Drinking Water

Drinking Water Problems
- Chronic vs. Acute
- Aesthetic
- Special populations (e.g., nitrates and “blue baby” syndrome)
- Naturally occurring vs. anthropogenic sources
- Organic/Inorganic chemicals
- Bacteria (*E. coli*)
- Viruses (*Giardia lamblia*)

Public Drinking Water Systems
- Water for human consumption with at least 15 service connections, or 25 users
- Community water systems: Serve a permanent population
- Non-transient, non-community: Public facilities, like schools; service same population for at least 6 months
- Transient, non-community: Serve transients for 60 day/year; like roadside systems
Modern Drinking Water Treatment
Public Water System Supervision Program

Over 161,000 Public Water Systems Nationwide

- CWSs
- NTNCWSs
- TNCWSs

- CWSs: 89,192
- NTNCWSs: 53,347
- TNCWSs: 18,687
Ownership of Public Water Systems

![Bar chart showing ownership of public water systems by population category.]

- **Public**
- **Private**
- **Other**

Population categories are:
- <100
- 101-500
- 501-3,300
- 3,301-10,000
- 10,000+

Ownership percentages vary across these categories.
Policy History

Early History
- 4th Century B.C.: Hippocrates advises people to boil and strain water before drinking to prevent hoarseness
- Late 1800s/early 1900s: Disease outbreaks lead to establishment of community water systems
- Local and state governments begin developing public health programs
- States developed “multiple barrier” systems: source, treatment, and distribution system all subjected to scrutiny
- Think of public health/drinking water systems like a public good

Federal Involvement
- 1914; Public Health Service establishes drinking water standards for interstate carriers, mainly trains
- PHS integrated into Department of Health, Education, Welfare (date?)
- 1969: PHS does survey that find 60% of public water systems were contaminated; provides impetus for SDWA 1974
Early Success in Drinking Water Protection

Typhoid Mortality vs Year

Safe Drinking Water Act 1974

Public Water System Supervision Program

- EPA sets National Primary Drinking Water Standards
- Maximum Contaminant Level: Maximum concentrations allowed, or best available technology; takes costs into account; enforceable
- MCL Goal: Zero-risk level; non-enforceable
- Maximum residual disinfectant levels
- Primacy (All states but Wyoming have it)—CA uses two agencies (DHS, OEHHA), plus delegation to counties for some small systems

1986 Amendments

- Precipitated by EPA delays in standard setting
- Required EPA to regulate 83 contaminants in three years; 25 additional contaminants every three years after (w/ best available treatment tech.)
- Increased state-level monitoring stringency
- Created category of non-transient, non-community drinking water system
- Added Wellhead Protection Program
Safe Drinking Water Act 1996 Amendments

Overview

- Replaced ‘86 requirement of 25 per 3 years with risk-based assessment of five chemicals per five years (Contaminant candidate list)
- Forced EPA to finalize several proposed rules that were required by ’86 amendments but not completed (including arsenic)
- Cost-benefit analysis formal part of MCL standard setting
- Required states to develop Source Water Assessment Program that ranked threats to source waters
- Established Drinking Water State Revolving Funds to finance drinking water infrastructure
- Requires EPA to identify affordable technologies for small systems; if no affordable technology identified then small systems can have “variance technology”—this is in the process of happening
Setting Risk-Based Standards

Risk Assessment

- Hazard identification: Use animal studies to see if a substance is harmful
- Dose-response assessment: Identify level of harm for different doses; maybe a threshold effect
- Exposure assessment: Identify level of exposure in population; probability of different levels
- Risk characterization: Expected health risks; combine exposure and dose-response assessment

Cost-Benefit Analysis

- Benefits are monetized values of death and illnesses prevented by new regulation
- Costs are capital, operation, monitoring, paperwork
## Arsenic Cost-Benefit Analysis

<table>
<thead>
<tr>
<th>Arsenic Cost µg/L</th>
<th>Proposed Cost in millions</th>
<th>Proposed Bladder Benefits $M</th>
<th>Potential “What If” Benefits $M</th>
<th>Final Cost in $M</th>
<th>Final Benefits in $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>$645-756</td>
<td>$44-104</td>
<td>$42-448</td>
<td>$698-792</td>
<td>$214-491</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td><strong>$165-195</strong></td>
<td><strong>$18-52</strong></td>
<td><strong>$20-224</strong></td>
<td><strong>$180-206</strong></td>
<td><strong>$140-198</strong></td>
</tr>
<tr>
<td>20</td>
<td>$63-77</td>
<td>$8-30</td>
<td>$9-128</td>
<td>$67-76</td>
<td>$66-75</td>
</tr>
</tbody>
</table>

- One of 83 contaminants required in ‘86 Amendments
- EPA missed several deadlines; ’96 Amendments set a new deadline
- Involved a variety of National Research Council Reports
- Figures represent annual costs and benefits
- Costs asymmetrically distributed across small and large water systems; $20 per household for systems serving > 10,000 people; $145 for systems serving between 25-100 people
Economies of Scale for Meeting Drinking Water Standards

Table III-1.--Comparison of Average Costs \( \text{\$/1\} \) Per Household by System Size for Three Recent Rulemakings

<table>
<thead>
<tr>
<th>System size</th>
<th>Arsenic $2/$</th>
<th>Radon $3/$</th>
<th>Stage 1 DBPR $4/$</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-100</td>
<td>$327</td>
<td>$270</td>
<td>$177</td>
</tr>
<tr>
<td>101-500</td>
<td>163</td>
<td>99</td>
<td>123</td>
</tr>
<tr>
<td>501-1,000</td>
<td>71</td>
<td>27</td>
<td>84</td>
</tr>
<tr>
<td>1,001-3,300</td>
<td>58</td>
<td>27</td>
<td>55</td>
</tr>
<tr>
<td>3,301-10,000</td>
<td>38</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>10,001-50,000</td>
<td>32</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>50,001-100,000</td>
<td>25</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>100,001-1 million</td>
<td>21</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>&gt; 1 million</td>
<td>1</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

Source (notice of proposed rulemaking on arsenic affordability criteria):

[Federal Register: March 2, 2006 (Volume 71, Number 41)]
[Notices]
[Page 10671-10685]
Monitoring and Enforcement

Monitoring
- MCLs have a monitoring framework; describes schedule of monitoring
- Monitoring frequency and methodology depends on many factors, including type of contaminant and system, and past compliance
- Drinking water systems required to publish annual Consumer Confidence Report on monitoring
- States collect monitoring data in Safe Drinking Water Info. System

Compliance (2001 data; similar patterns since)
- 26% of PWS report violations, 23% of population served by non-compliant system
- 91% of violating systems served fewer than 3,300 users
- 87% of violations were monitoring/reporting; 13% health based; 94% of systems had no health violations
- Most frequently violated monitoring requirements and MCL is the total coliform—human waste
Native American Water Systems, 2004

- 818 systems, ~680,000 users
- 95% of systems are small; <3,300 users
- 89% reported no health violations
- 89% of violations were monitoring/reporting
## PRIMARY DRINKING WATER STANDARD (Regulated in order to protect against possible adverse health effects.)

<table>
<thead>
<tr>
<th>SUBSTANCE (UNITS)</th>
<th>YEAR SAMPLED</th>
<th>MCL</th>
<th>PHG (MCLG)</th>
<th>WEIGHTED AVERAGE</th>
<th>RANGE LOW-HIGH</th>
<th>VIOLATION</th>
<th>TYPICAL SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (ppb)</td>
<td>2004</td>
<td>50</td>
<td>NA</td>
<td>4.6</td>
<td>ND-11</td>
<td>No</td>
<td>Erosion of natural deposits; runoff from orchards; glass and electronics production wastes.</td>
</tr>
<tr>
<td>Barium (ppm)</td>
<td>2004</td>
<td>1</td>
<td>2</td>
<td>ND</td>
<td>ND-0.22</td>
<td>No</td>
<td>Discharge of oil drilling wastes and from metal refineries; erosion of natural deposits.</td>
</tr>
<tr>
<td>Chromium (ppb)</td>
<td>2004</td>
<td>50</td>
<td>(100)</td>
<td>17</td>
<td>2-50</td>
<td>No</td>
<td>Discharge from steel and pulp mills and chrome plating; erosion of natural deposits.</td>
</tr>
<tr>
<td>Fluoride (ppm)</td>
<td>2004</td>
<td>2</td>
<td>1</td>
<td>0.20</td>
<td>ND-0.4</td>
<td>No</td>
<td>Erosion of natural deposits; water additive which promotes strong teeth; discharge from fertilizer and aluminum factories.</td>
</tr>
<tr>
<td>Gross Alpha particle Activity (pCi/L)</td>
<td>2002</td>
<td>15</td>
<td>NA</td>
<td>2.9</td>
<td>0.49-7.08</td>
<td>No</td>
<td>Erosion of natural deposits</td>
</tr>
<tr>
<td>Gross Beta particle Activity (pCi/L)</td>
<td>2002</td>
<td>50</td>
<td>NA</td>
<td>1.8</td>
<td>ND-4.15</td>
<td>No</td>
<td>Decay of natural and man-made deposits</td>
</tr>
<tr>
<td>Nickel (ppb)</td>
<td>2004</td>
<td>100</td>
<td>12</td>
<td>ND</td>
<td>ND-10</td>
<td>No</td>
<td>Erosion of natural deposits; discharge from metal factories.</td>
</tr>
<tr>
<td>Nitrate (as nitrate, NO₃³⁻) (ppm)</td>
<td>2004</td>
<td>45</td>
<td>45</td>
<td>14</td>
<td>2-54</td>
<td>No</td>
<td>Runoff and leaching from fertilizer use; leaching from septic tanks; sewage; erosion of natural deposits.</td>
</tr>
<tr>
<td>Selenium (ppb)</td>
<td>2004</td>
<td>50</td>
<td>(50)</td>
<td>8.6</td>
<td>ND-36</td>
<td>No</td>
<td>Discharge from petroleum, glass and metal refineries; erosion of natural deposits; discharge from mines and chemical manufacturers; runoff from livestock lots (feed additive).</td>
</tr>
<tr>
<td>Total Coliforms (% positive samples)</td>
<td>2004</td>
<td>5% positive samples</td>
<td>(0)</td>
<td>1.3</td>
<td>NA</td>
<td>No</td>
<td>Naturally present in the environment</td>
</tr>
<tr>
<td>Trichloroethylene [TCE] (ppb)</td>
<td>2004</td>
<td>5</td>
<td>0.8</td>
<td>&lt;0.50</td>
<td>ND-0.64</td>
<td>No</td>
<td>Discharge from metal degreasing sites and other factories</td>
</tr>
<tr>
<td>TTHMs [Total Trihalomethanes] (ppb)</td>
<td>2004</td>
<td>80</td>
<td>NA</td>
<td>&lt;4.1</td>
<td>ND-4.1</td>
<td>No</td>
<td>By-product of drinking water chlorination</td>
</tr>
</tbody>
</table>
Perchlorate

- Limits uptake of “iodide” into thyroid gland; possible affects on human growth with pregnant women and children as vulnerable pop.
- Found in mainly in groundwater (348 sources identified in CA with more than 4 ppb); by-product of solid rocket fuel manufacturing
- There is no MCL set for perchlorate; it is on the Contaminate Candidate List and is subject to the Unregulated Contaminant Monitoring Rule
- Big fights over appropriate risk assessment (rat study); NRC report
- 2004: Forced by state legislation, CA Office of Environmental Health Hazard Assessment sets a “public health goal” of 6 parts per billion—this is the CA state version of the MCL goal
- “Notification level” of 6 ppb requires a public health warning and DHS recommendation to stop using source
- CA and EPA in process of developing MCL
Other Programs

Underground Injection
- Underground injection wells generally inject wastes from agriculture or energy production into aquifers
- More than 400,000 injection wells in US
- EPA regulates five “classes” of UIW
- UIWs must have permits or comply with general rules, which specify conditions for underground injection
- Primacy here too; CA has joint state/federal program

Source Water Protection
- Sole Source Aquifer Program (‘74): EPA must review federal projects to insure SSA is not contaminated; SSAs are petitioned into program; 70 nationwide
- Wellhead Protection Program (‘86): Delineate and identify
- Source Water Assessment Program (‘96): Delineate source water boundaries, identify contaminant sources,
Problems

A Laundry List

- Delays and conflict in setting MCL
- Concern about adequacy of scientific analysis in risk-based standard setting
- Resource constraints at EPA and State level; EPA estimate annual funding shortfall of $10-20 million dollars for meeting analysis requirements
- Funding gap between estimated costs of infrastructure upgrades and available government grants
- Association of Metropolitan Water Agencies insists on good science...why?
- Severe problems with small water systems (compliance capacity and motivation)
- Lack of public awareness
- End-of-pipe versus source water protection