Lecture 10, Part 1, Exposure to Contaminants from Potable and/or Surface Water and/or Groundwater

Conrad (Dan) Volz, DrPH, MPH
sierrakellydan@msn.com
cdv5@pitt.edu
724-316-5408

The Chain of Causation: Regional Land and Water Management Problems to Tertiary Public Health, Social, and Economic Outcomes

Volz, CD., 2007.How do water, land management, ecological and contamination issues interact to produce tertiary public health, medical, social and economic problems? Journal of Occupational and Environmental Medicine, March, 2007

Holistic Water Management as it Relates to Exposure Assessment

- -The integration of traditional/non-traditional public health issues like:

-stormwater drainage.

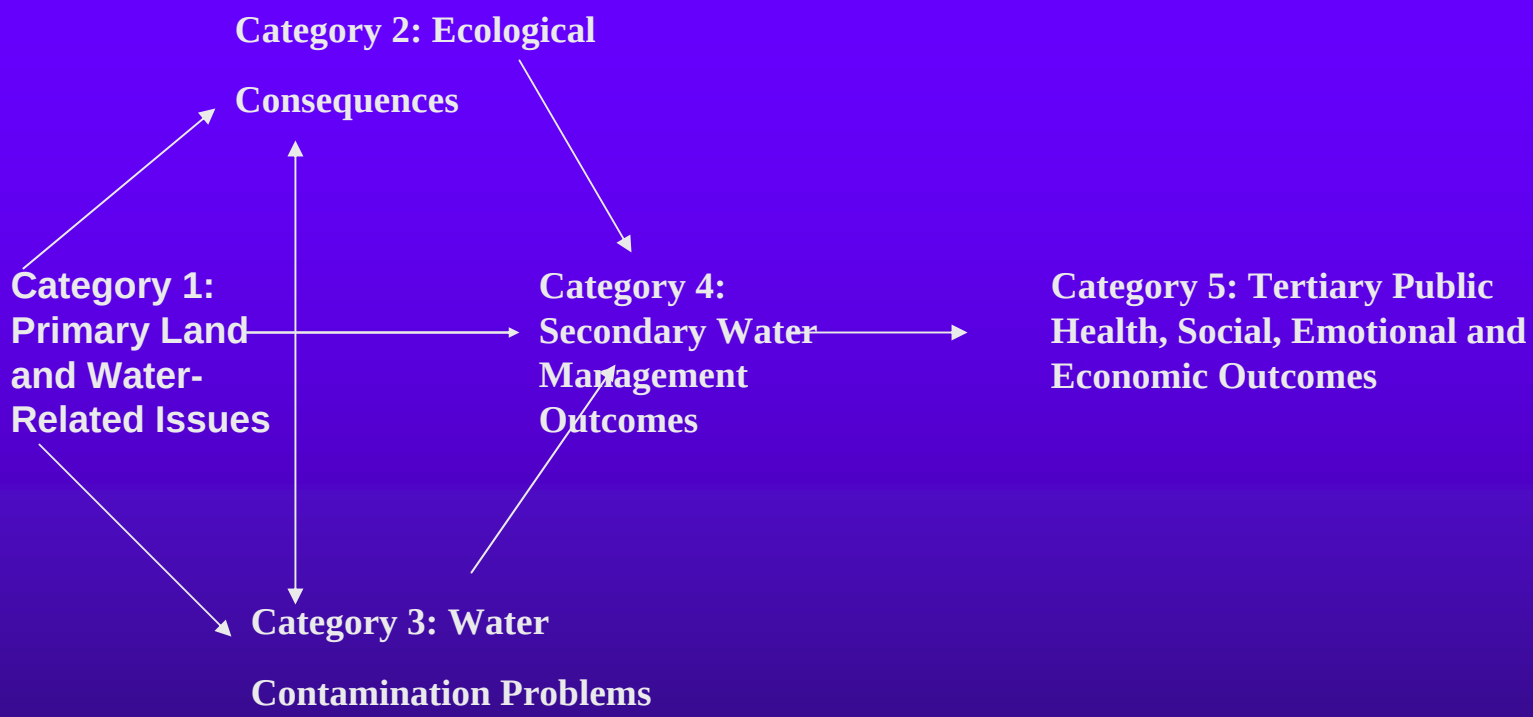
-water quantity and quality.

-combined and sanitary sewer overflows, wildcat sewers and failing on-lot systems.

-watershed protection and associated development and transportation projects.

-flooding.

Figure 1, A Chain of Causation: Primary Land and Water-Related Issues to Tertiary Public Health, Social, Emotional and Economic Outcomes



Category 1 Primary Regional Land and Water Management Issues

- Sprawl
- Lack of Coordinated Water/Land Management Plans
- Development in Headwaters and Critical Watersheds
- Inappropriate Transportation Projects
- Fragmented State, Federal and Local Regulatory Climate
- Aging/Inadequate Municipal Sewer Infrastructure
- Fragmentation of Water/Sewer Authorities

Primary Category 1 Problems Continued

- Legacy and Ongoing Industrial Pollution
- Spills/ Accidental Releases of Toxic/Hazardous Substances
- Treating Surface and Groundwater as Not Interconnected
- Water Priced Low
- Abandoned/Active Mines
- Household Hazardous Waste
- Municipal Infighting Over Development
- Power Plant and Industrial Air Emissions /Deposition and Transport in Water
- Attitudes/Behaviors Concerning Unlimited Water Use

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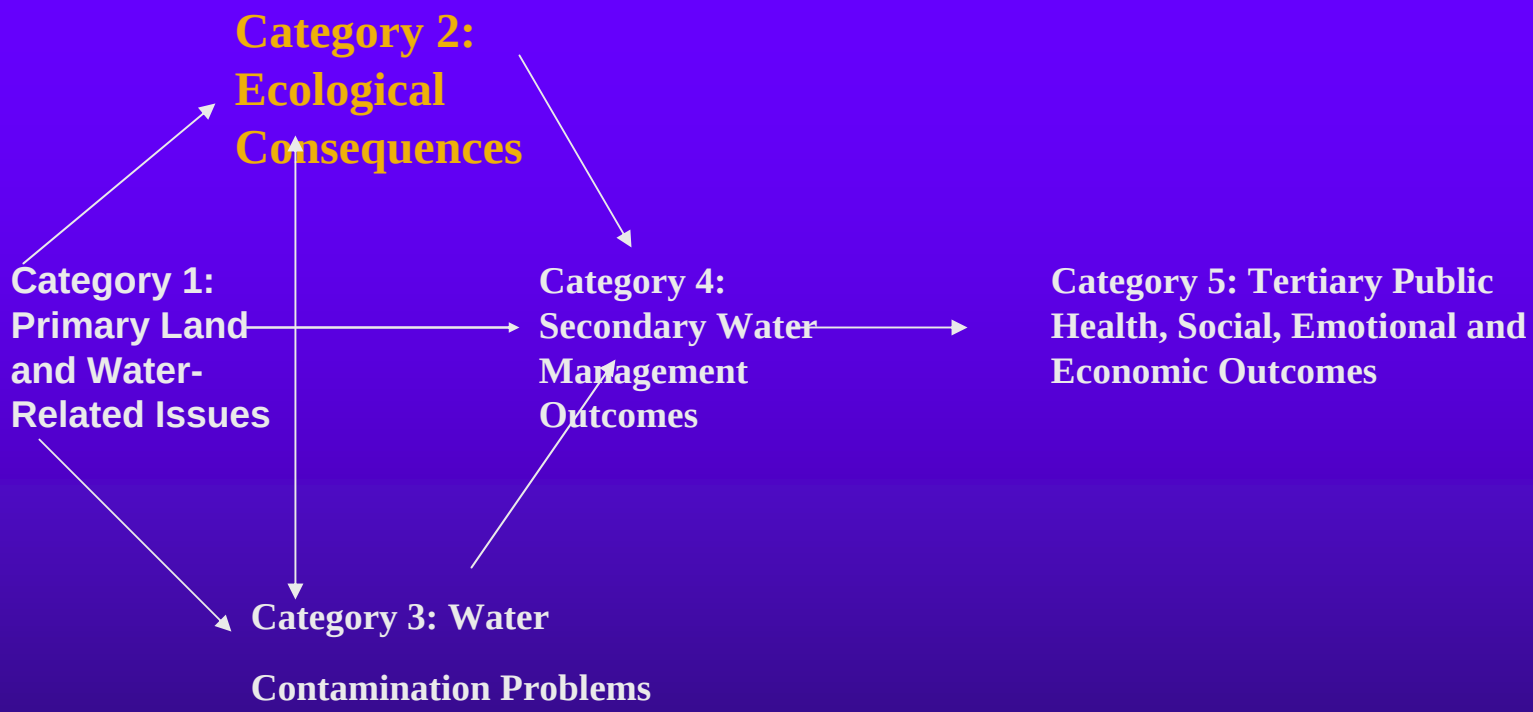

Category 2: Ecological Service Losses

- Wetland Loss / Riparian Habitat Loss
- Deforestation
- Loss of Topsoil and Plant Cover
- Loss of Natural Drainage Patterns
- Changes in Large River Flow Characteristics
- Decrease Reserve Farmland
- Decrease Groundwater Recharge
- Stream/Land Erosion
- Algal Blooms and Fish Kills
- Uptake of Contaminants in Biota/Foodweb

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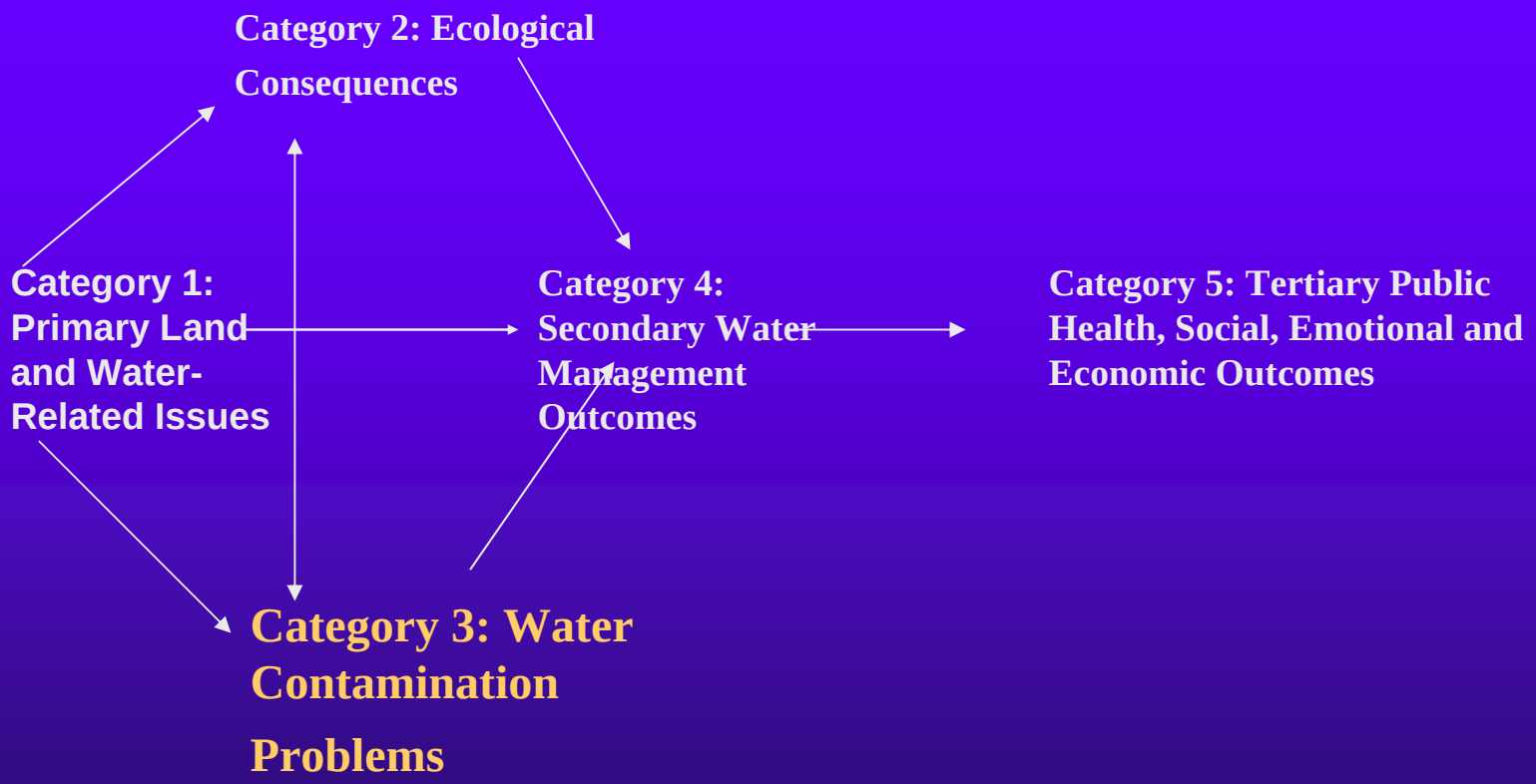

Table 3, Category 3: Water Contamination Problems

- High Turbidity/Dissolved Solids
- First Stormsurge Toxic Materials
- Impervious Topping Compounds
- Nitrates
- Low-High pH
- Oil/Grease
- Persistent Organic Compounds
- Combined/ Sanitary Sewer Overflows
- Increase in Pet Fecal Matter
- Low Dissolved Oxygen Levels/High BOD

Table 3, Category 3: Water Contamination Problems Continued

- Acid Mine Drainage
- Methylmercury
- Organohalogen Compounds
- Arsenic and Other Heavy Metals

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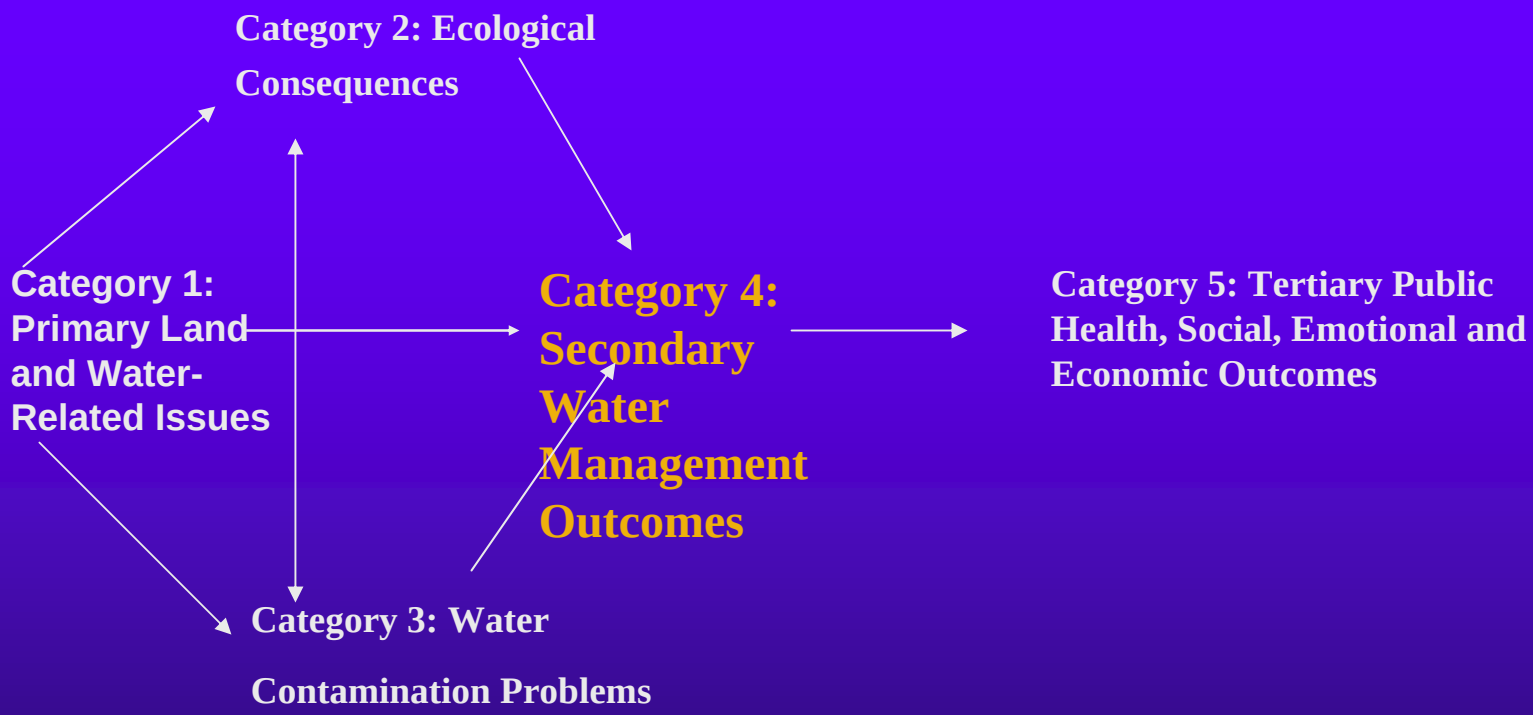

Category 4: Secondary Water Management Outcomes

- Increase Sediments in Surface Water
- Decreased Production Clean Surface/Groundwater
- Habitat Loss/Fracture
- Increased Stormwater/ Snowmelt Runoff
- Increased Contaminant Loads Surface/Groundwater
- Flooding
- ↓Confined/Unconfined Aquifers/Storage Ability

Category 4: Secondary Water Management Outcomes Continued

- Human Pathogens in Surface Water (Primary for Recreation)
- Human Pathogens in Groundwater Increase Potential –Mine Blowouts
- Consumption of Contaminated Fish
- Human Exposure-
- Carcinogens
- Toxic Substances
- Endocrine-Active Substances

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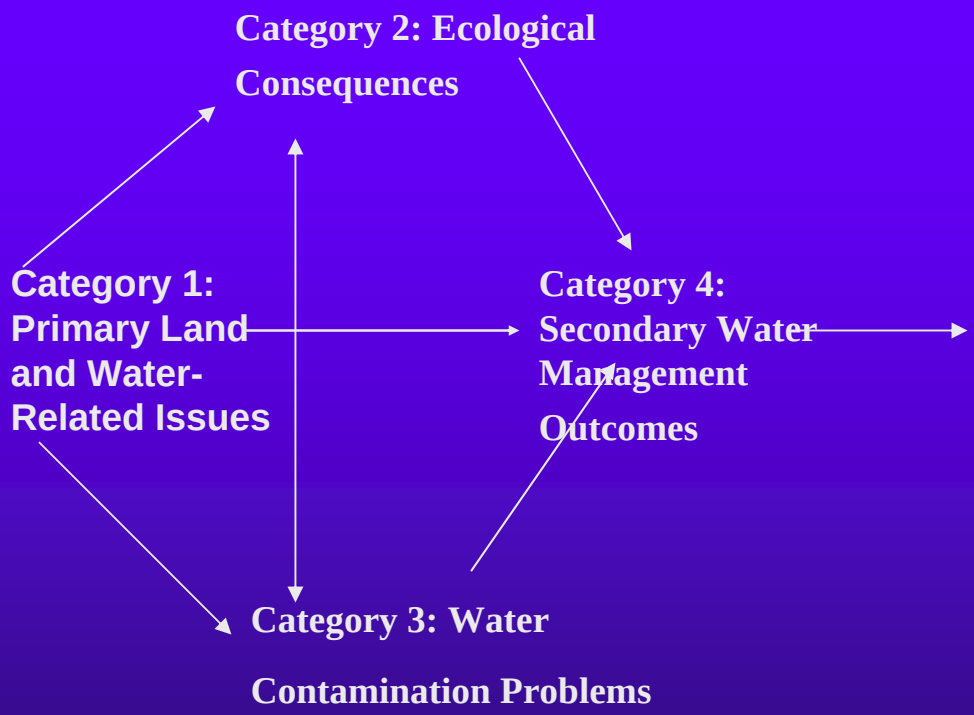

Category 5: Tertiary Public Health, Social, Emotional and Economic Outcomes

Category 5: Tertiary Public Health, Social, Emotional and Economic Outcomes

- Property- Flood Damage
- Flood- Loss of Human Life
- ↑ Stormwater Management Costs
- ↑Costs Water Purification
- ↓Human Aesthetic Value
- ↓Recreation Potential
- ↓Economic Growth
- ↑Costs-Flood Protection/Insurance
- ↓ in Water Quantity
- ↑Risk Waterborne Pathogen Diseases

Category 5: Tertiary Public Health, Social, Emotional and Economic Outcomes Continued

- Loss of Aquatic/Terrestrial Species
- ↑Risk Cancer/Humans
- ↑Risk Other Environmental Disease

Exposure to contaminants in water can occur via ingestion, dermal absorption and inhalation routes.

- Exposure via ingestion can be further subdivided-

1. Direct ingestion via drinking water or water used in cooking. (Direct ingestion of potable water is the primary mode of exposure to waterborne contaminants)
2. Intrinsic water intake (i.e., the water that is intrinsic in foods prior to preparation).

Common Water Contaminants

1. Pathogens- parasites, bacteria and viruses.
2. Volatile Organic Compounds- benzene, alcohols, methylethlylketone (MEK), chlorinated solvents (TCE).
3. Disturbances in pH and alkalinity.
4. Metals, Metalloids and Elements- Hg, As, Se, Pb, Cr, Cd.
5. Persistent Organic Pollutants (POPs)- DDT, PCB's, many pesticides.

Water Pathogen Example-Cryptosporidium parvum a human and animal intracellular parasite

- Cryptosporidiosis, a disease caused by ingestion of water contaminated by C. parvum, has become the most important waterborne illness over the last 20 years.
- Its oocysts, shed by infected people into sewage systems and domestic and wild animal carriers into drainage basins and manure piles, are very resistant to environmental conditions, wastewater treatment and water purification (Robertson et al., 1992).
- Cryptosporidium parvum oocysts shed into the sewer system are released directly into our streams and rivers and groundwater during combined sewer overflows (CSO's), sanitary sewer overflows (SSO's), and wastewater treatment plant failures.

Cryptosporidiosis Continued

- A massive outbreak in Milwaukee of Cryptosporidium infection transmitted through the **public water supply** affected approximately 400,000 people with mild, moderate and severe watery diarrhea in 1993 (Mackenzie et al., 1994).
- Deaths among the imunocompromised were reported (Hoxie, 1997) and the mortality rate among infected, imunocompromised individuals was estimated to be over 50% (Rose, 1997). The outbreak resulted in an estimated total cost of over US $93 million including direct medical costs and productivity losses (Corso, 2003).
- C. parvum and Giardia cysts are present in high titers downstream from CSO/SSO outfalls in the Pittsburgh area.
- It is important to note that this outbreak was associated with **high water runoff from snowmelt and precipitation**, high water turbidity (cloudiness) at water intakes, and a failure of the water filtration system.

Principal Mechanisms by which Contaminants in Water can Traverse Through the Skin

- Passive transfer or diffusion-Passive diffusion is the mechanism most commonly expressed in dermal exposure models.
- Facilitated Diffusion
- Active Transport

Passive Diffusion Processes

- The rate of passive diffusion is a function of the concentration gradient of the contaminant on the surface of the skin and in the tissue immediately below the skin and
- The ease with which a molecule of the contaminant can move through the lipophilic interior of the skin membrane. Ease of passage is a function of the partition coefficient of the contaminant(e.g., the octanol-water partition coefficient, *K*ow), molecular weight, the degree of ionization and the porosity of the skin. Porosity of the skin to VOCs present in drinking-water treated with chlorine has been shown to be temperature dependent (Gordon et al., 1998).

From; Human Exposure Assessment-WHO

Conrad Daniel Volz, DrPH, MPH [1, 2, 3]

- [1]Scientific Director, Center for Healthy Environments and Communities (CHEC)
- [2] Assistant Professor, Department of Environmental and Occupational Health, Graduate School of Public Health (GSPH), University of Pittsburgh
- [3] Co-Director for Exposure Assessment and Control; University of Pittsburgh Cancer Institute, Center for Environmental Oncology (UPCI-CEO)