Current Issues in Water Quality Management from A to Z

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Everything from Arsenic to Zero Discharge
...with a monsoon of letters in between...

CWA    TMDL    CAFO
EQA    BADCT    GPL
SDWA    CERCLA    BRP
LUST    WQARF

Regulating Water Quality—the Feds
Pop Quiz!

• US Environmental Protection Agency
  • Established 19__ under President ________
Regulating Water Quality—the Feds

- US Environmental Protection Agency
  - Established 1970 under President Richard M. Nixon

A Trip Back in Time—
“The Black Lagoon Beneath Our Feet”

- Environmental Quality Act of 1986 establishes ADEQ
- ADEQ becomes independent agency on July 1, 1987
- Three new state water quality programs established
  - Aquifer Protection Permit (APP) Program
  - Water Quality Assurance Revolving Fund (WQARF)
  - Pesticide Contamination Prevention Program

Regulatory Classes of Water

- Drinking Water
- Surface Water
- Groundwater
- Reclaimed Water
  - Treated wastewater
  - Gray water

Water Quality Program Components

Prevention

Monitoring & Assessment

Compliance & Enforcement

Remediation
Current Water Quality Issues

A is for...

• Arizona Pollutant Discharge Elimination System (AZPDES) program
• Aquifer Protection Permit (APP) program
• Arsenic and more – the Safe Drinking Water Program
• Beyond the A’s

Clean Water Act (CWA) and AZPDES

• CWA protects the quality of “waters of the US”
  – essentially surface waters
• Primary federal law for controlling water pollution
• In 2002, ADEQ became the 45th state to gain primacy for federal CWA authorities
• AZPDES: Arizona’s name for the NPDES (National Pollutant Discharge Elimination System) permit
**CWA Purpose**

“...to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.”

**CWA National Goals**

“Zero discharge,” or the elimination of polluting discharges to the nation’s waters, by 1985

- Restore waters to “fishable and swimmable”
- “No toxics in toxic amounts”
**CWA and AZPDES**

- Program is evolving due to past success
- Traditional emphasis:
  - Chemical pollutants
  - Point sources
- Now, increasing emphasis on:
  - Biological and physical integrity
  - Nonpoint sources
  - Watershed approach to meeting standards (TMDL or Total Maximum Daily Load)

**AZPDES (CWA) Program Components**

- Individual permits
- General permits
- Pretreatment
- Biosolids / sewage sludge
- Surface water quality standards
### AZPDES Individual Permits

- Issued to all major facilities discharging to a water of the US (164 facilities in AZ)
  - WWTPs (about 75% of all permits)
  - Industrial facilities including power plants
  - Mines
- Permit requires discharge to meet SWQS
- Self-monitoring is the cornerstone of all environmental programs, including AZPDES
  - Random audits of monitoring reports
  - Regular site inspections

### AZPDES General Permits

- Developed for numerous & generally smaller discharges
- Stormwater general permits
  - EPA: 30% of surface water pollution in US is due to stormwater runoff
  - Industrial facilities
    - 1019 permits issued
  - Municipalities (MS4)
    - 8 Large (>100,000 pop.) and 41 Small
  - Construction sites (generally >1 acre)
    - 10,024 issued to date
- Must comply with stormwater pollution prevention plan (SWPP)
AZPDES CAFO* General Permit

- About 150 CAFOs in AZ
  - 29 feedlots (cattle going to slaughter)
  - 2 poultry
  - 1 piggery
  - rest are dairies
- Aimed at protecting/restoring surface waters, but collateral groundwater benefits, too
- Must contain all wastewater onsite & protect from a 25 yr / 24 hr storm event
- Nutrient management plan
- Pond liner requirements

*Concentrated Animal Feeding Operation

Impaired Waters

- ADEQ assesses surface waters every 2 yrs for meeting standards
  - lists impaired waters every 2 yrs (CWA Sec. 303d list)
  - 78 listed impaired waters in AZ
- Primary pollutants causing impairment in AZ
  1. Metals
  2. Turbidity/sediment
  3. Nutrients (nitrogen, phosphorus)
     - irrigation return flows
     - manure handling
  4. Microbial contamination
  5. Pesticides (e.g., DDT)
  6. Low oxygen, low pH
**TMDL Program**

- **Goal:** Return impaired waters to meeting standards
- ADEQ determines loads and load allocations of pollutants
  - Point sources (end-of-pipe)
  - Nonpoint sources
- TMDL implementation plan for load reductions
- Follow up monitoring for effectiveness

**M is for Mercury**

- Increasing data on mercury bioaccumulation in AZ lakes
- Fish advisories now issued for 14 waterbodies
  - Roosevelt Lake, Lake Pleasant, Lake Mary, Parker Canyon, Peña Blanca, Alamo, Lyman, Tonto Cr. below Bear Flat
- Potential sources
  - Atmospheric fallout from power plants
  - Abandoned mine workings, tailings
  - Natural concentrations in rocks & soils
  - Mercury in wastewater discharges
- Atmospheric fallout now appearing dominant
**Mercury Strategy**

- TMDL required for all Hg-impaired waters
- Long-term strategy:
  - Determine source contributions and loads
    - ADEQ has funded fate & transport studies by NAU and UA
  - Prevent new sources from entering environment
  - Reduce contributions from existing sources

**Aquifer Protection Permits**

- **Objective:** Protect aquifers for drinking water use
  - All aquifers in Arizona are classified for drinking water protected use
- **Mechanism:** Permits to control discharges (APPs)
Aquifer Protection Permits

- **Individual APPs**
  - Mines
  - Power plants & other industrial facilities
  - Sewage treatment plants (306)

- **General APPs**
  - On-site wastewater treatment facilities
    - Serve 20% of AZ population
    - Permit applies to septic tank & alternative systems up to 3000 gpd
    - More stringent permit for 3-24,000 gpd: Requires nitrogen removal
    - 12,000 new systems permitted per year during housing boom
    - Now about 6000 systems approved per year
  - Sewage collection systems
  - Other small miscellaneous discharges
**Septic Tanks**

- Linked to both groundwater & surface water contamination by nitrogen/nitrate
- Cause usually is high densities (more than 1 per acre in populated areas)
- APP program requires alternative system technologies that reduce nitrogen in new, high-density developments

**The Twin Pillars of APP Protection**

1. Facility must not exceed any AWQS at a point of compliance (POC) in the aquifer
   - *If AWQS is already exceeded, no further degradation is allowed at the POC*
   - *POC is usually set in the aquifer at the limit of where pollutants are placed (e.g., dike, impoundment, etc.)*
The Twin Pillars of APP Protection

2. Facility must employ Best Available Demonstrated Control Technology (BADCT)
   - Example: BADCT for new or expanding WWTPs
     • Pathogen-free effluent
     • Nitrogen removal
     • Clear (non-turbid) discharge
     • Odor control

Size of Wastewater Treatment Plants Permitted Under APP

- Greatest Design Flow:
  230 mgd (Phoenix 91st Ave WWTP)

- WWTP Sizes
  \[ \begin{align*}
  \geq 10 & \quad \text{mgd} = 20 \\
  5-9.9 & \quad \text{mgd} = 7 \\
  1-4.9 & \quad \text{mgd} = 68 \\
  0.1-0.99 & \quad \text{mgd} = 109 \\
  <0.1 & \quad \text{mgd} = 96
  \end{align*} \]
Reclaimed Water Use in Arizona

- 90% of reuse occurs in just four states, Arizona being one

Why Arizona?
Stay tuned!
More after the break
Gray water, too!

Source: Western Water, July/August 2008

AZ Pesticide Contamination Prevention Program

- Established in original EQA
  - To prevent groundwater pollution, such as the major DBCP and EDB problems discovered in the late 1970’s

Yuma area  West Salt River Valley  East Salt River Valley
Wells contaminated by DBCP or EDB, mapped in 1988
Arizona’s Pesticide Program

- Ag pesticides are screened for mobility & persistence
- If too mobile or persistent, listed on Groundwater Protection List
  - Strict field application and reporting requirements for GPL pesticides
- 69 pesticides currently listed on GPL, mostly herbicides
- Intensive soil & groundwater monitoring for listed pesticides
- Wildly successful—no significant groundwater contamination problems since program inception

Drywell Regulation

- Used for stormwater runoff control
- Almost unique to Arizona
- Caused major groundwater contamination problems prior to regulation under EQA

Typical modern drywell installation (Diagram courtesy of Torrent Resources)
Drywell Regulation

- 46,411 registered to date
- 96% in Maricopa County
  - driven by stormwater control ordinance requiring no ponded water after 36 hours
- In 2006, registrations peaked at 3772
- 47% have been constructed in residential areas
- Installed at virtually every new apartment, hotel, office, and complex in Maricopa County

Drywell Regulation

- Now more widely being considered as a means of groundwater recharge

Drywell draining large retention basin at a park in Phoenix

Modern drywell installation at a new subdivision
Safe Drinking Water

• ADEQ administers the federal Safe Drinking Water Act (SDWA) in AZ for EPA

• 1600 regulated public water systems in AZ serve more than 5,000,000 people

• Maximum Contaminant Levels (MCLs) are set for about 100 contaminants

Drinking Water Current Issues

• Mopping up compliance for lowered arsenic MCL in 2006
  - Still 20 systems under unilateral orders or consent orders

• EPA going forward on setting perchlorate MCL again

• EPA revising Total Coliform Rule
  - Total Coliform Bacteria MCL eliminated
  - Replace with treatment technology requirements
  - Fecal coliform & E. coli MCLs stay
The Disinfection By-Product Challenge

• New EPA regulations for DBPs worry water utilities
• MCL for total trihalomethane (Total THM) lowered from 100 ppb to 80 ppb
• MCLs for new DBPs added
• Beginning in 2012 for larger systems, results can’t be averaged within system
  – compliance is required at most susceptible locations

Chloroform

The Disinfection By-Product Challenge

• Carcinogenic DBPs form during disinfection by Cl & other disinfectants
• DBP levels are higher when dissolved and particulate organic precursors are in source water
• Alternative disinfectants may form new and even more potent DBPs
• This is the most challenging and costly hurdle DW utilities face in coming years

Bromate
Disinfection By-Products & Forest Fires

- Arizona State University is conducting fire impact study
- Dissolved and particulate organic matter will be sampled in Salt River reservoir system
- Organic levels and transformations will be modeled
- Goal: Predict DBP impacts at drinking water treatment plants on downstream canal system

Drinking Water Issues on the Horizon

- Total Chromium and Chromium-6
  - current MCL of 100 μg/l is for Total Cr
  - however, Cr-6 is the toxic valence
  - speculation is that EPA will set a separate MCL for Cr-6 of 3-10 μg/l
  - would put many systems in NW & central AZ out of compliance
Drinking Water Issues on the Horizon

- Fluoride MCL (currently 4 mg/l)
  - Current MCL applies only to “community water systems”
  - EPA may lower MCL
  - EPA may extend MCL to “non-transient, non-community systems”
    - schools, businesses, etc., with own water systems
  - Could put many AZ systems out of compliance

Arizona Drinking Water Violations
(rank by number of NOVs)

1. Disinfection byproducts (Monitoring & Reporting)
2. Disinfection (mostly M&R for chlorine levels)
3. Consumer Confidence Reports
4. Lead/copper (M&R)
5. Chemical/radiological constituents (M&R)
6. Chemical/radiological exceedances
   - mostly for arsenic
7. Total coliform (M&R)
8. Total coliform exceedances
Water Quality Standards Setting

- **Drinking water standards (MCLs)**
  - EPA promulgates, then ADEQ adopts

- **Surface water quality standards**
  - Stds are developed for different uses (DW, Ag, Aquatic & Wildlife, etc.)

- **Aquifer Water Quality Standards**
  - Essentially same as drinking water MCLs

- **Reclaimed Water Quality Standards**
  - 5 reclaimed water quality classes (A+, A, B+, B, C)

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Emerging Contaminants

Again, stay tuned!

More later.
Salinity: The perennial contaminant!

- *But not well addressed by regulatory programs*
- Salt buildup has been an issue since prehistoric times
- Irrigated agriculture & other water uses concentrate salts in soils, groundwater, and surface water in desert basins
- EPA recommends levels below 500 ppm for drinking
  - CAP water already is 500 – 700 ppm
  - Pumped groundwater used in AZ up to:
    - 1000 ppm or more for drinking
    - 3000 ppm or more for irrigation

The Curse of Salinity

- Central AZ salt imbalance: 1M tons/yr of added salt
  - Imported in surface waters (CAP, Salt, Verde)
  - Imported for water softeners
- One cycle of city use increases salinity in reclaimed water by 200 – 500 ppm
  - Home water softeners are big contributors in newer residential areas
- Salinity impacts
  - Early piping and appliance failure
  - Higher industrial water treatment costs
  - Lower crop yields and reduced crop types
  - “Burning” of turf
  - Groundwater rendered unusable for drinking
- Central Arizona Salinity Study (CASS) is developing strategies
- Desalination is still very costly

City of Scottsdale RO Treatment Facility
Remedial Programs

• Cleanup of sites with soil and groundwater contamination
• Rely on Responsible Parties (RPs) whenever possible
• Three key programs
  – Federal Superfund (CERCLA) (Comprehensive Environmental Response, Compensation and Liability Act)
  – State Superfund (WQARF) (Water Quality Assurance Revolving Fund)
  – Tanks Program for USTs

Federal Superfund (CERCLA)

• Comprehensive Environmental Response, Compensation, and Liability Act of 1980
• Currently 9 “Superfund” (aka National Priorities List or NPL) sites in AZ
  – Apache Nitrogen Products, Benson
  – Hassayampa Landfill, southwest of Buckeye
  – N&S Indian Bend Wash, Scottsdale & Tempe
  – Motorola 52nd St, Phoenix
  – Phoenix-Goodyear Airport, Goodyear
  – Williams AFB, Mesa
  – Yuma Marine Corps Air Center
  – Tucson Airport Area
  – Iron King Mine-Humboldt Smelter
State Superfund (WQARF)

- Water Quality Assurance Fund
- Established by EQA amid publicity of many discoveries of solvent-contaminated groundwater plumes in early 1980s
- Hazardous substance cleanup of contaminated soil, groundwater, and surface water
- Funded by legislative appropriations, cost recovery, and special taxes and fees
  - Fund has been repeatedly swept by Legislature to balance budget

Solvent cleanup of groundwater at West Van Buren Area WQARF Site

State Superfund (WQARF)

- Solvents and metals are primary contaminants
- 35 sites listed on WQARF Registry
  - 22 in greater Phoenix area
  - 7 in Tucson area
  - 6 in rest of state

Drilling monitor well and preparing for aquifer pump test at Tyson Wash WQARF Site, Quartzsite
UST and LUST: ADEQ’s Tank Program

- Addresses petroleum fuel tanks
  - Generally not covered by CERCLA & WQARF
- LUST sites are everywhere – metro and rural!
- Gasoline/diesel are main primary fuels
- Fuel additives complicate cleanup
  - Octane enhancers: BTEX (benzene, ethylbenzene, xylene, toluene)
  - 1,2-DCA (a recalcitrant chlorinated solvent once added as a lead scavenger)
  - Oxygenates (mainly MTBE)

UST and LUST: ADEQ’s Tank Program

- Cleanups must address soil vapor, dissolved, and NAPL (non-aqueous phase liquid)
- Cumulative LUST cases: 8523
- LUST closures to date: 7557 (89%)
- Open cleanup cases: 966 (11%)
- Most leaks occurred before 1998
Impact of Climate Change on Water Quality: A Hierarchy of Modeling and Predictions

• Greenhouse gas trends
• Temperature modeling
• Precipitation predictions
• Water supply impacts
• Water quality impacts

Water Quality Impacts of Climate Change

• Still poorly studied
• Current status: mostly hypothetical statements & generalized predictions
• Learn from current analogues (e.g., Australia)
• Incorporate water quality into adaptive management scenarios
Temperatures in the Southwest

- Models predict global average rise of 6-7 °F by 2100
- Southwest is considered a “loser” in climate change
- AZ showing the fastest temperature increases in the US
- Avg. increase predicted to be 8-12°F
- 10% chance of 20 °F increase by 2100

Precipitation Modeling

- Higher temperatures evaporate more water
- Harder to get a saturated air mass, but more moisture in atmosphere for precipitation
- More extreme flood and drought extremes

**Projected Soil Moisture and Dry Days**

- Drier soils
- More dry days
- Reduced snowpack
- Rise in snow line
- Earlier runoff
- More evaporation
- Increased sublimation
- More variable precipitation

**Water Supply Implications**

- Extreme drought likely to increase from less than 3% of the globe today to 30% by 2100
  - Hadley Center, UK

- Potential permanent drought by 2050 throughout the Southwest if CO\textsubscript{2} rises to 450 ppm and above
  - A 1930s Dust Bowl would stretch from Kansas to California
  - Science, 2007

- US Southwest is one of 7 regions in world facing permanent Dust Bowl
  - NOAA, 2009
**Water Supply Implications for the Southwest**

- Overall reduced water supply
- More intense precipitation events
- Increased risk of flash floods; infrastructure failures
- Seasonal shifts in runoff patterns
- Reduced groundwater recharge

**Implications for the Colorado River**

- All models agree that there will be 5-40% less water in the Colorado R.

- U of A believes most likely scenario is 20% less water by 2050

- U of A believes there is a 30% chance Lakes Powell and Mead will be empty by 2050 if we don’t start taking steps today

- If this happens, the CAP will no longer be able to deliver water

- Temperature affects both supply and demand
**Southwest Water Quality Considerations**

- Higher water temperatures
  - reduced dissolved oxygen
  - stress on aquatic species
  - reduced habitat for cold water species
  - increased severity of algal blooms
- Reduced flows, especially in summer
  - higher pollutant concentrations
  - ecosystem impacts
- Increased sediment, wildfire runoff & dust deposition
- Increased surface water salinity
- Increased salinity to groundwater

**Southwest Water Quality Considerations**

- Increased suspended solids and organic carbon in surface waters will have very negative impact on drinking water treatment
  - Sediment
  - nutrients
  - fire-related runoff
  - increased average & extreme concentrations

- More severe taste and odor problems from algal blooms
Southwest Water Quality Considerations

- Switch to groundwater pumping may impose other treatment requirements
  - Nitrate, arsenic, salinity
- High water temperatures may aid growth of dangerous emerging pathogens
  - *Naegleria fowleri*
  - *Vibrio cholerae*
  - *Legionella pneumophila*
  - *Mycobacterium avium*

Final Thoughts

- Better monitoring data, monitoring approaches, data capture, and research are needed to properly assess:
  - watershed conditions
  - reclaimed water usage
  - occurrence and impact of emerging contaminants
  - impacts of drought/climate change
- Drought/climate change and water quality impacts will become increasingly entangled
- No lack of career possibilities to address the current and emerging water quality issues from A to Z
- Critical need to translate these complex issues to the general citizenry
Water Quality from A – Z


Or else, e-mail me at: cgg@azdeq.gov