drainage Channel

Innovative Site Design

- Reduce paved surface (e.g., street)
- Use vegetated drainage channels
- Reduce parking ratio and imperviousness
- Stormwater treatment measures
- Maintain open space (e.g., cluster development)
- Direct rooftop runoff to pervious areas
- Create riparian buffer
- Conserve native vegetation


OVERLAND
OVERLAND
INFILTRATION INTO FIELDS
MANAGED LAWN
DISPERSAL FROM ROOF
OVERLAND TO BIO-RETENTION
OVERLAND
TRADITIONAL STORM DRAIN SYSTEM
BIO-RETENTION
OVERLAND THROUGH WOODS
STONE CASCADE
STORM-WATER WETLAND
EXISTING SWALE

Typical Base Capital Construction Costs for BMPs

BMP Type	Typical Cost* ($/cf)	Notes	Source
Retention and Detention Basins	0.50-1.00	Cost range reflects economies of scale in designing this BMP. The lowest unit cost represents approx. 150,000 cubic feet of storage, while the highest is approx. 15,000 cubic feet. Typically, dry detention basins are the least expensive design options among retention and detention practices.	Adapted from Brown and Schueler (1997b)
Constructed Wetland	0.60-1.25	Although little data are available to assess the cost of wetlands, it is assumed that they are approx. 25% more expensive (because of plant selection and sediment forebay requirements) than retention basins..	Adapted from Brown and Schueler (1997b)
Infiltration Trench	4.00	Represents typical costs for a 100-foot long trench.	Adapted from SWRPC (1991)
Infiltration Basin	1.30	Represents typical costs for a 0.25-acre infiltration basin.	Adapted from SWRPC (1991)

Typical Base Capital Construction Costs for BMPs

BMP Type	Typical Cost* ($/cf)	Notes	Source
Sand Filter	3.00-6.00	The range in costs for sand filter construction is largely due to the different sand filter designs. Of the three most common options available, perimeter sand filters are moderate cost whereas surface sand filters and underground sand filters are the most expensive.	Adapted from Brown and Schueler (1997b)
Bioretention	5.30	Bioretention is relatively constant in cost, because it is usually designed as a constant fraction of the total drainage area.	Adapted from Brown and Schueler (1997b)
Grass Swale	0.50	Based on cost per square foot, and assuming 6 inches of storage in the filter.	Adapted from SWRPC (1991)
Filter Strip	0.00-1.30	Based on cost per square foot, and assuming 6 inches of storage in the filter strip. The lowest cost assumes that the buffer uses existing vegetation, and the highest cost assumes that sod was used to establish the filter strip.	Adapted from SWRPC (1991)

Base Costs of Typical Application of Stormwater BMPs

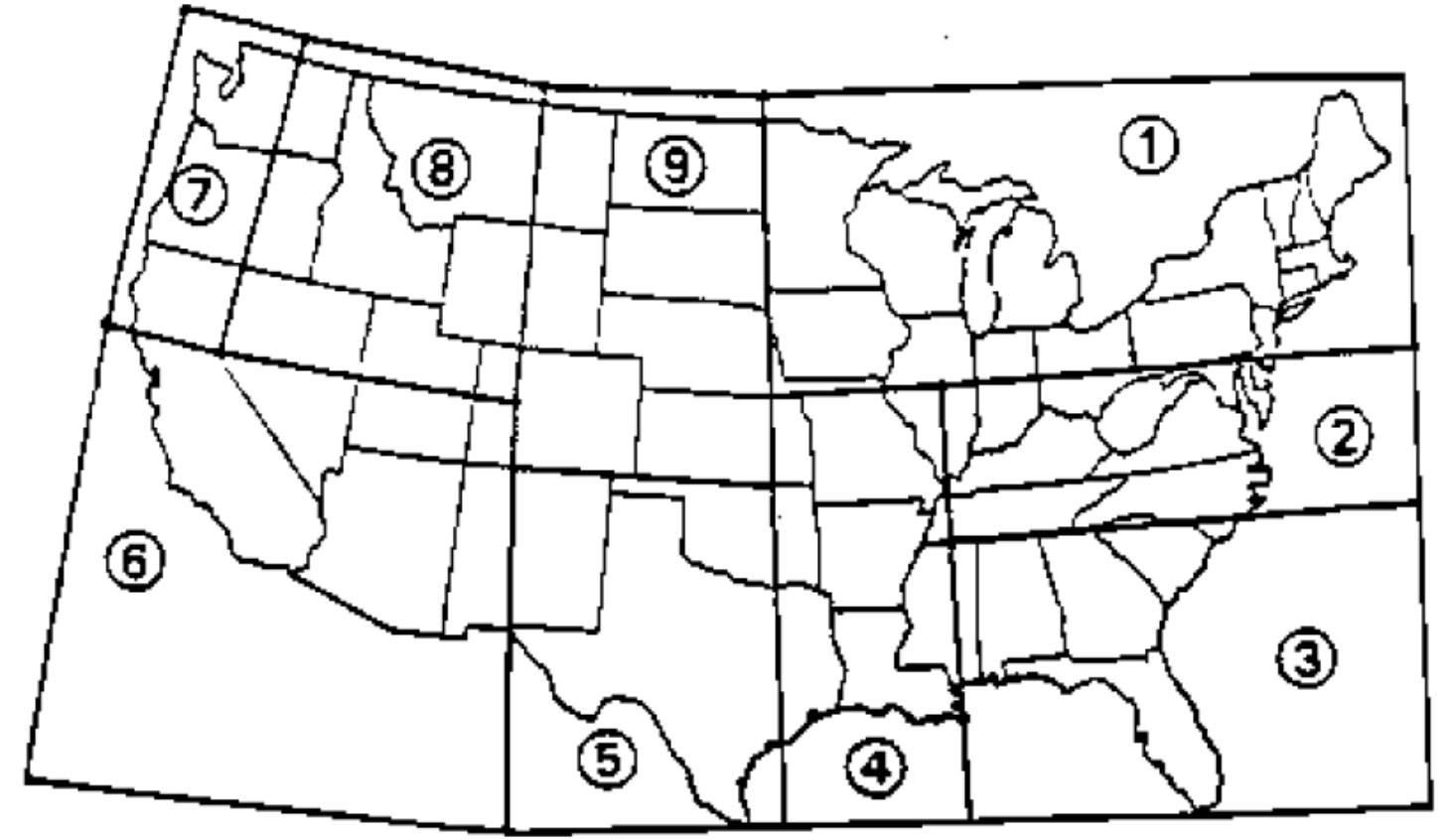
BMP Type	Typical Cost ($/BMP)	Application	Data Source
Retention Basin	$100,000	50-Acre Residential Site (Impervious Cover = 35%)	Adapted from Brown and Schueler (1997b)
Wetland	$125,000	50-Acre Residential Site (Impervious Cover = 35%)	Adapted from Brown and Schueler (1997b)
Infiltration Trench	$45,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from SWRPC (1991)
Infiltration Basin	$15,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from SWRPC (1991)

Base Costs of Typical Application of Stormwater BMPs

BMP Type	Typical Cost ($/BMP)	Application	Data Source
Sand Filter	$35,000-$70,000[2,3]	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from Brown and Schueler (1997b)
Bioretention	$60,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from Brown and Schueler (1997b)
Grass Swale	$3,500	5-Acre Residential Site (Impervious Cover = 35%)	Adapted from SWRPC (1991)
Filter Strip	$0-$9,000[3]	5-Acre Residential Site (Impervious Cover = 35%)	Adapted from SWRPC (1991)

Regional Cost Adjustment Factors

Rainfall Zone	1	2	3	4	5	6	7	8	9
Adjustment Factor	1.12	0.90	0.67	0.92	0.67	1.24	1.04	1.04	0.76



Preventive and Mitigating Approaches to Protect Source Water

- Land use management
  - Preserve or restore original hydrologic regimes
  - Moderate impacts from land use changes on hydrologic regimes
  - Eliminate the probability of contaminant release into the environment and source water
- Pollution prevention
  - Minimize release of contaminants from existing establishments and land use through control measures

Land Use Management Tools

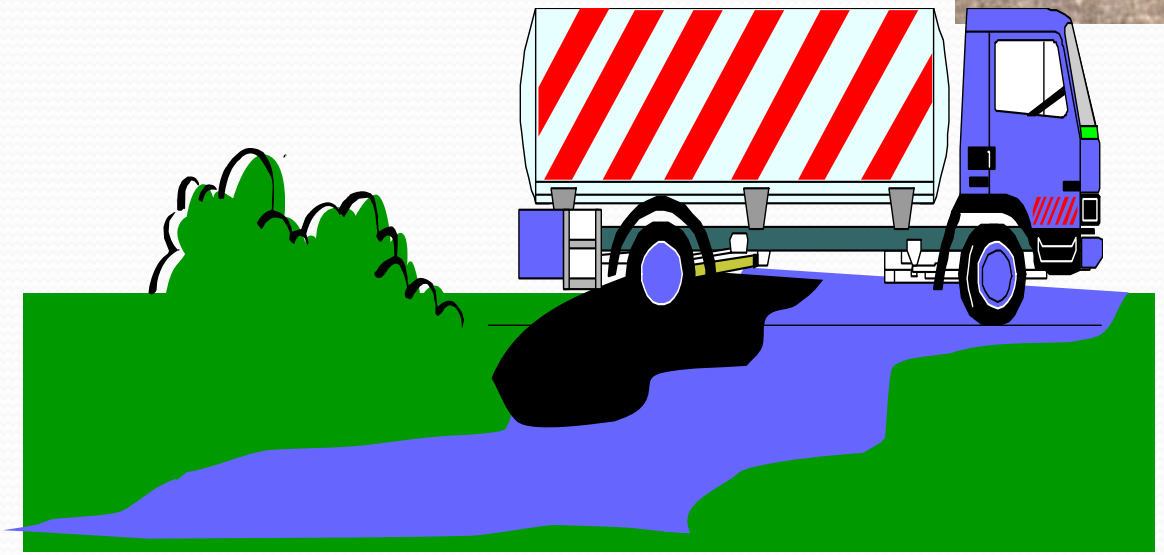
- Subdivision growth controls
- Zoning
- Land purchase
- Acquisition and Transfer of development rights
- Land use prohibitions

Regulations and Permits

- Construction and operating standards
- Permit requirements
- Public health regulations

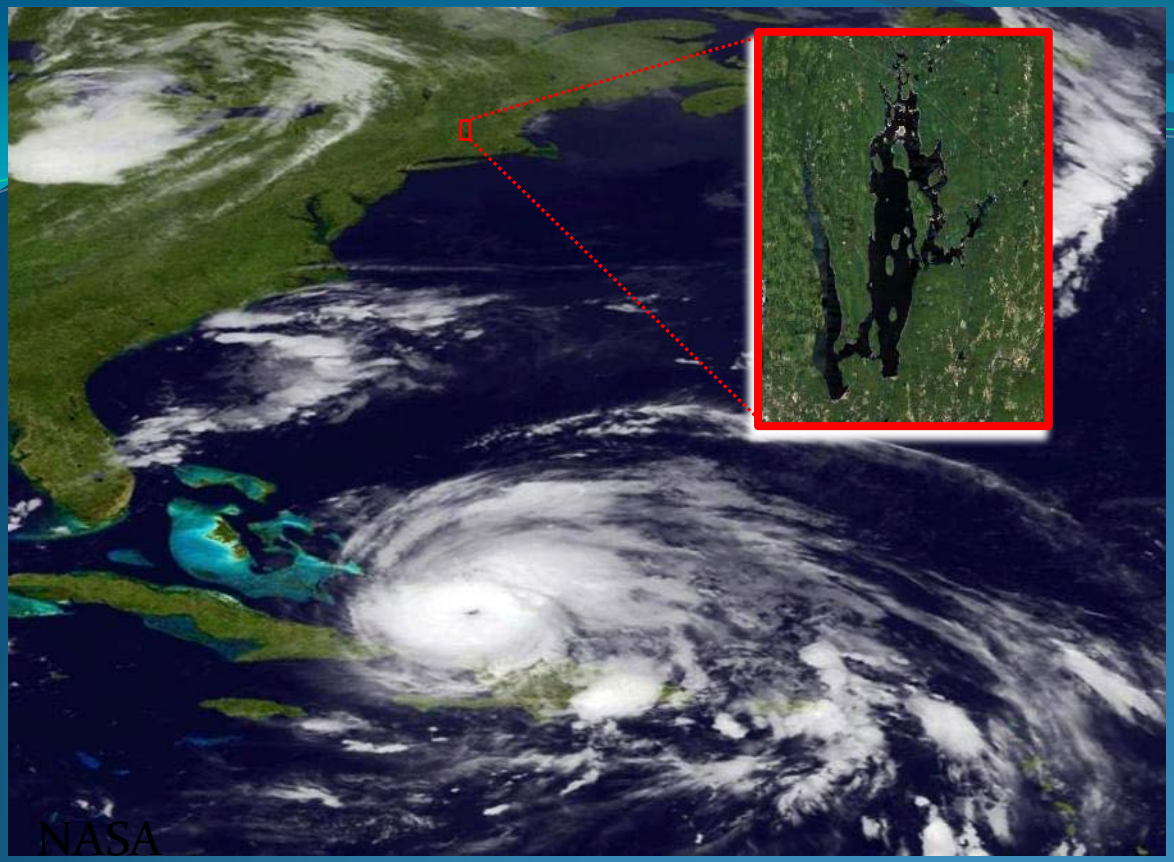
Other Tools

- Public education
- Financial incentives
- Emergency response planning



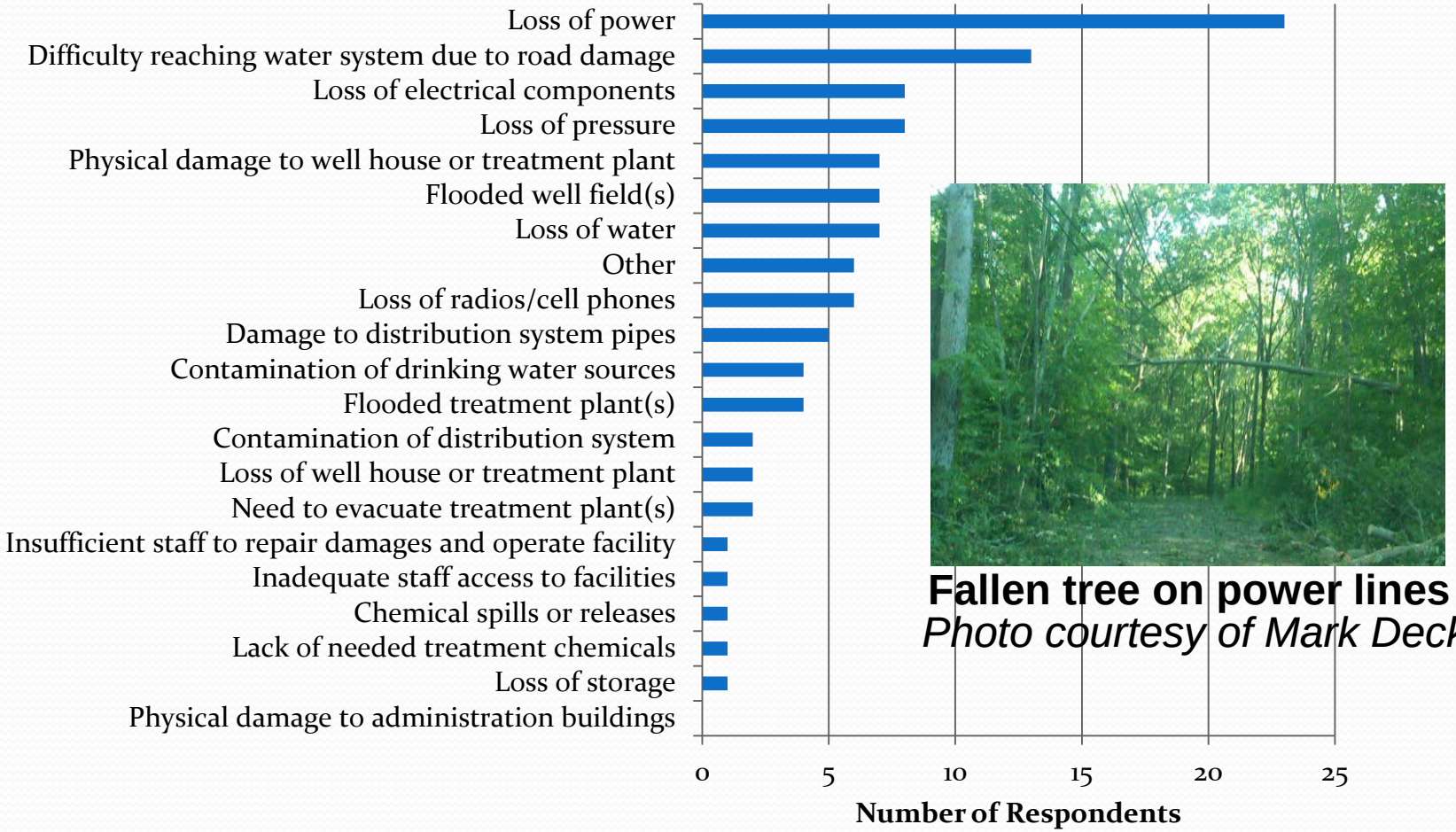
Stormwater and Extreme Events:

- Weather driven events such as flood – drastically impact water quantity and quality
  - Combined sewer overflows
  - Sanitary sewer overflows
  - Flooding of water treatment facilities
  - Flooding of wastewater treatment facilities
  - Inundation of wellheads and clogging of intakes
  - Transport of debris/waste/products from upstream and upslope locations
  - Power outage



Operational and Economic Impacts of Hurricane Irene on Drinking Water Systems

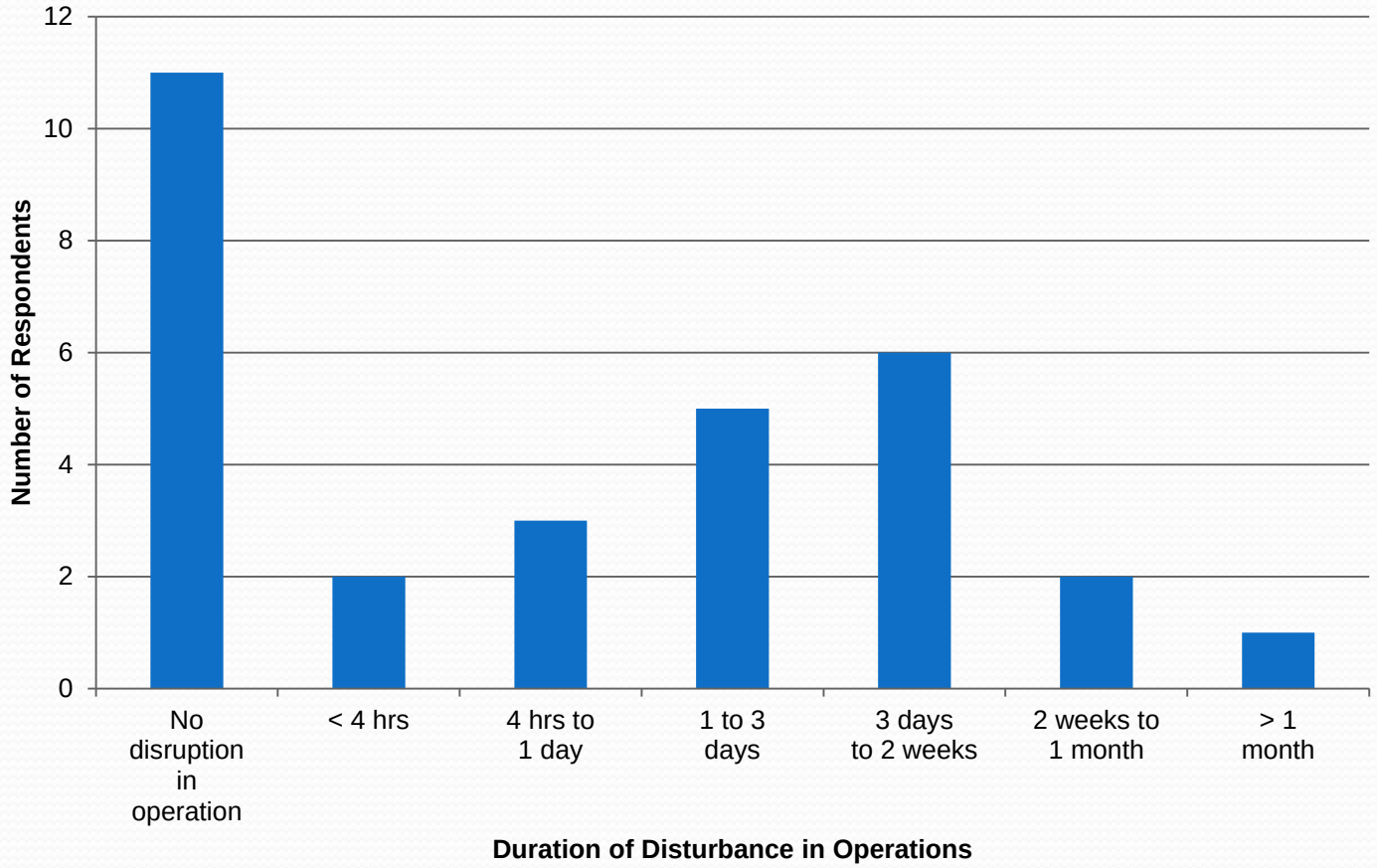
Impacts to Drinking Water Systems During and Following the Storm



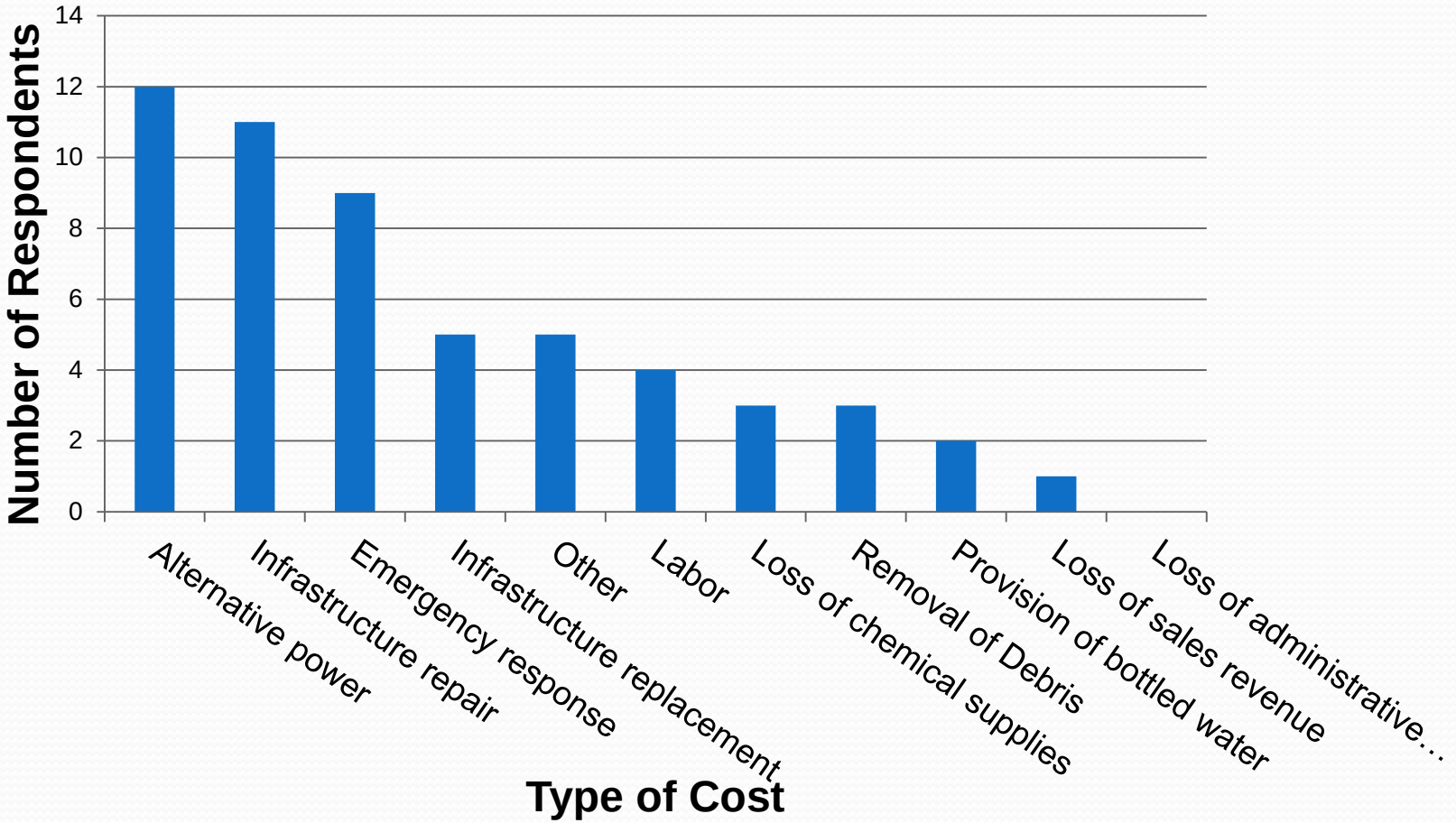
Fallen tree on power lines
Photo courtesy of Mark Decker

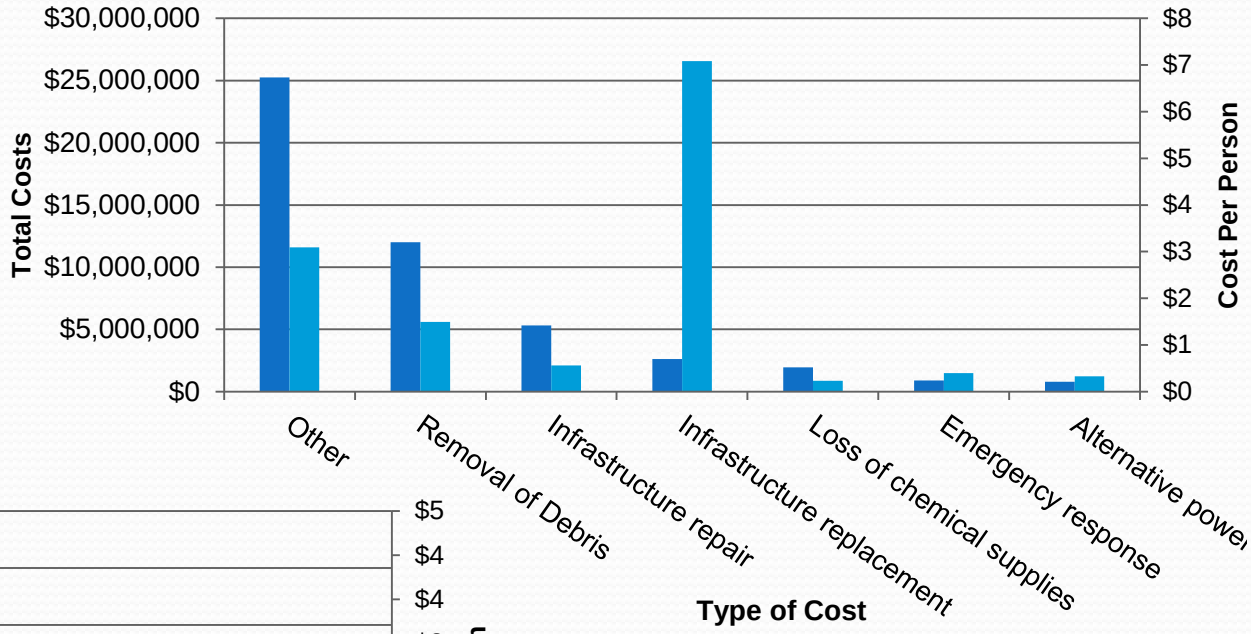
Note: Several respondents reported more than one impact in the figure above.

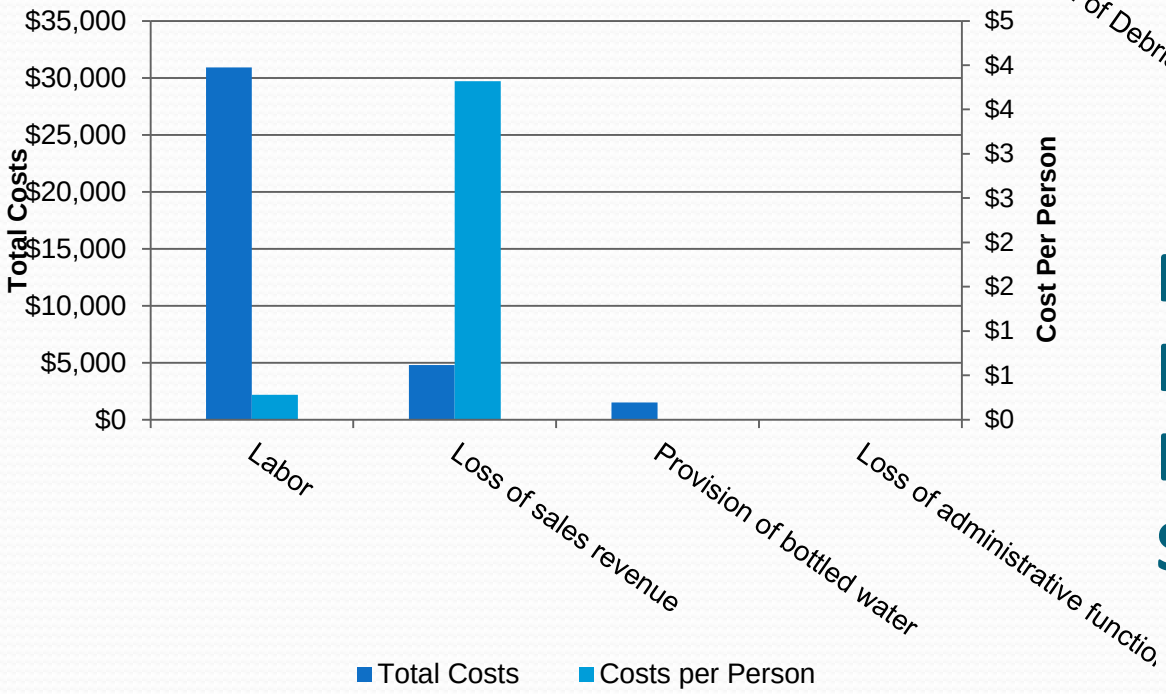
Amount of Time Required for Systems to Become Fully Operational Following Hurricane Irene



Type of Costs Reported by Drinking Water Systems due to the Hurricane







Magnitude of Costs Reported by Drinking Water Systems

Thank you! Questions?