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WATERSHEDS AND POLLUTANTS

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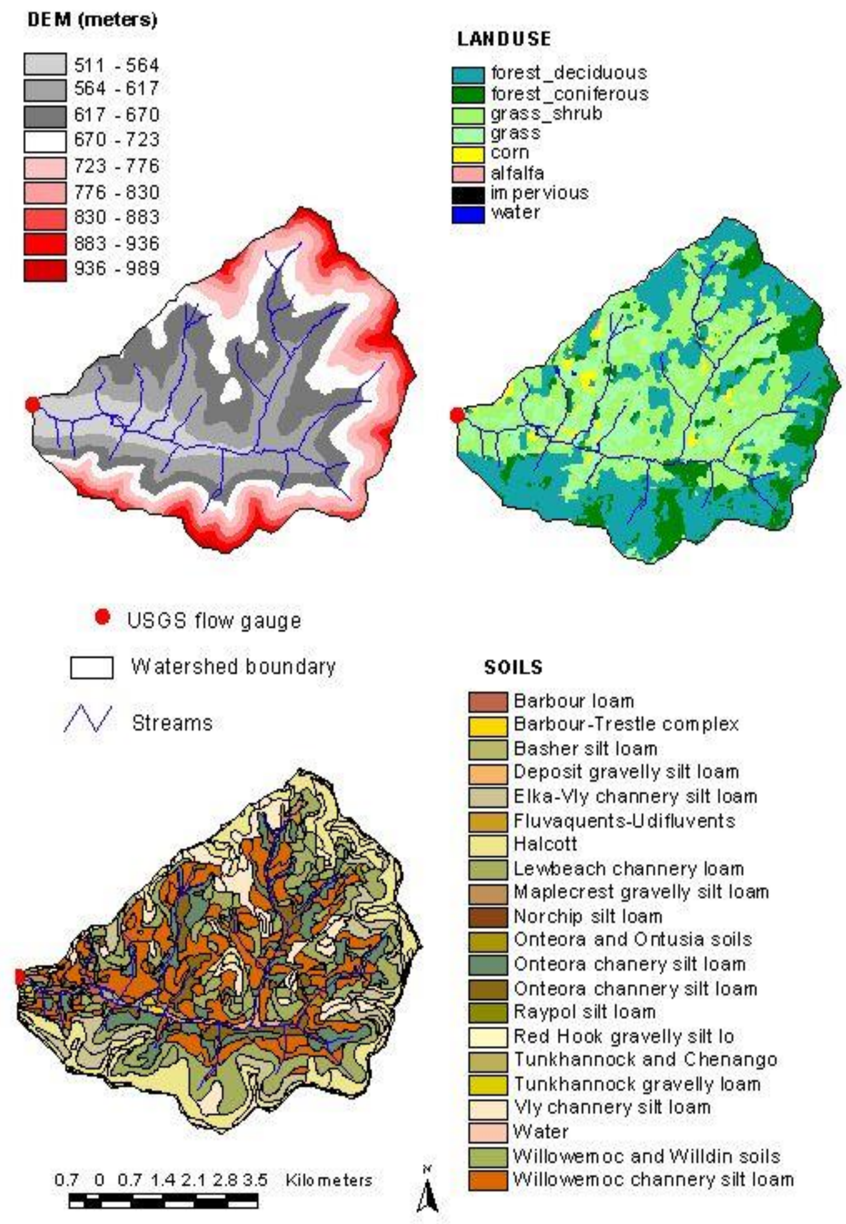
Watersheds

a unit of land from which surface and subsurface runoff, and groundwater (usually) flow to a common outlet

Characteristics:

- **Boundary (divide)**
- **Outlet and base**
- **Size and Shape**
- **Elevation and Gradient**
- **Aspect and Orientation**
- **Drainage network**
- **Soils and Geology**
- **Land Use and Vegetation**
- **Cultural Activities**



Water inputs, storage and outputs

- Precipitation – frontal, convective, orographic
- Infiltration, percolation – will vary over watershed (usually infiltration is better high up on watershed, but not always)
- Storage in watershed
  - Depressions (in the field)
  - Detention – en route to streams (e.g. wetlands)
  - Channels – en route to outlet (rivers, ditches)
  - Groundwater – until groundwater rises above stream level
  - Retention – precip that does not escape as runoff

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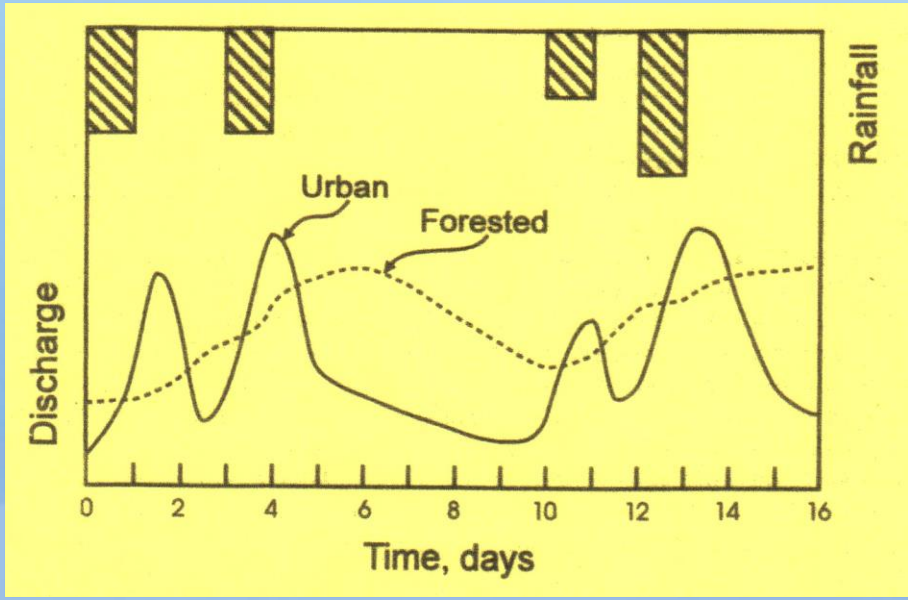
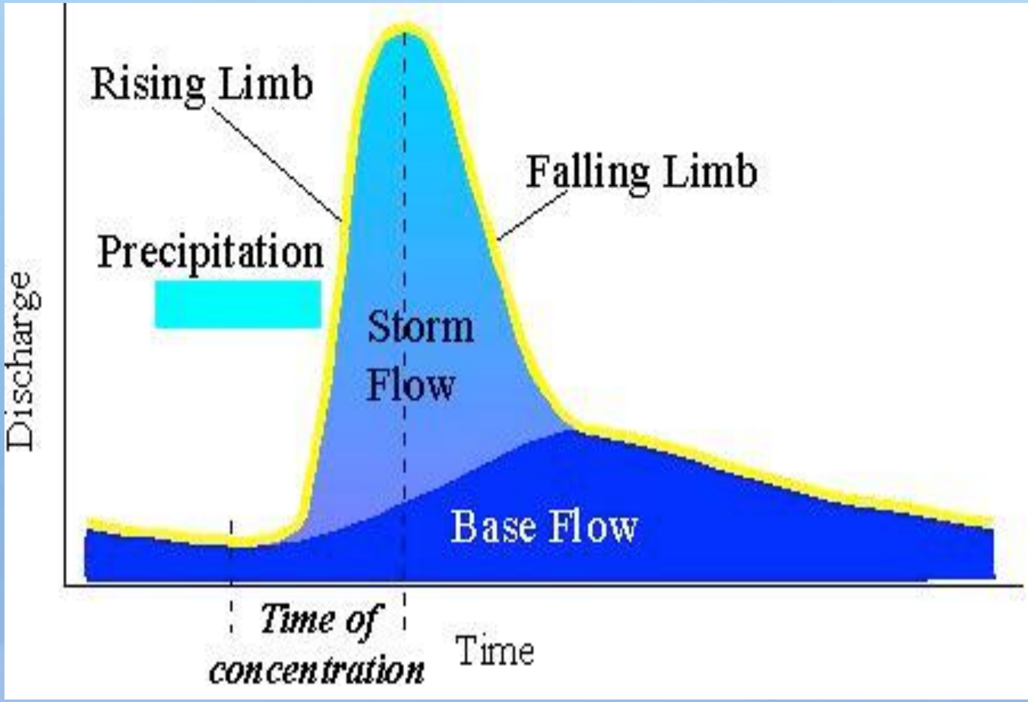
Water inputs/outputs of watersheds

- Vegetation – interception (e.g. mature alfalfa can intercept 2”)
- Base flow – groundwater feeds stream
  - Perennial
  - Intermittent
- Storm flow – mostly considered to be direct runoff that feeds stream after precipitation event (ephemeral stream, concentrated flow path)
- Surface, channel and subsurface runoff – effect of land use change (impervious surface, removal of forest, channel alterations)
- Evaporation and transpiration – vary spatially and temporally in watershed.



Hydrograph

- Graphical representation of stream flow rate over time
- Rising limb – increase in flow rate
- Peak flow rate
- Falling limb – decrease in flow rate
- Stream flow rate x concentration = load
- Pollutograph may differ from hydrograph:
  - May peak before peak flow rate (e.g. sediments and sediment-bound compounds, fecal matter)
  - May peak after peak flow rate (e.g. nitrate, chloride, other ions dissolved in groundwater)
  - Also depends on location of pollutant source

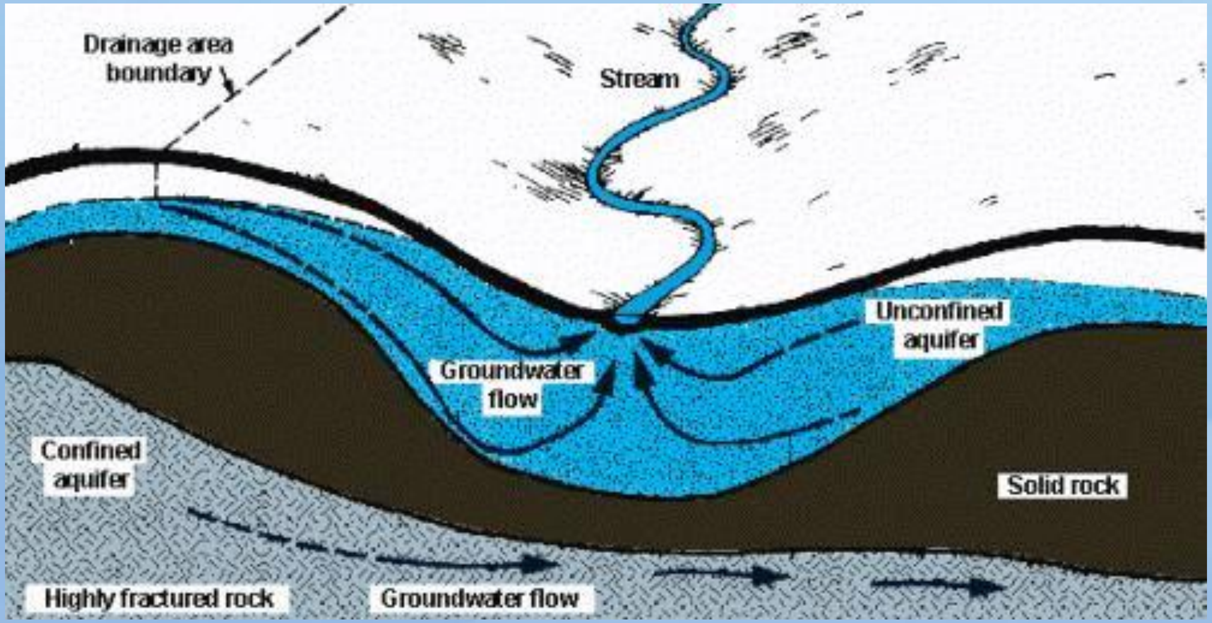


Pollutant delivery

- "Availability"
  - Low soil water adsorption coefficient = not readily attach to soil (e.g. nitrate) – moves in runoff and groundwater
  - High soil water adsorption coefficient = readily attach to soil (e.g. phosphorus) – moves primarily in runoff, soil acts as filter
- Nutrient budgets – attempt to decrease pollutant availability
- TMDL = maximum load a water body can receive and still meet water quality standards. Farmers help meet TMDLs by using conservation plans and nutrient management plans

Aquifers

- geologic formations that store groundwater in the saturated pores of these sediment or rock formations, and are sufficiently permeable to transmit economic quantities of water to wells or springs.

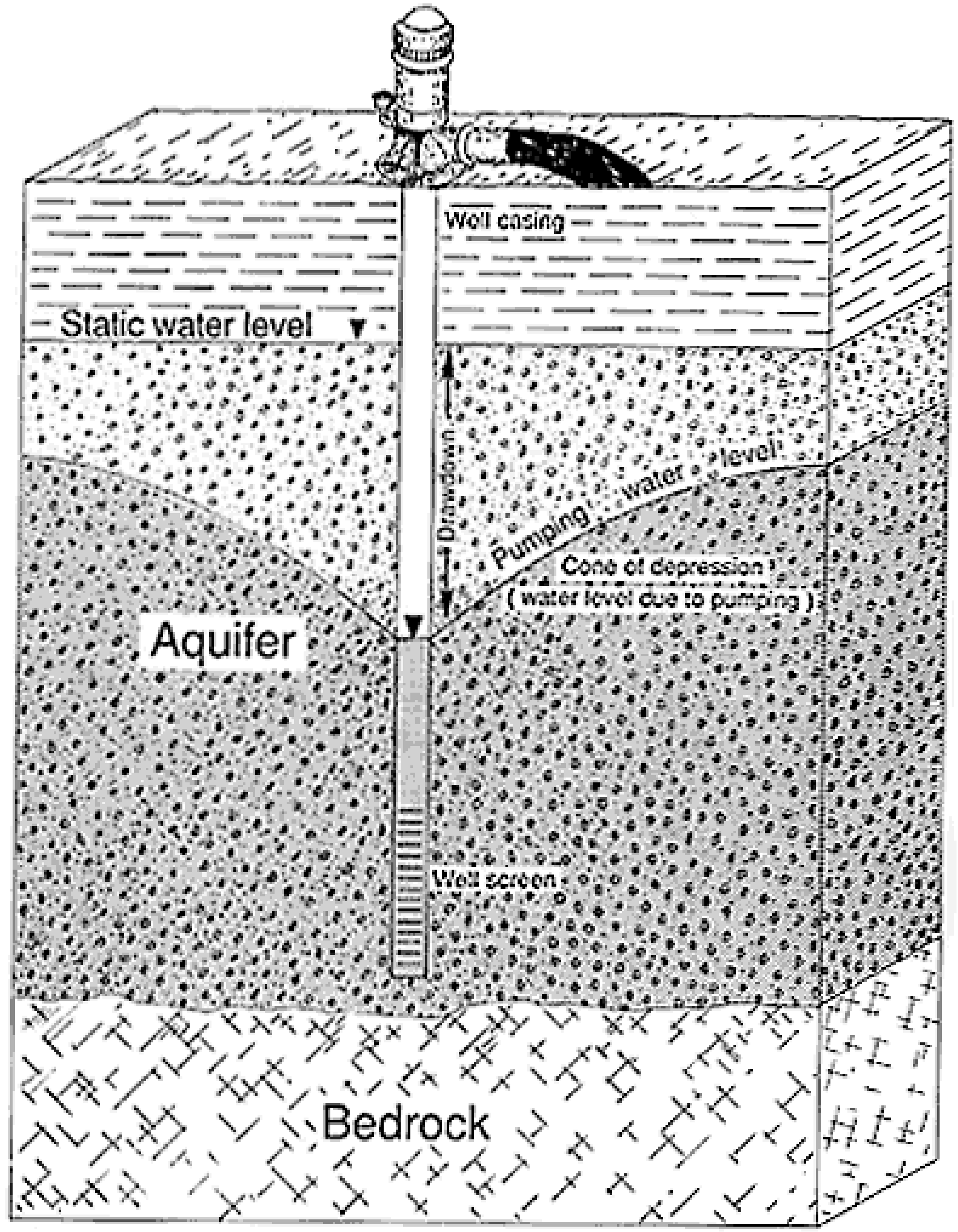


Confined: Upper boundary relatively impervious – groundwater under pressure. Level constant (but pressure varies)

Unconfined: Upper boundary free to atmosphere – groundwater not under pressure. Level varies with groundwater recharge.

Well water yields

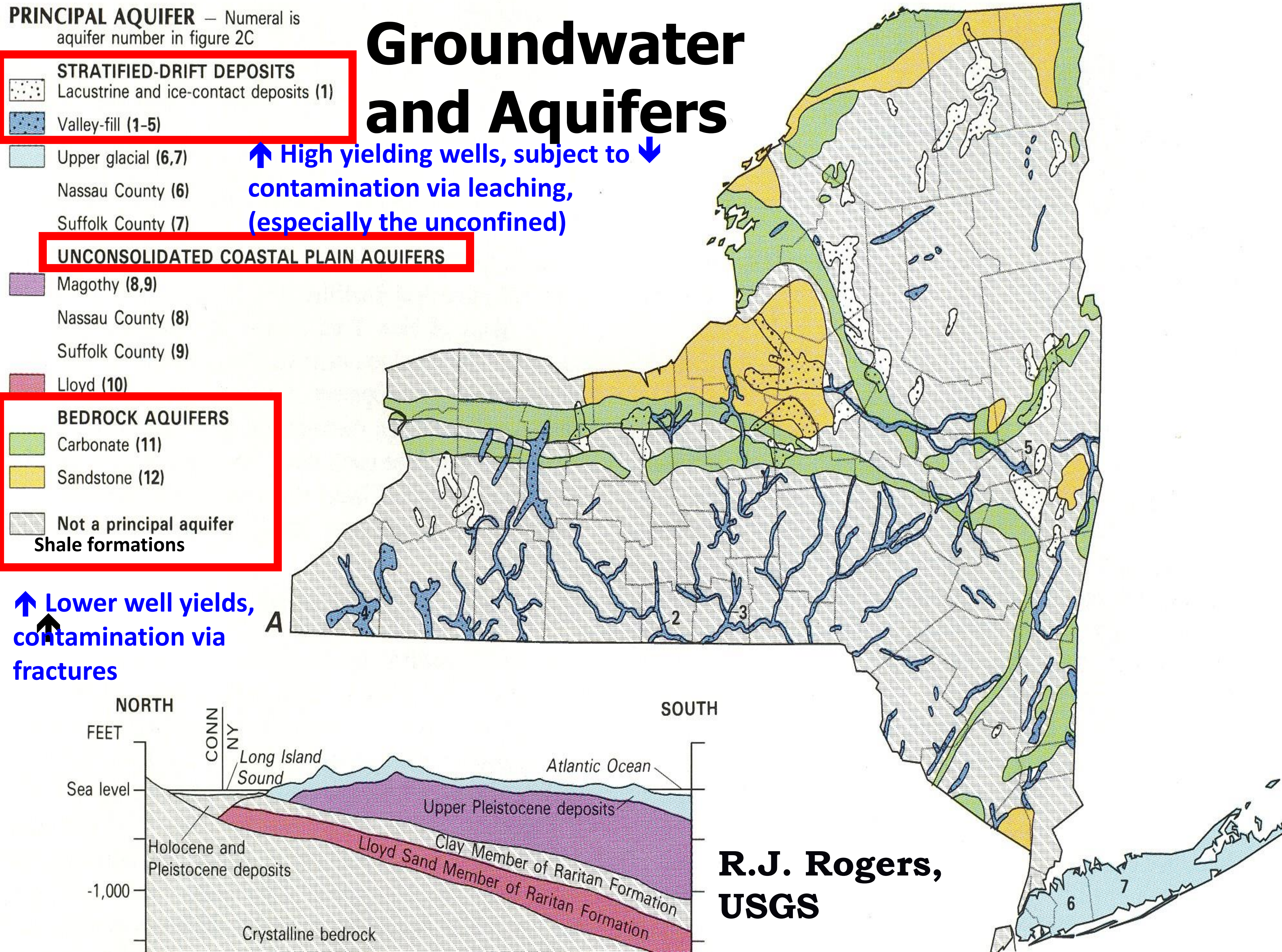
- Sorted gravel: 500-1500 gpm
- Sorted sands, outwash: 100-500 gpm
- Fine sands, silty sand: 10-100 gpm
- Limestone: 1000s gpm
- Sandstone: 50-200 gpm
- Shale: 2-50 gpm
- Farm use – need in excess of 100 gpm



Groundwater and Aquifers

↑ High yielding wells, subject to ↓ contamination via leaching, (especially the unconfined)

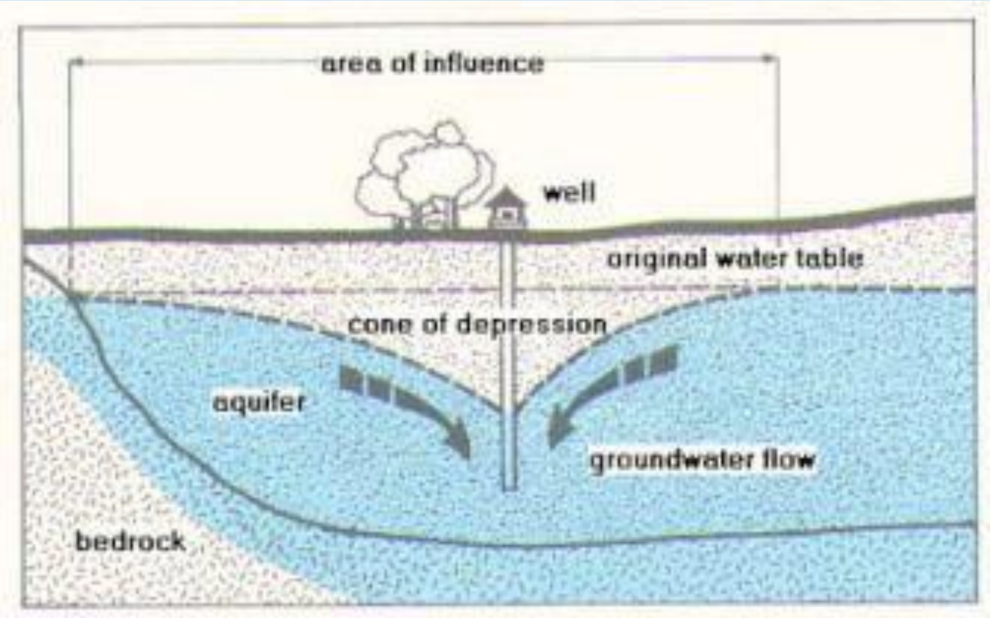
↑ Lower well yields, ↑ contamination via fractures



R.J. Rogers, USGS

Well terminology

- Drawdown: lowering of watertable cf level in aquifer
- Cone of depression: from level in well to limit of drawdown
- Capture zone: to boundary of ‘groundwater shed’ of well (anything in that zone can affect quantity and quality of well water)



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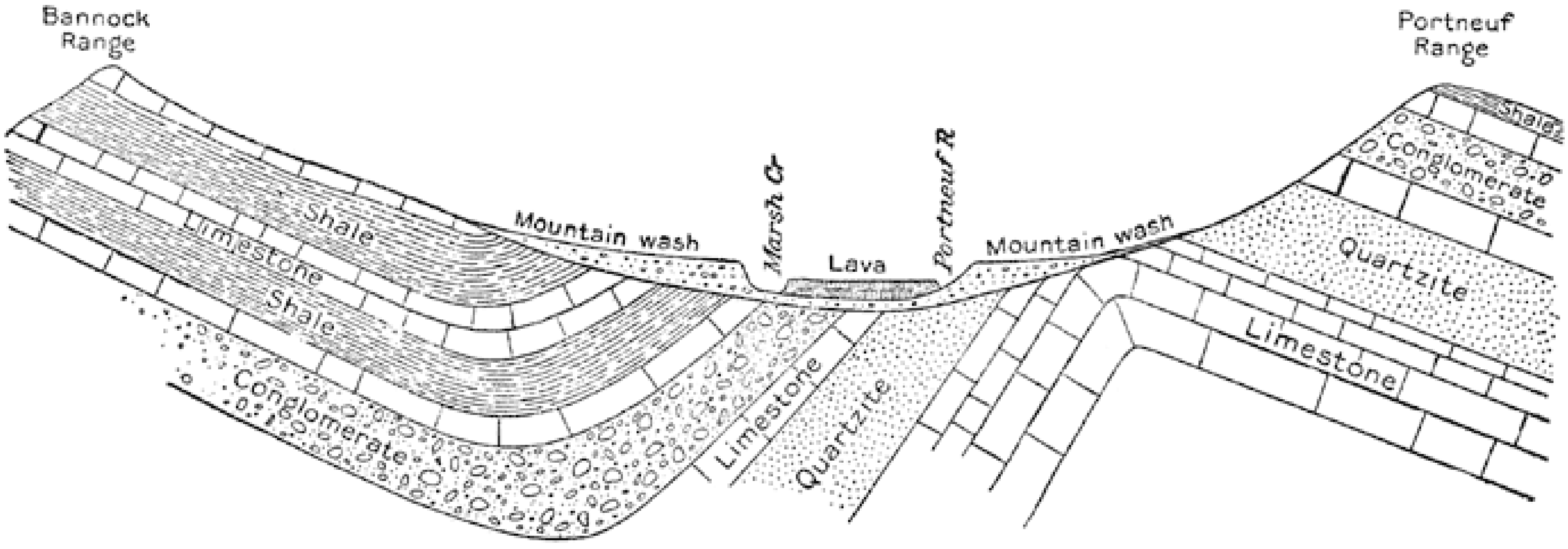
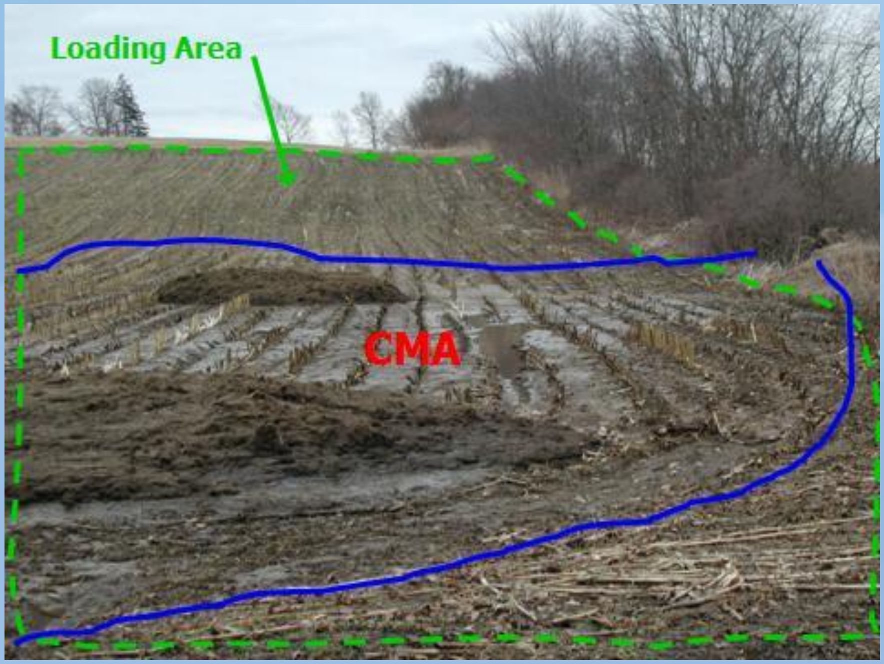
Geology and water pollution

- Soil and rock layers vary in permeability
- Layering affects water flow
- Slope of layers affects water flow
- Highly permeable soil and geological formations – ease of groundwater contamination
- Impermeable layers (e.g fragipans) may inhibit downward water flow and force groundwater to surface (seeps) – potential for surface water contamination



Hydrologically Sensitive Areas

- High hydrologic risk for water movement off-site
  - Impervious areas (barnyard, bunker)
  - Impermeable (frozen, hardpan) and erosion prone (sloping, low permeability) soils
  - Saturated soils
  - Flood plains
  - Streams
  - Groundwater recharge areas (highly permeable soil, sinkholes)
- Critical management zone – where application of pollutant overlaps with HSA (e.g. manure along sink hole)



Examples of Hydrologically Sensitive Areas

- Relatively impervious/erosion prone areas
- Flowing surface water bodies
- Saturated soils (Variable Source Areas)
- Groundwater recharge areas

Function of wetlands, buffers

- Slow water flow – remove sediments
- Anaerobic - reduction of nitrate, pesticides

Multiple barrier concept

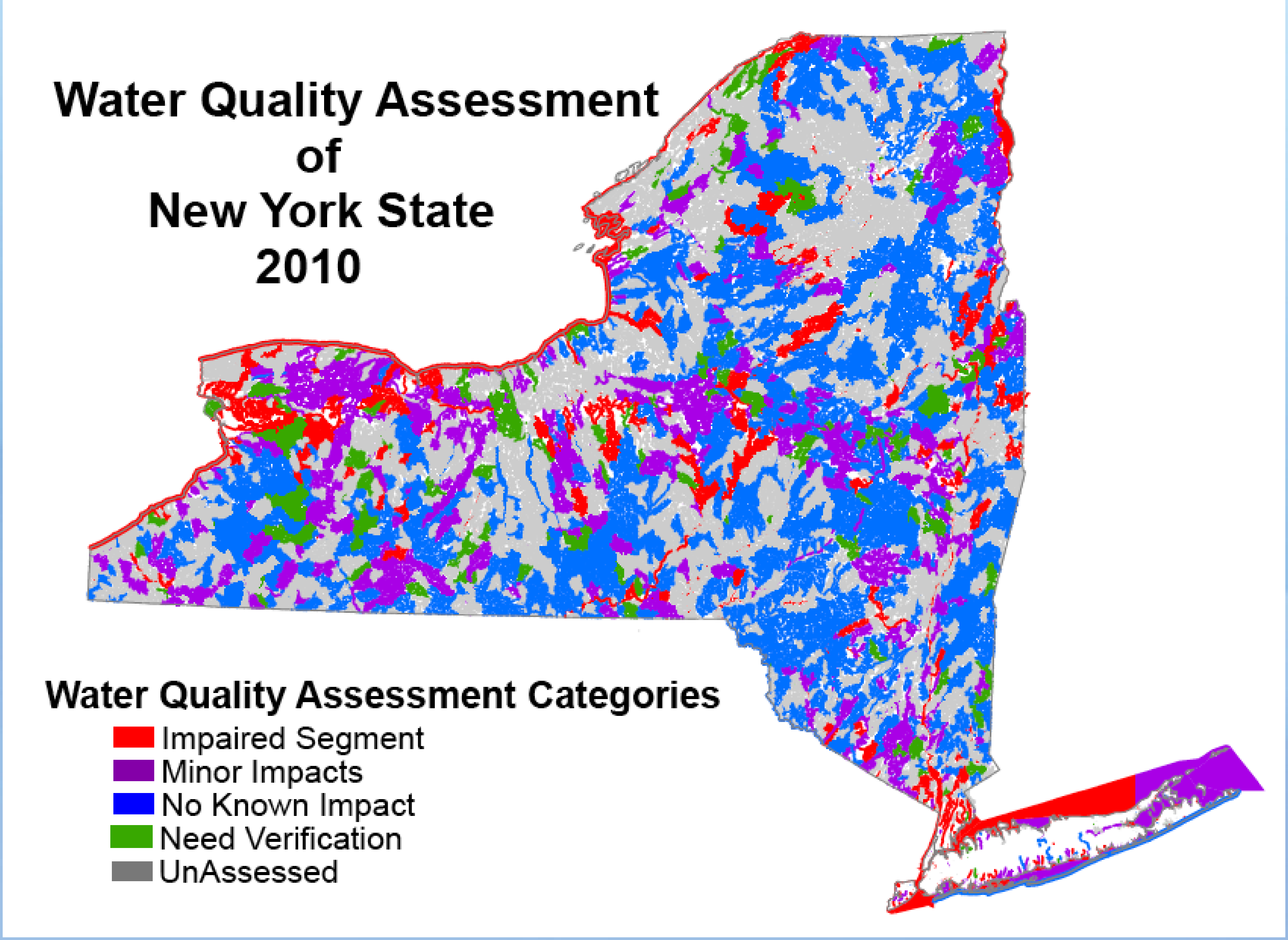
Multiple barriers are needed to avoid pollution, e.g. in case of pathogens:

1. Import restrictions, biosecurity to avoid introduction of pathogens
2. Animal health and hygiene to avoid spread
3. Waste management to reduce availability
4. Land application BMPs to reduce transport and off-site export

Impaired water bodies

Critical pollution threshold exceeded

- Part of Clean Water Act – states need to assess and report on quality of waters in state
- NY – Dept. Environ. Cons.
- Maps available on-line
- Lists type of pollutant causing impairment, and probably cause
- Prioritizes where action is needed (resources, enforcement)


Water Quality Assessment
of
New York State
2010
Water Quality Assessment Categories
Impaired Segment
Minor Impacts
No Known Impact
Need Verification
UnAssessed

Non-point source pollution

- Pollution w/o well-defined source, e.g.
  - Agriculture
    - Soil erosion
    - Nutrients, pathogen loss from manure
    - Spray drift
  - (Sub)urban
    - Nutrient losses from lawns, golfcourses,
    - On-site sewage disposal
    - Erosion from logging, construction
- Soil erosion – largest pollutant on mass-basis
- Pesticides – rarely found in surface waters at levels exceeding drinking water standards
- Pathogens, phosphorus – frequently problematic in surface waters
- Nitrates – often determined in levels exceeding drinking water standard in ground water
- Pesticides in groundwater – atrazine in ag areas, simazine in urban

Non-Point Source Pollution

Point source pollution

- Source of pollution (ground or surface water) well-defined
- Ag:
    - Nutrients, pathogens, BOD from barnyards, silage bunkers, lagoons, milking parlors)
    - Nutrients, pesticides from storages and transfer stations
    - Petrochemical loss from fuel storage, machinery shop
    - Nutrients, BOD from food processing
- Non-ag:
    - – Nutrients, pathogens, BOD from waste water facilities
    - – Inorganic and organic chemicals from industrial facilities

Main sources of pollution from ag

- N – runoff, tile drainage, leaching from manure, fertilizer applications
- P – soil erosion from soils testing high in P, suspended and dissolved P from manure applications in runoff and tile discharge
- BOD – runoff from recent applications of manure or wastewater
- Erosion – bare/tilled cropland, roads, ditches

Main sources of pollution from ag ctd

- Pesticides: pesticide runoff, leaching, drift
- Pathogens: calf housing, manure application (esp. surface applied before rain) – surface waters and tile drains most heavily impacted
- Silage leacheate: uncovered bunkers
- Processing waste: e.g. untreated milk parlor waste

Environmental Impacts of pollutants

- N – eutrophication, hypoxia, nitrate and ammonium affect aquatic organisms, methemoglobinemia in animals and humans
- P – eutrophication and hypoxia
- BOD – oxygen depletion can cause fish kill etc
- Sediment – turbidity affects aquatic habitat, sedimentation of reservoirs, streams, treatment costs of water
- Pesticides – loss of aquatic life, problems for humans and animals
- Pathogens – can cause illness in humans or animals
- Silage leacheate – highly contaminating, low pH, high BOD, nitrogen, phosphorus, suspended organics make difficult to treat for drinking water
- Process wastewater – milkwater high in dissolved P, barnyard waste similar to silage leacheate (but more dilute)

Indicators of water pollution

- Turbidity – sediment, BOD, total coliform input
- Shininess – DOC, pesticides, petrochemicals
- Ammonium-N concentrations > 2ppm affects aquatics
- Nitrate-N > 10 ppm drinking water standard, >2ppm eutrophication hazard, >25ppm livestock hazard
- Stream organisms (mayflies, caddisflies, riffle beetles)

Control of water pollution

- BMPs (may not be BAT due to prohibitive cost or impracticality)
- NPS: Conservation and Nutrient management plans, feed management, manure separation
- PS: diversions, barnyard runoff treatment, recycling flush water

Laws

- Clean Water Act (1972) – primary federal law for surface water quality
- Safe Drinking Water Act (1974) regulates public drinking water quality
- Coastal Zone Management Act (1972) – regulates NPSP to coast waters
- FIFRA (1947) – regulates pesticides sales, distribution, and use to protect applicators, consumers and the environment
- Local and state laws

Point Source Pollution Control : Barnyard

- Reduce odors, improve aesthetics, reduce contaminants
- **Exclude clean water** by diverting runoff from above barnyard, and collect or divert roof runoff.
- Earthen barnyard: may infiltrate water, but groundwater contamination possible
- Concrete: better for livestock health, easily cleaned, slightly sloping and rough can reduce runoff
- Construction and maintenance: easy and regular cleaning, slope to runoff collection area remove suspended solids before release to vegetated filter or treatment area.
- Try to eliminate barnyard altogether

Point Source Pollution Control: Barnyard

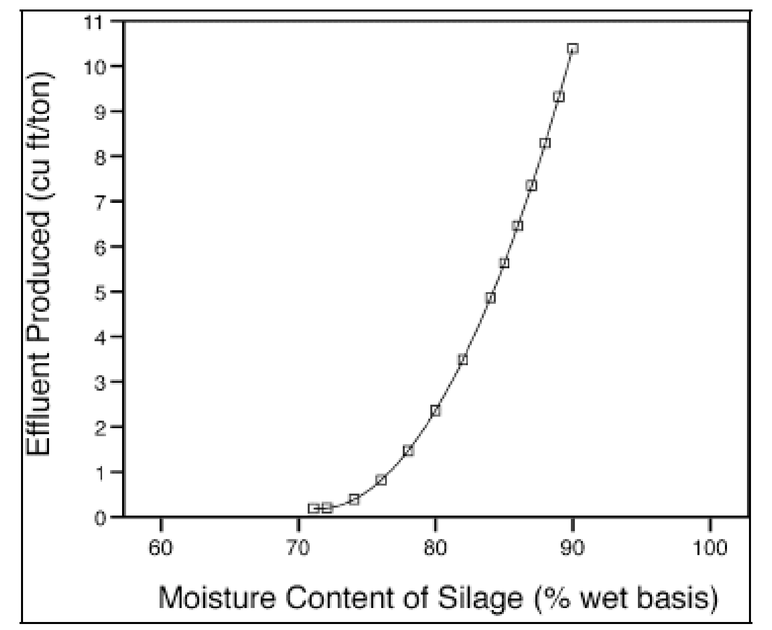
- **Stone-filled trench** - simple, but cannot process large quantities of wastewater, can pollute groundwater if built on permeable soils, not effective at P adsorption, odors, clogging.
- **Lime flocculation** – suited for removing P from milk waste, expensive for large quantities and waste still needs to be disposed of
- **Spray irrigation** – most effective for handling large quantities of waste water, use nutrients effectively, but large storage needed, no spraying on frozen or saturated soils, pumping and piping costs.
- **Aerobic sceptic system** – may be pre-treatment for leach field application, but more expensive than traditional sceptic system, only for small quantities of waste
- **Inclusion in liquid manure handling system** – needs to be expanded in size to allow this

Point Source Pollution Control – Milk waste

- Sceptic system/leach fields: low cost, suited to treat small quantities
- Vegetative filter areas: higher cost, suited to treat larger quantities, need to screen out solids first and design filter properly
- Aerobic lagoon: storage and disposal flexibility, lower land and labor needs, but may generate offensive odors, need to be aerated, may overtop, etc.
- Organic filter bed: Suited for small quantities, good for absorbing ammonium-N, but may release P, no longer recommended in NY.
- Constructed wetlands: high level of treatment, inexpensive to operate, self-maintaining, can handle variable quantities of waste and reduce land-application, but wastewaters may kill vegetation, water levels fluctuate too much, mosquitos, odors, etc.

Point Source Pollution Control: Silage leacheate

- Grass vs corn – finer chop size, higher moisture content, but denser pack lead to lower leacheate runoff during rain events
- Avoid by harvesting crops at proper moisture content, not filling during rain, cover bunkers quickly
- Treat by leading to solid or liquid manure storage, or dilute and apply to vegetative filter or crop



http://www.omafra.gov.on.ca/english/engineer/facts/04-031.htm