Spring 2007, Norm Brown

ESM 223

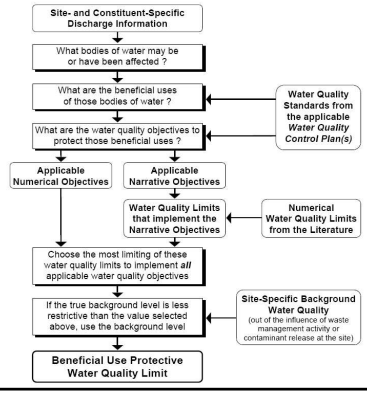
Lecture 3 –
Local and Basin-wide Water Quality Conditions

Outline

- Water Quality Standards
- Water Quality Constituents – Types, Fate and Transport Overview
- Some Examples and Case Studies

Water Quality Standards (continued from last lecture)

FIGURE 1. SELECTING BENEFICIAL USE PROTECTIVE WATER QUALITY LIMITS



CVRWQCB, 2003

Note there are differences between surface water and groundwater; e.g., CTR & NTR are for aquatic life and exposure to surface water, and are not applicable to groundwater drinking water sources. However, for groundwater, there are other water quality objectives and criteria.

Consider also issues of *combined* chemical toxicity.

Basin Plans

Beneficial Use Definitions

Beneficial uses for waterbodies in the Los Angeles Region are listed and defined below. The uses are listed in no preferential order.

Municipal and Domestic Supply (MUN)
Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Agricultural Supply (AGR)
Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

Industrial Process Supply (PROC)
Uses of water for industrial activities that depend primarily on water quality.

Industrial Service Supply (IND)
Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.

Ground Water Recharge (GWR)
Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

… and many others…

- California – Regional Boards; Stakeholders
- Take precedence, if more stringent than wider State or Federal standard

Table 2-2. Beneficial Uses of Ground Waters[BC]

DWR Basin No.	BASIN	MUN	IND	PROC	AGR	AQUA
	PITAS POINT AREA ae	E	E	P	E	
4-1	OJAI VALLEY					
	Upper Ojai Valley					
	West of Sulfur Mountain Road	E	E	E	E	
	Central area	E	E	E	E	
	Santa Ana	E	E	E	E	
4-2	Lower Ojai Valley					
	West of San Antonio–Senior Canyon Creeks	E	E	E	E	
	East of San Antonio–Senior Canyon Creeks	E	E	E	E	
4-3	VENTURA RIVER VALLEY					
	Upper Ventura	E	E	E	E	
	San Antonio Creek area	E	E	E	E	
	Lower Ventura	E	E	P	E	

FIGURE 3. GROUNDWATER ALGORITHM TABLE

Water Quality Objective / Criterion	Relevant Portion of Objective / Criterion	Source	Concentration	Units
Chemical Constituents	Drinking Water MCL (lowest)	DHS		
	Numerical Water Quality Objective	Basin Plan		
	Beneficial Use Impairment Limit			
Toxicity	Human Health – Drinking Water			
Tastes & Odors	Taste & Odor Based Limits for Water			

CVRWQCB, 2003

Economic Considerations:
- PHGs *v.* MCLs

Other considerations for specific standards:
- Antidegradation requirements

Other considerations for standard review/revision:
- Changes brought about by DL/QL improvements

Other considerations for public perception:
- Constituents with popular or emerging concern
  - E.g., PPCPs, DBPs

Water Quality Constituents

A brief tour of stuff that's in soil and groundwater.

- The stuff of rocks
  - Fe, As, TDS, SO4, naturally-radioactive materials.
  - Nutrients in special situations
- The stuff of animals & civilization
  - Nutrients
  - VOCs (this is a huge category)
  - Bacteria, viruses, but filtering and residence time act to limit these
  - Tritium and other radioactive materials
  - Pharmaceuticals and Personal Care Product chemicals
  - Disinfection byproducts (Groundwater issue through some ASR projects)
- The stuff of the world around
  - Chloride (As a contaminant; as an isotopic tracer)
  - Turbidity & Colloids
  - CO2 (→ carbonic acid, pH)

Water Quality Constituents

Some things contaminants are doing:

- Reacting
  - Leaching
  - Mineralizing
  - Transforming (e.g., being digested)
- Sorbing
- Migrating
  - As ions, molecules, colloids
- Poisoning
  - As we'll see, this can be more complex to define

Source/Sink

Advection/ Dispersion

When is a water quality constituent toxic to organisms? What are the implications for costs and timing of water quality management options?

How do physical-chemical behaviors differ between soil, unsaturated sediments and saturated sediments?

Water Quality Constituents

Localized – Distributed

- Distribution
  - Areally
  - Relative to geology, infrastructure
  - Gradients
- Calculating migration times
  - Transport retardation, degradation
  - Tracers and Proxies
- What happens when there is interchange between surface and groundwater (hyporheic zone)?

Fate and Transport

- Darcy's Law: saturated flow rate through porous media* is:
  - Proportional to head loss
  - Inversely proportional to migration distance

$$Q = -KA\frac{dh}{dl}$$

*There are some simplifying assumptions here…

$$v = -K\frac{dh}{dl}$$

Fate and Transport

- Reactive contaminants
  - Adsorption and Desorption (Retardation)
  - General equation form:

Advection + Dispersion + [Source|Sink] = Net (Rate of) Change of Solute Mass through REV

Bulk groundwater flow (Darcy's Law)

Mechanical mixing and Molecular diffusion

Liquid-Solid Partitioning; Chemical, Physical, Biological destruction and transformation

Conservation of Mass (only this part needed for nonreactive constituents)

What do you need to know or assume? For example, Concentration Gradients & Energy Potentials; Flownets and Max/Min Limits

Management Goals

- Single- or Multiple-Focus Approaches
  - Monitoring
  - Prevention
  - Load Reduction and Waste Management
  - Remediation/Restoration
  - Abandonment
- Risk Analysis (much more on this in lecture 4)
- Cost-Benefit Analysis (more on this also)
- Water Quality Management integrates defined contaminant and supply goals with financial, legal & institutional considerations.
- Timeframes, Sustainability and Energy implications
- Uncertainty demands, and benefits from flexibility in management planning and infrastructure and…

E.g., Divisions in end users (and infrastructure requirements) [cf recycled water]

Arsenic

- Distribution
- Health Impacts and Water Quality Standards
- Treatment and Blending Options
- Special Impacts to small water supply agencies
- cf PHG and MCL differences regarding economic factors

Nitrogen and Nitrate

- Species
- Distribution (specific to *groundwater*)
- Health Impacts and Water Quality Standards
- Sources and trends; Some research results that might surprise you
- Humid *v.* Arid environments
- Treatment and Blending Options
- The case of Chino Basin

Trichloroethylene (TCE)

- History / Use / Source
- "Typical" occurrences in groundwater
- Distribution
- Health Impacts and Water Quality Standards
- Treatment and Blending Options
- Source – Plume Issues; Sorbtion

MTBE

- History of Use and Phase-out
- Health Impacts and Water Quality Standards
- Chemistry and Plume dynamics
- Misfit for motor fuel thinking and regulation with respect to water quality management and cleanup
- Remediation and water supply management options
- Costs

Selected Topics

Some other "small but big" things:

- Cross-aquifer perforated wells
- Degradation rates
- Monitoring data availability
- Under the cover of night: uncivil actions