SAFE HARBOR
ENVIRONMENTAL MANAGEMENT
HABITAT RESTORATION

Smart Water: Ground Water and Hydrophilic Chemicals

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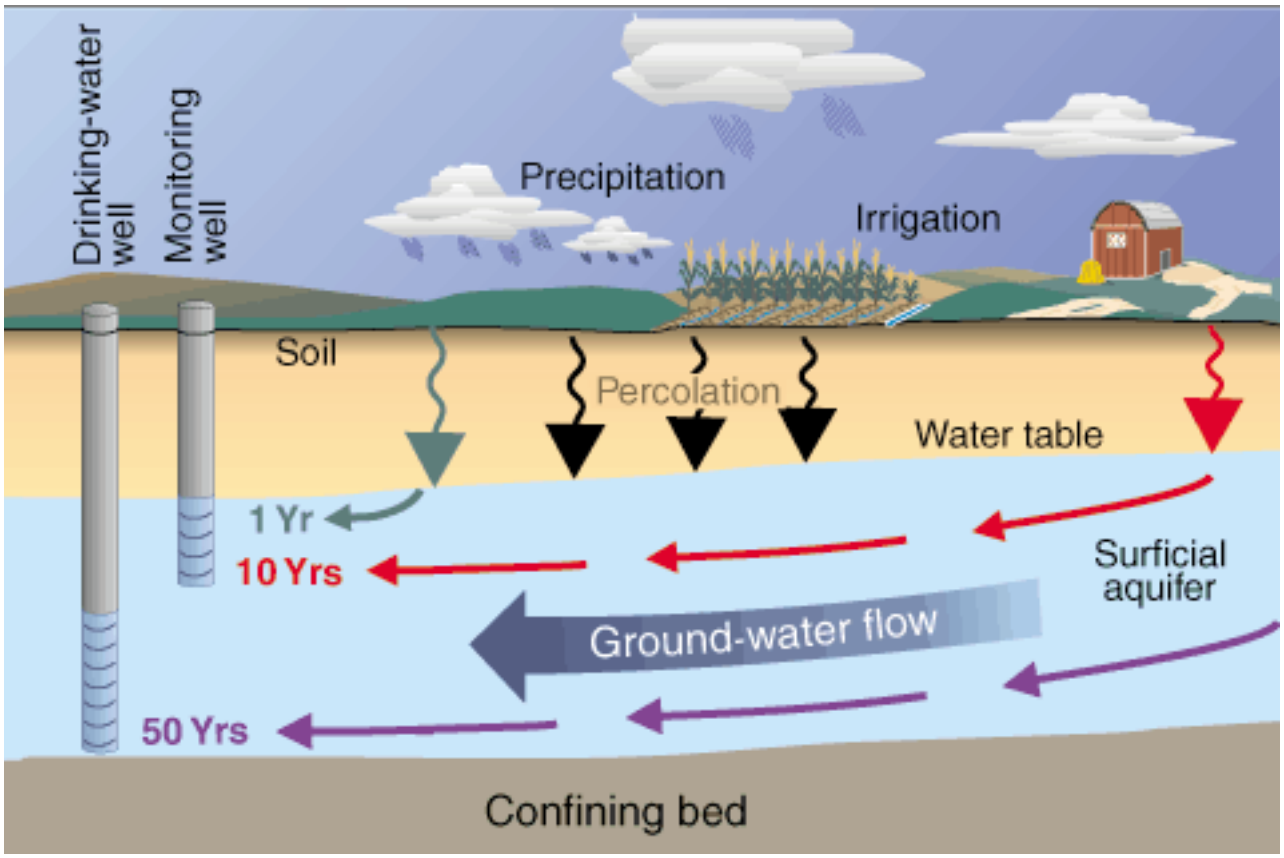
What goes on underground may be unseen but not without risk. Groundwater is capable of transporting more than water. We are already aware of nitrogen contamination and salt water intrusion. The sleeping giant of hydrophilic chemicals however, remains unseen, unmeasured and mostly unknown. The goal of this compilation of material is to provide links and basic information on what may be hitching a ride with our ground water.

I. Chemical transport through ground water



The effects of past and present land-use practices may take decades to become apparent in ground water. When weighing management decisions for protection of ground-water quality, it is important to consider the time lag between application of pesticides and fertilizers to the land and arrival of the chemicals at a well. This time lag generally decreases with increasing aquifer permeability and with decreasing depth to water. Lag time may increase with down slope gradient. In response to reductions in chemical applications to the land, the quality of shallow ground water improves before deep ground water, which could take decades.

II. Basic information

Drinking Water Contaminants

- The following link is from the Environmental Protection Agency (EPA) website that lists drinking water contaminants, their maximum contaminant levels (MCLs) and what happens with long-term exposure:
  http://water.epa.gov/drink/contaminants/index.cfm#content

- The following link is from the EPA Contaminant Candidate List 3 (CCL3): "CCL 3 is a list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations, that are known or anticipated to occur in public water systems, and which may require regulation under the Safe Drinking Water Act (SDWA). The list includes, among others, pesticides, disinfection byproducts, chemicals used in commerce, waterborne pathogens, pharmaceuticals, and biological toxins. The Agency considered the best available data and information on health effects and occurrence to evaluate thousands of unregulated contaminants. EPA used a multi-step process to select 116 candidates for the final CCL 3. The final CCL 3 includes 104 chemicals or chemical groups and 12 microbiological contaminants."
  http://water.epa.gov/scitech/drinkingwater/dws/ccl/ccl3.cfm

- Silent Spring Institute has much information on Cape Cod related issues with groundwater quality and contamination, especially the mapping:
  http://www.silentspring.org/our-research/health-and-environmental-mapping/cape-cod-breast-cancer-and-environment-atlas

- An article from the New York Times regarding the tightening of regulations on safe drinking water: http://www.nytimes.com/2010/03/23/business/23water.html?_r=1

- 310 CMR 22: Mass documentation about regulating drinking water: http://www.mass.gov/dep/service/regulations/310cmr22.pdf

III. Pesticides

- From the Silent Spring Institute Health and Environmental Mapping of Cape Cod, "Laboratory tests in animals have linked some pesticides with tumors or effects on reproductive organs. Some pesticides have also been shown to be endocrine disruptors, including some that mimic estrogen in animal and cell studies. Human studies of links between pesticides and breast cancer are difficult, as we do not have good measures of women's exposures to pesticides years ago; but in 2007, researchers reported on a study that found higher breast cancer risk among women who had higher levels of DDT in stored blood samples that were drawn when DDT was still in use and the women were in their twenties. Women who were under 14 years old when DDT came into use were at higher risk for breast cancer later on, the study showed."

  "Historically, pesticides have been widely used on Cape Cod, especially for mosquito control, and in the decades before it was banned, DDT was used in sprayings throughout the Cape. These maps show areas of large-scale pesticide application between 1956 and 1990, as well as areas of pesticide applications to agriculture and wetlands on Cape Cod in 1951. These old maps retain their relevance; even though much of this land has been developed since 1951, the pesticides used back then tend to degrade very slowly, and previously applied pesticides likely persist today."

  "Silent Spring Institute researchers have added to the maps the locations of cranberry bogs and golf courses from multiple sources, representing both current and historical land use. Numbers coded in green indicate the years in which a portion of the town was sprayed, and the italicized numbers indicate the years in which an entire town was sprayed. For all other years shown, the area sprayed is unknown."

http://www.silentspring.org/our-research/health-and-environmental-mapping/cape-cod-breast-cancer-and-environment-atlas

- List of insect control and years sprayed on Cape Cod: http://library.silentspring.org/atlas/pesticides/index.asp

- Fact sheet by U.S. Geological Survey on pesticides in groundwater:

  "Pesticide contamination of ground water is a subject of national importance because ground water is used for drinking water by about 50 percent of the Nation's population. This especially concerns people living in the agricultural areas where pesticides are most often used, as about 95 percent of that population relies upon ground water for drinking water. Before the mid-1970s, it was thought that soil acted as a protective filter that stopped pesticides from reaching ground water. Studies have now shown that this is not the case. Pesticides can reach water-bearing aquifers below ground from applications onto crop fields, seepage of contaminated surface water, accidental spills and leaks, improper disposal, and even through injection waste material into wells.

  Pesticides are mostly modern chemicals. There are many hundreds of these compounds, and extensive tests and studies of their effect on humans have not been completed. That leads us to ask just how concerned we should be about their presence in our drinking water. Certainly it would be wise to treat pesticides as potentially dangerous and, thus, to handle them with care. We can say they pose a potential danger if they are consumed in large quantities, but, as any experienced scientist knows, you cannot draw factual conclusions unless scientific tests have been done. Some pesticides have had a designated Maximum Contaminant Limit (MCL) in drinking water set by the U.S. Environmental Protection Agency (EPA), but many have not. Also, the effect of combining more than one pesticide in drinking water might be different than the effects of each individual pesticide alone. It is another situation where we don't have sufficient scientific data to draw reliable conclusions".
  http://ga.water.usgs.gov/edu/pesticidesgw.html

IV. Carcinogens

- A Cornell U factsheet about carcinogens in drinking water:
  http://envirocancer.cornell.edu/FactSheet/Pesticide/fs7a.drnkwtr.cfm
  http://envirocancer.cornell.edu/factsheet/Pesticide/fs7a.drnkwtr.pdf

- A Clinical Trial testing for possible Cancers from drinking water:
  http://clinicaltrials.gov/ct2/show/NCT00559793

- Environmental Working Group conducted research on Chromium 6 in tap water:

  > "Laboratory tests commissioned by Environmental Working Group (EWG) have detected hexavalent chromium, the carcinogenic "Erin Brockovich chemical," in tap water from 31 of 35 American cities… The National Toxicology Program has concluded that hexavalent chromium (also called chromium-6) in drinking water shows "clear evidence of carcinogenic activity" in laboratory animals, increasing the risk of gastrointestinal tumors. In September 2010, a draft toxicological review by the U.S. Environmental Protection Agency (EPA) similarly found that hexavalent chromium in tap water is "likely to be carcinogenic to humans.""
  > http://static.ewg.org/reports/2010/chrome6/html/home.html

V. Hormones

- From text," This study by the Toxic Substances Hydrology Program of the U.S. Geological Survey shows that a broad range of chemicals found in residential, industrial, and agricultural wastewaters commonly occurs in mixtures at low concentrations downstream from areas of intense urbanization and animal production. The chemicals include human and veterinary drugs (including antibiotics), natural and synthetic hormones, detergent metabolites, plasticizers, insecticides, and fire retardants. One or more of these chemicals were found in 80 percent of the streams sampled. Half of the streams contained 7 or more of these chemicals, and about one-third of the streams contained 10 or more of these chemicals. This study is the first national-scale examination of these organic wastewater contaminants in streams and supports the USGS mission to assess the

quantity and quality of the Nation's water resources. A more complete analysis of these and other emerging water-quality issues is ongoing." http://toxics.usgs.gov/pubs/FS-027-02/pdf/FS-027-02.pdf

- The EPA conducted research in 2007 about the retention times and other properties of hormones and steroids in mediums of water, soil & biosolids: http://water.epa.gov/scitech/swguidance/methods/bioindicators/upload/2008_01_03_methods_method_1698.pdf

- Nancy Mesner from Utah State University put together this very informative presentation about pharmaceuticals in drinking water: http://breeze.usu.edu/p96304316/

- This is an EPA fact sheet about the environmental life cycle of pharmaceuticals: http://www.epa.gov/esd/bios/daughton/drug-lifecycle.pdf

VI. Hormone Mimicking Compounds

- Research by Yale, "The presence of hormone mimicking compounds in secondary wastewater effluents and in freshwater bodies has caused great concern over their potentially adverse health impact on humans and wildlife. Most of these compounds are of significant industrial importance. Prominent amongst them are alkylphenolethoxylates (APEs) and bisphenol A (BPA). APEs are a group of nonionic surfactants extensively used as industrial cleaning and wetting agents, emulsifiers, and domestic detergents. Despite a significant environmental concern over the use and disposal of these chemicals, the demand for APEs grows steadily with a current annual production estimated to be approximately 500,000 tons (1). Similarly, BPA is extensively employed in the production of epoxy resins and polycarbonates. The annual BPA production is reported to be in excess of 1 million tons (2). APEs together with some BPA enter the aquatic environment primarily as components of industrial and domestic wastewater. During the biological wastewater treatment process, APEs degrade into a complex mixture of several biorefractory metabolites, mostly consisting of short chain alkylphenols such as nonylphenol and octylphenol (3). Unfortunately,

these metabolites are often more persistent, toxic, and bio-accumulative than their parent compounds." http://www.yale.edu/env/elimelech/publication-pdf/Nghiem-Schafer-Elimelech-SST-2005.pdf

- Endocrine disruptors are chemicals that interfere with endocrine systems, in both animals and humans, producing adverse developmental, reproductive, neurological, and immune effects after long amounts of exposure. "A wide range of substances, both natural and man-made, are thought to cause endocrine disruption, including pharmaceuticals, dioxin and dioxin-like compounds, polychlorinated biphenyls, DDT and other pesticides, and plasticizers such as bisphenol A. Endocrine disruptors may be found in many everyday products– including plastic bottles, metal food cans, detergents, flame retardants, food, toys, cosmetics, and pesticides." Endocrine disruptors act through a number of mechanisms by temporary, or permanently altering feedback loops involving the brain, pituitary, testes, ovary, thyroid gland, or other organs. Their actions are attributed to mimicking, or interfering with normal functioning of sex hormones such as estrogen, progesterone, and testosterone.
  http://www.niehs.nih.gov/health/topics/agents/endocrine/index.cfm
  http://www.epa.gov/ncer/science/endocrine/highlights.html

VII. Perchlorates

- Perchlorates are colorless salts that are easily dissolvable in water. They are very reactive and are found in explosives, fireworks, and rocket motors. Human exposure to perchlorate can occur through the ingestion of food as well as drinking water. Historically, perchlorate was used as a medication to treat an over-reactive thyroid gland. Perchlorate inhibits the thyroid's uptake of iodine necessary for metabolism, growth and neurological development in children. The most sensitive population to perchlorate exposure are unborn babies, infants and developing children since thyroid hormones are essential for normal growth and development. Exposure to excessive amounts of perchlorate for a long time may cause neurodevelopmental effects in children and hypothyroidismin adults.
  http://www.atsdr.cdc.gov/toxguides/toxguide-162.pdf

Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Toxicological Profile for Perchlorates. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services.

VIII. Heavy metals

- "Heavy metal pollution can arise from many sources but most commonly arises from the purification of metals, e.g., the smelting of copper and the preparation of nuclear fuels. Electroplating is the primary source of chromium and cadmium. Through precipitation of their compounds or by ion exchange into soils and muds, heavy metal pollutants can localize and lay dormant. Unlike organic pollutants, heavy metals do not decay and thus pose a different kind of challenge for remediation. Currently, plants or microrganisms are tentatively used to remove some heavy metals such as mercury. Plants which exhibit hyper accumulation can be used to remove heavy metals from soils by concentrating them in their bio matter. Some treatment of mining tailings has occurred where the vegetation is then incinerated to recover the heavy metals. One of the largest problems associated with the persistence of heavy metals is the potential for bioaccumulation and biomagnification causing heavier exposure for some organisms than is present in the environment alone."

- http://library.thinkquest.org/04oct/01590/pollution/pollutants.html

- **From Healthy Waters Filter Company: http://www.healthy-water-best-filters.com/heavy-metals-in-water.html**

  "Heavy metals represent a common type of chemical pollution in water. They can be found naturally in bedrock and sediment, which can leach out from acidic rain or they may be introduced into water from industrial sources and household chemicals. Heavy metals harm humans through direct ingestion of contaminated water or through accumulation in the tissues of other organisms that are eaten by humans. These are some common heavy metals found in water:

  Aluminum (Al): Enters the environment through leaching due to acid deposition. Causes anemia and loss of bone strength, and may also contribute to dementia and Alzheimer's disease. Aluminum is used for numerous products, from household utensils to workplace gadgets &

more. It accumulates in cells like the nerve cells, which are long-lived so the accumulation can go on for decades.
In the body, aluminum acts as a poison. In particular, it affects the brain & therefore affects mental processes like memory & thinking.
Studies show that persons exposed to aluminum in water, or any other products that may contain aluminum - baking soda, salt &supplements - are at risk for developing Alzheimer's. Alzheimer's is a devastating disease which progressively robs sufferers of memory, intelligence & their personality. Apart from assuring you do not receive extra aluminum in your water, also be sure not to take in extra aluminum from other sources. For example, do not cook in aluminum or consume hot foods or liquids from aluminum containers.

Antimony (Sb) is also a metal that has been found in water at levels above federal guidelines. Short terms effects of antimony consumption include diarrhea, nausea & vomiting Longer term effects of this form of water pollution aren't clear but may include heightened cancer risk.

Arsenic (As): Enters the environment through herbicides, wood preservatives, and mining industry. Causes damage to skin, eyes, gastrointestinal tract, and liver. May also cause cancer.
Natural Resource Defense Council fact sheet on Arsenic in drinking water: http://www.nrdc.org/water/drinking/qarsenic.asp

Barium (Ba) is another metal that is used in numerous products such as electronics, ceramics, fireworks & more. Its disposal & its byproducts often end up causing water pollution. There have been occurrences of barium levels in drinking water in excess of federal guidelines in states that manufacture ores. These include Arizona, Utah & Texas - all linked to industries which can lead to over-exposures to barium.
Barium consumption is linked to gastrointestinal problems, muscle weakness, & hypertension.

Cadmium (Cd) is yet another metal that is used in a variety of industries. Health effects of exposure to cadmium include gastrointestinal disturbances, convulsions, liver problems, kidney disorders & damage to bone & blood. High levels of cadmium have been detected in Arizona & Texas.

Chromium (Cr) is also found in numerous household products. It is a vital human micronutrient that is taken in supplement form by millions of people. However, at excess levels, you may be getting much more than you know & that can be quite dangerous. Chromium poisoning seems to affect the skin, irritating it & causing skin ulcers. Longer term effects include damage to liver, kidneys & nerve cells.

Copper (Cu) in water is usually associated with tubing & plumbing which water comes into contact with. Ingesting copper from polluted water can damage the liver and the nervous, immune & circulatory systems.

Lead (Pb): Sources include paint, mining wastes, incinerator ash, water from lead pipes and solder, and automobile exhaust. Causes damage to kidneys, nervous system, learning ability, ability to synthesize protein, and nerve and red blood cells.

Mercury (Hg): Enters the environment through the leaching of soil due to acid rain, coal burning, or industrial, household, and mining wastes. Causes damage to nervous system, kidneys, and vision.

IX. Pathways of Pharmaceuticals

- Taken from www.capecodgroundwater.org, ”Nitrate-nitrogen, besides being a contaminant itself, can also indicate the possible presence of other wastewater contaminants such as disease causing organisms, solvents, cleaners, petroleum compounds, PPCP’s (pharmaceuticals and personal care products) and other emerging contaminants. “Emerging contaminants" are chemicals or microorganisms that are not commonly monitored or regulated in the environment, but are suspected of having potentially adverse ecological and (or) human health effects. They can include hormones, human and veterinary pharmaceuticals, and household products like soaps and lotions, insect repellents, perfumes and other fragrances, sunscreens, and hand sanitizers.”

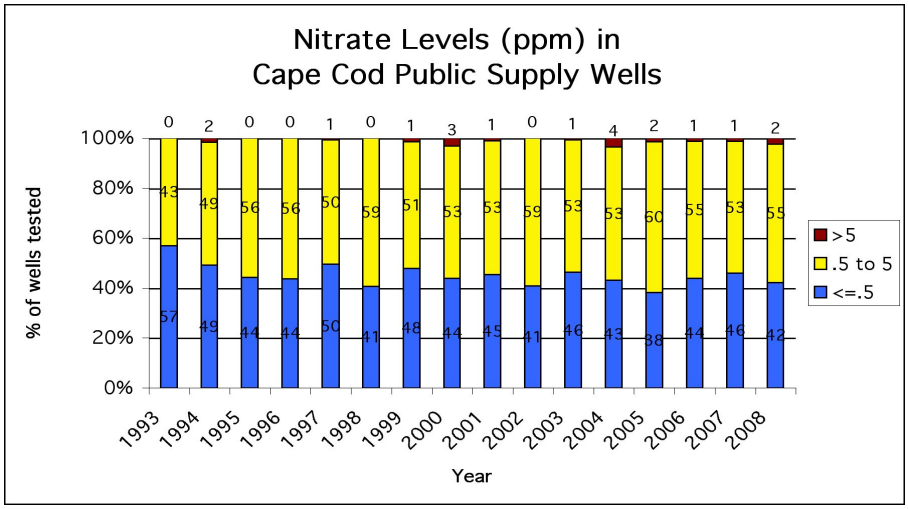
- “In June 2004 the U.S. Geological Survey and the Barnstable County Health Department (Zimmerman 2005), sampled wastewater sources and public, semipublic, and private drinking water supplies on Cape

Cod that were thought to be affected by wastewater because of previously high nitrate-nitrogen concentrations. Forty-three of the eighty-five PPCP and organic wastewater contaminant compounds that were analyzed for were detected in the wastewater samples. Thirteen were detected in low concentrations (less than 1 microgram/liter) in the private and semipublic drinking water supplies and three, an antibiotic, an antidepressant, and a solvent, were detected in the public water supply."

"Although the ability to detect these emerging compounds at extremely low levels in drinking water has been greatly improved, the human health effects from these low level concentrations are not well documented."

- Health fact sheet from the Natural Resource Defense Council on Pharmaceuticals in drinking water: http://www.nrdc.org/health/files/dosed4pgr.pdf

X. Nitrogen From the www.capecodgroundwater.org, "Nitrate-nitrogen is a major component of human wastewater. Nitrogen passes through septic systems virtually untreated and is introduced to the underlying groundwater. Nitrate, is often used as an indicator of drinking water quality. A maximum contaminant limit (MCL) of 10 ppm of nitrate as nitrogen for drinking water supplies has been established by the USEPA and adopted by MA state regulation. The limit was established to protect infants from methemoglobinemia or "blue-baby" syndrome, a potentially fatal blood disorder which can occur when too much nitrate limits the amount of oxygen in the blood. Although inconclusive, some health studies have also linked high nitrate levels to certain types of cancer. The Barnstable County Regional Policy Plan established a nitrogen loading concentration of 5 ppm to ensure that nitrate levels in drinking water will not approach the federal standard. This protection standard had been adopted both locally and at the state level. The quality of Cape Cod's community public drinking water supply is generally very good, but over the past 15 years there has been a

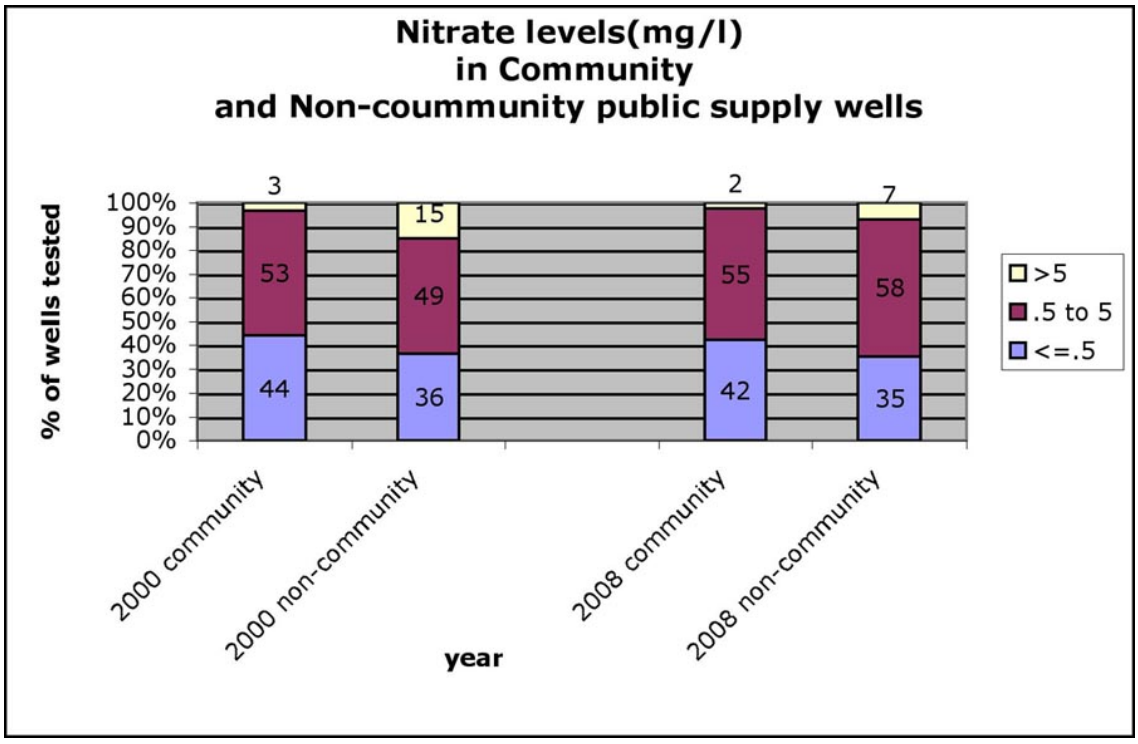


trend toward some degradation.

Between 1993 and 2008, the percentage of public supply wells tested that had nitrate levels at or below .5 ppm (considered very clean) fell from 57%-42%. During the same time period the percentage of public drinking water levels with nitrate levels between .5 and 5 ppm (the RPP limit) increased from 43%-55%. The percentage of wells testing above the 5ppm standard has varied between 0% and 4% during the past 15 years and no community public supply wells have tested over 10ppm.

The 2008 nitrate concentrations in the Cape's community supply wells are shown on Figure 8. In general, the wells with higher concentrations are the older ones that are located down gradient of high density residential areas. However, even well protected water supply wells have somewhat elevated concentrations of nitrate that is derived from septic systems and other non-point sources.

Small volume, non-community drinking water wells, which are generally shallower, pump less water and are often closer to septic systems, have shown a greater degradation than the larger and deeper community wells. Since 2000, the number of very clean non-community public wells with nitrate levels below .5 ppm has stayed around 35% compared to 42-44% of the deeper community public supply wells. The non-community wells with levels greater than 5 mg/l ranged from 7-15% compared to 3% of the community wells. The number of non-community wells with nitrate levels greater than the MCL of 10 mg/l has ranged from 2-6. All of the wells exceeding the drinking water limit are located on the Outer Cape where wastewater disposal and private water supply often occur on the same lot. In response to poor water quality, Wellfleet invested in a public water supply system to serve its Central downtown district and Eastham has begun water supply site investigations as a first step to provide a public water system.



XI. Are there alternatives?: We use drinking water to flush toilets, into systems which may contribute to contaminating the water we drink. Then we pay for water and sewer systems.

This link to MASS DEP is a FAQ when looking at alternative systems. It answers questions about what is acceptable and what you apply for:
http://www.mas s.gov/dep/water/wastewater/faqsia.htm#areany
Do our water resources seem so unlimited that we willingly use drinking water to flush our toilets? This counter intuitive practice deserves re-examination. With plenty of "Sink to Toilet" water reuse systems available, maybe it's time to move forward?

Some helpful links for more information:

Dry, incinerating toilets: http://www.incinolet.com/

Water re-use: sink to toilet:

- http://www.ecogeek.org/content/ view/815/
- http://www.treehugger.com/bathroom- design/watersaver-technologies-aqus-uses- sink-greywater-for-toilet.html

XII. Are international companies buying our water rights?

1. Article about T. Boone Pickens purchasing water rights: http://seekingalpha.com/article/24410-t-boone-pickens-invests-in-water-should-you

2. Newsweek article about foreign companies purchasing US water rights: http://www.newsweek.com/2010/10/08/the-race-to-buy-up-the-world-s-water.html

XIII. Who owns "water rights"?

- "It is now time to consider access to safe drinking water and sanitation as a human right, defined as the right to equal and non-discriminatory access to a sufficient amount of safe drinking water for personal and domestic uses—drinking, personal sanitation, washing of clothes, food preparation and personal and household hygiene—to sustain life and health. States should prioritize these personal and domestic uses over other water uses and should take steps to ensure that this sufficient amount is of good quality, affordable for all and can be collected within a reasonable distance from a person's home."
- Office of the UN High Commissioner for Human Rights on The Right to Water, September 2007
- The World Health Organization came out with a document addressing the following:
    - The legal definition of the human right to water and its relationship to other civil, cultural, economic, political, and social rights;
    - Discusses the right to water as a human right, and examines its implications on the roles and responsibilities of various stakeholders;
    - Examines the various communities affecting and being affected by the right to water;
    - Considers the contribution the right to water can and should make towards making drinking-water a reality for all;
    - Explores a human rights-based approach to water.

http://www.who.int/water_sanitation_health/rightowater/en/index.html

Another interesting link: http://waterrightexchange.com/

XIV. Update

As reported in local Cape Cod papers, Silent Spring Institute found 27 chemicals in 20 private wells tested on Cape Cod. This article mentions perfluorinated and endocrine disrupting compounds, which are not included in this report.

http://www.wickedlocal.com/provincetown/newsnow/x178196398/27-chemicals-found-in-Cape-Cod-wells#axzz1diD2mOqu

Public wells:

http://silentspring.org/our-publications/study_reports/emerging-contaminants-cape-cod-drinking-water

Private wells:

http://silentspring.org/our-publications/study_reports/emerging-contaminants-cape-cod-private-drinking-water-wells

Chemicals found in Cape Cod wells

http://www.capecodonline.com/apps/pbcs.dll/article?AID=/20111103/NEWS/111030346&emailAFriend=1

XV. Are there consequences for contaminating water supplies?

Some NGOs and scholars argue that the right to water also has a trans-national or extraterritorial aspect. They argue that given the fact that water supplies naturally overlap borders, States also have a legal obligation not to act in a way that might have a negative effect on the enjoyment of human rights in other States.
http://fian.org/resources/documents/others/germanys-extraterritorial-human-rights-obligations-in-multilateral-development-banks/pdf

XVI. Strategies for managing water supply in salt water intrusion areas

http://www.clemson.edu/restoration/events/past_events/sc_water_resources/t4_proceedings_presentations/t4_zip/foldesi.pdf

Note: *Safe Harbor Education Initiatives are self-funded. Contact us if you would like to support to our research and educational efforts: Gordon Peabody, August 2012*

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