LID Hydrology and Soil Issues

Eric Berntsen

Stormwater Program / SWRCB

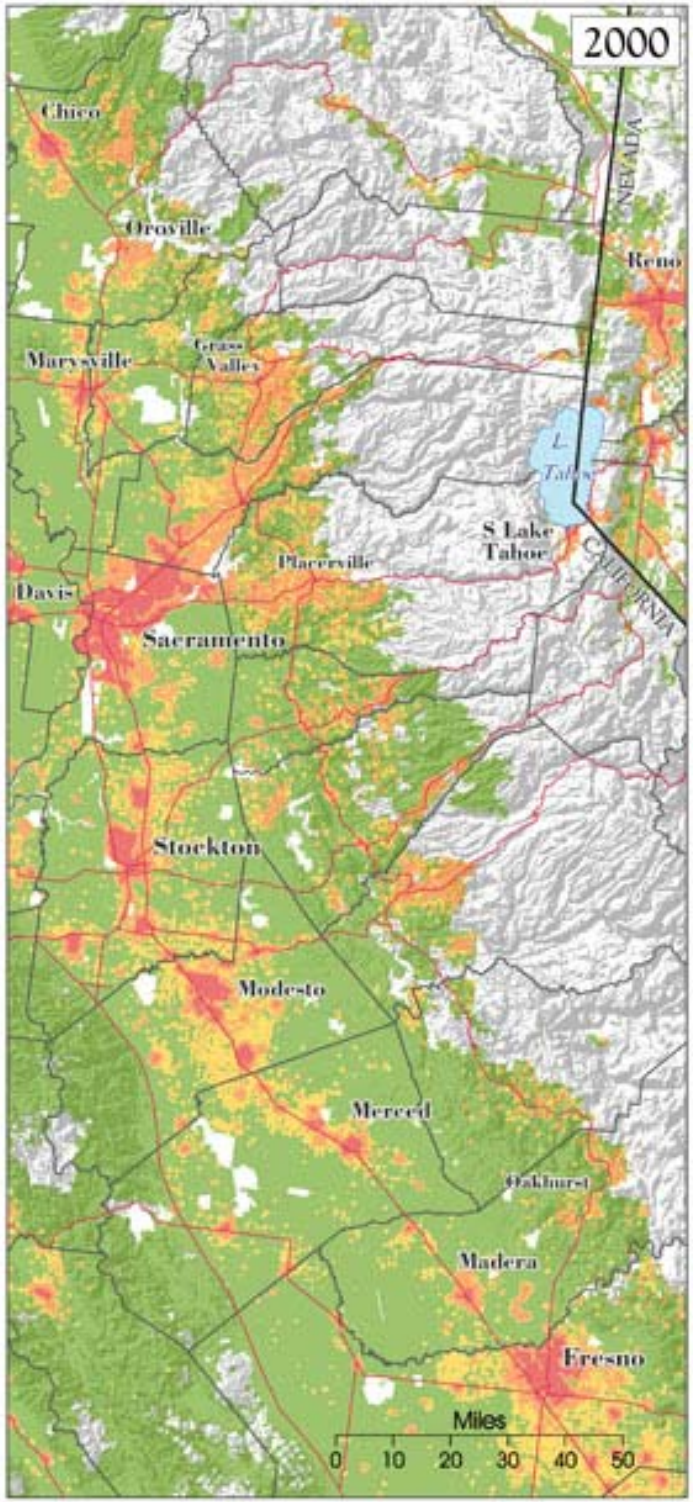
growth

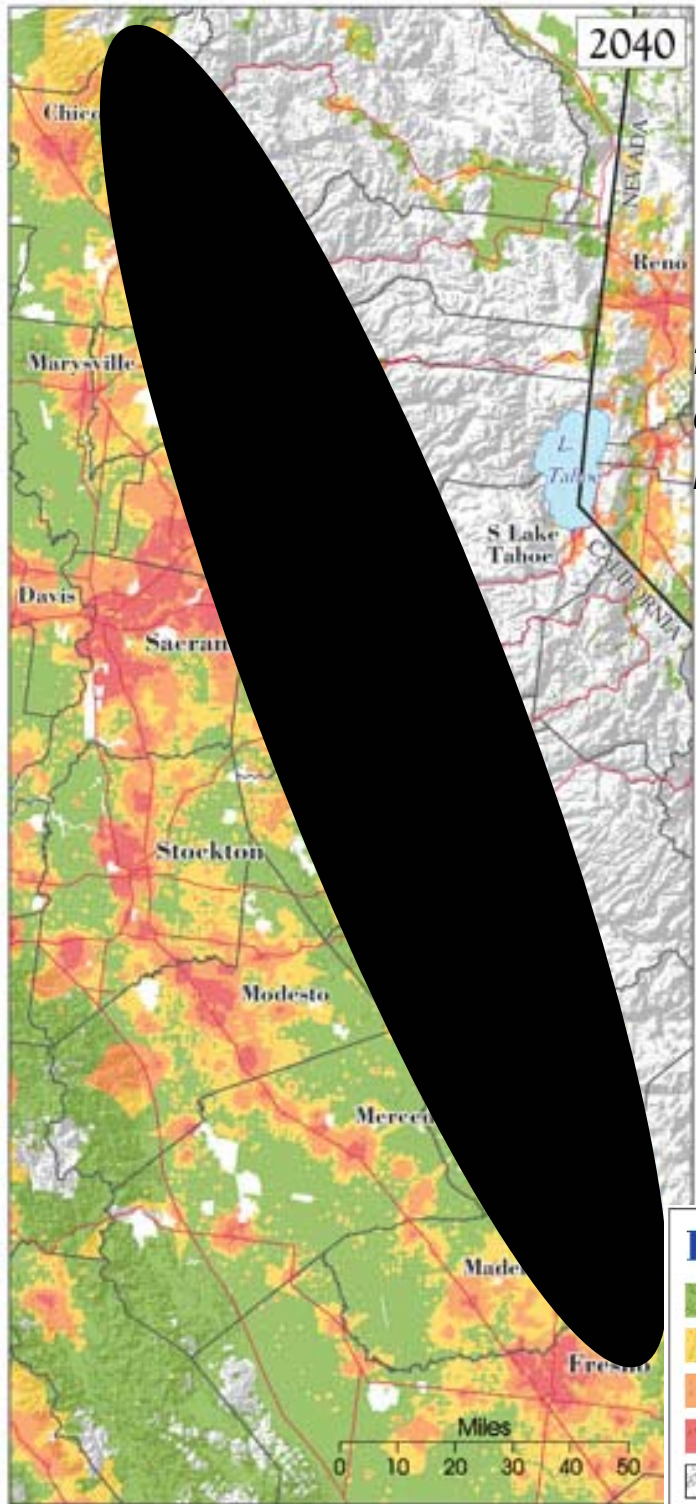
…happens

© Dan L. Perlman/EcoLibrary.org

Exurbanization in the Sierra Foothills

from "New Geographies of the American West" by William Travis



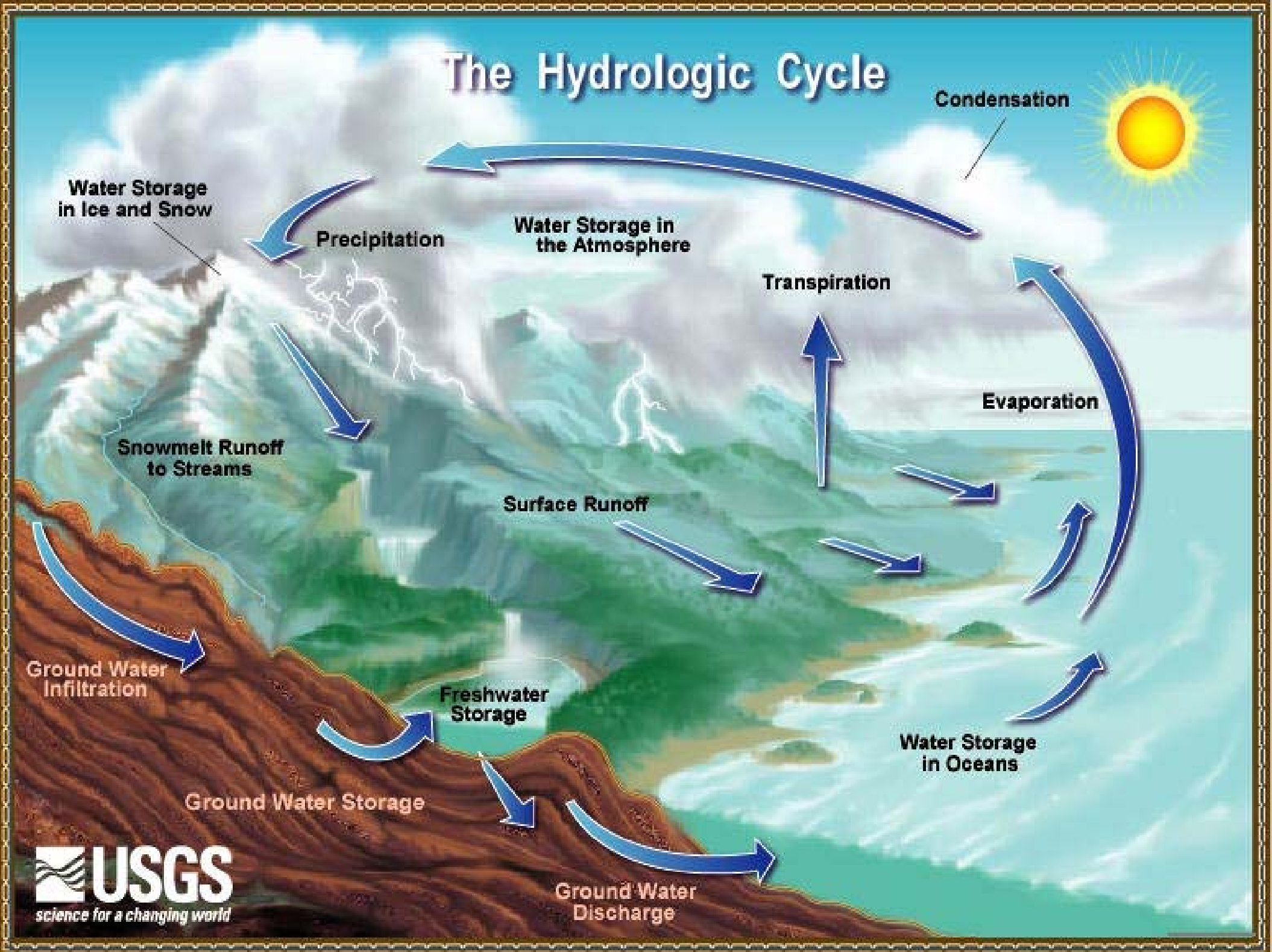


Land Use Categories

- Rural (<1 unit per 40 acres)
- Exurban (1 unit per 10 to 40 acres)
- Low Density Suburban (1 unit per 0.5 to 10 acres)
- Urban/Suburban (>2 units per acre)
- Not Buildable

the problem is not growth

it's hydromodification


The Hydrologic Cycle
Condensation
Water Storage in Ice and Snow
Precipitation
Water Storage in the Atmosphere
Transpiration
Evaporation
Snowmelt Runoff to Streams
Surface Runoff
Ground Water Infiltration
Freshwater Storage
Water Storage in Oceans
Ground Water Storage
Ground Water Discharge
USGS
science for a changing world

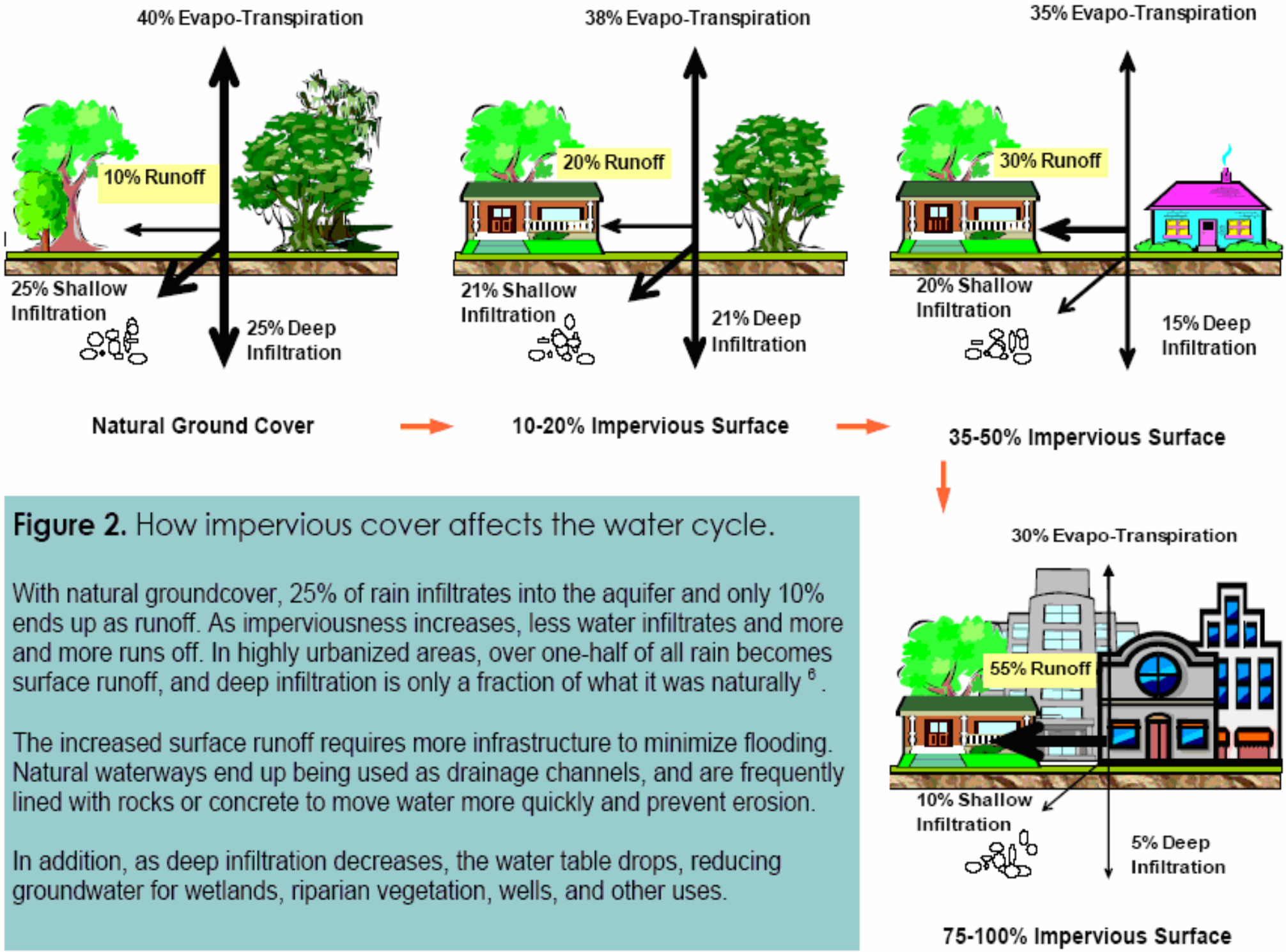


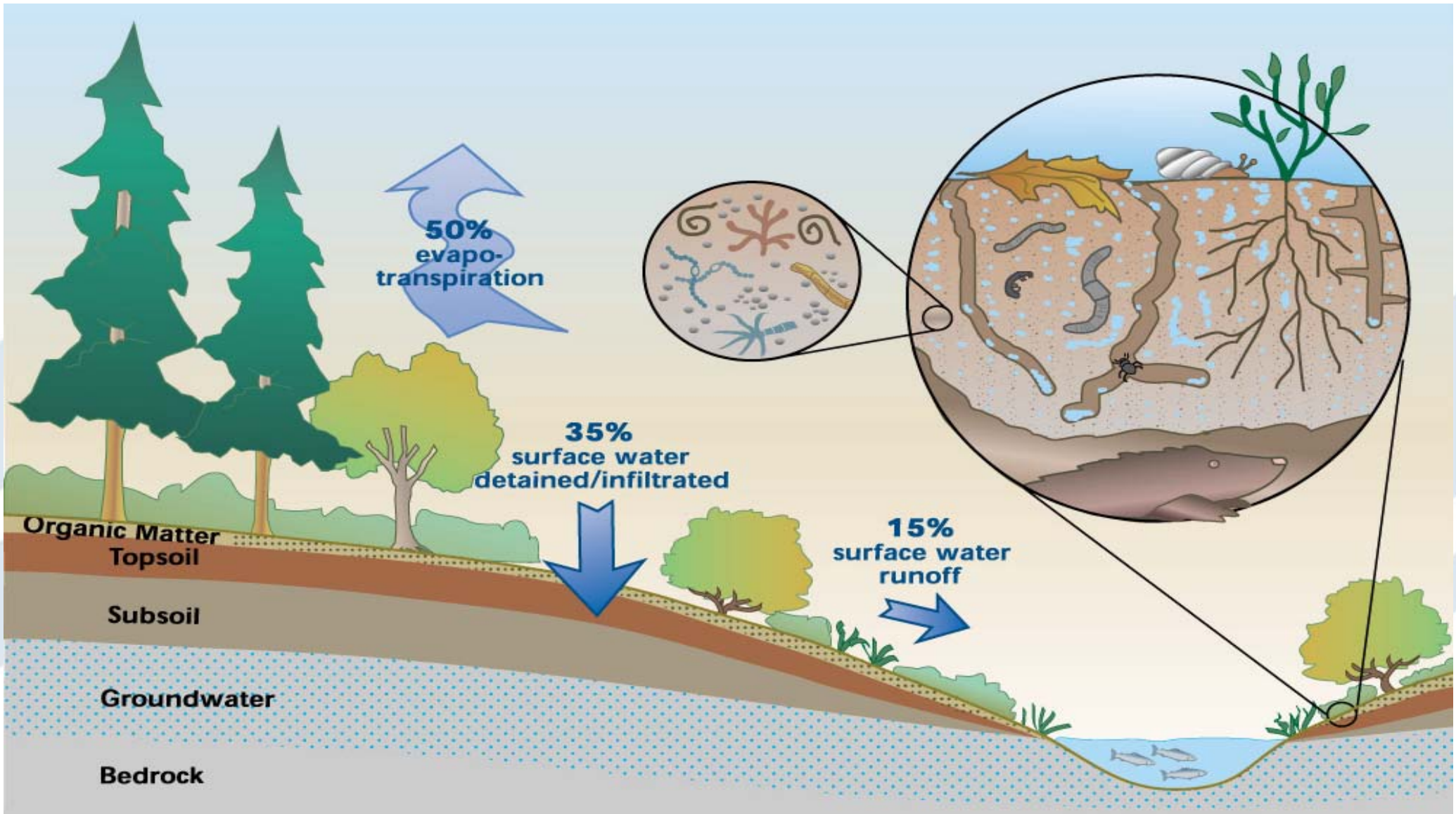
Figure 2. How impervious cover affects the water cycle.

With natural groundcover, 25% of rain infiltrates into the aquifer and only 10% ends up as runoff. As imperviousness increases, less water infiltrates and more and more runs off. In highly urbanized areas, over one-half of all rain becomes surface runoff, and deep infiltration is only a fraction of what it was naturally [6].

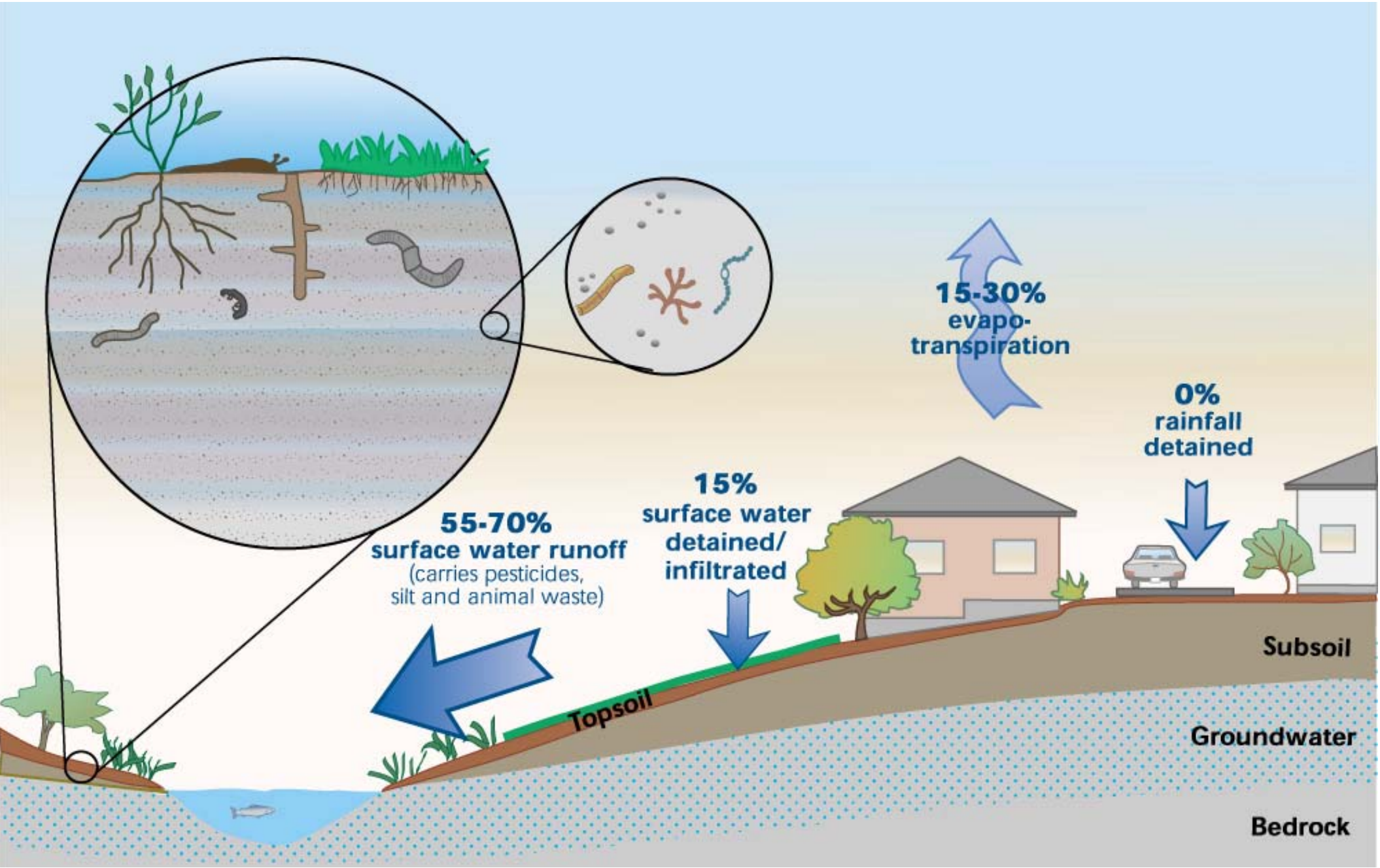
The increased surface runoff requires more infrastructure to minimize flooding. Natural waterways end up being used as drainage channels, and are frequently lined with rocks or concrete to move water more quickly and prevent erosion.

In addition, as deep infiltration decreases, the water table drops, reducing groundwater for wetlands, riparian vegetation, wells, and other uses.

Native Soil


50%
evapo-
transpiration
35%
surface water
detained/infiltrated
15%
surface water
runoff
Organic Matter
Topsoil
Subsoil
Groundwater
Bedrock

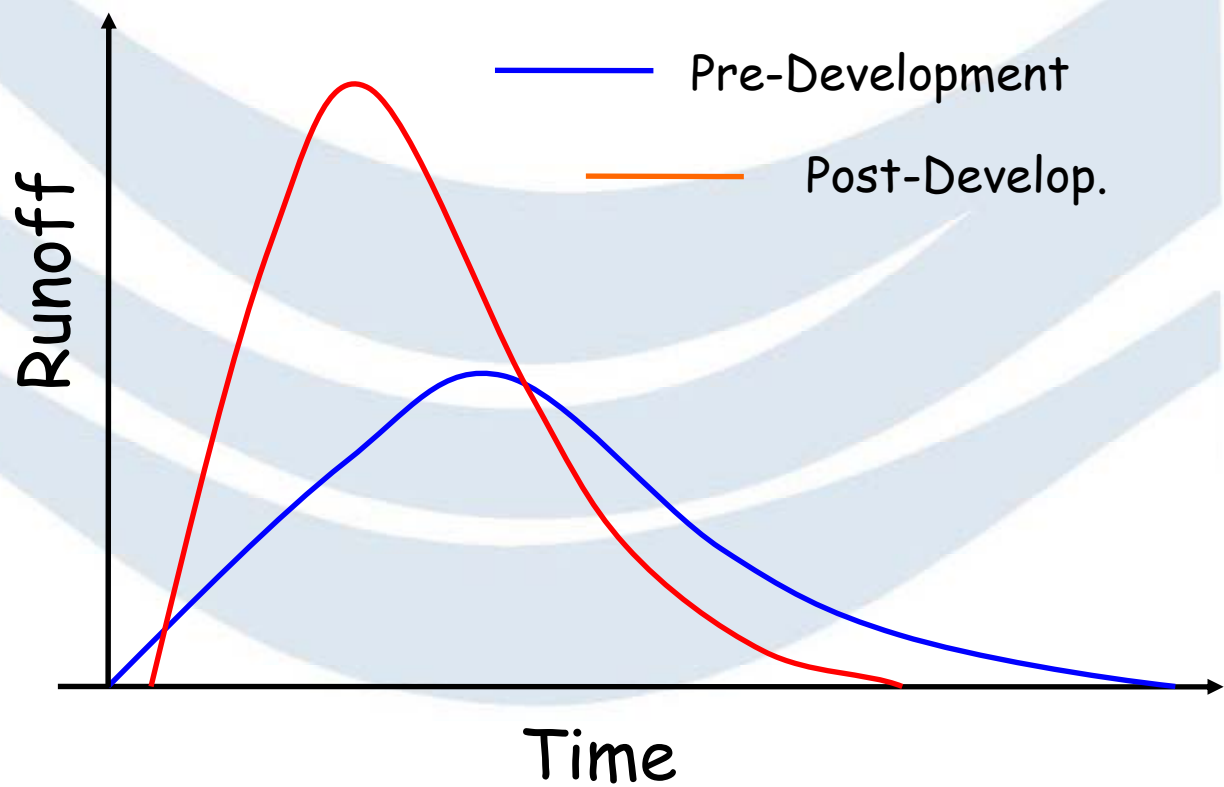
Disturbed Soil



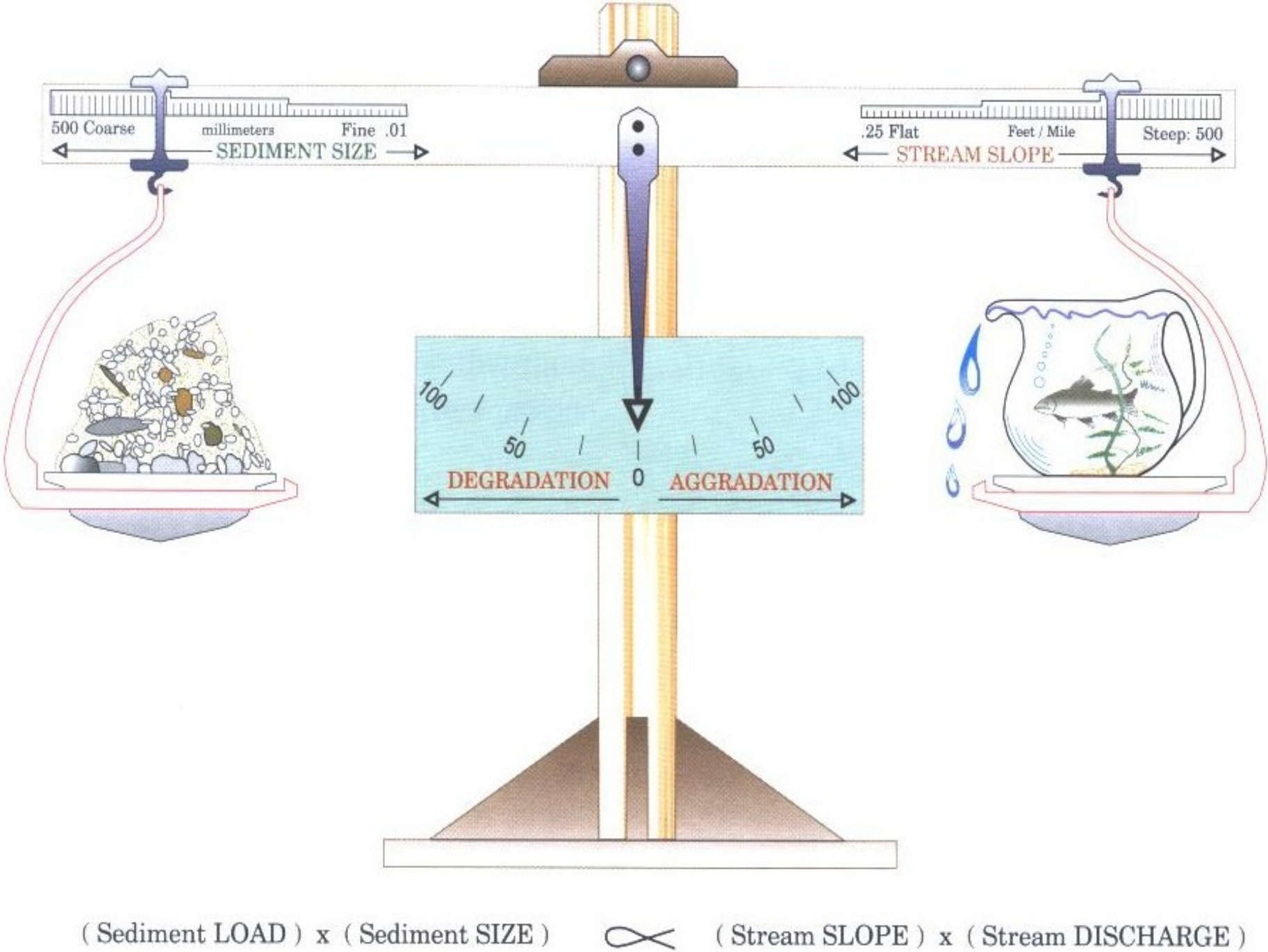
Hydrologic Changes

Urbanization tends to increase storm water runoff:

- peak flows
- volume
- frequency

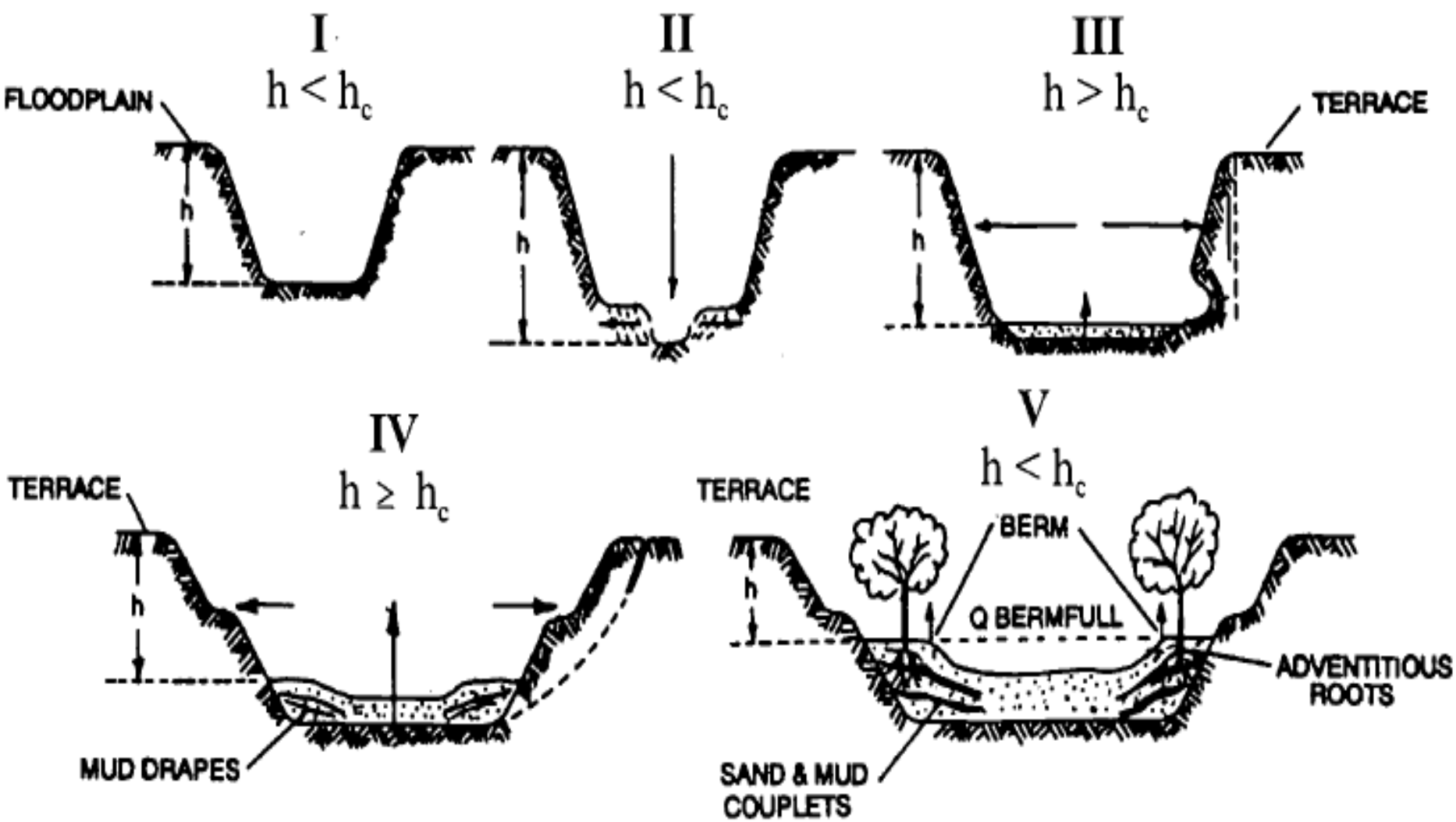


From Haltiner (2006)



After Lane (1955) as cited in Rosgen (1996)

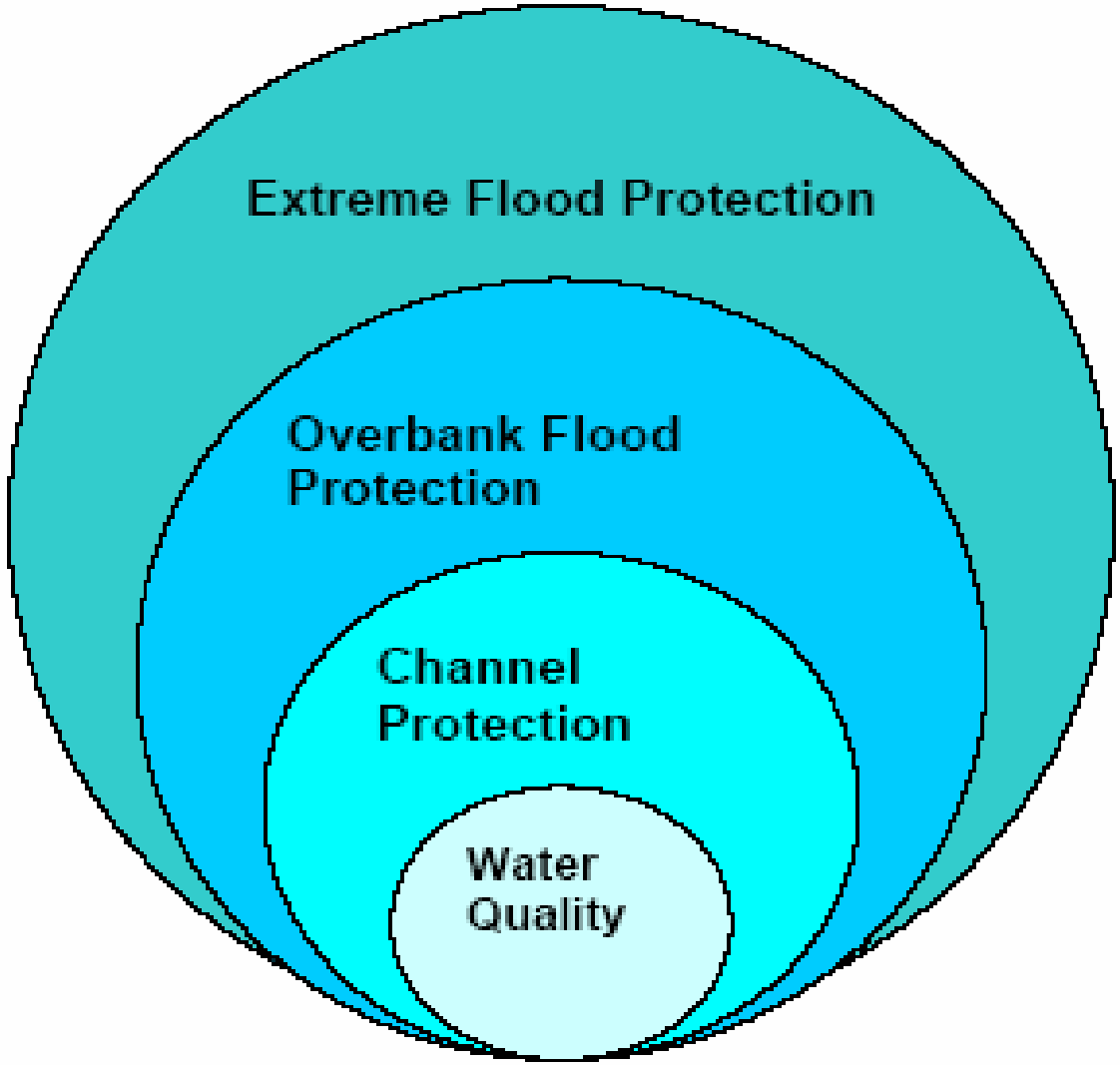
Channel Changes Associated with Urbanization



Post-Construction Impacts

Sources of Impairment (USEPA 2006)

	Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries
Sources[b]	Agriculture (48%)[a]	Agriculture (41%)	Municipal Point Sources (37%)
	Hydrologic Modification (20%)[c]	**Hydrologic Modification (18%)**	Urban Runoff/Storm Sewers (32%)
	Habitat Modification (14%)[d]	Urban Runoff/Storm Sewers (18%)	Industrial Discharges (26%)
	Urban Runoff /Storm Sewers (13%)	Nonpoint Sources (14%)	Atmospheric Deposition (23%)
	Forestry (10%)	Atmospheric Deposition (13%)	Agriculture (18%)
	Municipal Point Sources (10%)	Municipal Point Sources (12%)	**Hydrologic Modification (14%)**
	Resource Extraction (10%)	Land Disposal (10%)	Resource Extraction (12%)



From Georgia Stormwater Manual

Low Impact Development (LID) Principles

LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source.

LID Benefits

- **Multifunctionality** – landscaping costs also serve as stormwater treatment costs, etc.

- **Lower lifetime costs** – e.g., lower overall operation, repair, maintenance, and decommissioning costs

- **Reduced offsite costs** – fewer offsite sewer collection and treatment costs

- **Functional use of open space land** – LID practices can be put in open space, thereby not reducing developable land

- **Additional environmental and social benefits** – multiple objectives met

LID is Cost Effective

TRADITIONAL DEVELOPMENT	LID
$** Pay to Pipe / Pump offsite **$ Risk onsite WQ violations / fines	Treat onsite
$ Pay to treat at end of Pipe	Reduced piping / pumping costs
$ Excavate, grade site and haul away materials	Utilize natural terrain / preserve natural channels

Reports of Reduced Costs

- Case studies show reduction of 25-30% over conventional projects.
- Somerset Rain Gardens[1]
  - Original retention ponds - $400,000
  - Implementation using natural drainage - $100,000
- Pembroke subdivision[2]
  - Used LID practices to eliminate stormwater ponds
  - Saved $200,000

Sources: 1- "Low-impact Development" by Mary Catherine Hager
2- "Stormwater Strategies: Community Responses to Runoff Pollution" NRDC

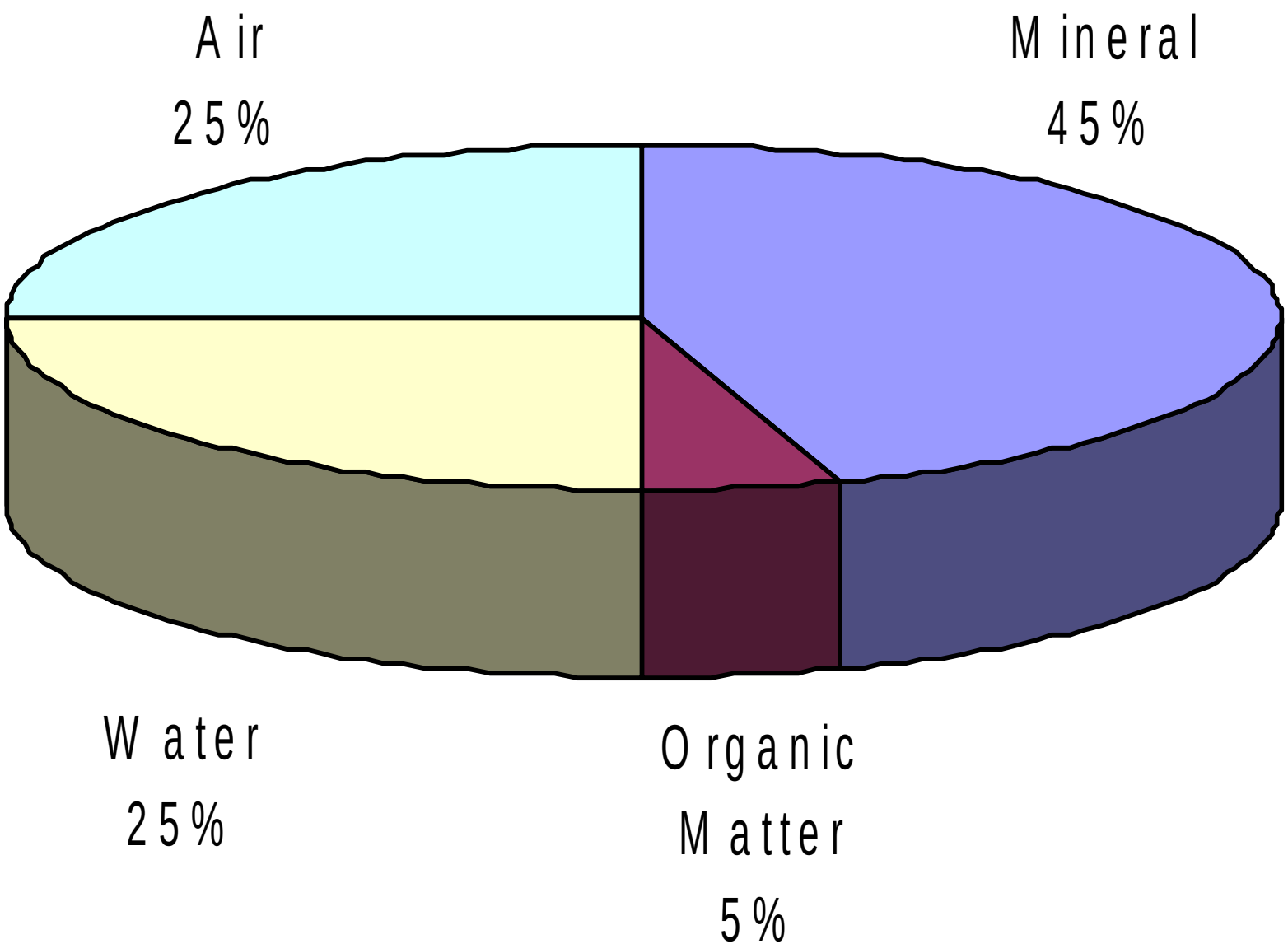
Examples of LID-type of design/construction in CA

- Village Homes (Davis) – community level
- Hall House (T.R.E.E.S. Project in Los Angeles) – residential lot level
- Inland Empire Utility Agency (Chino) – commercial lot level
- NRDC Headquarters (Santa Monica) – commercial lot level
- Audubon Center at Debs Park (Los Angeles) – open space with structures and public use on 17 acres
- More on the way – stay tuned

Ways to mimic pre-development water balance and T_c

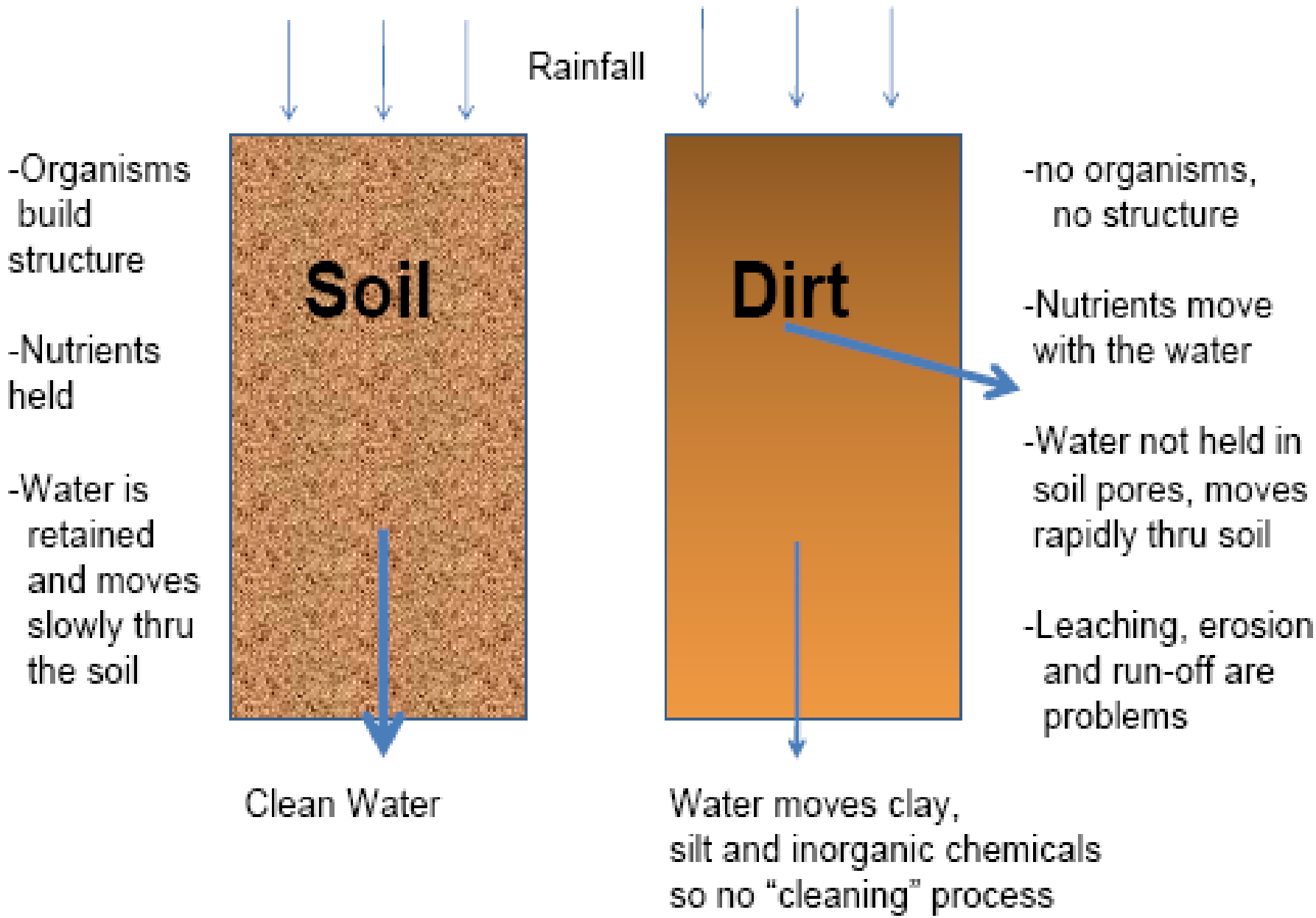
- Soil quality improvement (porosity)
- Native and drought tolerant vegetation
- Trees
- Permeable pavement
- Riparian buffers
- A general reduction of connected, impervious surfaces in runoff pathways
- Bioretention
- Disconnected downspouts/rain chains/rain barrels

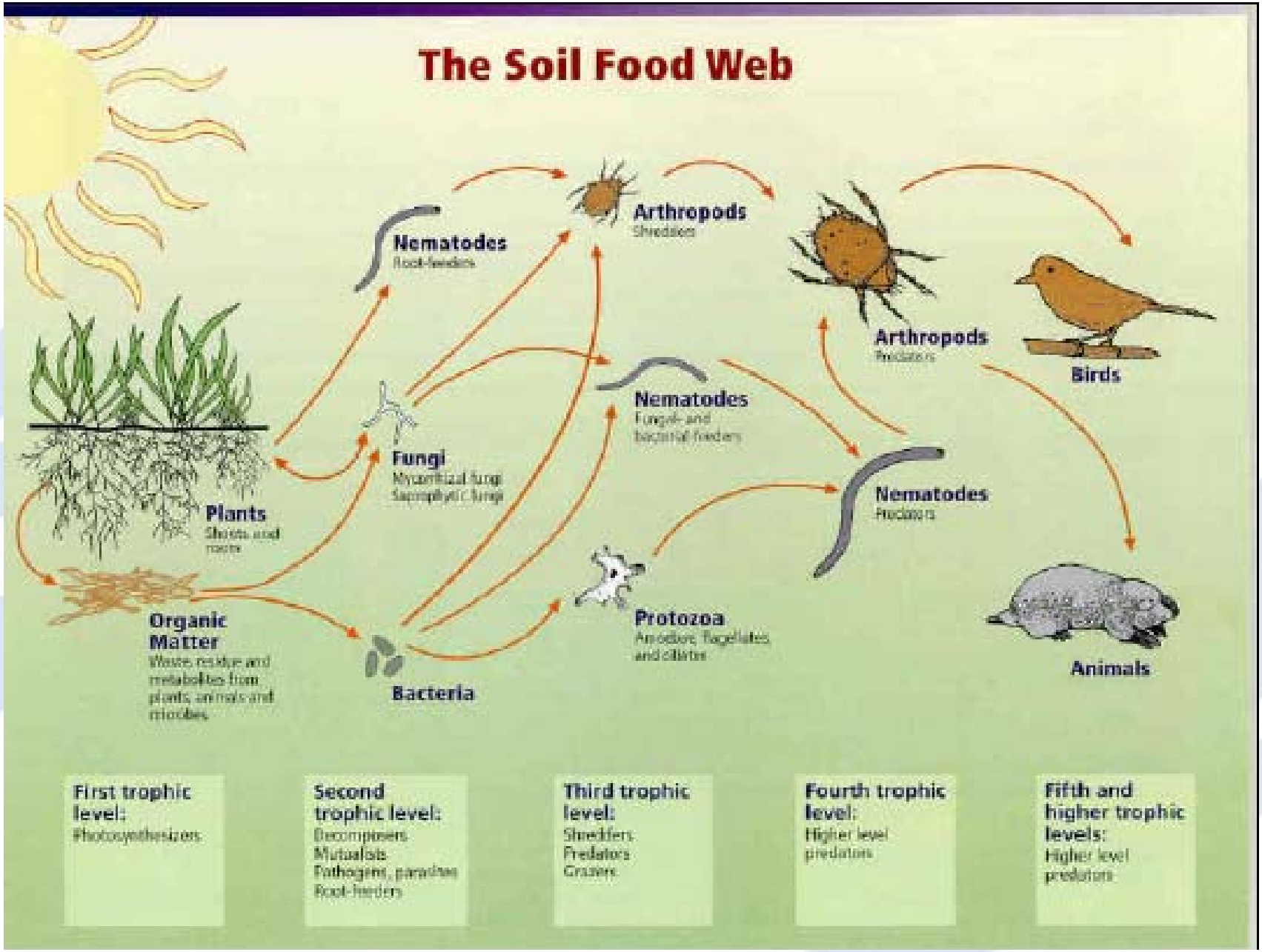
Ideal Soil Structure for Plant Growth



What happens when we maintain soil quality?

- More nutrient and water retention
- Less need for fertilizer, pesticides, etc.
- Filtering and decomposition of toxins


Rainfall
-Organisms build structure
-Nutrients held
-Water is retained and moves slowly thru the soil
Soil
Clean Water
Dirt
-no organisms, no structure
-Nutrients move with the water
-Water not held in soil pores, moves rapidly thru soil
-Leaching, erosion and run-off are problems
Water moves clay, silt and inorganic chemicals so no "cleaning" process


The Soil Food Web
Nematodes
Root-feeders
Arthropods
Shredders
Arthropods
Predators
Birds
Nematodes
Fungal- and bacterial feeders
Fungi
Mycorrhizal fungi
Saprophytic fungi
Nematodes
Predators
Plants
Shoots and roots
Organic Matter
Waste, residue and metabolites from plants, animals and microbes
Bacteria
Protozoa
Amoebae, flagellates and ciliates
Animals
First trophic level:
Photosynthesizers
Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders
Third trophic level:
Shredders
Predators
Grazers
Fourth trophic level:
Higher level predators
Fifth and higher trophic levels:
Higher level predators

Bacteria	Fungi	Protozoa	Beneficial Nematodes	Micro-arthropods
Disease Suppression	Disease Suppression	Make nutrients plant available	Make nutrients available to plants	Make nutrients available to plants
Nutrient Retention	Nutrient Retention	Build soil structure	Stimulate prey groups	Stimulate prey
Build Soil Structure	Build Soil Structure	Indicators of lack of oxygen, compaction	Build soil structure	Build soil structure
Decompose Toxins	Decompose Toxins		Inhibit root-feeding nematodes	Taxicabs

How do we get the biology?

- Compost
- Compost tea
- Inoculate

Sources of Information

- Soil Biology Primer (http://soils.usda.gov/sqi/concepts/soil_biology/biology.html)
- River-friendly landscaping guidelines (www.riverfriendly.org)
- California Native Plant Society (www.cnps.org)
- *Sustainable Landscape Construction—A Guide to Green Building Outdoors* By J. William Thomson and Kim Sorvig

Runoff Reduction Example

Let's say we have a 5 acre site where 80% is impervious (4 acres).

How much of the water quality storm (85th percentile event) runoff volume can be retained in the 1 acre of pervious surface?

Runoff Reduction Example

Assume:

-85% percentile storm event = 0.6 inches

-Soil depth is 1 foot

-25% porosity

- Runoff coefficient for impervious surface is 0.95

Runoff Reduction Example

Runoff from impervious surface

0.6 inches X 1 foot/12 inches X 4 acres X 43,560 square feet/acre X 0.95 = 8,276 cubic feet

Storage available in soil

1 foot X 1 acre X 43,560 square feet/acre X 0.25 = 10,890 cubic feet

There's enough storage in the soil

What if we compact pervious areas to 90%?

Storage available in soil

1 foot X 1 acre X 43,560 square feet/acre X 0.1 = 4,356 cubic feet

We can't store the water quality volume any more