Groundwater/ Surface Water Interactions: A Comprehensive Watershed Approach Nonpoint Source Contamination

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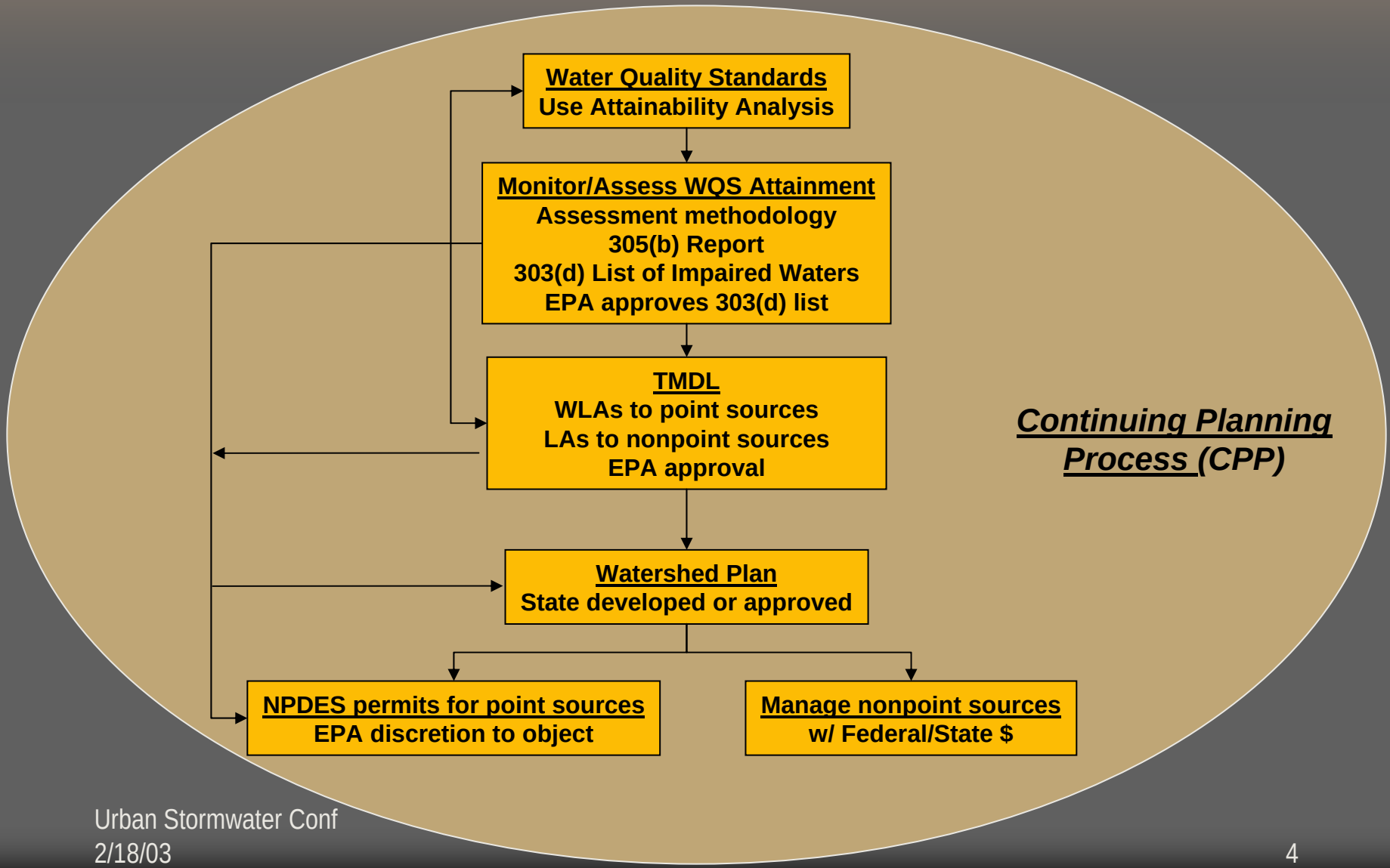
History CWA Water Quality Based Approach

- 1972 Clean Water Act
  - WQ based approach had not been effective
  - Congress temporarily abandoned the WQ based approach
  - Uniform technology based effluent requirements for all point sources
- 1983 water quality based effluent limitations
  - Required for discharges to impaired waters where technology based requirements were not enough to meet state WQS
  - Impaired waters listed
  - TMDLs to establish allowable loadings for all impaired waters
  - Continuing Planning Process

What Have We Learned

- Nonpoint sources must also be controlled to meet WQS
  - Most stormwater sources have since become point sources
- There are other causes of water quality impairment besides pollutants
  - Habitat destruction
  - Changes in the hydrologic regime (impermeable surfaces)
- Water quality is best managed on a watershed basis
  - Considering all causes and sources of impairment and threats

CWA Watershed Framework



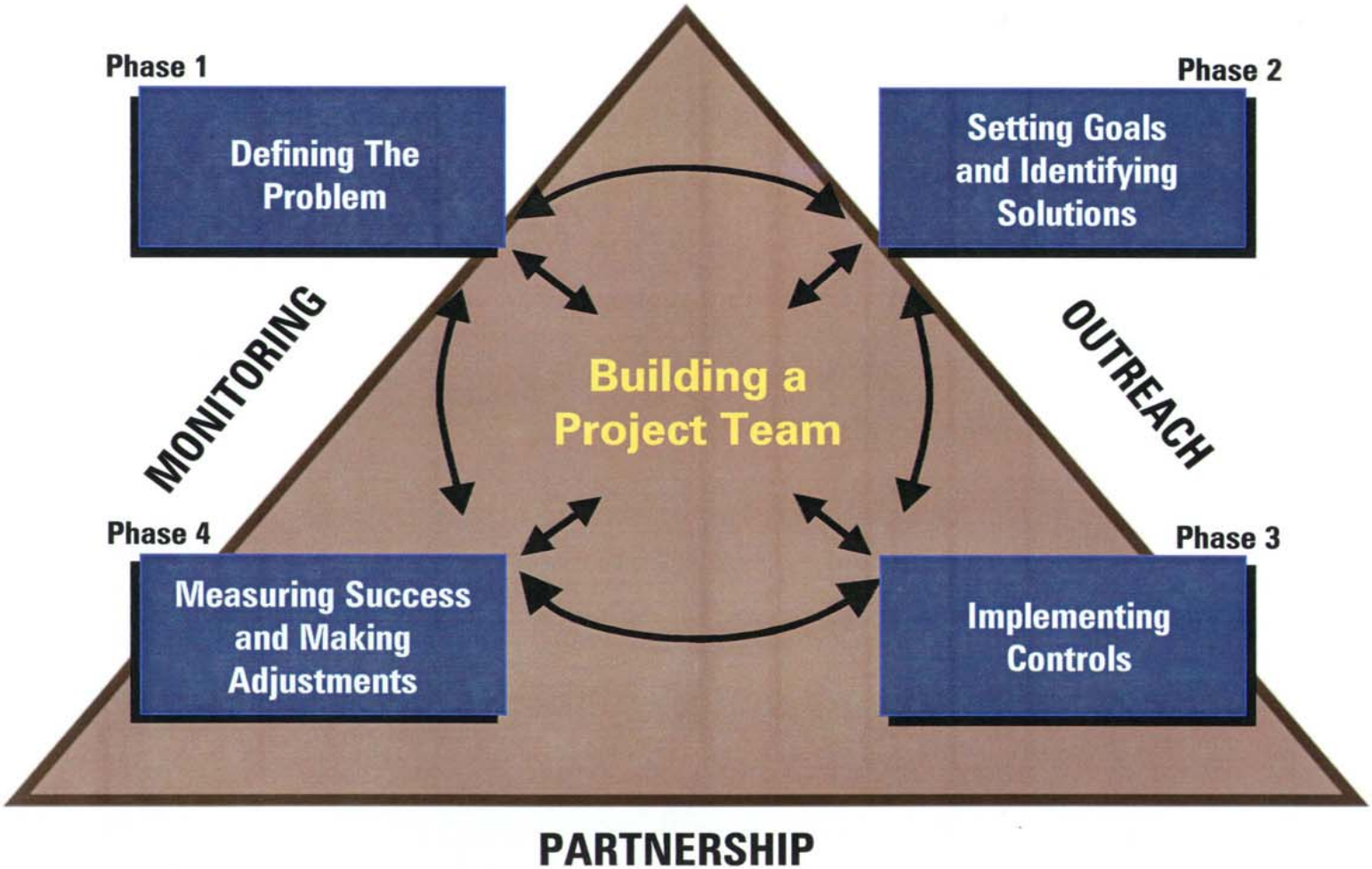
Leading Sources

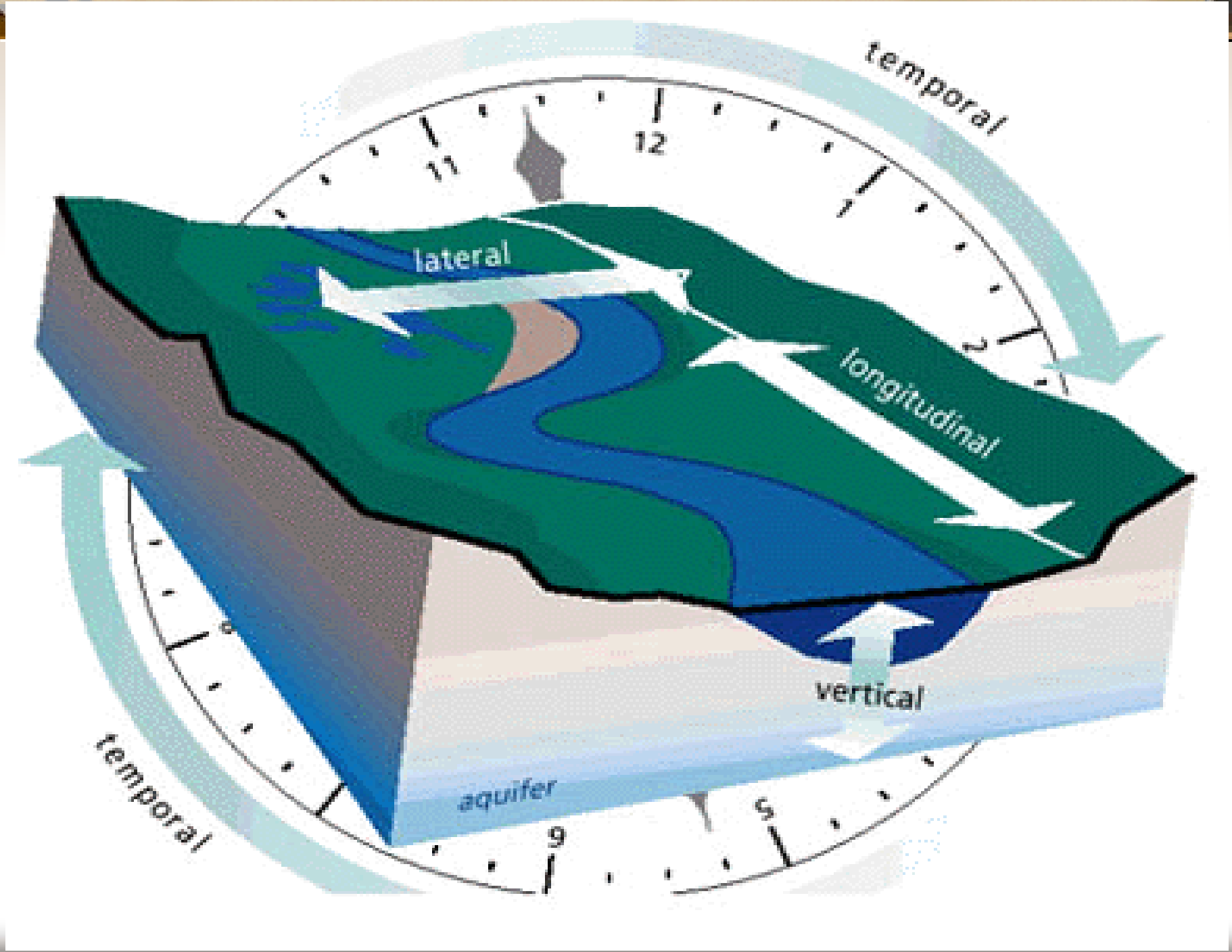
Rivers & Streams	Lakes, Ponds & Reservoirs	Estuaries
Agriculture	Agriculture	Municipal Point Source
Hydro-modification	Hydro-modification	Urban Runoff/storm sewers

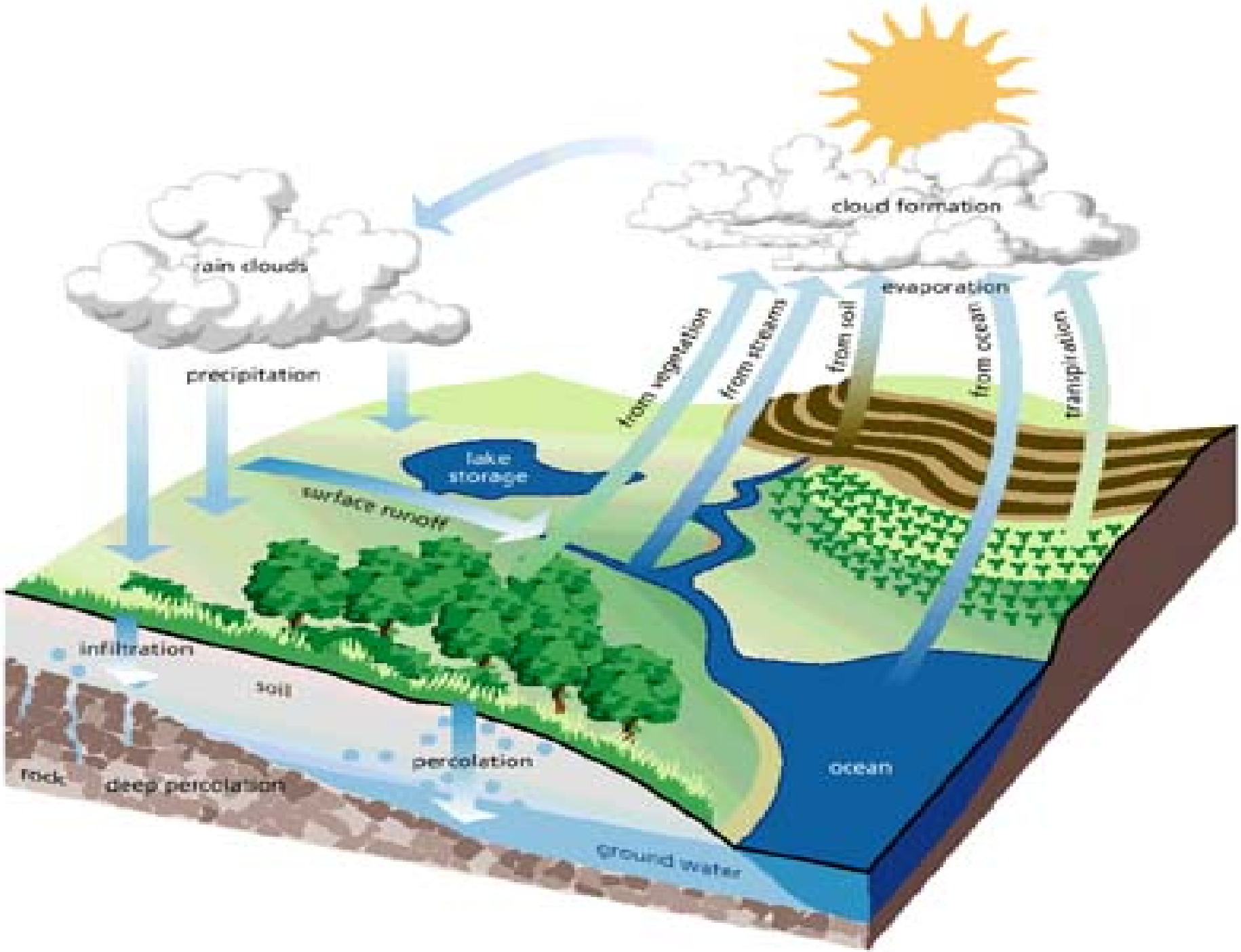
Leading Pollutants

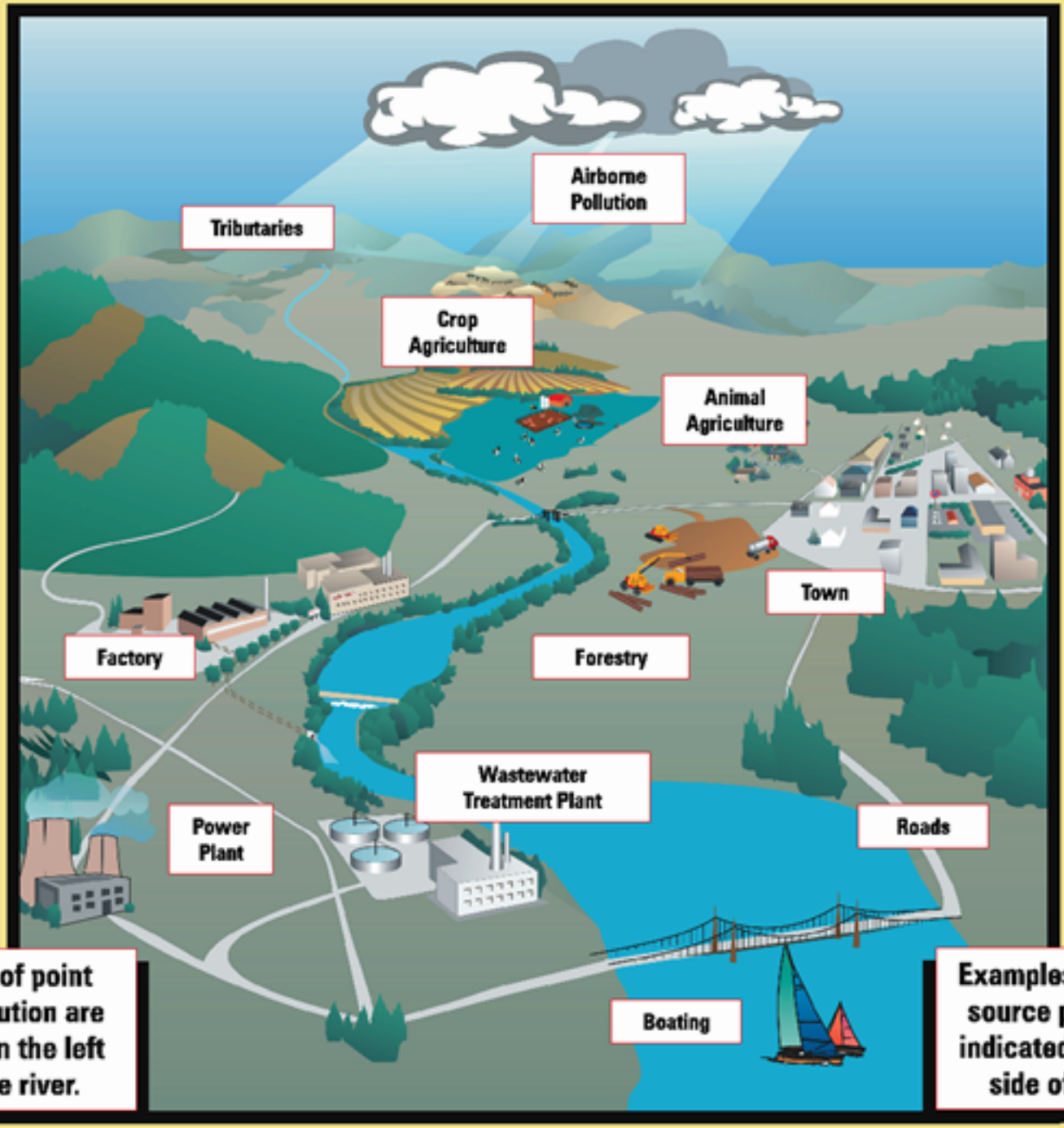
Rivers &Streams	Lakes, Ponds & Reservoirs	Estuaries
Siltation	Nutrients	Pathogens
Pathogens	Metals	Organic Enrichment
Nutrients	Siltation	Metals

Watershed Management Process




temporal
lateral
longitudinal
vertical
aquifer
temporal


cloud formation
rain clouds
evaporation
precipitation
from vegetation
from streams
from soil
from ocean
transpiration
lake storage
surface runoff
infiltration
soil
percolation
rock
deep percolation
ocean
ground water



Examples of point source pollution are indicated on the left side of the river.

Examples of nonpoint source pollution are indicated on the right side of the river.

Monitoring Planning Process

Management Goals and Activities

Identify Questions

Develop Monitoring Objectives

Define Monitoring Parameters & Procedures

Collect Data

Analyze and Evaluate Data
Relative to Monitoring Objectives

Answer Questions

Management Recommendations
and Follow-up

Sampling Design Considerations

- Site Locations
- Sampling Frequency
- Statistical Survey Design
- Protocols and Standard Methods

Watershed Processes Vulnerable to Change

- Hydrology
- Sediment Transport
- Nutrient Cycling
- Trophic Interactions/Competition

Characterizing Change

- Source/Cause
- Effect
- Frequency
- Duration
- Intensity/Magnitude

Human-Made Agents of Change

- Modification of river flow
- Agriculture
- Timber harvest
- Urbanization
- Fire suppression
- Mining
- Harvesting of fish and wildlife
- Introduction of exotic species
- Accelerated climate change

Water runoff is affected by land cover

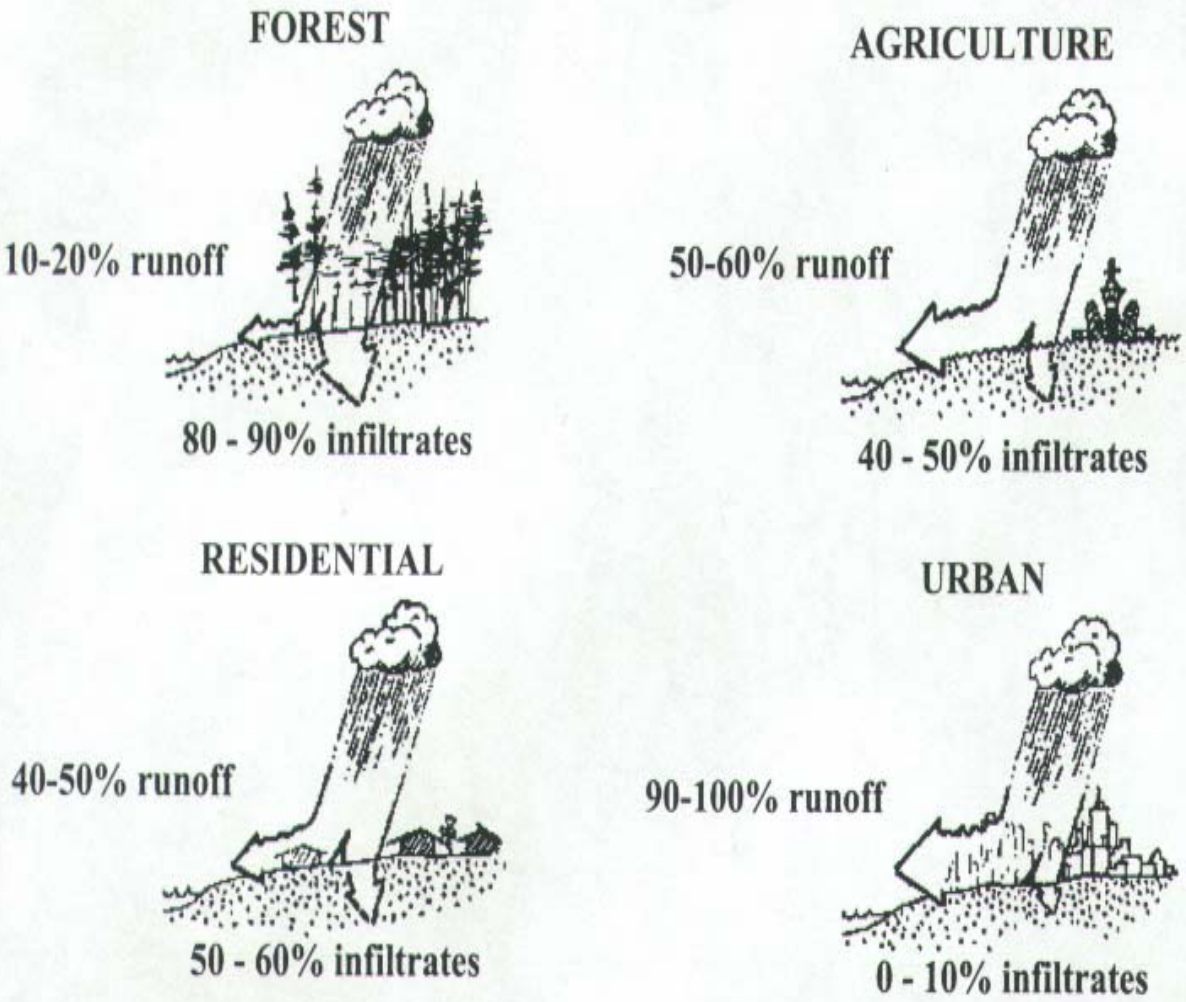


Figure 2-7.—Runoff is reduced on land with vegetative cover and increased on land with impermeable surfaces such as roads, parking lots, and house roofs. (adapted from Marsh and Borton, 1975)

Effects on Hydrology

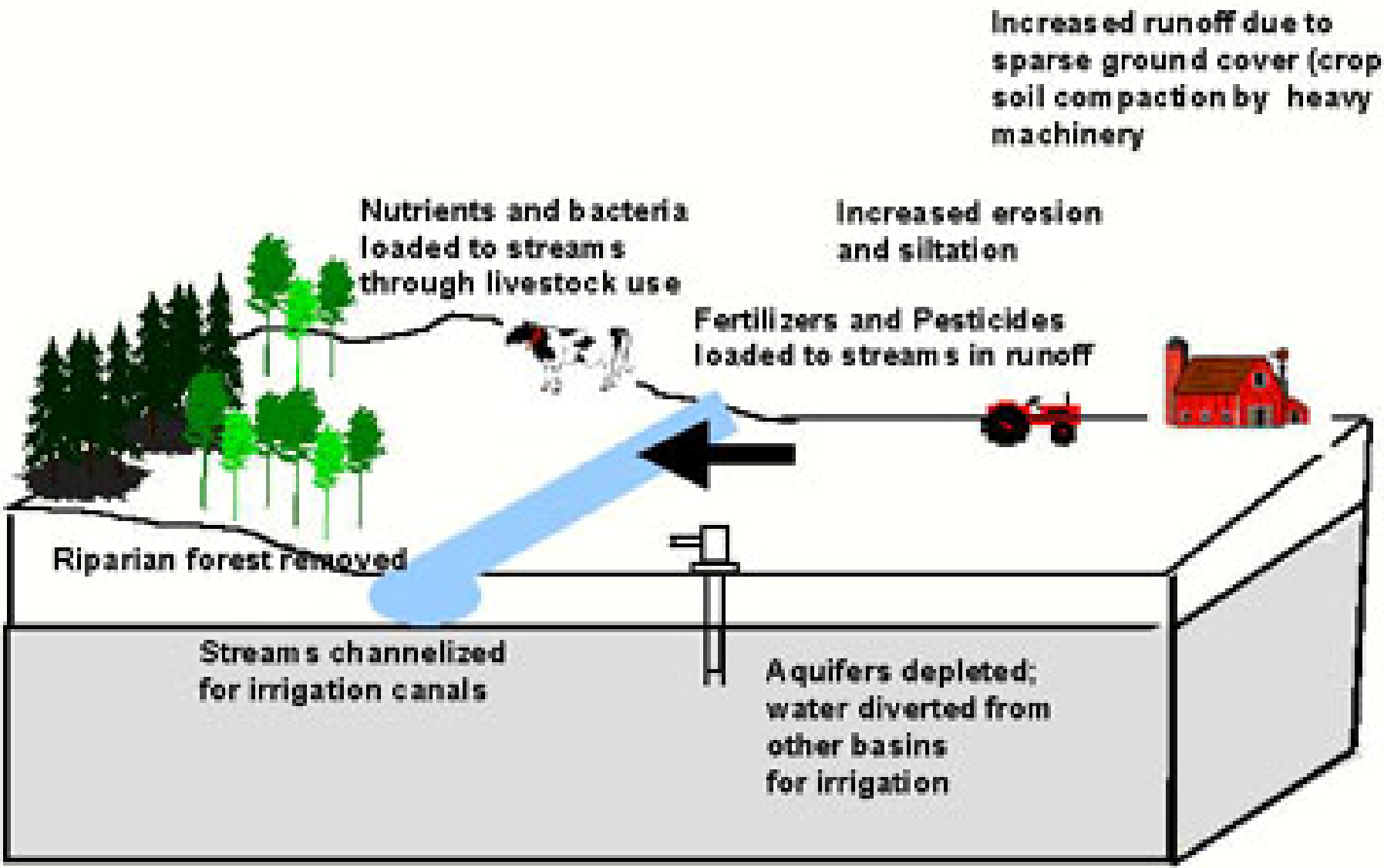
Vegetation Removal by Land Use Practices:
Forestry
Agriculture
Urbanization

Evapotranspiration (-)
Infiltration (-)
Surface Runoff (+)

Frequency and Magnitude of High Stream Discharge (++)

Effects on Hydrology (Continued)

Effects of Agriculture on Stream Hydrology and Chemistry



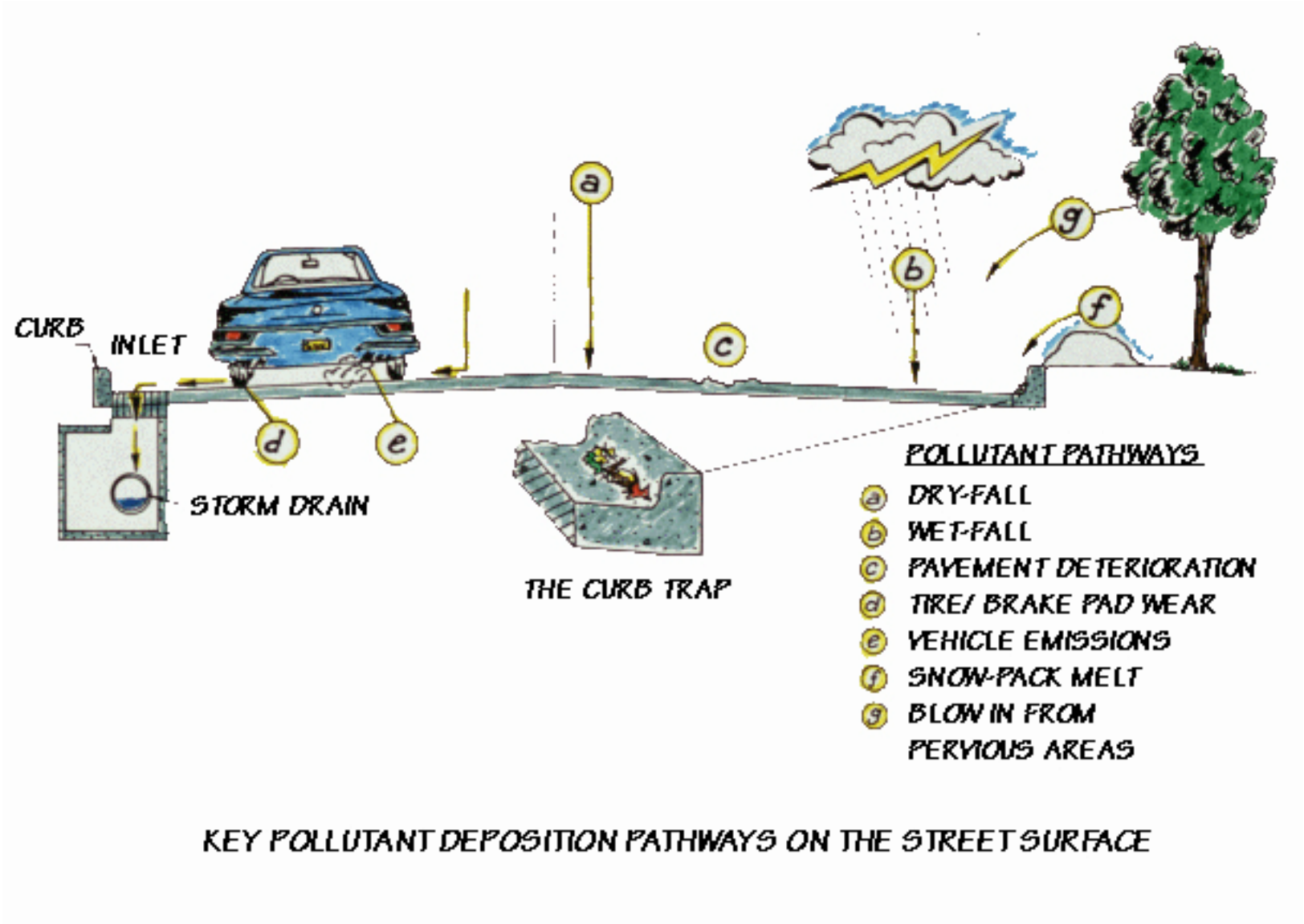
RCWP Groundwater Projects

- Conestoga Headwaters, Pennsylvania
- Garvin Brook, Minnesota
- Oakwood Lakes – Poinsett, South Dakota

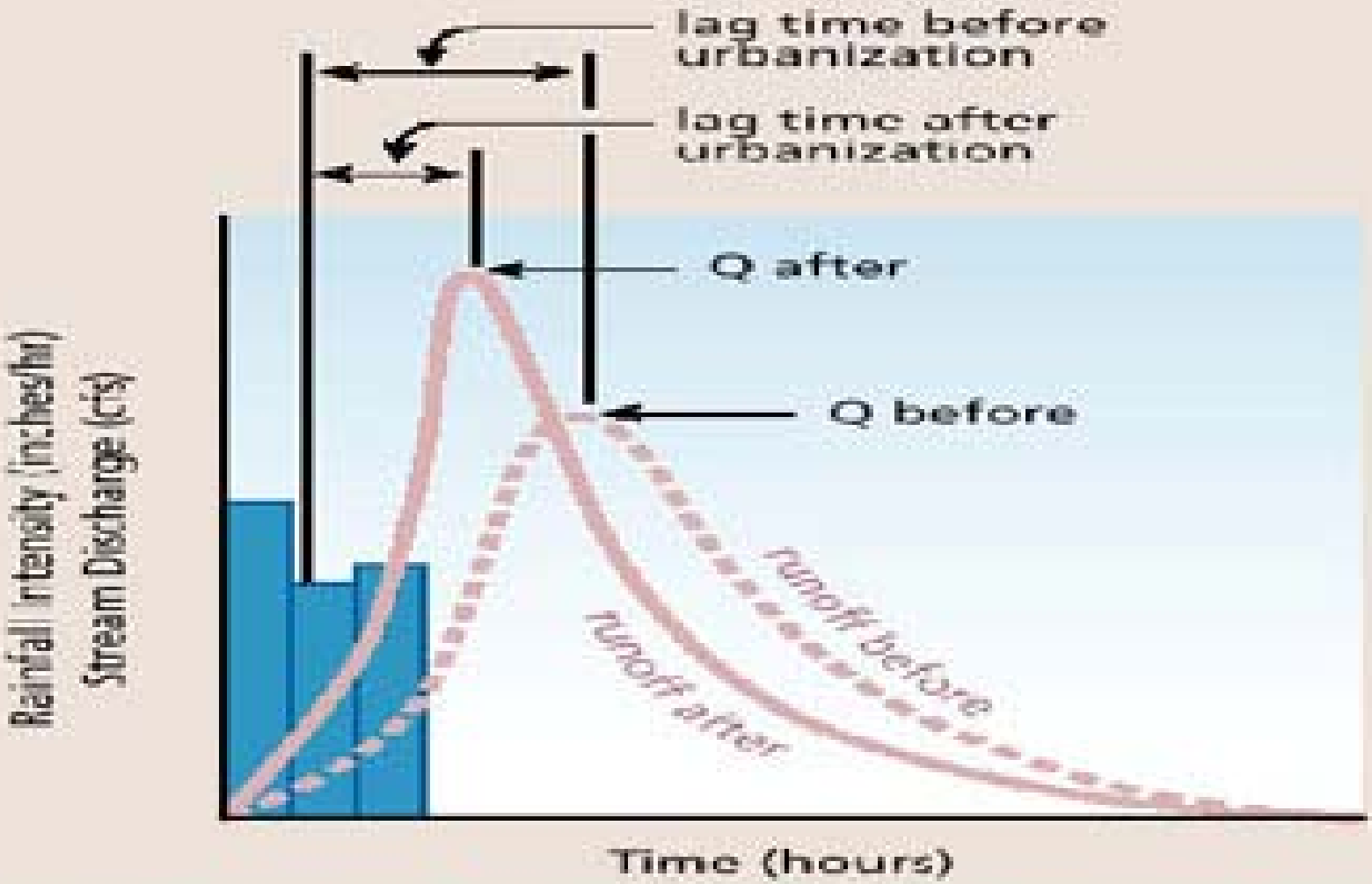
Impacts of Land Development

The effects of urbanization on aquatic resources can be organized into four categories:

- Hydrology
- Geomorphology
- Water Quality
- Habitat

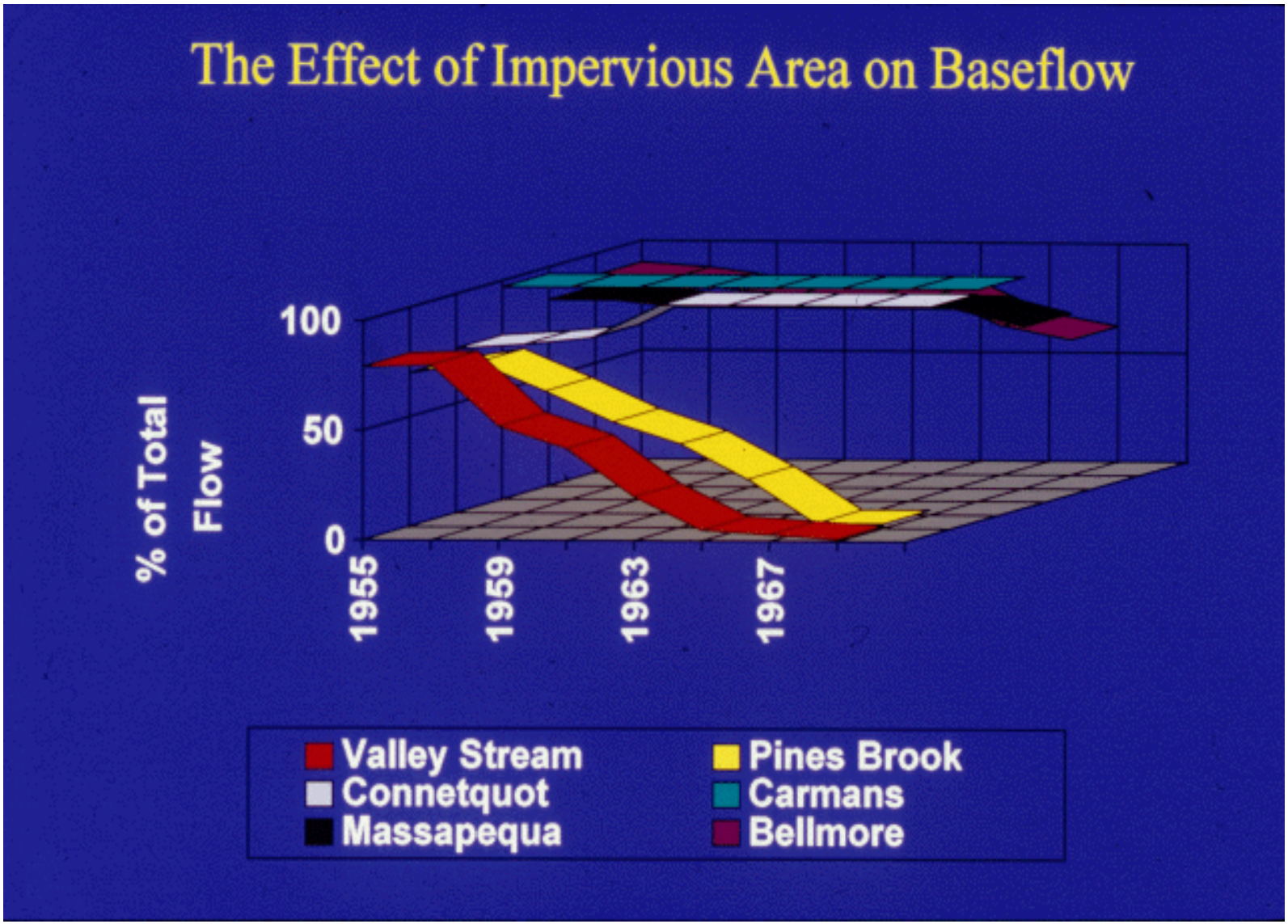


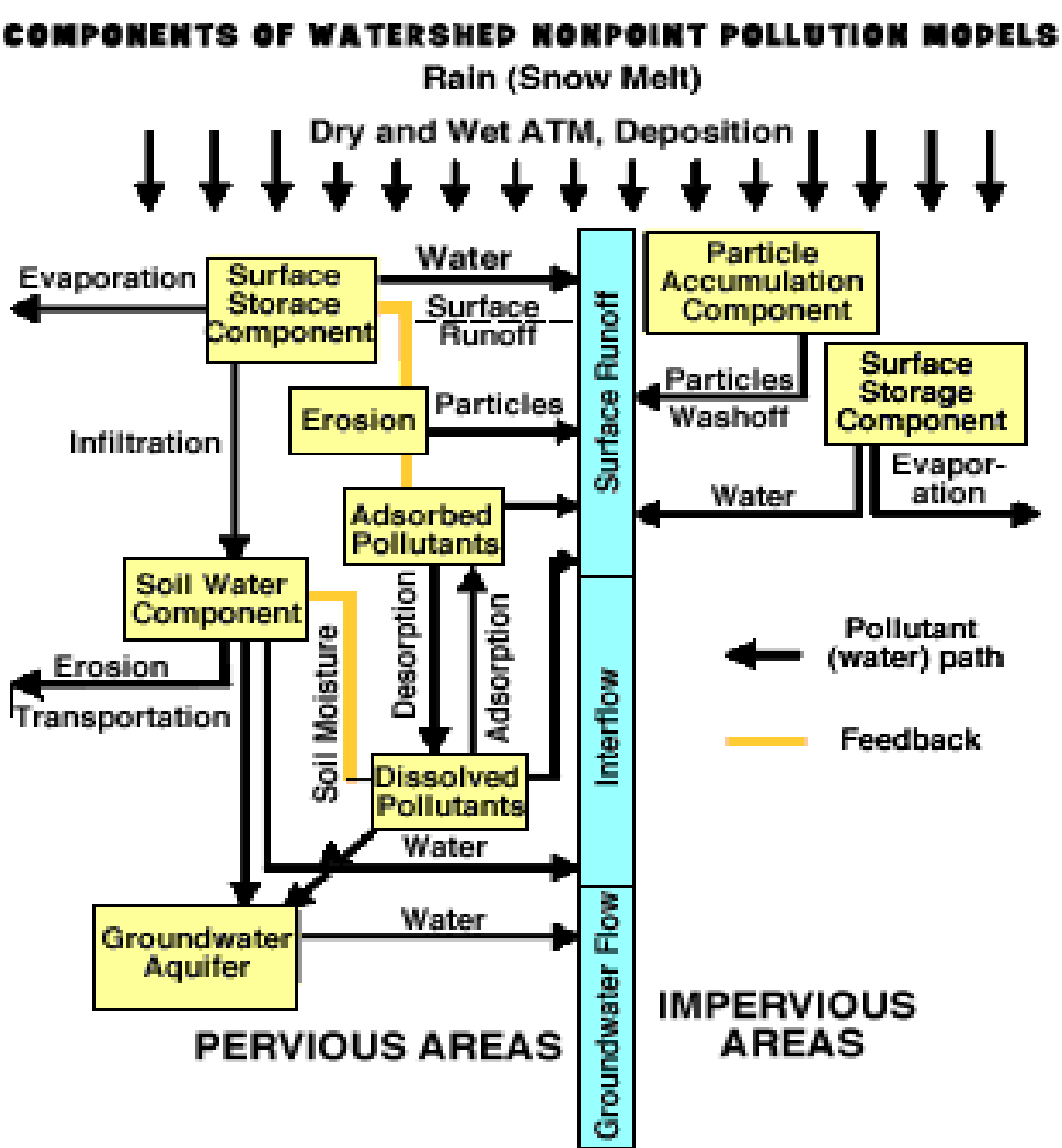
Numerous types of pollutants can enter a stream from the street surface.



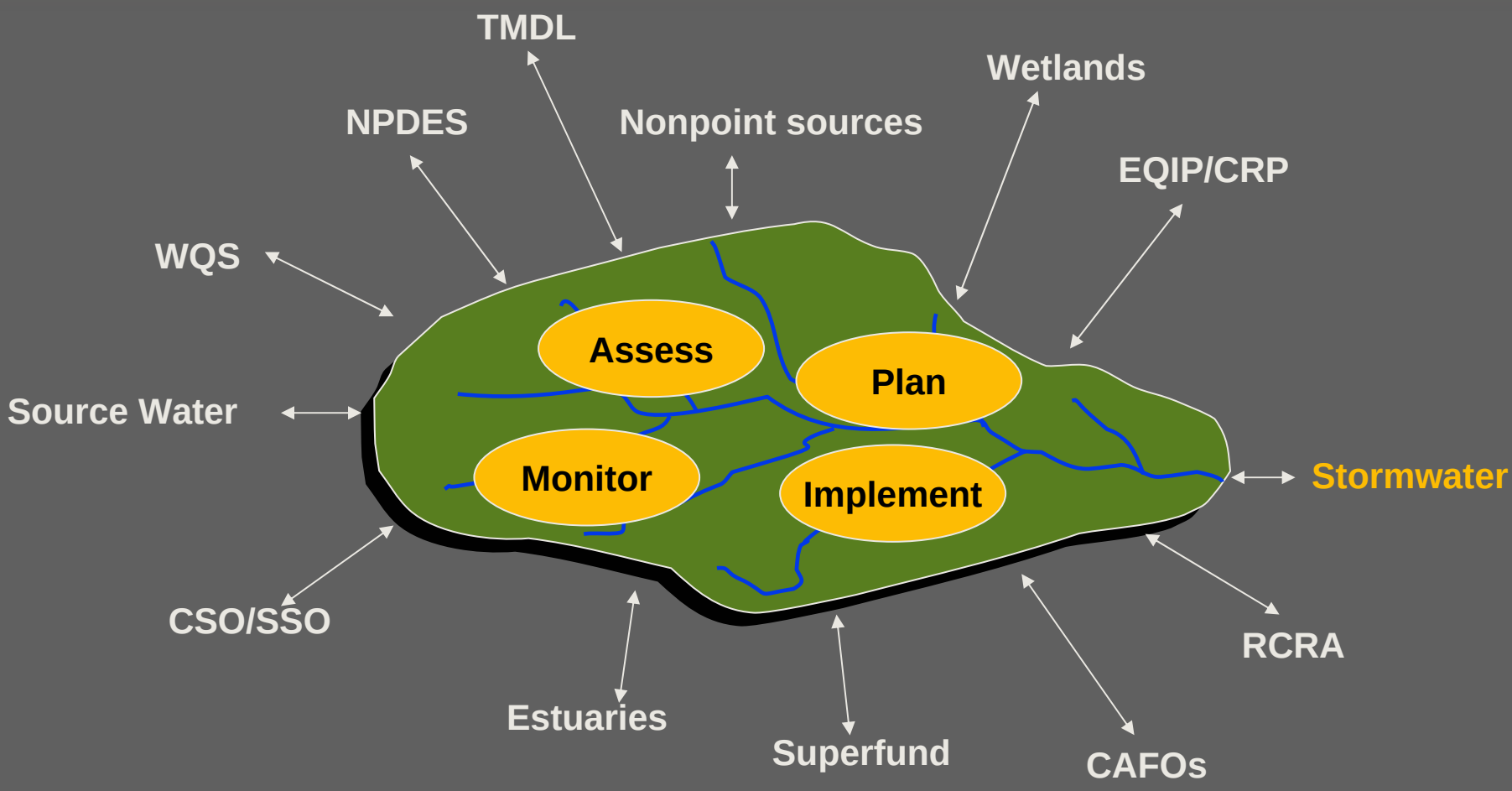
A comparison of hydrographs before and after urbanization (blue bars indicate rainfall rate and timing). The discharge curve is higher and steeper for urban streams than for non-urbanized streams due to faster and greater runoff.

This often means that a headwater stream that was once perennial now becomes intermittent. One example is a set of streams in the Long Island, New York region. The graph shows the predominantly agricultural watersheds that have been able to sustain flow during dry weather.



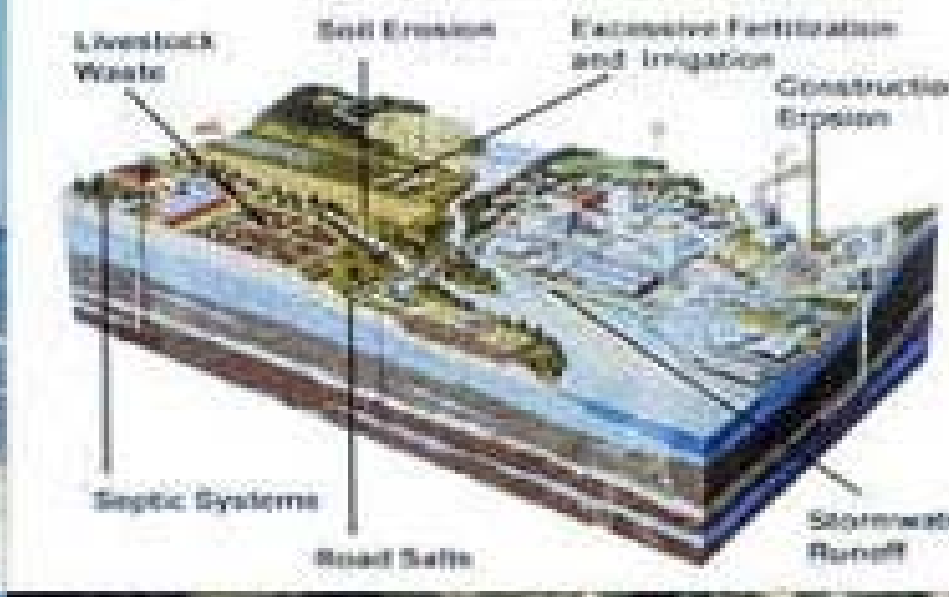

COMPONENTS OF WATERSHED NONPOINT POLLUTION MODELS
Rain (Snow Melt)
Dry and Wet ATM, Deposition
Evaporation
Surface Storace Component
Water
Surface Runoff
Particle Accumulation Component
Particles
Washoff
Surface Storage Component
Evapor-ation
Water
Erosion
Particles
Infiltration
Adsorbed Pollutants
Soil Water Component
Desorption
Adsorption
Soil Moisture
Erosion
Transportation
Dissolved Pollutants
Water
Groundwater Aquifer
Water
Interflow
Groundwater Flow
Pollutant (water) path
Feedback
PERVIOUS AREAS
IMPERVIOUS AREAS

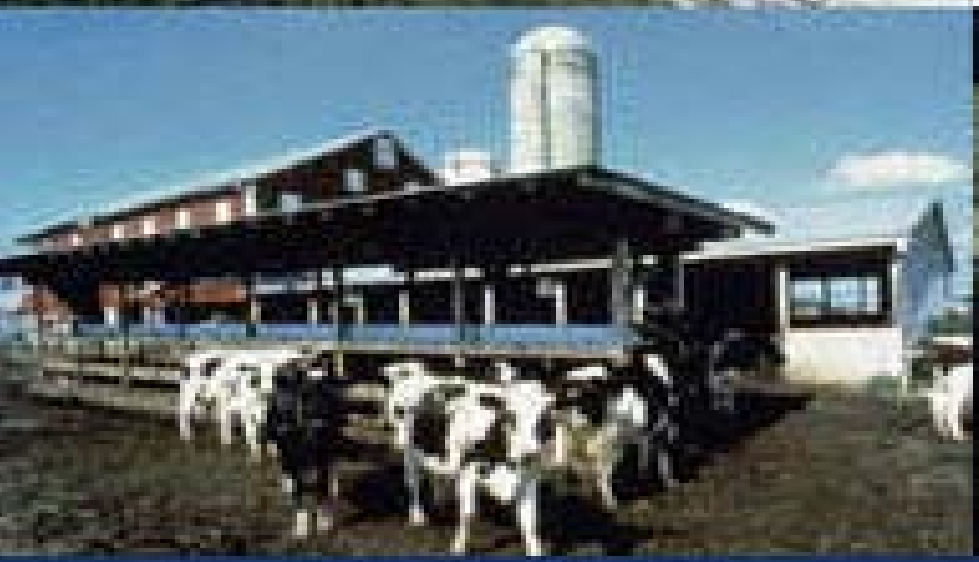
Integrated Watershed Planning



TMDLs

- A planning document that informs water quality managers and the public of
  - the total pollutant loading that may be present in a water and still allow attainment of state water quality standards, and
  - a practicable allocation of that loading to
    - Individual point sources (wasteload allocations), and
    - nonpoint sources (load allocations) of the pollutant





Watershed plans may vary as widely as watersheds do. A successful plan will integrate community interests with protection of natural resources and watershed process.

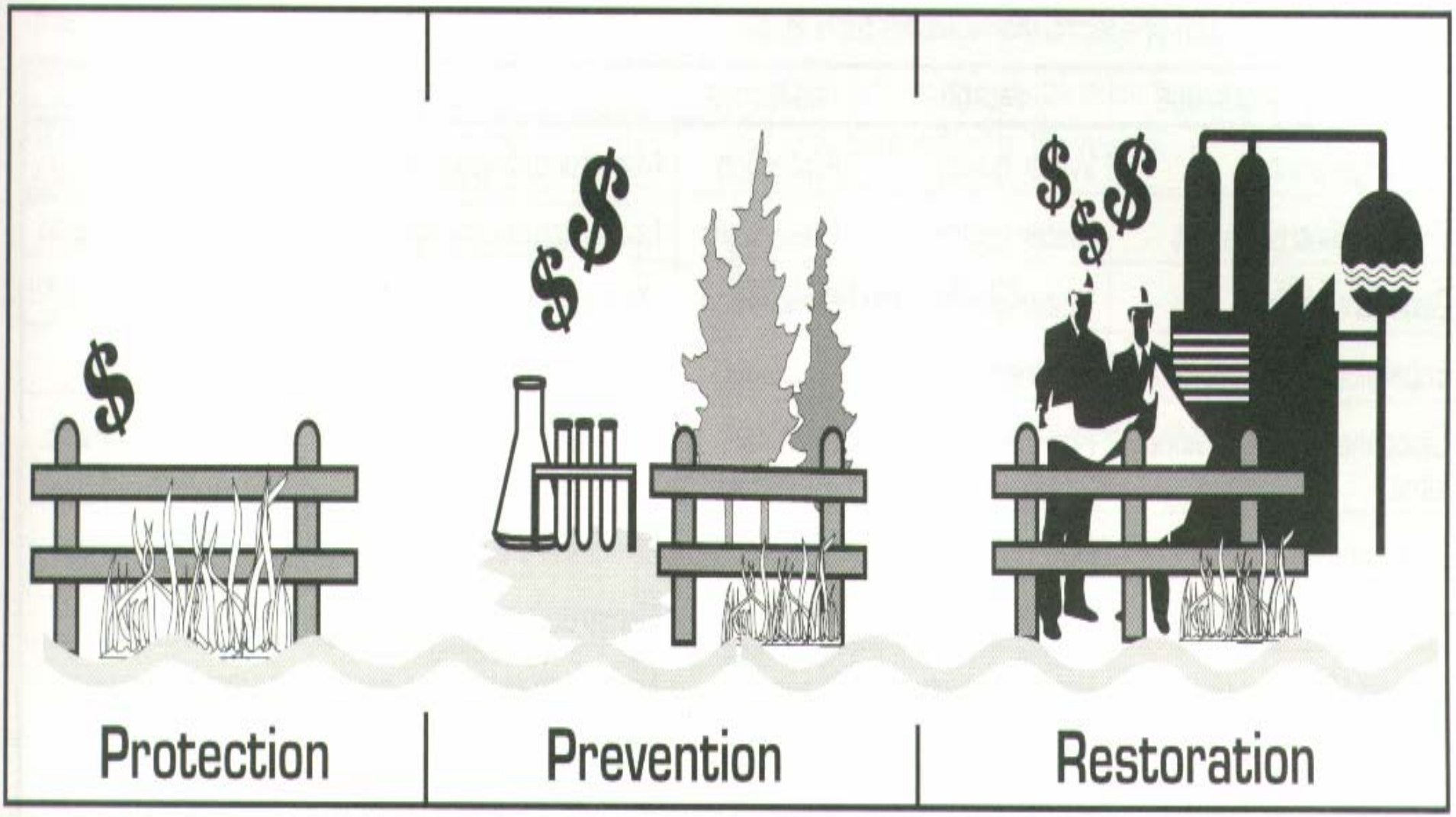
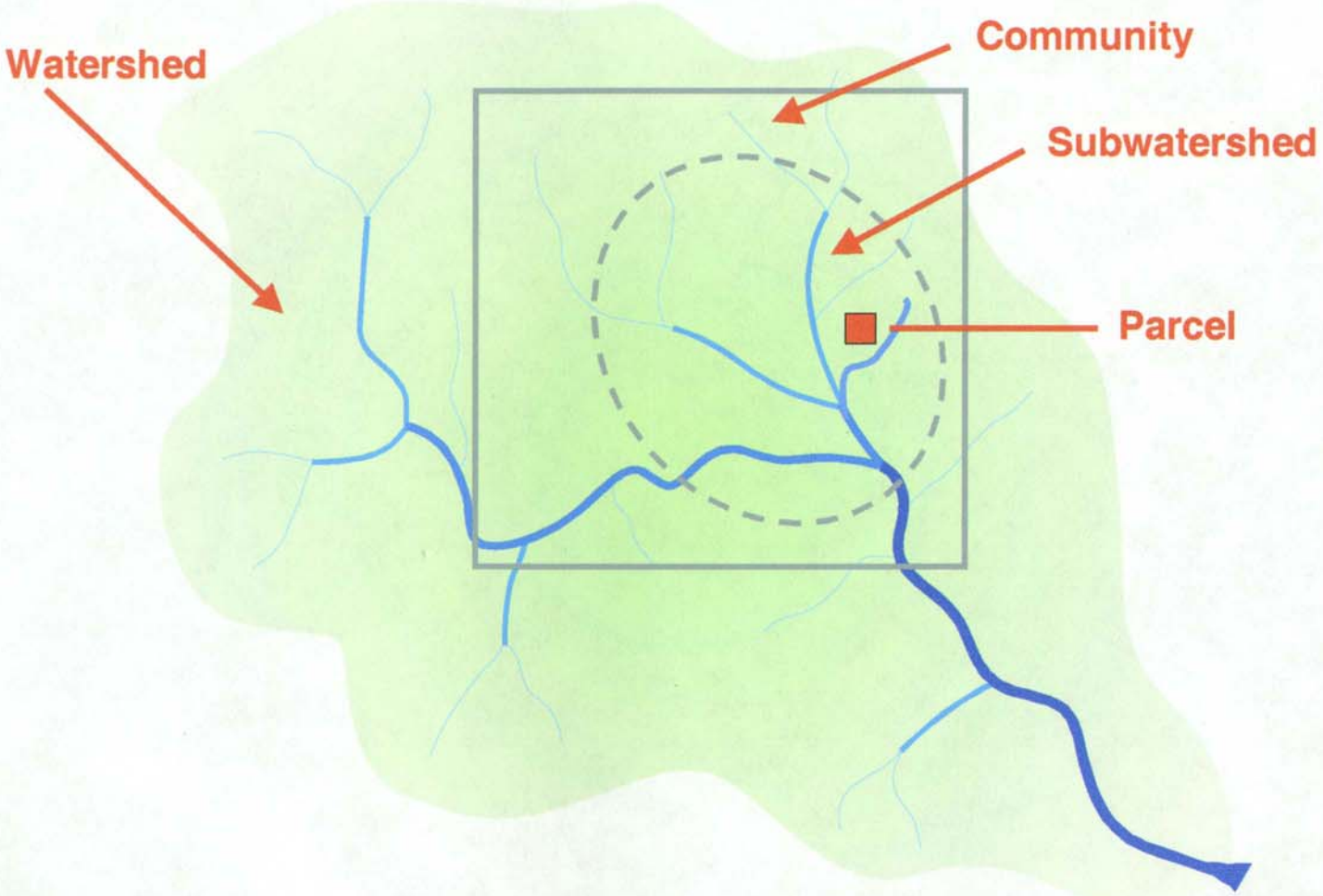


Figure 2.10—Management techniques vary in intensity.

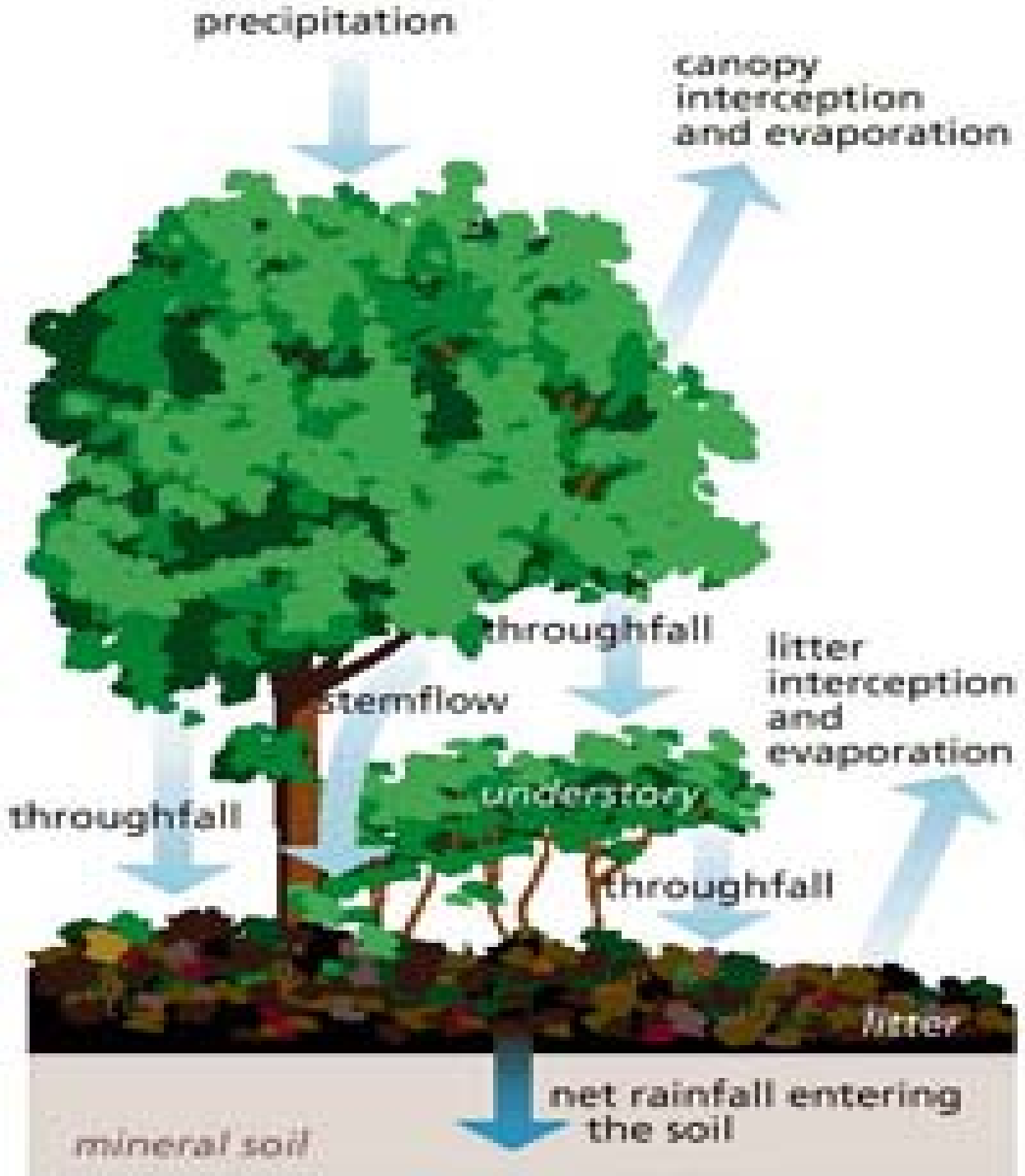
General management approach by landscape zone

Landscape Zone	Management Goal
Upland	Source reduction control (SRC)
Transitional	SRC + disrupt pollutant transport (DPT)
Riparian	SRC + DPT + treatment

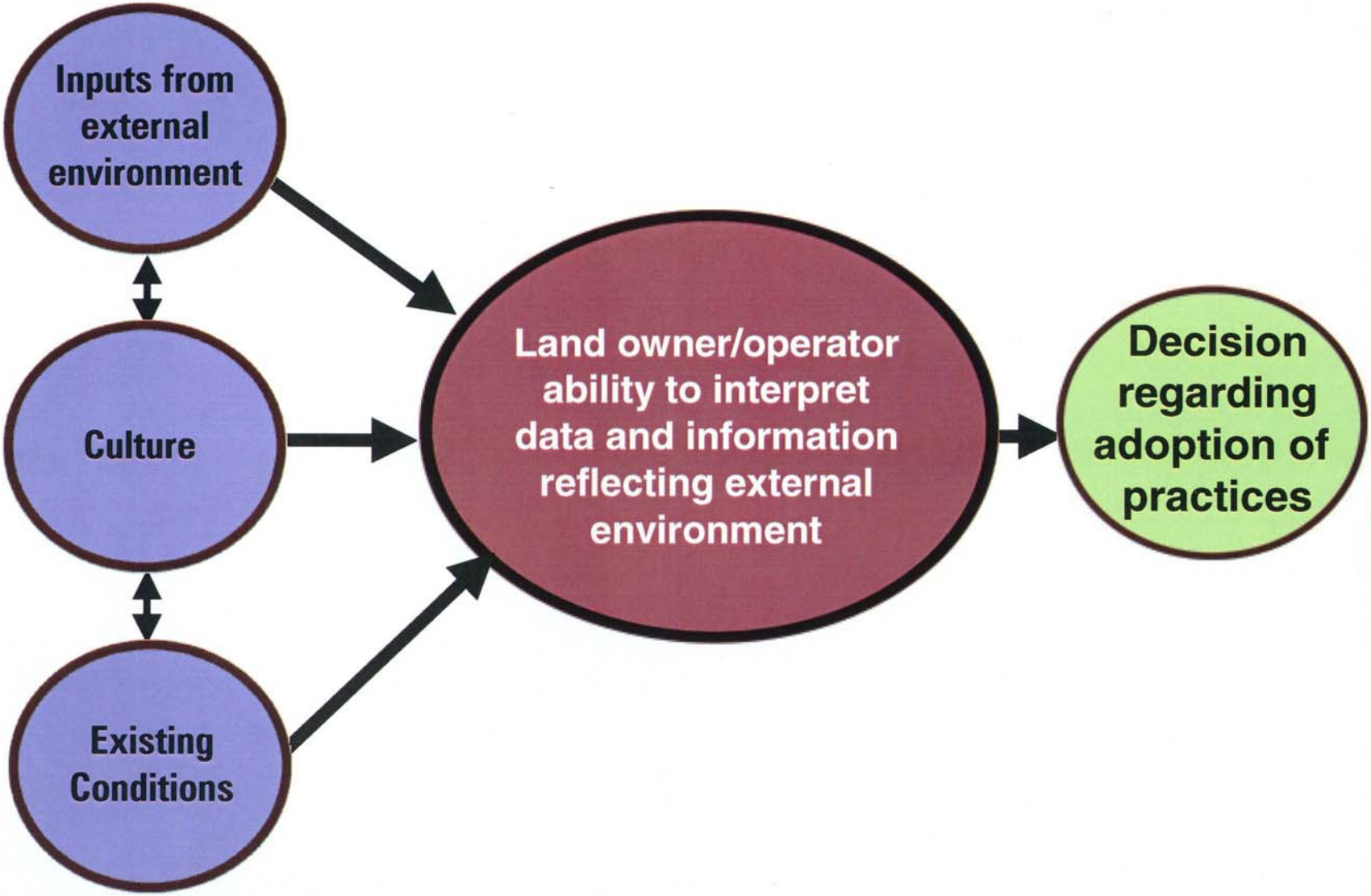
A Hierarchy of Implementation



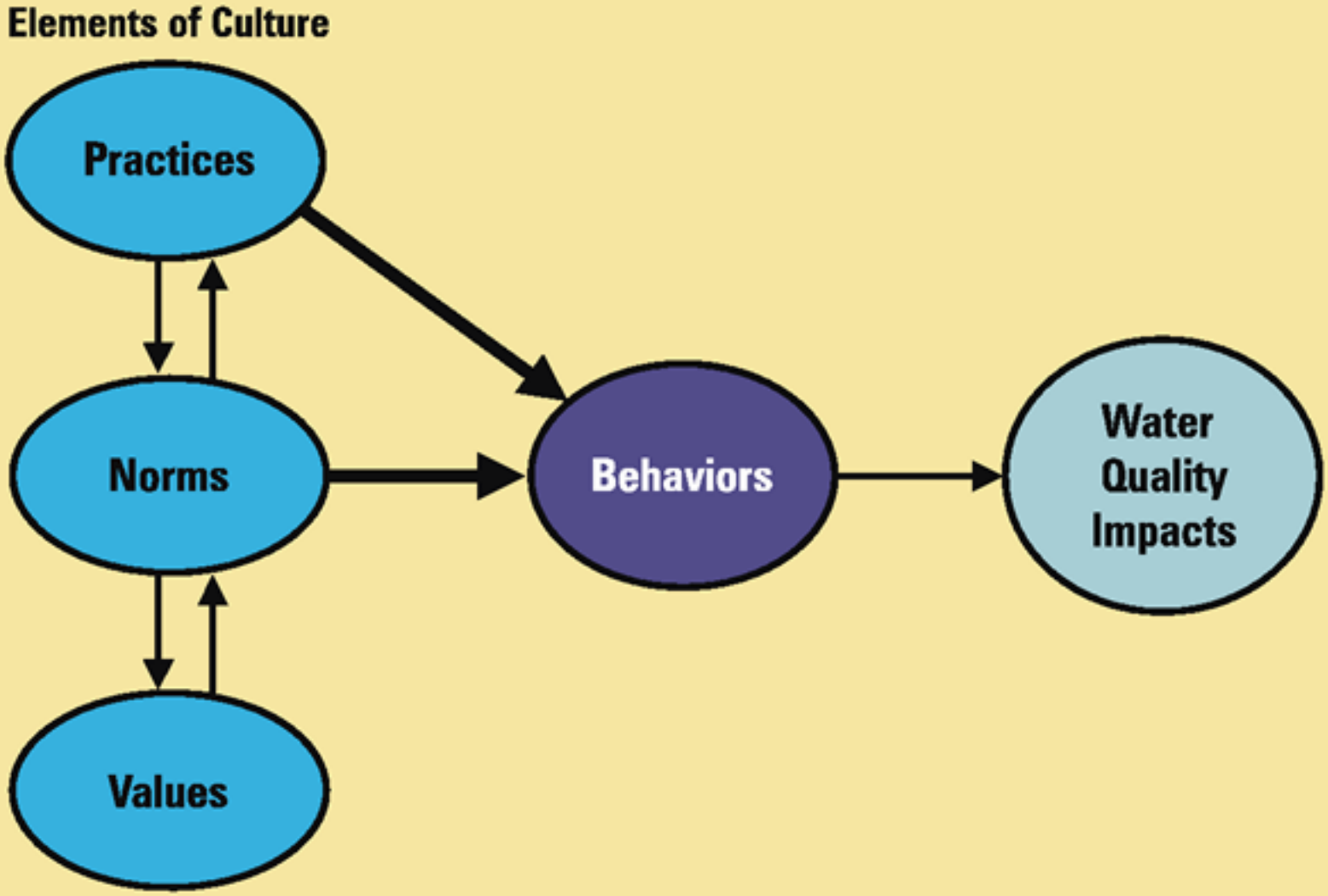
Source: EPA Office of Water, Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices


precipitation
canopy interception and evaporation
throughfall
stemflow
litter interception and evaporation
throughfall
understory
throughfall
litter
net rainfall entering the soil
mineral soil

Adopting New Best Management Practices



Cultural Elements Influence Behaviors



Note: The thicker arrow denotes the predominant impact of values on behaviors.

Summary: CORE 4 agricultural management practices . . . .

1. Conservation tillage
2. Crop nutrient management
3. Pest management
4. Conservation buffers

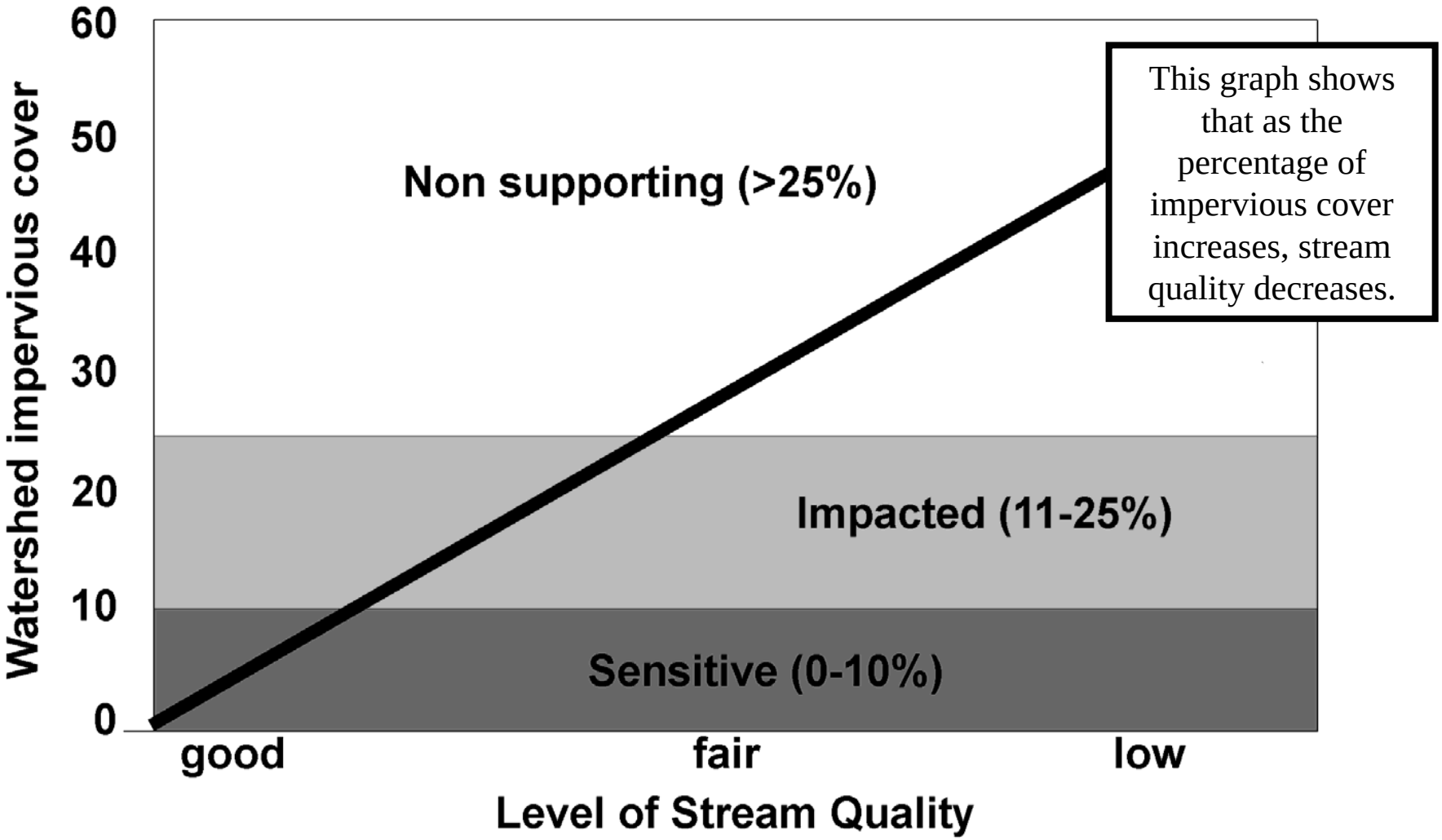
Urban Stream Classification Model

Impervious cover <10% = sensitive

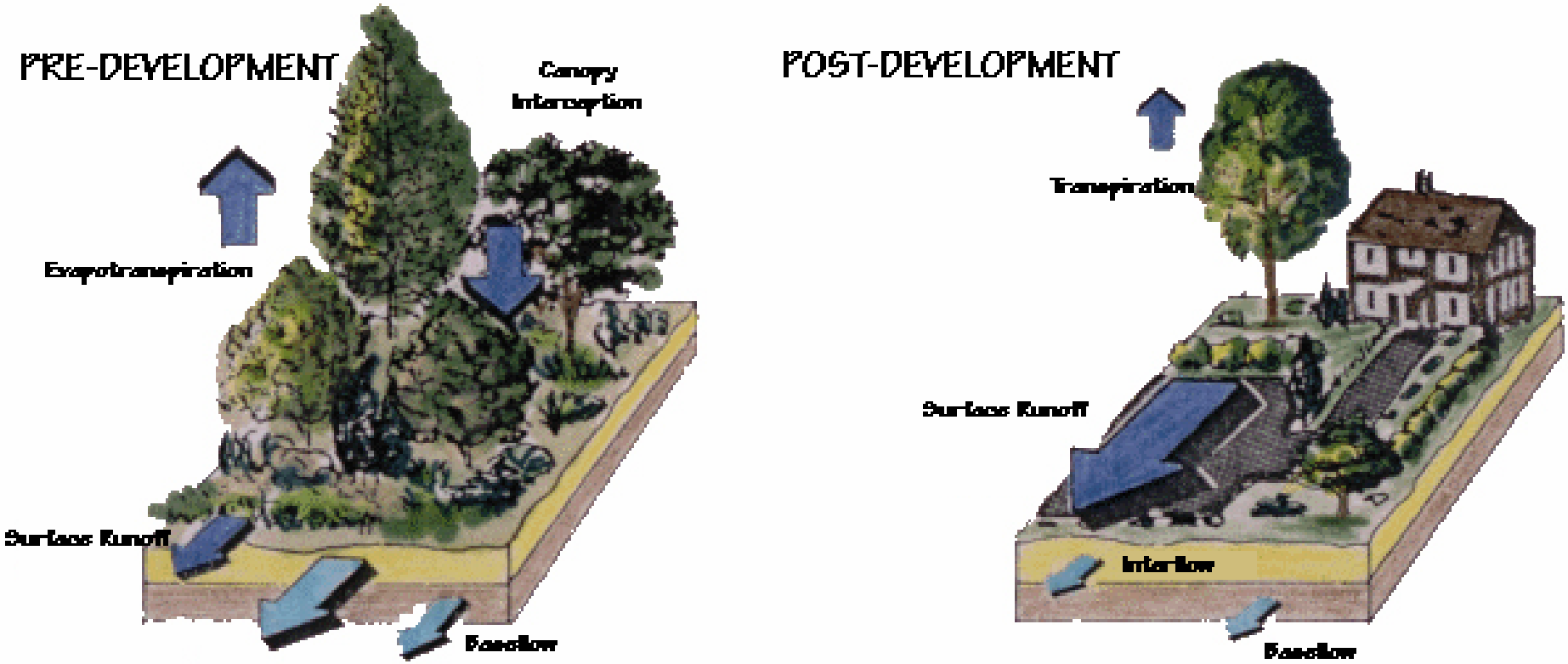
Impervious cover 10-25% = impacted

Impervious cover >25% = non-supporting

Relationship Between Impervious Cover and Stream Quality

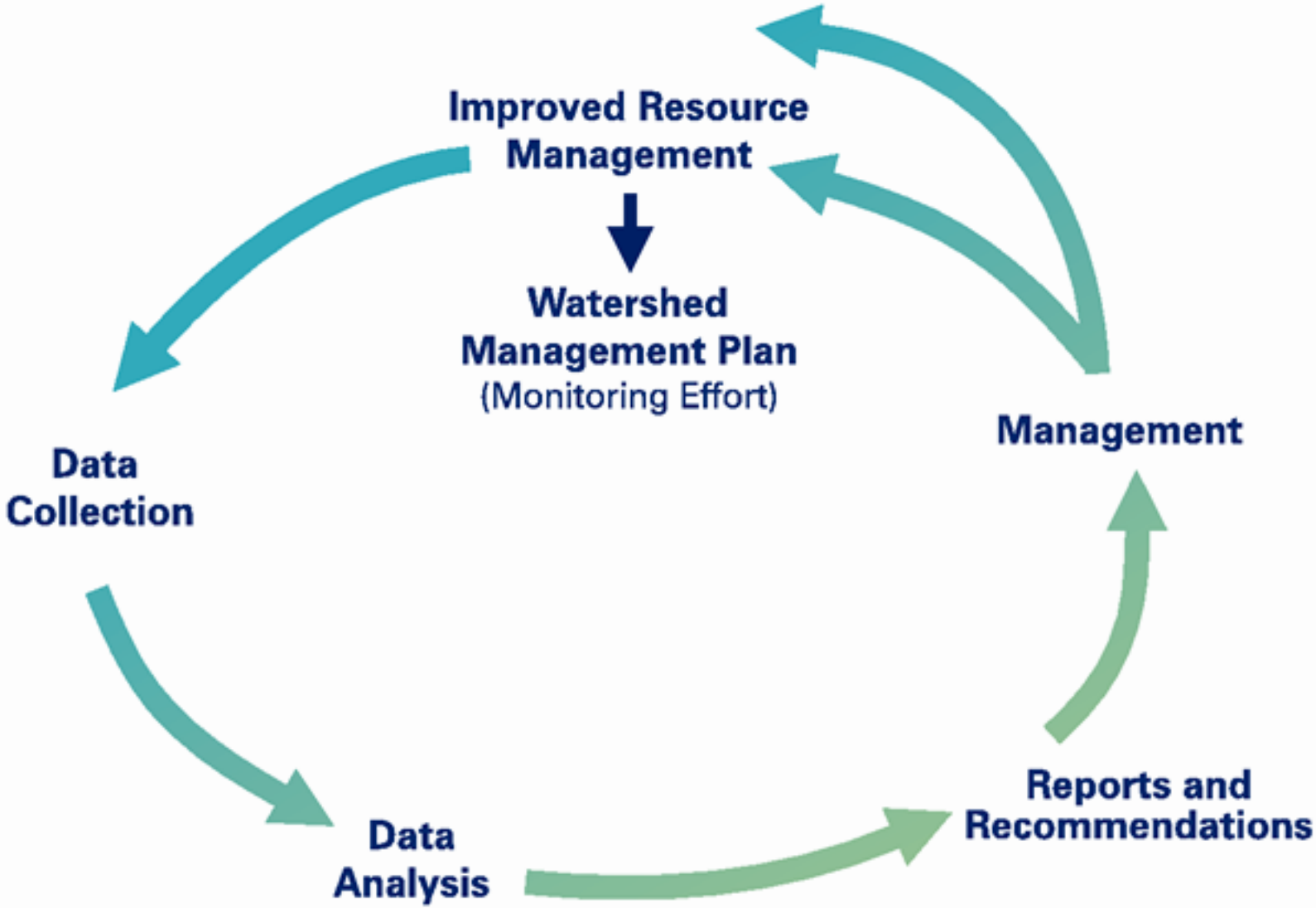


WATER BALANCE



This diagram shows how development and its corresponding increase in impervious cover disrupts the natural water balance. In the post-development setting, the amount of water running off the site is dramatically increased.

Monitoring to Support Adaptive Management



References

- Water Quality Monitoring Guide; USDA-NRCS
- Water Quality Monitoring for Clean Water Partnership: A Guidance Document; MPCA, 1990
- A Review of Methods for Assessing Nonpoint Source Contaminated Ground-Water Discharge to Surface Water; USEPA 1991
- Ground Water Monitoring: A Guide to Monitoring for Agricultural Projects; Goodman, German, and Bishoff, 1995

Conclusion

That’s All Folks