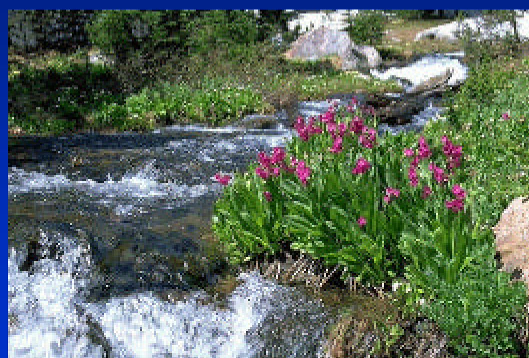
Source Water Protection

Best Management Practices and Other Measures for Protecting Drinking Water Supplies



Acknowledgements

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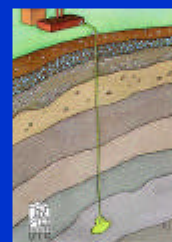
Drinking Water Academy

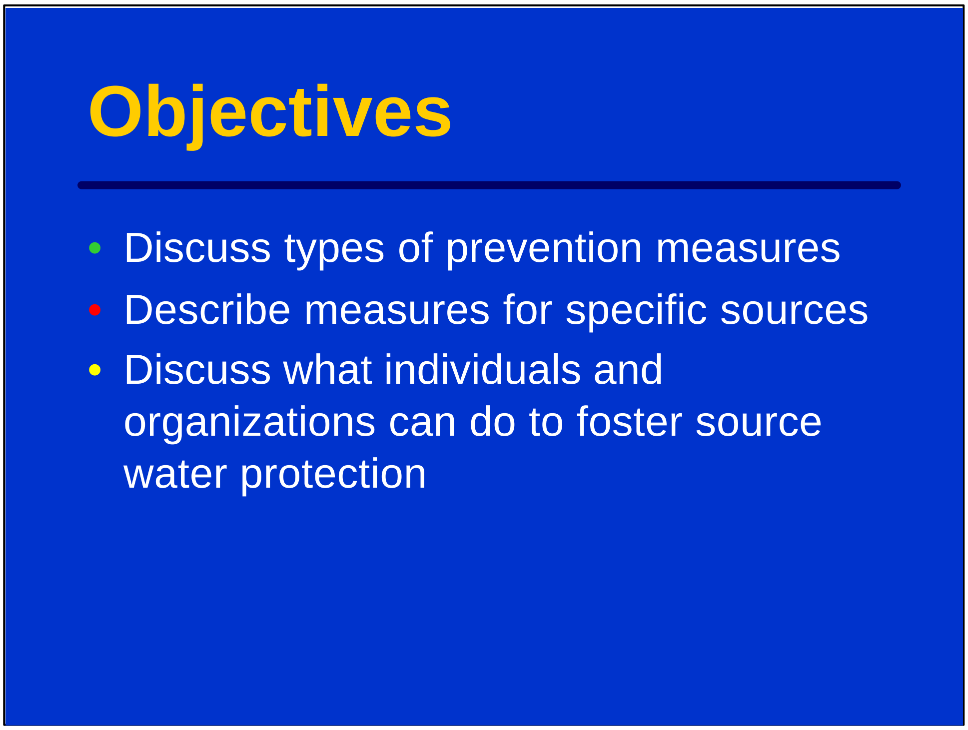


- The mission of the Drinking Water Academy (DWA) is to enhance the capabilities of State, Tribal and EPA staff to implement Safe Drinking Water Act (SDWA) requirements. Through classroom instruction, Web-based training, and the availability of training modules and other information, the DWA works to bring new personnel up to speed and enhance the skills of current drinking water staff.
- The DWA provides training in SDWA's three major program areas:
  - o Public water system supervision;
  - o Underground injection control; and
  - o Source water protection.
- The DWA provides an introductory course in each of these three areas, as well as an introductory overview of SDWA. It also provides regulatory training and technical training on specific topics such as sanitary surveys.
- This course builds on the introductory source water protection course. The purpose of this course is to provide information on source water contamination prevention measures to technical assistance providers who, in turn, will assist local level water suppliers and communities who are responsible for implementing such measures.

Objectives

- Define source water and explain its importance
- Describe potential threats to source water
- Discuss SDWA's major source water protection programs
- Define source water protection measures

- This training will cover a number of topics. By the end of the session, you should be able to:
  - Define source water and explain its importance;
  - Describe potential threats to source water;
  - Discuss SDWA's major source water protection programs; and
  - Define source water protection measures.



- In addition, you should be able to:
  - Discuss types of prevention measures;
  - Describe measures for specific sources; and
  - Discuss what individuals and organizations can do to foster source water protection.

Introduction to Source Water Protection

DRINKING WATER ACADEMY

DWA

Definition and Importance of Source Water Protection

- Source water protection is defined as efforts to protect drinking water sources
  - Surface water
  - Ground water
- Why protect source water?
  - Public health protection
  - Economic benefits
  - Environmental benefits
  - Public confidence

- Whether a public water system relies on surface water, ground water, or a combination of the two, protection of a water system's source is important.
  - If source water becomes contaminated, threats to public health are increased.
  - In addition, expensive treatment or replacement or relocation of the water supply may be required. Treatment or relocation costs are passed on to every user served by the public water system and local property values may be reduced.
  - Water is a limited resource. If a source becomes contaminated, there may not be another source available that can be developed.
- Protection of existing sources of water is a prudent way to protect public health and keep treatment costs to a minimum.
- Existing Federal laws have tended to focus on specific sources, pollutants, or land uses that may affect water quality, and have not addressed the need for an integrated, multi-disciplinary approach to environmental management. Historically, successes in controlling water pollution have been most widespread in surface water through control of point sources and in ground water by preventing contamination from hazardous waste sites.

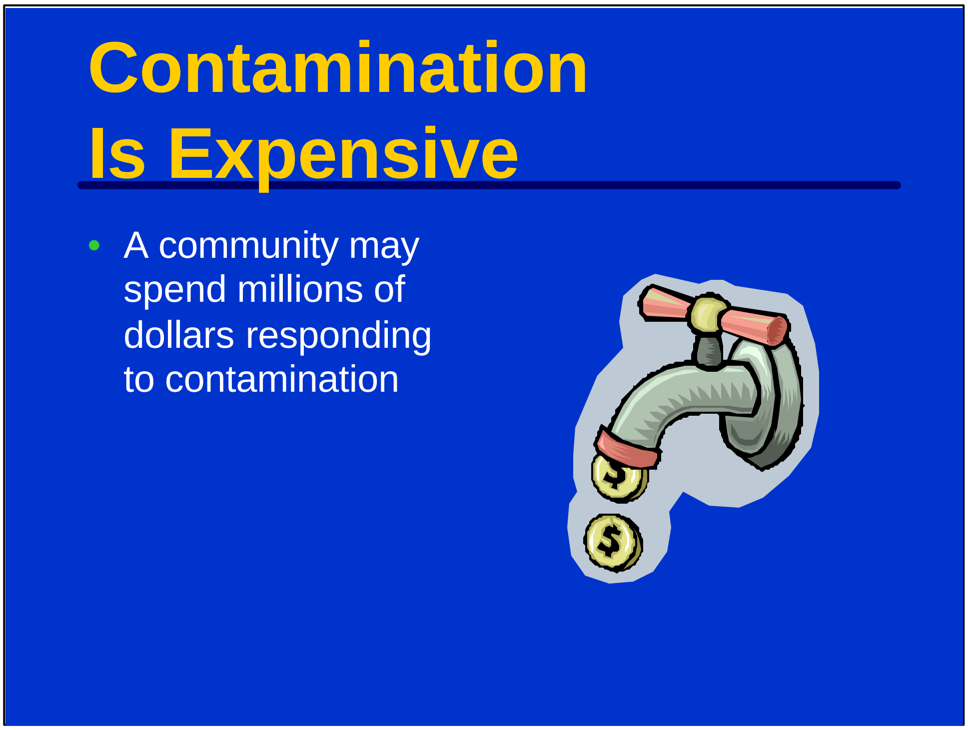
Benefits of Source Water Protection

- "An Ounce of Prevention Is Worth a Pound of Cure."
- Many communities are implementing protection efforts to prevent contamination of their drinking water supplies. These communities, counties, and locally financed water districts have found that the less polluted water is before it reaches the treatment plant, the less extensive and expensive the efforts needed to safeguard the public's health.
- Studies have shown that the cost of dealing with contaminated ground water supplies for the communities studied was, on average, 30 to 40 times more (and up to 200 times greater) than preventing their contamination.
- Further, clean water and healthy ecosystems offer other unquantifiable benefits, in terms of the quality of our lives.
- This section describes the benefits of preventing drinking water contamination. It describes and compares the costs of contamination and the benefits or costs-avoided due to preventive measures.

Avoid Costs of Contamination

- Quantifiable costs – treatment and remediation; finding and replacing water supplies; public information campaigns; regulatory compliance; loss of property value and tax revenue
- Less quantifiable costs – health costs; lost productivity; lost economic development opportunities; lost consumer confidence

- The benefits to communities of protecting their drinking water supplies might best be understood by describing the costs of failing to protect them. These costs include those that are relatively easy to capture in monetary or economic terms and those that are not. Easily quantifiable costs of drinking water supply contamination include:
  - treatment and/or remediation,
  - finding and developing new supplies and/or providing emergency replacement water,
  - abandoning a drinking water supply due to contamination,
  - paying for consulting services and staff time,
  - litigating against responsible parties,
  - conducting public information campaigns when incidents arouse public and media interest in source water pollution,
  - meeting the regulations of the Safe Drinking Water Act, such as the Disinfection Byproduct and monitoring requirements,
  - loss of property value or tax revenue, and
  - loss of revenue from boating or fishing when a lake or reservoir is used as a drinking water supply.
- Costs that are not easily quantified include:
  - health related costs from exposure to contaminated water,
  - lost production of individuals and businesses, interruption of fire protection, loss of economic development opportunities, and
  - lack of community acceptance of treated drinking water.



- One basic truth is that dealing with contamination is expensive. Consider the following communities' experiences.
  - In **Perryton, TX**, carbon tetrachloride was detected in the ground water supply. Remediation cost this small community an estimated $250,000.
  - Pesticides and solvents in **Mililani, HI**'s ground water required the system to build and operate a new treatment plant. The plant cost $2.5 million, and annual operation costs are $154,000.
  - The towns of **Coeur d'Alene, ID** and **Atlanta, MI** have experienced contamination of their ground water supplies. Each had to replace its water supply, at costs of approximately $500,000.
  - Solvents and Freon in the ground water serving **Montgomery County, MD** are requiring the county to install water lines and provide free water to its customers. This has cost the County over $3 million, plus $45,000 per year for 50 years.
  - *Cryptosporidium* in **Milwaukee**'s river water sickened hundreds of people and required the city to upgrade its water system. The cost of the system improvements, along with costs to the water utility, city, and Health Department associated with the disease outbreak were $89 million.
- Preventing drinking water contamination can save communities similar response costs.

Saving Money Through Prevention

- Cost savings via complying with standards
- Monitoring waivers
- Water as a commodity or raw material -- quality matters

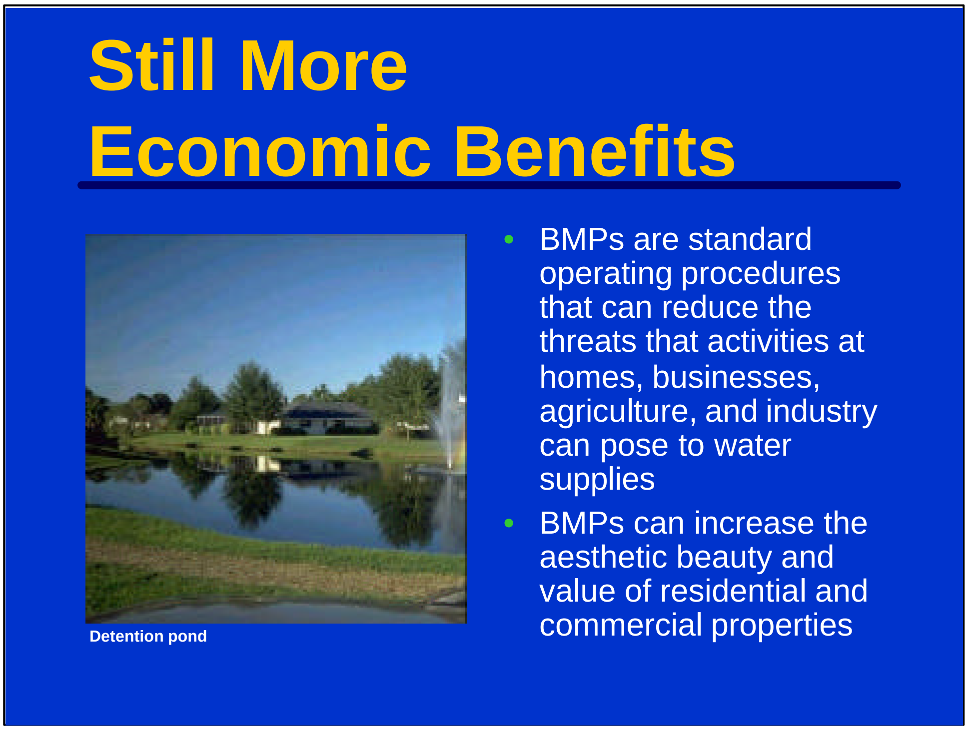
- Prevention can save communities money in other ways.
- Communities with effective drinking water contamination prevention programs may enjoy substantial **savings in the costs of complying** with SDWA or similar state regulations. For example, water purveyors that minimize algae growth by implementing programs that prevent nutrients from entering water supply reservoirs will likely minimize the cost for treating the water to remove total organic carbon in compliance with the Disinfection Byproducts Rule.
- Water suppliers with programs in place to prevent contamination of drinking water also may be eligible for **waivers** from some monitoring requirements, thereby reducing monitoring costs. Such waivers have already saved Massachusetts water systems approximately $22 million over the three-year compliance cycle, while Texas water systems saved $49 million over two and one-half years.
- In addition, **water can be thought of as a commodity** that water systems sell and farmers use as a raw material. Once it becomes contaminated, it loses value because it cannot be sold to customers, or it must be treated prior to being sold or used. Uncontaminated water has value to the PWS, determined by the price of water its customers are willing to pay.

Other Economic Benefits

- Real estate values
- Business development
  - Tax revenues
  - Jobs
- Recreation and tourism revenue

- Preventing contamination of drinking water can also help to **maintain real estate values** in areas served by protected water supplies. In regions affected by water supply contamination, declines in real estate values have been clearly documented, such as in Cape Cod, Massachusetts.
- Protecting water supplies may also **prevent the loss of existing or potential tax revenues and jobs** when businesses refuse to locate or remain near places with known or suspected problems. For example, a survey by the Freshwater Foundation found that five Minnesota cities collectively lost over $8 million in tax revenues because of real estate devaluation as a result of ground water pollution.
- Preventing contamination of a water supply that serves as a major scenic or tourist attraction can **safeguard local tourism and recreation revenues**. For example, the annual value of tourism and recreation in the Keuka Lake watershed in upstate New York was conservatively estimated at $15 million in 1996. Keuka Lake provides drinking water for the villages of Penn Yan, Hammondsport, Keuka Park, and Dresden.

> "The integrity of a town's water reflects upon the integrity of the companies within that town."
>
> *Sam Rowse, President of Veryfine Products in Westford, MA, on businesses' preference for communities with protected water supplies.*

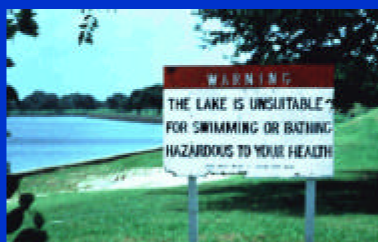


- Some best management practices, such as aesthetically designed runoff controls offer financial benefits in addition to their environmental benefits. When designed and sited correctly and safely, artificial **lakes or wetlands can increase the value of surrounding property** (and the tax revenue they generate).
- Developers often realize higher (and quicker) sales from homes adjacent to a wet pond; walking paths and fitness equipment can add to the aesthetics of the area and provide recreational uses, further increasing property values. In general, the proximity to water raises the value of a home, by up to 28 percent, according to a 1993 study conducted by the National Association of Home Builders.
- A few cases illustrate this point:
  - In the Sale Lake subdivision of Boulder, CO, lots surrounding a constructed wetland drew a 30 percent price premium over those with no water view.
  - In the Hybernia community of Highland Park, IL, waterfront lots surrounding a constructed detention pond/stream system draw a 10 percent premium above those with no water view.
  - BMPs can increase rental values as well. At the Lynne Lake Arms in St. Petersburg, FL, apartments or townhouses facing detention ponds on the property return rents of $15 to $35 more per month than those that do not. Similar trends are seen in rental fees for commercial property, such as office space in Fairfax County, VA.

Non-Monetary Benefits

- In addition to the monetary benefits of preventing contamination of drinking water supplies, there are benefits that are difficult (or controversial) to assign a dollar value. While difficult to quantify monetarily, they have a direct link to quality of life. Their importance may rival or exceed that of monetary benefits. For example, protection of human health is the driving force behind the Nation's water supply protection programs.
- Other quality of life benefits include safeguarding resources for future generations, building confidence in the water supply, and maintaining healthy ecosystems and opportunities for recreation.

Health Benefits



- Reduce risk to human health
  - illnesses and death
  - productivity and wages
  - medical expenses

- Preventing contamination of drinking water supplies should result in reduced risk to human health from both acute and chronic ailments. Overall, the U.S. is doing a good job delivering safe drinking water to the public, but challenges remain and may increase as new waterborne disease agents and chemicals are found in water supplies. Although most people experience only mild illnesses from waterborne microbes, pathogenic organisms such as *Cryptosporidium* and some strains of *E. coli* can be transmitted to people through drinking water and cause serious illness or even death.
- In addition to threats posed by microbial contaminants, other substances can contaminate water supplies. Metals, volatile organic carbons, synthetic organic chemicals, and pesticides can cause serious health problems for persons exposed to them over long periods of time at levels exceeding health-based drinking water standards. Potential health effects of long-term exposure to these pollutants include cancer, birth defects, and organ, nervous system, and blood damage.
- The health-related costs of contamination can include lost wages, hospital and doctor bills, and in extreme cases, death.

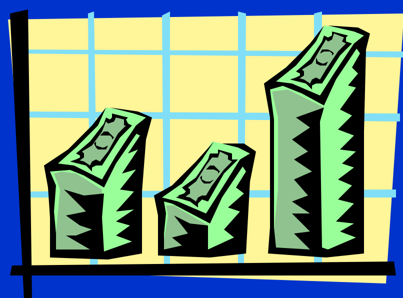
- Stewardship of water resources is an important goal for people in a community who care about the fate of their children and grand children. **Protecting water supplies for future generations** brings with it a sense of accomplishment and legacy, and generates an attitude of pride in the community.
- Effective communities often exhibit a prevailing attitude of **trust toward the local government** structure. If residents have a high level of confidence in the ability and commitment of the people on whom they depend for clean water, they are much more likely to be supportive of these departments on a day-to-day basis, as well as at town or city council meetings when programs and budgets are presented. This attitude is critical to continued success in providing high quality water.
- By ensuring clean water resources, a community helps to support the biological systems on which life depends. **Plant and wildlife ecosystems** benefit from clean water as much as people do. In addition to providing drinking water, clean water resources often **enhance recreational activities**, such as swimming, fishing, and boating. These and other activities, in addition to enhancing the quality of life for people who engage in them, may provide enormous tourism or other economic benefits to local economies.

The Costs of Prevention

- Vary based on the prevention measure(s) selected
- Differ from community to community

- Of course, there are costs associated with preventing contamination of drinking water supplies.
- The cost to an individual supplier or community greatly **depends on the types of preventive measures** it chooses to implement. Protective measures can be relatively simple and inexpensive (such as public education programs) to expensive (such as purchasing land or easements). Program costs include staffing; program planning, development, and administration; land or easement purchases; and structural management measures.
  - **Constructed management devices** such as wetlands and retention basins, can cost approximately $100,000 for a 50-acre site, plus the value of the land they occupy.
  - **Housekeeping measures** such as street sweeping cost public works departments depending on the frequency at which they are performed.
- These costs may **vary greatly from community to community** and place to place, and will depend on such factors as the value of real estate in a particular area and the measures the community selects to protect its water supplies.

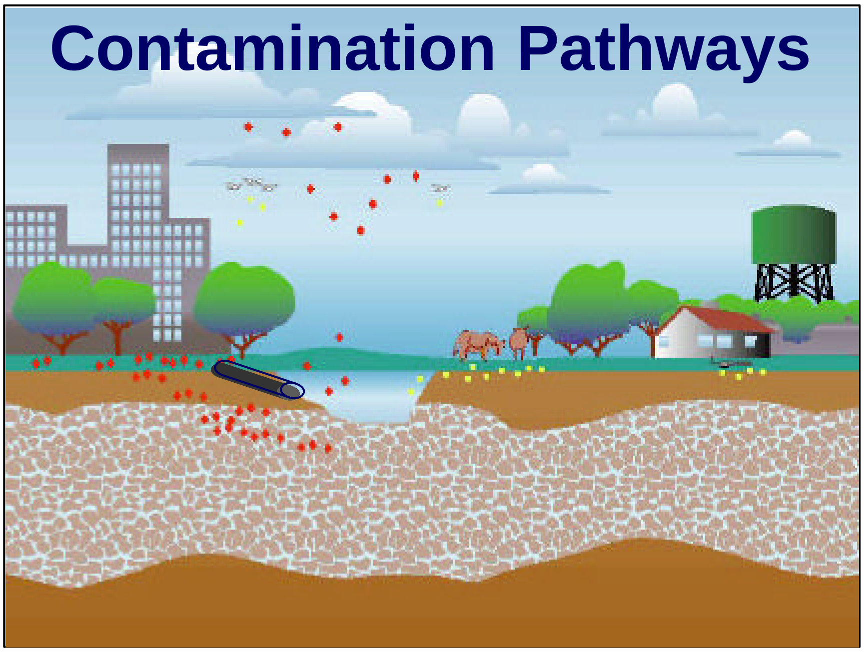
Comparing Costs and Benefits



- Responding to contamination can be as much as 200 times as costly as prevention

- EPA studied the contamination and prevention costs to six small- and medium-sized communities that experienced contamination of their ground water supplies and subsequently developed a wellhead protection program.
  - Costs of contamination included costs of remediation activities, replacing water supplies, and providing water.
  - Prevention costs include basic program costs for delineating a protection area, identifying potential sources of contamination, developing an initial management plan, and planning for alternative water supplies and other responses in case of an emergency.
  - The ratio of the benefits of avoiding contamination to the costs of the wellhead programs ranged from 5 to 1 to 200 to 1.

- Comparing the costs of contamination to the costs to prevention reveals that prevention programs are generally well worth the cost and effort as an effective "insurance" against contamination and its associated costs.
- If you add the considerable quality of life benefits that are potentially provided by a source water protection program, the program may prove to be a bargain.



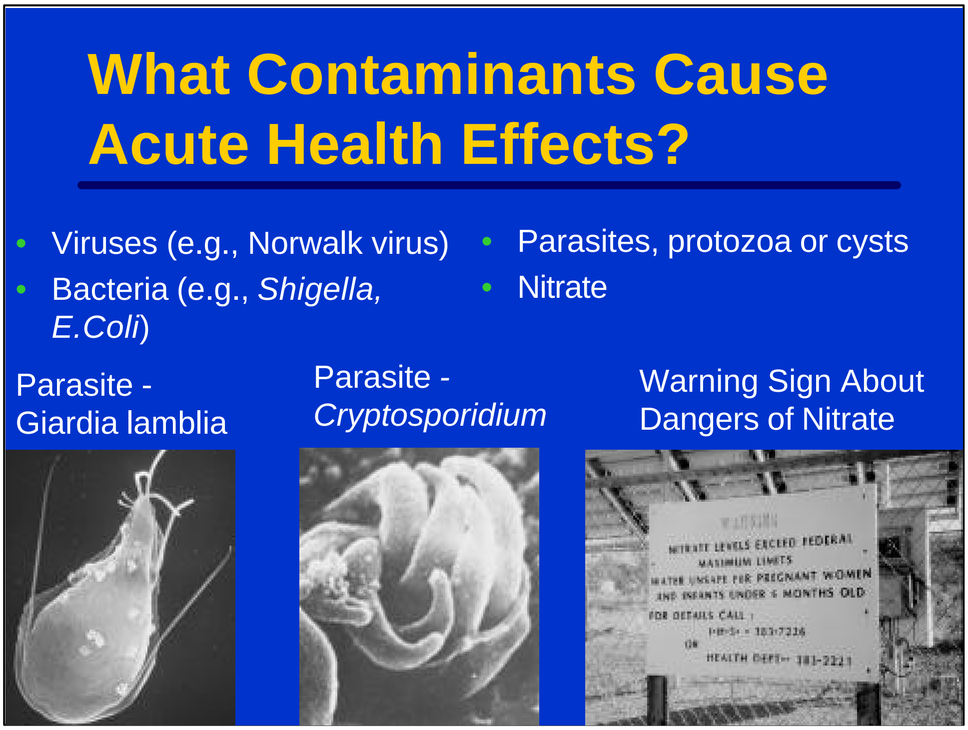
- ***Surface water*** is vulnerable to contamination from direct discharges, runoff and ground water inflow. Chemical and microbiological contaminants (represented by the red diamonds) may enter surface water through runoff, or through direct disposal into rivers or streams; acid rain may affect surface water sources; and contaminated ground water may interact with surface water and spread contamination. Surface water is vulnerable to both chemical and microbiological contamination and in most cases requires treatment, filtration and/or disinfection before it is safe to drink. Runoff from surface areas in a watershed, either near a drinking water supply intake or in upstream tributaries, may contain contaminants, including human or animal wastes (represented by the yellow circles). In addition, contaminated ground water may recharge streams or lakes spreading the contamination to a surface water source.
- ***Ground water***, which is protected by layers of soils and other subsurface materials, sometimes does not require treatment prior to use. However, ground water can become contaminated through infiltration from the surface, injection of contaminants through improperly constructed or defective injection wells (including septic systems), or by naturally occurring substances in the soil or rock through which it flows. Depending on the hydrogeologic setting, contaminants in ground water may migrate from the source and pollute water supplies far away. The properties of the ***aquifer*** (i.e.,ground water within the subsurface zone of saturation in sufficient quantities to support a well or spring) and overlying soils affect contaminant movement. For example, highly permeable aquifers conduct ground water flow quickly, allowing little time to detect a contamination plume before it reaches a drinking water supply.
- ***Ground water under the direct influence of surface water*** (GWUDI) faces the same risks as surface water and the same treatment should be used before using GWUDI as a source of drinking water.

What Health Effects Can Contaminated Source Water Cause?

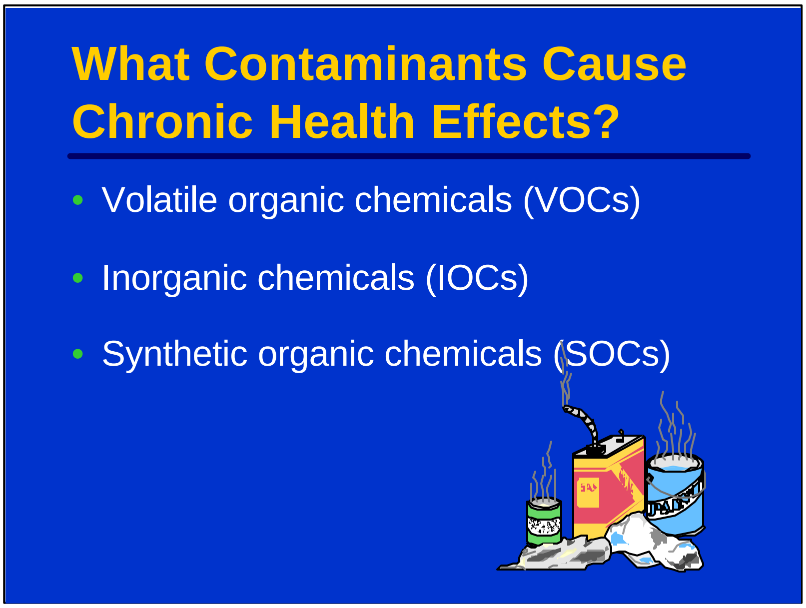
- Acute health effects

- Chronic health effects

- There are two major types of health effects—acute and chronic.
  - o ***Acute health effects*** are immediate (appearing within hours or days) effects that may result from exposure to certain contaminants such as pathogens (disease causing organisms) or nitrate that may be in drinking water.
    - – ***Pathogens*** are usually associated with gastrointestinal illness and, in extreme cases, death, especially among immuno-compromised individuals, such as AIDS patients.
    - – ***Nitrate*** in drinking water also poses an acute health threat to infants. High levels can interfere with the ability of an infant's blood to carry oxygen. This potentially fatal condition is called methemoglobinemia or "blue baby syndrome." Nitrates may also indicate the possible presence of other more serious residential or agricultural contaminants such as bacteria.
  - o ***Chronic health effects*** are the possible result of exposure over many years to a drinking water contaminant, especially at levels above its maximum level established by EPA. Chronic health effects include birth defects, cancer, and other long-term health effects. Contaminants causing chronic health effects are mostly chemical contaminants and include, among others, byproducts of disinfection, lead and other metals, pesticides, and solvents. For example, some disinfection byproducts are toxic and some are probably carcinogens. Exposure to lead can impair the mental development of children. However, there is usually little risk from short-term exposure to these contaminants at levels typically found in drinking water.



- ***Pathogens***, which can cause acute health effects, are microorganisms that can cause disease in humans, animals and plants. They may be bacteria, viruses, or parasites and are found in sewage, in runoff from animal farms or rural areas populated with domestic and/or wild animals, and in water used for swimming. Fish and shellfish contaminated by pathogens, or the contaminated water itself, can cause serious illnesses.
    - A ***virus*** is the smallest form of microorganism capable of causing disease. A virus of fecal origin is called an enterovirus and is infectious to humans by waterborne transmission. These viruses, such as the Norwalk virus and a group of Norwalk-like viruses, are of special concern for drinking water regulators. Many waterborne viruses can cause gastroenteritis, with symptoms that include diarrhea, nausea, and/or stomach cramps. Gastroenteritis can be fatal for people with compromised immune systems. The World Health Organization counts waterborne viruses as second only to malaria in lost work time and dollars in the global economy.
    - ***Bacteria*** are microscopic living organisms usually consisting of a single cell. Waterborne disease-causing bacteria include *E. coli* and *Shigella*.
    - ***Protozoa*** or ***parasites*** are also single cell organisms. Examples include *Giardia lamblia* and *Cryptosporidium*. *Giardia lamblia* was only recognized as being a human pathogen capable of causing waterborne disease outbreaks in the late 1970s. During the past 15 years, *Giardia lamblia* has become recognized as one of the most common causes of waterborne disease in humans in the United States. The protozoa *Cryptosporidium* (often called "crypto") is commonly found in lakes and rivers and is highly resistant to disinfection used in chlorine. *Cryptosporidium* has caused several large outbreaks of gastrointestinal illness.
    - ***Nitrate*** in drinking water at levels above 10 ppm is a health risk for infants less than six months old. High nitrate levels in drinking water can cause blue baby syndrome. Nitrate levels may rise quickly for short periods of time because of rainfall or agricultural activity.



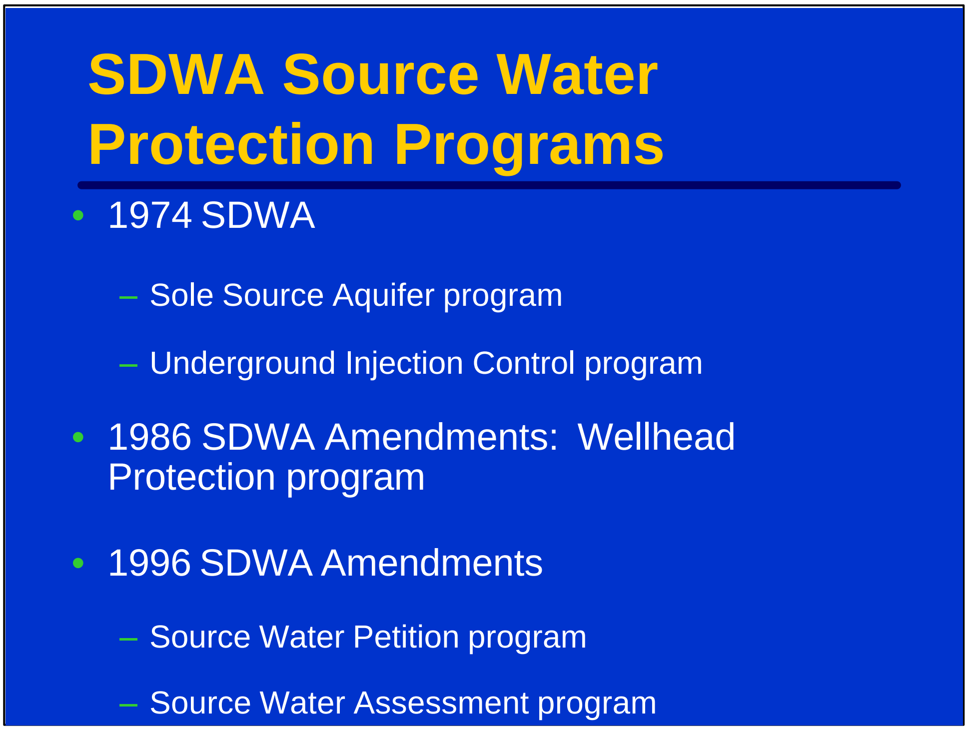
- Contaminants that can cause chronic health effects include byproducts of disinfection, lead and other metals, pesticides, and solvents. Sources of these contaminants include:
  - ***Commercial activities*** such as automotive repair facilities, laundromats and dry cleaners, airports, gas stations, photographic processors, and construction sites often use materials that are toxic.
  - ***Industrial activities*** such as chemical manufacturing and storage, machine or metalworking shops, and mining operations often use substances that can contaminate drinking water supplies.
  - ***Petroleum product storage*** in underground tanks is one of the greatest threats to ground water quality.
  - ***Agricultural activities*** such as use of pesticides, herbicides, and fertilizers applied to crops on farmland may be highly toxic and can remain in soil and water for many months or years. These same substances are used by millions of homeowners as well.
  - ***Urban*** activities such as improper disposal or leaks of household hazardous wastes, can seep into the ground or run into storm drains and contaminate ground water.
  - ***Other sources of water contamination*** include chemicals used for road de-icing and maintenance, landfills, and surface impoundments.
- ***Volatile organic chemicals*** (VOCs) vaporize at relatively low temperatures. They include mostly industrial and chemical solvents such as benzene and toluene. Benzene has the potential to cause chromosome aberrations and cancer from a lifetime exposure at levels above the maximum contaminant level. Toluene has the potential to cause pronounced nervous disorders such as spasms, tremors, impairment of speech, hearing, vision, memory, and coordination; and liver and kidney damage from a lifetime exposure, especially at levels above the MCL.
- ***Inorganic chemicals*** (IOCs) include metals and minerals. Some of these have the potential to cause chronic health effects. For example, lead has the potential to cause stroke, kidney disease, and cancer from a lifetime exposure, especially at levels above the MCL.
- ***Synthetic organic chemicals*** (SOCs) are man-made and include pesticides such as atrazine and alachlor. Atrazine has the potential to cause weight loss; cardiovascular damage; retinal and some muscle degeneration; and cancer from a lifetime exposure at levels above the MCL. Alachlor can cause eye, liver, kidney, or spleen problems; anemia; and an increased risk of cancer from life-time exposure, especially at levels above the MCL.

SDWA's Major Source Water Protection Programs

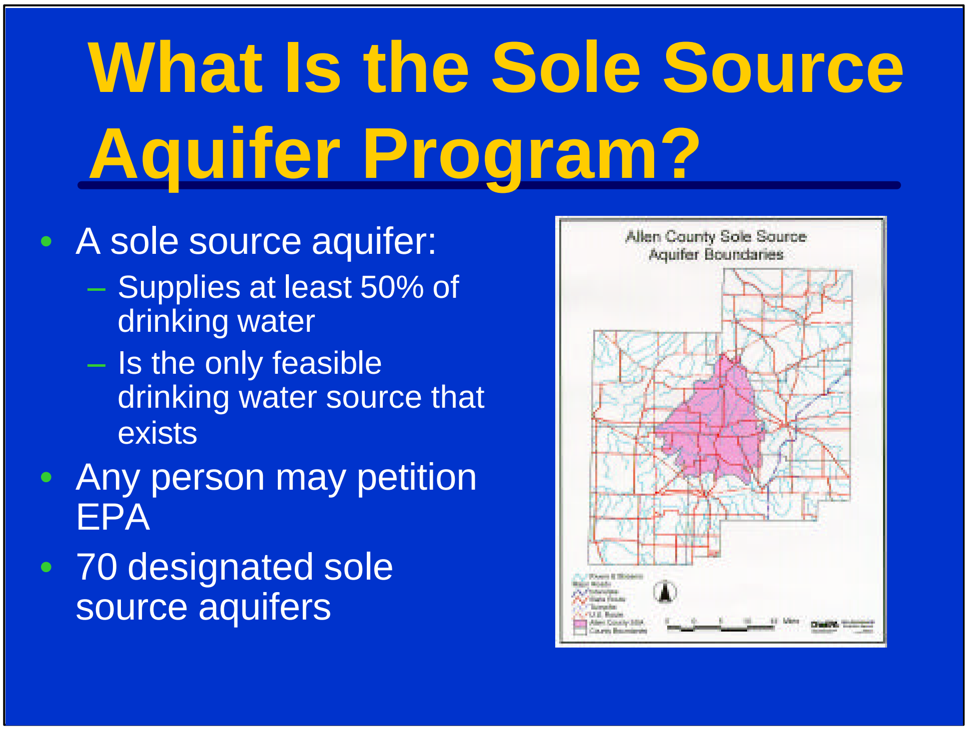
Historical Basis - Early State Approach

- Multiple barrier approach used by States since early 1900s included source selection and protection
- Sanitary surveys to check system from source to tap

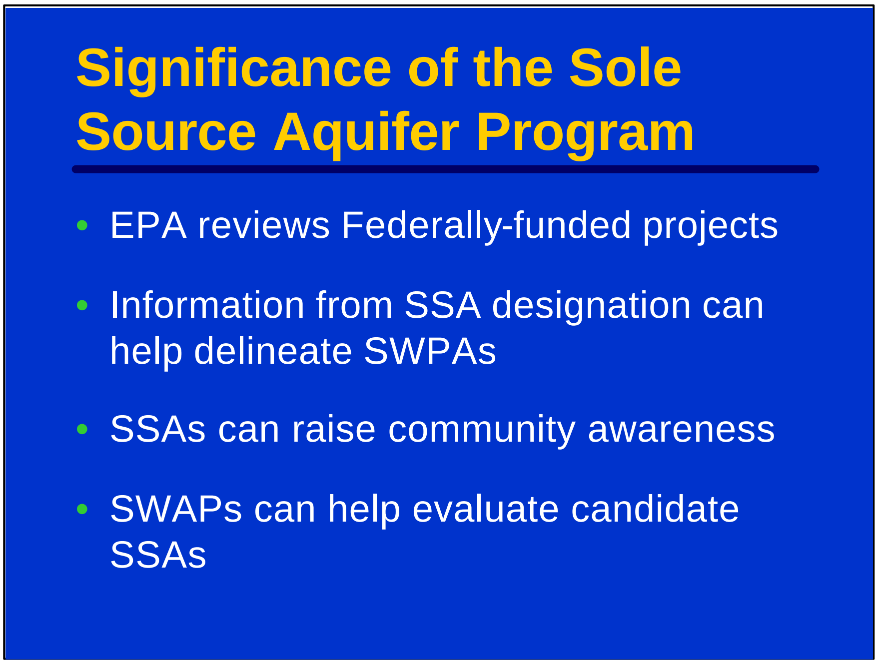
- In the 19th century, State public health agencies began to protect sources of drinking water in response to widespread epidemics attributed to drinking water contamination from pathogens. By the mid-1900s, State public health departments were well-established regulatory agencies.
- The predominant philosophy in these State programs was a multiple barrier approach to prevent or treat drinking water contamination. The first barrier was selection and protection of an appropriate source. For surface sources, this meant locating and constructing water intakes to ensure little or no contamination from fecal bacteria. For ground water sources, this meant constructing wells in appropriate locations, at appropriate depths, and with approved construction methods (e.g., casing and grouting).
- Other barriers included treatment (selected to be appropriate to the quality of the source water) and distribution (to promote full circulation and avoid stagnant water conditions that might facilitate microbial contamination). The integrity of distribution systems was periodically checked to avoid any type of cross-connection whereby untreated or contaminated water might enter the system.
- One method to implement the multiple barrier approach was to conduct routine sanitary surveys where State sanitarians or engineers inspected water systems and checked all components of the system from source to tap. Sanitary surveys identified problems and potential problems thereby preventing contamination of water supplies.



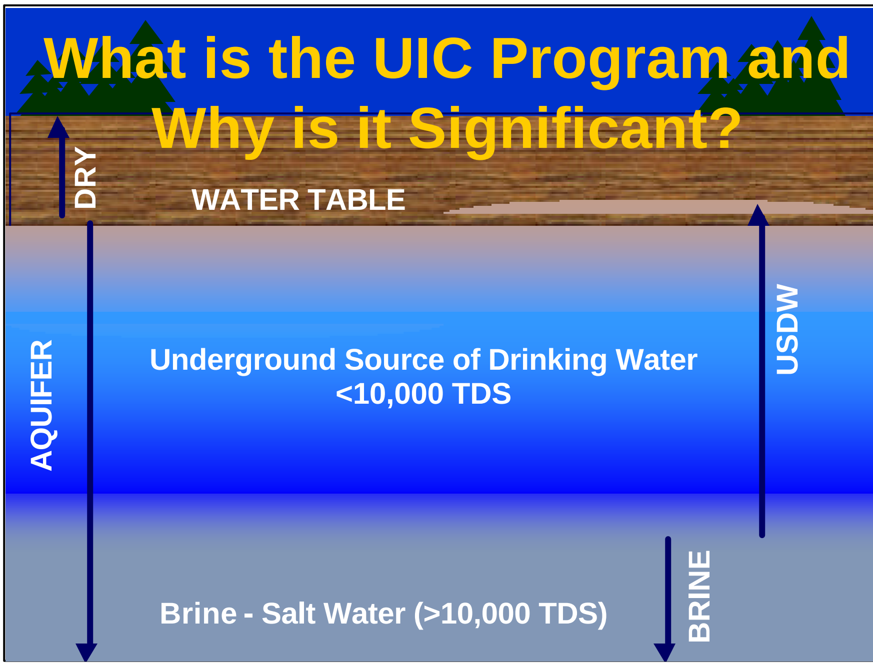
- The Federal government began a limited role in protecting drinking water with the creation of the U.S. Public Health Service (PHS) in 1912 and the PHS's subsequent regulation of drinking water in interstate commerce (e.g., on interstate carriers). Prior to 1974, States were responsible for protecting drinking water and ground and surface water sources.
- SDWA, first enacted in 1974, included provisions for a program to protect ground water sources -- the ***Sole Source Aquifer program***. This program prohibits Federal financial assistance for projects that might contaminate an aquifer that has been designated by EPA as a sole or principal source of drinking water for an area.
- The 1974 SDWA also included provisions for the ***Underground Injection Control*** (UIC) program. This program protects Underground Sources of Drinking Water (USDWs) from contamination through injection wells.
- The 1986 SDWA Amendments established the ***Wellhead Protection (WHP) Program*** in Section 1428. This non-regulatory program includes provisions to protect the surface and subsurface areas around public drinking water wells and offers communities a cost-effective means of protecting vulnerable ground water supplies.
- The 1996 Amendments established the Source Water Assessment Program (discussed later) and the ***Source Water Petition Program.*** This program, authorized by SDWA Section 1454, is voluntary for States, and is intended to support locally-driven efforts designed to address a limited number of contaminants identified in the statute. See the State Source Water Protection Programs Guidance (August 1997) at www.epa.gov/safewater/swp/swp.pdf for additional information.
- Except for the UIC program, EPA's ground water and source water programs are not regulatory. There are no enforceable national ground water standards. These programs typically educate, facilitate, coordinate, and assist with protection of ground water.



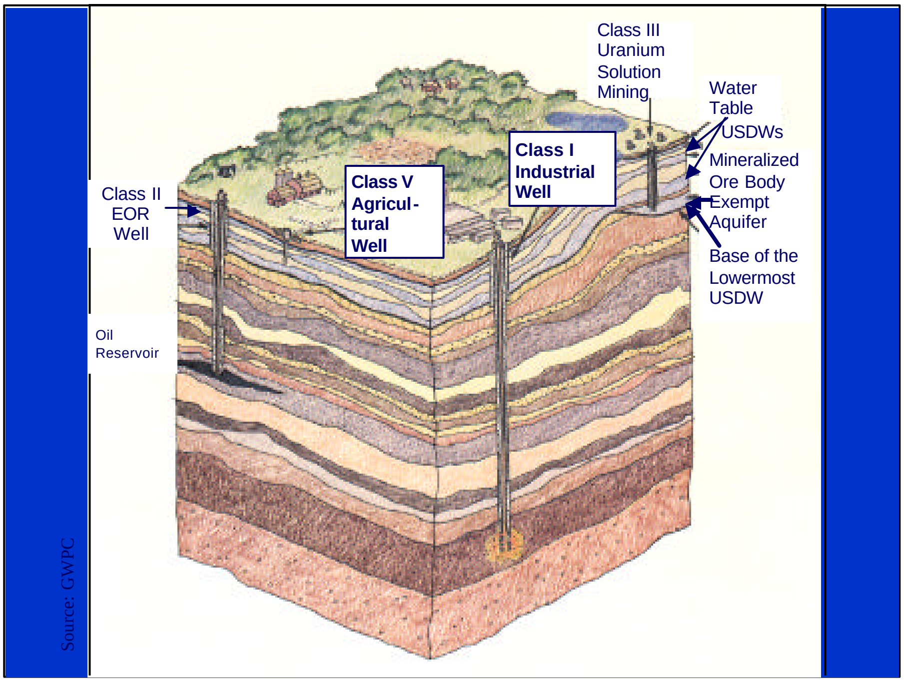
- The Sole Source Aquifer Protection Program is authorized by Section 1424 of the Safe Drinking Water Act of 1974. The program provides for EPA review of proposed Federal financially-assisted projects, such as highway improvements, wastewater treatment facilities, or agricultural projects that can potentially contaminate a designated sole source aquifer.
- A ***sole source aquifer***, or principal source aquifer:
  - o Supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer; and
  - o Is the only physically, legally, and economically feasible water source for all those who depend on the aquifer for drinking water.
- Any person or organization may apply to designate an aquifer as a sole source by submitting a petition to EPA. As of February 2000, there are 70 designated sole source aquifers in the U.S.



- Proposed projects with Federal financial assistance that have the potential to contaminate SSAs are subject to EPA review by a ground water specialist. This review may be coordinated with National Environmental Policy Act (NEPA) reviews and with relevant Federal, State and local agencies. Examples of projects that might be subject to review include highways, wastewater treatment facilities, construction projects that involve storm water disposal, public water supply wells and transmission lines, agricultural projects that involve the management of animal waste, and projects funded through Community Development Block Grants. Project reviews can result in:
  - EPA requirements for design improvements, ground water monitoring programs, maintenance and educational activities that would not otherwise occur; or
  - Direct technical assistance, by identifying specific activities that may lead to ground water contamination. In addition, technical assistance usually involves site-specific coordination of ground water protection activities among State and local environmental and public health protection agencies.
- The hydrogeologic and water usage information required by EPA during the process of designating a sole source aquifer can help define source water protection areas and determine the susceptibility of water supplies. Sole source aquifer project reviews can be a valuable source of information on potential contaminant sources in source water protection areas.
- A sole source aquifer designation can also increase community awareness on the use, value, and vulnerability of aquifers and build support for implementing various ground water protection efforts at the local level.
- The information from source water assessments can be used to help evaluate whether an area meets SSA designation criteria, and can provide useful information for project reviews, such as the location of delineated source water protection areas, potential or existing sources of contamination, and local variations in aquifer susceptibility.
- Some States have chosen to regulate activities in SSAs to provide additional ground water protection.



- The UIC program mission is to protect underground sources of drinking water from contamination by regulating the construction and operation of injection wells.
- Injection is defined as subsurface emplacement of fluids through a bored, drilled, or driven well or through a dug well where the depth of the dug well is greater than the largest surface dimension; or a dug hole whose depth is greater than the largest surface dimension; or an improved sinkhole; or a subsurface fluid distribution system.
- Protection of ground water from this potential source of contamination is significant since there are estimated to be more than 600,000 injection wells in the U.S. that dispose of a variety of wastes including hazardous waste. (Only a small portion of injection wells inject hazardous waste.)
- Underground sources of drinking water (USDWs) are important sources of drinking water. In order to understand the definition of a USDW, there are some basic concepts that must be understood.
  - Water contains dissolved minerals, especially salt. The salinity of water is expressed as Total Dissolved Solids (TDS), measured as parts per million (ppm) or the equivalent milligrams per liter (mg/L).
  - Water with between 0 and 500 mg/L TDS is considered to be suitable for human consumption. Water that has a higher salinity than drinking water may be used for many other purposes (e.g., agricultural and industrial uses). In addition, water containing up to 10,000 mg/L TDS can potentially be treated to reduce TDS to drinkable quality levels. Waters containing in excess of 10,000 mg/L TDS are called brine, or simply salt water.
- Thus, Underground Sources of Drinking Water are aquifers (geologic formations where water collects in quantities sufficient to support a well or spring) with less than 10,000 mg/L TDS.
- The graphic is a simplified picture of this. Whether there is a layer of fresh water with high TDS water underneath depends on the location.
- EPA regulates underground injection control wells in order to protect USDWs.

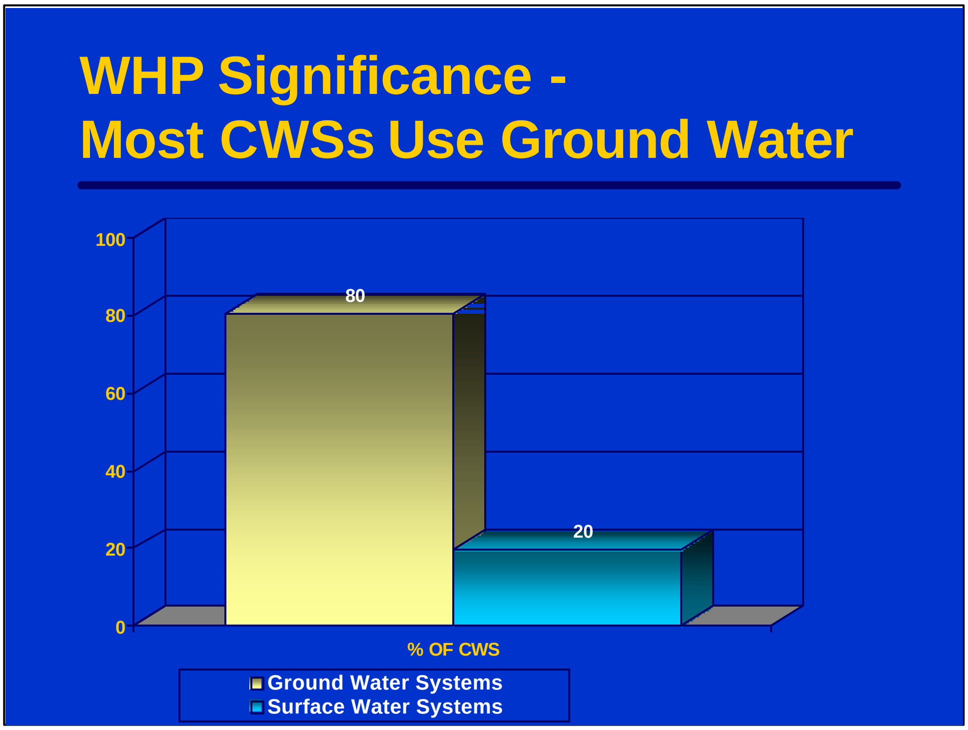


- Injection wells may be used to purposefully *inject* fluid; they may also serve as a conduit for fluids to drain or seep into the subsurface.
- Injection wells are used to put fluid *into* the subsurface versus drinking water wells which are used to take water *out of* the subsurface.
- There are many types of injection wells. In order to regulate the universe of wells, EPA established five classes of injection wells.
  - ***Class I wells*** are technologically sophisticated wells that inject large volumes of hazardous or non-hazardous wastes into deep, isolated rock formations.
  - ***Class II wells*** inject fluids associated with oil and natural gas production.
  - ***Class III wells*** inject super-hot steam, water, or other fluid into mineral formations, which is then pumped to the surface and the minerals are extracted.
  - ***Class IV wells*** inject hazardous or radioactive wastes into or above underground sources of drinking water. These wells are ***banned***. All existing Class IV wells were approved under State and Federal cleanup programs, such as those under RCRA or CERCLA.
  - ***Class V wells*** use injection practices that are not included in the other classes. Class V wells vary widely. Some are technologically advanced wastewater disposal systems used by industry, and others are "low-tech" holes in the ground.

What Is Wellhead Protection?

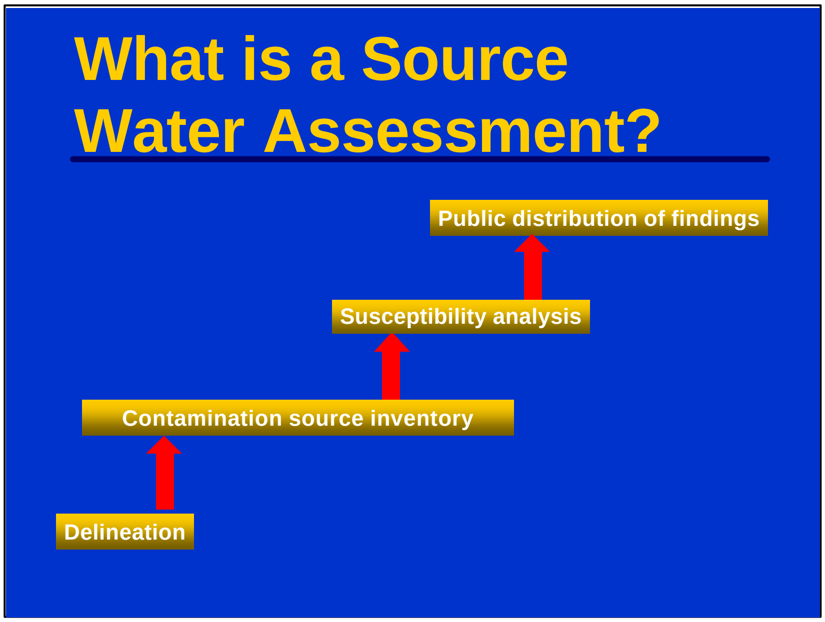
- Protection of ground water sources
- Authorized by SDWA Section 1428 of the 1986 Amendments
- EPA-approved, State-designed wellhead protection plans can receive Federal funding to protect ground water sources
- Requirements for Federal compliance

- ***Section 1428 of the 1986 SDWA Amendments created the Wellhead Protection (WHP) Program***, which offered communities a cost-effective means of protecting vulnerable ***ground water*** supplies. This program does not address surface water supplies.
- The 1986 Amendments required each State to submit a comprehensive State wellhead protection plan to EPA within three years. EPA reviewed the State-proposed wellhead protection programs; if a program was disapproved, the State could not receive Federal funds to implement its program. Congress believed that this enabled EPA to direct the use of scarce Federal dollars in the most effective way, while letting States continue to pursue their preventative programs. Currently, 49 States and two Territories have EPA-approved WHP programs.
- To establish wellhead protection programs, communities delineate vulnerable areas and identify sources of contamination. Through regulatory or non-regulatory controls, local officials and volunteers manage contamination sources and protect their water supply, as well as plan for contamination incidents or other water supply emergencies.



- Wellhead protection efforts are significant because many water systems use ground water as their primary source of drinking water.
- Of all community water systems (i.e., a public water system that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents), just over 80 percent rely on ground water as their primary source. Most of these systems are small systems. (Of community water systems, 93 percent serve fewer than 10,000 people.) Smaller water systems are more likely to choose ground water sources, which usually require less treatment and usually involve smaller capital expenditures.
- Although small systems relying on ground water are numerous, they serve only a small fraction of the population. For example, systems that serve 3,300 people or fewer make up over 85 percent of CWSs nationwide, yet serve less than 10 percent of the population.
- Wellhead protection efforts continue today and make up a significant part of the source water protection program.

Source Water Assessment Program



- ***Public Water System Supervision (PWSS) primacy States*** (i.e., States approved by EPA to administer a State PWSS program in lieu of the Federal PWSS program) ***are required by the SDWA Amendments of 1996, Sections 1453 and 1428(b), to complete a source water assessment for each public water system.*** These assessments can be done for each system or on an "area-wide" basis involving more than one PWS.
- A ***source water assessment*** provides important information for carrying out protection programs. In fact, Congress intended source water assessments to serve as the basis of local source water protection programs. This "know your resource and system susceptibility" part of protection involves identifying the land that drains to the drinking water source and the most prominent potential contaminant risks associated with it. To be considered complete, a source water assessment must include four components:
  - Delineation of the ***source water protection area*** (SWPA), the portion of a watershed or ground water area that may contribute water (and, therefore, pollutants) to the water supply.
  - Identification of all significant potential sources of drinking water contamination within the SWPA. The resulting ***contamination source inventory*** must describe the sources (or categories of sources) of contamination either by specific location or by area.
  - Determination of the water supply's susceptibility to contamination from identified sources. The ***susceptibility determination*** can be either an absolute measure of the potential for contamination of the PWS or a relative comparison between sources within the SWPA.
  - ***Distribution*** of the source water assessment results to the public. Assessments are not considered completed until results are communicated to the public.
- Several agencies within a State are likely to be involved in the effort to establish a plan to assess source water protection areas. Usually, environmental protection agencies or health departments take the lead; departments of agriculture or agricultural extension programs, and soil and water conservation boards may also be involved. States are also encouraged to initiate interstate or international partnerships to protect source water protection areas that cross borders.
- Local governments and water systems will be key partners in assessing source water and implementing local SWP programs. Local partners can provide input on assessments and gather local support for SWP management, especially where regulatory controls will be implemented.

Source Water Assessments as the Basis of Protection

- Provide important information
- May be used to prioritize protection activities

- Completed source water assessments provide important information. Typically, information collected during an assessment includes delineated protection areas, locations of wells and intakes, inventories and locations of potential contaminant sources, determinations of relative threats to drinking water sources, and hydrogeological data.
- Source water assessment information, in conjunction with other watershed assessment efforts, by identifying relative threats to water quality, can help water systems and localities determine protection priorities for addressing these threats.

Elements of State SWAPs

- Public participation in developing SWAP
- Plan to delineate areas, inventory contaminants, determine susceptibility
- Timetable for implementation, agencies involved, plan to update assessments
- Plan to make the results of assessments available to the public

- According to SDWA Section 1453, each State must develop and submit to EPA a ***Source Water Assessment Program (SWAP)*** that includes four elements:
  - Public, technical, and citizen advisory group involvement in the development of the State-wide SWAP.
  - A plan to complete source water assessments for each public water system (PWS) to identify watersheds and ground water recharge areas that supply public drinking water systems, inventory potential contaminant sources, and determine the water system’s susceptibility to contamination.
  - A plan to implement its chosen source water assessment approach, i.e., a timetable for completing assessments, roles of various State and other agencies, and plans for updating the assessments.
  - A plan to provide the public with access to the results of the susceptibility determination.
- All States were required to submit their SWAP strategies to EPA by February 6, 1999. EPA has since approved the States’ submittals. Each State has two years, plus a possible extension of up to 18 months, to complete all of its source water assessments after EPA approval of their SWAP.
- States must implement source water assessments according to the approved program.

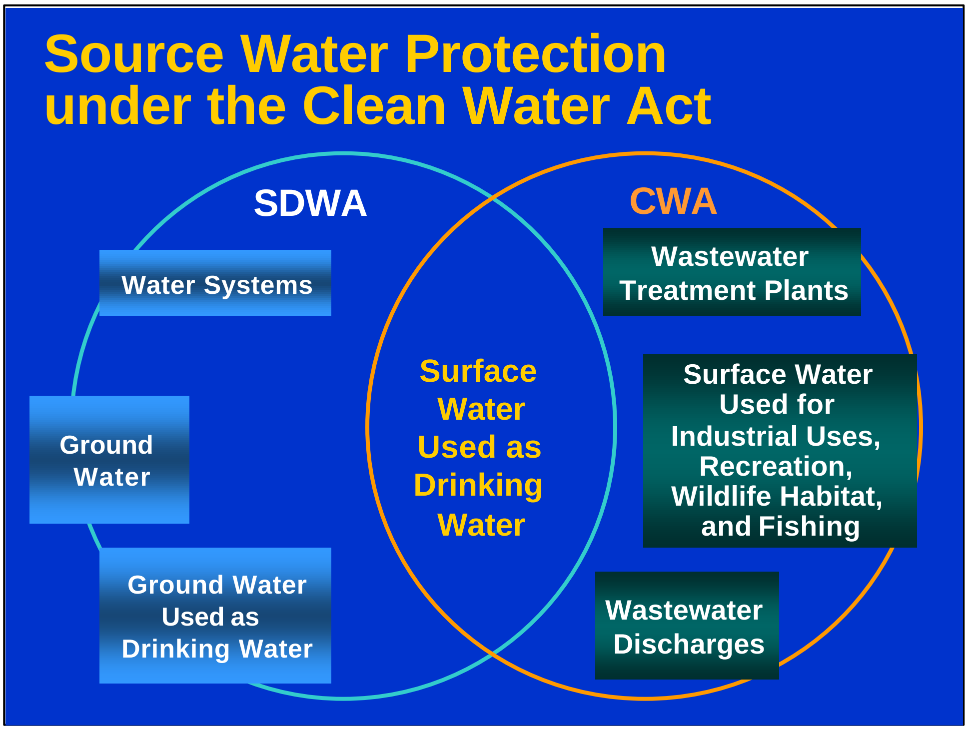
Other Source Water Protection Programs and Initiatives

- There are many programs administered by EPA and by other Federal agencies that can be used to protect source water, especially surface water.
- EPA-administered programs include those under the Clean Water Act. EPA also uses the hazardous waste and underground storage tank programs under the Resource Conservation and Recovery Act (RCRA); the Superfund program under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); and the pesticides program under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) to enhance source water protection.
- Other Federal agencies that administer relevant programs include the Departments of Agriculture, Transportation, and the Interior, the Army Corps of Engineers, and the U.S. Geological Survey.
- In addition, the National Environmental Policy Act (NEPA) provides an important opportunity to point out potential drinking water impacts and recommend alternative sites or mitigative measures.
- In addition to these programs, EPA is carrying out or supporting some key source water protection initiatives, including a Source Water Contamination Prevention Strategic Plan and source water protection field projects through grants to the National Rural Water Association and the Environmental Finance Center Network.

Source Water Protection Initiatives

- Source Water Contamination Prevention Strategy
- National Rural Water Association
- Environmental Finance Center Network

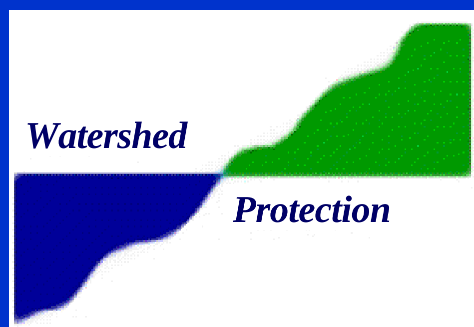
- EPA is working with the States and other partners to develop a Source Water Contamination Prevention Strategic Plan as a national framework for source water protection efforts. The **goal** of the plan is to ***protect current and potential drinking water sources and the health of those who rely on those sources***. The proposed long-term **vision** is that ***all interested stakeholders using a variety of tools in a coordinated fashion, establish barriers that significantly lower the risk of contamination entering current and potential drinking water resources***.
- The objectives of the plan will include enhancing coordination with Clean Water Act and other EPA programs and with other Federal agencies to better support local source water prevention priorities.
- The National Rural Water Association has hired new field technicians to help water systems and localities in 27 project areas in 11 States to develop and implement source water protection plans through 2001.
- The Environmental Finance Center Network is also helping water systems and localities develop and implement source water protection plans in eight project areas in eight States.



- The Safe Drinking Water Act and the Clean Water Act intersect in protecting surface water used as drinking water.

Source Water Protection under the Clean Water Act

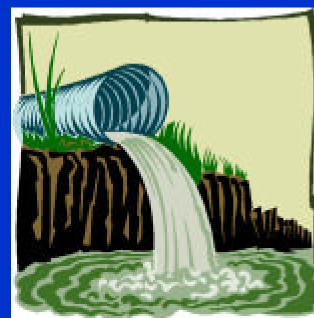
Clean Water Action Plan
RESTORING AND PROTECTING AMERICA'S WATERS



- The Clean Water Action Plan (CWAP) is a 1998 Presidential initiative. Its goal is to protect public health and restore the nation's waterways by emphasizing collaborative strategies built around all activities that affect bodies of water and the communities they sustain.
    - o The CWAP provides for cooperation between State, Federal, Tribal, regional, and local governments, as well as private partners. It provides a forum to collaborate on strategies for protecting and restoring priority watersheds.
    - o A key element of the Action Plan is the integration of public health and aquatic ecosystem goals when identifying priorities for watershed restoration and protection. The Action Plan assigns priority to drinking water source areas needing protection.
- Under the CWAP, States, Tribes, local governments, organizations and the public will work together to conduct unified watershed assessments. This process will assess watershed conditions; identify watersheds where aquatic systems do not meet clean water and natural resource goals; identify the highest priority watersheds for restoration and target a subset of that group for restoration action strategies; determine what other issues, such as protection of drinking water, need to be addressed; and ensure that all the appropriate stakeholders are involved in the process.
- Completed source water assessments can help Federal agencies direct protection programs to highest priority source waters and help guide agency decisions regarding placement and construction of new facilities.
- The signatories to the CWAP agreement include: EPA, the U.S. Postal Service, the Department of Energy, the Department of Transportation, the Department of the Interior, the Tennessee Valley Authority, the Department of Defense, the U.S. Department of Agriculture, and the Department of Commerce.

Source Water Protection under the Clean Water Act

- "Point" sources or "non-point" sources
- National Pollutant Discharge Elimination System (NPDES)
- Water quality standards
- Total Maximum Daily Loads (TMDLs)



- The CWA, SDWA's partner in water legislation, designates surface water contamination sources as "point sources" or "non-point sources." ***Point sources*** are direct discharges to a single point; examples include discharges from sewage treatment plants, and some industrial sources. ***Non-point sources*** are diffused across a broad area and their contamination cannot be traced to a single discharge point. Examples include runoff of excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas; oil, grease, and toxic chemicals from urban runoff and energy production; and sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks.
- The primary regulatory mechanism provided by the CWA is the ***National Pollutant Discharge Elimination System*** (NPDES) permit program. It requires permits for all discharges of pollutants to surface waters from pipes, outlets, or other discrete conveyances (i.e., point sources). Permits are not required, however, for non-point sources. Under the CWA, non-point source pollution is addressed through non-regulatory means.
- ***Water quality standards*** are set by authorized States and Tribes to restore and maintain the physical, chemical and biological integrity of the nation's waters and to meet the goal of "fishable/swimmable" water. A water quality standard consists of three elements:
  - o The designated beneficial use of a water body;
  - o The water quality criteria (i.e., the quality of the water) necessary to protect that use; and
  - o An antidegradation policy.
- Under CWA Section 303(d), States are required to identify waters that do not meet water quality standards after the implementation of nationally required levels of pollution control technology, and to develop ***Total Maximum Daily Loads*** (TMDLs) for those waters. TMDLs are used to determine the maximum allowable amount of pollutants that can be discharged to impaired waters. Based on this determination, pollutant loadings are allocated among pollution sources in a water segment. TMDLs also provide a basis for identifying and establishing controls to reduce both point and non-point source pollutant loadings. State lists that identify waters needing TMDLs, and TMDLs developed for specific water bodies, are a useful source of information for the development of source water assessments.

- There are many other Federal agencies that have programs that can contribute to source water protection.
- USDA's Natural Resource Conservation Service obtains advice from State Technical Committees, which may include State water agencies, on source water-related activities under the Environmental Quality Incentives Program (EQIP). State water program officials have opportunities to integrate source water assessment and protection objectives with USDA conservation program concerns. NRCS provides technical advice and some cost-share assistance to farmers on best management practices.
- USDA also sponsors the Farm*A*Syst and Home*A*Syst network of 50 State interagency programs that help farmers, ranchers and homeowners identify environmental and health risks on their property, and take voluntary actions to reduce these risks and protect drinking water. USDA has a number of other programs that foster source water protection, including the Cooperative State Research Education and Extension Service, the Forest Service, and the Rural Utilities Service.
- USGS provides scientific information on water resources, biological resources, mapping, and geology, to support wise management of our natural resources. USGS will provide water-quality and land-use data that may be useful in drinking water source assessments. In addition, on a cost-share basis, USGS can provide technical assistance on source water protection area delineation, including hydrogeological analyses, ground water age-dating and flow modeling, and delineation of ground water contributing areas using flow models.
- EPA and the Department of Transportation have a partnership to implement the Transportation Equity Act for the 21st Century (TEA-21), which includes provisions to ensure environmentally sound transportation systems.
- The Department of Transportation is also in the process of identifying drinking water unusually sensitive areas (USAs). DOT is evaluating Federal and State data sources in order to generate the drinking water USAs. This will allow transportation projects to be reviewed for potential drinking water impacts.

- The U.S. Fish and Wildlife Service within the Department of the Interior (DOI) has a National Wetlands Inventory Project that provides maps and digital wetland data with site specific classification and location information. Land management agencies at DOI, including the Bureau of Land Management, the National Park Service, the Bureau of Reclamation, and the Office of Surface Mining, can be important partners in coordinating source water assessments.
- EPA and the Army Corps of Engineers jointly administer Section 404 of the Clean Water Act, which regulates the discharge of dredged or fill material into waters of the U.S. This program can be used for watershed and special area management planning.
- The Council on Environmental Quality implements the National Environmental Policy Act (NEPA), which requires environmental assessments or environmental impact statements for Federally-funded activities. NEPA ensures that adverse environmental impacts will be avoided or mitigated through the assessment process.

Who Ultimately Protects the Source?

- States are uniquely positioned and qualified to foster comprehensive source water protection programs because they implement most existing water and natural resource programs.
- However, in order to be effective, source water protection ultimately has to be implemented as a community-based program. While Federal and State programs can guide source protection programs, source water protection activities are largely the responsibility of local jurisdictions.
- Implementing a source water protection program involves community support, public education, land use planning, and planning for emergencies — all locally-based concepts. It may also involve many localities cooperating with support from regional, State or Federal entities.
- The remainder of this course discusses source water contamination prevention measures that can be implemented at the local level.

Introduction to Source Water Contamination Protection Measures

What are Source Water Protection Measures?

- Practices to prevent contamination of ground water and surface water that are used or potentially used as sources of drinking water
- Protection measures form the first barrier to drinking water protection

- Protection of drinking water sources is important to prevent contamination. The cost of cleaning up often exceeds the cost of prevention.
- Many types of management measures are available to address threats identified within a watershed. These include land use controls, such as subdivision and zoning regulations; regulations, permits, and inspections; constructed or vegetative systems; and good housekeeping practices for proper use of equipment and chemical products or wastes; and other tools, such as public education.
- Protection measures are part of a multi-barrier approach to drinking water protection, along with treatment, monitoring, operator capacity, and maintenance of the distribution system.
- The following slides present measures that communities, businesses, and individuals can take to protect source water.

- Depending on their situation, local government officials can choose from a variety of regulatory and non-regulatory measures to address identified or potential threats to their water supplies.
- ***Regulatory controls*** include zoning ordinances and subdivision controls, construction and operating standards, health regulations (such as storage tank and septic tank requirements), and permitting or inspections.
  - Examples of local zoning ordinances to protect ground water and surface water sources of drinking water can be found at http://www.epa.gov/r5water/ordcom/ and http://www.epa.gov/owow/nps/ordinance/.
- ***Non-regulatory controls*** include purchase of property or development rights, encouraging the use of best management practices, public education, household hazardous waste collection programs, and economic incentives such as agricultural cost-share programs.
- A combination of these methods is usually necessary for an effective management plan. In addition, the same end can usually be achieved through different means. For example, setbacks can be achieved through permits or local ordinances. The range of feasible tools will depend on the local authority to regulate land uses, and the nature of the contamination threats.
- To see how communities are combining protection measures to protect their drinking water supplies, go to EPA's compilation of local case studies in source water protection at http://www.epa.gov/safewater/protect/casesty/casestudy.html. The local contacts listed at the end of each case study should be able to provide you with some tips on how to put together your own protection plan.

- Many of the available management measures are known as best management practices (BMPs). BMPs are standard operating procedures that can reduce the threat that normal activities at homes, businesses, agricultural lands or industry can pose to water supplies. BMPs have been developed for many activities and industries that store, handle, or transport hazardous or toxic substances. They can help prevent the release of these substances or control these releases in an environmentally sound manner, and encourage the adoption of voluntary design or procedural standards.

- Many management measures are available to prevent pollution, control contaminants at the source, or treat wastewater. One alone usually is not sufficient, and combinations of measures work best.
- In choosing the most appropriate measures, local government officials and water system operators should consider their situations, and may need to prioritize the implementation of specific measures to make the most of the resources available to them.
- Local government officials should look creatively at existing ordinances and regulations. They may be able to use rules passed for other reasons to address source water issues. For example, if special permits are allowed when necessary to protect public safety or health, it is possible that they could be used for source water protection.
- Selection of management measures will be based on a variety of factors, including the physical properties of the watershed (annual precipitation, soil type and drainage, ground water and surface water hydrology, and space limitations), land uses and potential contaminants, type of contamination problem (e.g., point source or non-point source), public acceptance of measures, cost, maintenance needs, and aesthetics.

Land Use Controls

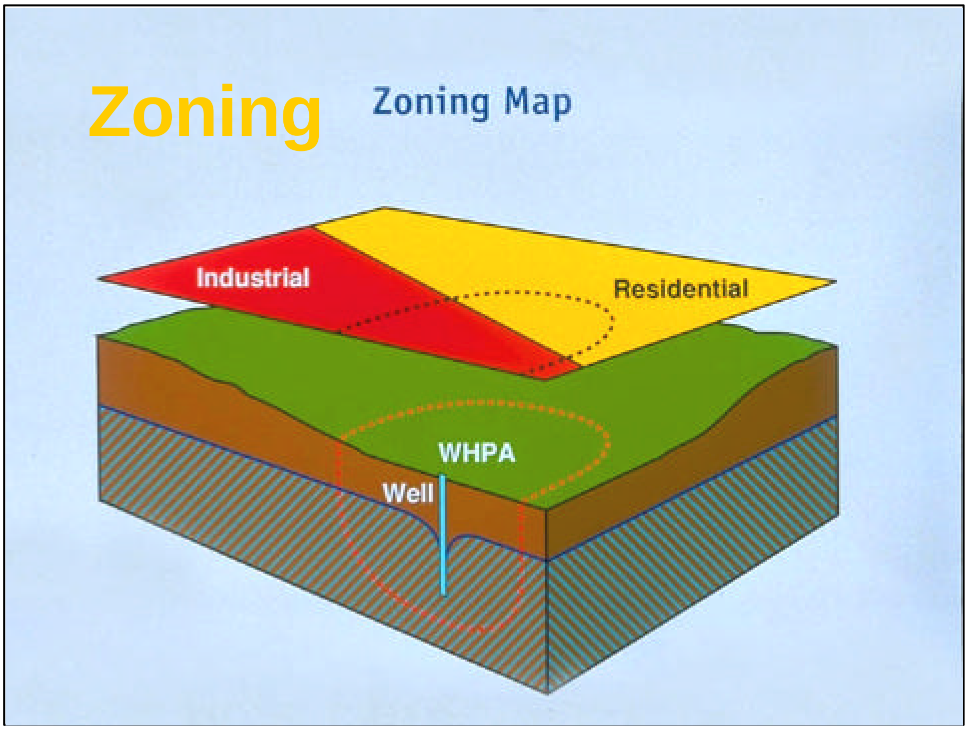
- Subdivision growth controls
- Zoning
- Land purchase
- Acquisition of development rights
- Land use prohibitions

- Land uses that pose risks to source water can be controlled or moved from sensitive areas. Local government officials can use subdivision and growth controls to reduce population density, or zoning ordinances to prohibit or restrict certain activities in SWPAs.
- By acquiring the rights to development on parcels of land through purchase or donation of the land, local government officials have complete control over the activities in critical areas.
- The high cost of purchasing property or development rights makes this impractical for many communities. Some States have grants for acquiring environmentally sensitive lands and non-profit organizations such as local or regional land trusts can assist communities by acquiring land within SWPAs. The American Farmland Trust and the Nature Conservancy are examples of non-profit organizations that focus on protection of water resources through land acquisition. USDA's Conservation Reserve Program also manages a program to obtain easements on environmentally sensitive land.
- Often, the greatest consideration in passing regulatory land use controls is the political acceptability of limiting certain activities. However, most people consider passing zoning ordinances to be the right and responsibility of local governments, and public education about the importance of protecting water supplies can increase the acceptance of land use controls.
- The next few slides describe land use controls for managing SWPAs.

Subdivision Growth Controls

- Primary purpose is to control division of land into lots suitable for building
- Can protect drinking water supplies from
  - Septic system effluent
  - Storm water runoff

- As the nation's population increases, sprawl and the proliferation of homes, businesses, and associated activities such as pesticide and fertilizer use, and septic systems, can threaten drinking water supplies.
- Subdivision regulations govern the process by which individual lots of land are created out of larger tracts. Subdivision regulations are intended to ensure that subdivisions are appropriately related to their surroundings. General site design standards, such as preservation of environmentally sensitive areas, are one example of subdivision regulations.
- Ways in which subdivision requirements can protect water supplies include:
  - Ensuring that septic systems and storm water infiltration structures do not contaminate ground water; and
  - Managing drainage (e.g., using erosion controls) to ensure that runoff does not become excessive as the area of paved surfaces increases and to provide recharge to aquifers.



- Zoning is the division of a municipality or county into districts for the purpose of regulating land use. Communities traditionally use zoning to separate potentially conflicting land uses from one another. Examples of how zoning can be used to protect drinking water sources include requirements that limit impervious surfaces, encourage open space, locate high risk activities away form drinking water sources, or encourage cluster development to reduce runoff. For example, Brunswick, Maine, adopted a threshold that no more than 5 percent of a site to be developed in its Coastal Protection Zone may be impervious area.
- Zoning is an effective regulatory tool for preventing threats to water sources from new development, and zoning ordinances are usually well-accepted as the prerogative of local governments. Unfortunately, zoning is of limited use in addressing threats from existing land uses, because they are "grandfathered" (i.e., exempt from new zoning requirements) when zoning laws take effect. Zoning ordinances may be difficult to pass where citizens want to encourage growth and economic development.
- Examples of local zoning ordinances to protect ground water and surface water sources of drinking water can be found at http://www.epa.gov/r5water/ordcom/ and http://www.epa.gov/owow/nps/ordinance/.

Land Purchase and Development Rights

- Land purchases
- Conservation easements
- Land trusts and conservancies

- The best way to control activities within sensitive areas is to purchase land and/or development rights to that land. Communities may purchase land outright or obtain conservation easements, which are voluntary arrangements preventing a landowner from performing certain activities or prohibiting certain kinds or densities of development. The easements become attached to the deed for the property, and remain in effect when it is sold or transferred. Restrictions in the deed make it clear that the land cannot be developed based on the rights that have been purchased.
- The primary disadvantage to purchasing property or development rights is the high cost, so it is impractical for many communities. Land trusts or conservancies can purchase land outright, or be recipients of conservation easements or land donations. Land owners can also gain tax benefits from donating their land for environmental protection. Some States offer grants or loans to communities for acquiring environmentally sensitive lands. Certain non-profit organizations such as local or regional land trusts, can assist communities by acquiring land.

Land Use Prohibitions

- Effective way to remove threats from sensitive areas
- Source-specific and chemical-specific standards

- Hazardous chemicals that are caustic, toxic, or volatile can endanger public health or water supplies. Authorities can opt to prohibit or limit the storage or use of large supplies of dangerous substances in sensitive areas.
- Land use prohibitions can be very effective ways to remove potential contamination sources from water supply areas. Because they are very restrictive, local government officials should use hydrologic studies to verify their necessity. If potentially threatening land uses already exist in the area, a phased-in approach may be more acceptable. For example, a ban on underground storage tanks could ban new USTs immediately, and phase out existing tanks as their service lives expire by requiring replacement tanks to be above ground.

- Land use prohibitions can be aimed at controlling either activities that use dangerous substances (source-specific standards) or the materials themselves (contaminant-specific standards).
- Examples of ***source-specific standards*** include:
  - o Prohibiting gas stations in sensitive areas, or requiring double-hulled or corrosion-resistant design of underground storage tanks.
  - o Septic system requirements, such as minimum setbacks from surface water or separations from the water table, or mandatory maintenance and inspections schedules.
- ***Contaminant-specific standards*** may prohibit the use of heavy metals, petroleum products, solvents, or radioactive materials in source water protection areas. Regulations on the application of pesticides, fertilizer, manure, and sludge are also examples of contaminant-specific standards.

Regulations and Permits

- Construction and operating standards
- Permit requirements
- Land use prohibitions
- Public health regulations

- Management measures can be imposed by regulation or through permit requirements. Local government officials can require owners of facilities that can endanger drinking water supplies to comply with standards for proper design, operation, or maintenance.
- In some communities, local government officials may encounter public resistance to regulations, and the cost to administer permitting or inspection programs can be high. However, regulations can be an effective way to control certain activities in source water protection areas. Most regulatory controls are subject to the provisions of State enabling legislation, and require careful drafting to avoid potential legal challenges.
- The next few slides describe regulatory options available to local government officials.

- Construction and operating standards may be imposed to reduce threats to water supplies from some activities. For example:
    - o Storage tanks may be required to have a double-hulled construction and leak detection systems.
    - o Homeowners with septic systems may be required to construct them using approved designs or maintain their systems regularly.
- Construction and operating standards may require some of the constructed devices, operating and maintenance practices, or product and waste disposal procedures described later in this section.

Permit Requirements

- Local authorities can require permits
- Permit fees can help recover program costs
- Permits can be site-specific
- Inspections enforce permit requirements

- Municipalities can require owners or operators of facilities that can pose a potential risk to water supplies to obtain permits. Permits allow authorities to maintain an inventory of potential contamination sources, periodically inspect facilities for compliance with ordinances, require minimum construction or operating standards (see previous slide), and periodically reexamine the appropriateness of the source or activity to determine if revisions (or discontinuance) are necessary.
- Permitting fees can help recover the costs associated with tracking and maintaining source-specific information.
- Existing Class V motor vehicle waste disposal wells are an example of a use for which a permit may be required.
- One provision of a permit may be periodic inspections. Inspections can identify people who are not complying with standards, and can also provide an opportunity to educate them about proper procedures and make sure they are following them.
- Permits can also be site-specific, and permit requirements can be tailored to the specific location or activity.

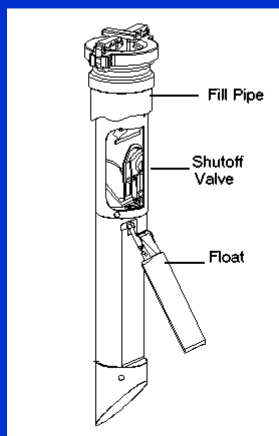
- Regulation by a local health department can help protect source waters. Examples of areas that health departments typically regulate are underground storage tanks, septic systems and floor drains.
  - Prohibition or registration of residential underground storage tanks, leak testing, ground water monitoring, and construction standards can help to reduce the risk from these tanks.
  - Regulations addressing the number and size of septic systems allowed in an area, construction and siting standards, bans on certain solvent cleaners, maintenance standards, and setback distances can help to ensure that septic systems do not contaminate source water.
  - Towns may implement controls prohibiting any floor drain that discharges to ground water when the drain is located in an area where pollutants may enter the drain.
- Health departments may regulate numerous other activities that could contribute to contamination of source waters. Coordination at the local level to ensure that the appropriate departments are involved in source water protection efforts is important.
- Health regulations are usually an accepted regulatory option for local governments. Although implementing a new program of inspections and enforcement may require significant resources, this infrastructure often already exists within local government. Local officials can direct or coordinate these resources to work on source water priorities.

Structural Measures

- Constructed systems or devices
- Vegetative measures

- Structural BMPs refer to man-made systems or devices designed to prevent contamination. They may work by preventing leaks or contamination, or stopping them at the source; collecting or diverting hazardous or toxic components of a waste stream; or encouraging filtration or infiltration of wastewater to allow natural processes to remove contaminants.
- Where they are not imposed by local regulations or ordinances (see above), land owners should be encouraged to adopt these BMPs.
- The next few slides describe and give examples of constructed and vegetative BMPs.

Constructed Systems or Devices



- Automatic shut-off and leak detection devices on USTS
- Secondary containment
- Drainage diversion
- Segregated floor drains
- Waste collection devices

- Constructed devices or retrofits to existing machinery or operations can detect equipment failures or leaks, contain contaminants at the source, or catch spilled chemicals. Examples include:
  - o Secondary containment structures, such as oil-retaining catch basins, containment berms for above ground storage tanks, or impervious surfaces for tank placement.
  - o At animal feeding operations, earthen ridges or diversion terraces to direct surface flow away from animal waste.
  - o Leak detection devices on storage tanks, including automatic tank gauges, vapor monitoring, interstitial monitoring, and ground water monitoring.
  - o Segregating floor drains from wastewater carrying hazardous or toxic wastes, such as photography development fluids.
  - o Devices to collect and store wastewater for proper disposal.

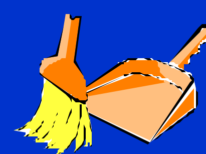
Vegetative Measures

Swales

- Natural vegetation is remarkably effective at filtering contaminants before they reach water bodies or seep into the ground water. It can also slow the speed of runoff to prevent erosion.
- Vegetative measures capitalize on these abilities to promote filtering or infiltration of waste water. They are often used to mitigate the damage caused by runoff over farm land, roads, or in urban areas.
- Examples include constructed wetlands, vegetated buffer strips along shore lines, or grassed swales or depressions that collect runoff, encourage infiltration, or reduce erosion.
- They often require little maintenance, other than proper management of runoff they collect, and can improve land values. For example, in residential areas real estate values may be higher for properties surrounding a constructed wetland. However, these vegetative measures also require proper management of runoff.

Good Housekeeping Practices

- Equipment operation and maintenance
- Product storage, use and handling
- Waste storage and disposal
- May be required by local ordinances or health regulations



- Homeowners and business owners should be made aware that careful handling of potentially dangerous substances and proper use of the equipment and chemicals they use every day can go a long way to protecting their water supply. These "good housekeeping" practices typically do not require significant expenditures or drastic changes to customary activities, and can often save money by eliminating waste of the products they buy.
- People should be encouraged to limit fertilizer applications to lawns and gardens, and properly store chemicals to prevent contamination of storm water runoff. Chemicals and oil should not be poured into sewers. Pet wastes, a significant source of nutrient contamination, should be disposed of properly.
- Employees should be trained in the use of BMP devices and safe use and storage of chemicals at the workplace.
- Some of these practices may be imposed by local ordinances or health regulations (such as maintenance requirements for septic systems). If not, their use should be encouraged through public education.

Equipment Operation and Maintenance

- Proper maintenance of vehicles and household, farm, construction, and industrial equipment prevents accidents, leaks, and breakdown of pollution preventing design. It also extends their service lives, saving owners money.
  - Septic system maintenance reduces the threat of leakage of the tank and possible contamination of ground water by pathogens. It can also save home and business owners money by avoiding costly repairs.
  - Vehicle maintenance increases the life span of cars and trucks, construction vehicles, and farm equipment. Properly maintained equipment reduces the likelihood of spills and accidents, and offers other environmental benefits, such as reducing air pollution.
  - Washing vehicles before they leave a construction site keeps sediment on the site and out of roadway storm sewers.
  - Inspecting storage tanks for potential leaks helps to ensure that chemicals do not spill on the ground or seep into the ground water. Avoiding leaks saves the tank owner money on the purchase of the substance stored.
  - Keeping equipment properly calibrated (e.g., for fertilizer and pesticide application) is also important.

Product Storage, Use and Handling

- Properly used, most chemical products available to homeowners are safe for the environment. One of the most basic aspects of proper product storage and use is following the manufacturer's directions. Land and business owners should understand that reading and following the directions on the label of pesticides, fertilizers, and automotive products can protect their drinking water supply. Other safe product use and handling practices include the following:
  - Pesticide and fertilizer application equipment should be loaded over impervious surfaces, so that any spills can be cleaned without seeping into ground water. Farmers and homeowners should purchase only what they need, and store and apply excess product to plants or crops during subsequent applications, or give leftovers to a neighbor instead of throwing them out.
  - Selecting appropriate low sudsing, low phosphate, biodegradable detergents at vehicle washing operations maximizes the effectiveness of oil/water separation and retention in control devices.

Proper Waste Storage and Disposal

Photos: Texas Chapter, APWA

- Relatively small amounts of waste from leaking containers and dumping dangerous substances (which may be illegal) can contaminate large volumes of water.
- Proper storage of products and disposal of wastes is important to protecting water supplies. For example:
  - o Recycling used oil and automotive fluids, batteries, pesticides and fertilizers, and household hazardous materials can be encouraged with community hazardous waste collection days.
  - o Absorbent pads should be kept at facilities where chemicals are used to quickly clean and contain spills.
  - o Storage above ground is preferred to underground storage, as this makes it easier to discover leaks.
  - o Motor vehicle fluids such as oil and gasoline, and pesticides should be stored in a covered structure, away from the elements to prevent damage to containers.

- Public education is critical to a drinking water supply management program. As people become aware of the importance of protecting their water supply and how easily this can be accomplished, management measures have a greater chance of success.
- Encouraging homeowners and farmers to manage their land in an environmentally responsible manner reduces risks due to contaminated runoff.
- Governments may provide financial incentives to encourage activities that protect sources of drinking water. For example, payments to farmers are available under the U.S. Department of Agriculture's Conservation Reserve Program for constructing vegetated buffer strips, and under the Environmental Quality Incentives Program for constructing animal waste control structures.
- Emergency response planning is the last step in the process: if protective measures should fail or disaster strikes, a response plan is key to mitigating adverse effects.
- These tools for source water protection are described on the next few slides.

Public Education

- Many people inadvertently contribute to pollution simply because they do not realize that their activities can contaminate water supplies. A public education campaign can explain how each business and household can protect drinking water sources.
- Appropriate topics for households include environmentally responsible landscaping and lawn care; safe use of pesticides, herbicides, and motor vehicle fluids; care of septic systems; proper disposal of chemicals and used oil (never to sewers or septic tanks); and water conservation techniques.
- Many communities have developed public education programs designed to encourage adoption of BMPs and waste minimization strategies.
- Public education can also build support for regulatory initiatives.

Responsible Land Management

- Land owners should be encouraged to conduct activities in a manner that reduces threats to drinking water supplies. Environmentally responsible land management does not mean that people must cease certain activities or make drastic changes to their businesses, rather that they re-think the way they go about their activities. For example:
    - o Environmentally sensitive landscaping relies on native plants that grow dense root systems to encourage infiltration and reduce erosion. These plants have the best chance for survival with the least amount of watering, pesticides, and fertilizers, saving the land owner money.
    - o Proper lawn maintenance involves aerating soils and planting climate-appropriate species of grasses that need the least chemical assistance to thrive.
    - o Conservation tillage, crop rotation, contour strip farming (shown above), and animal grazing management can protect valuable farm land and reduce loss of pesticides and nutrients to the environment and sediment.
    - o Integrated pest management is the coordinated use of pest and environmental information with available pest control methods to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to people, property, and the environment.
- Financial incentives are available from the U.S. Department of Agriculture for some of these agricultural measures.

- Despite the best management measures, accidents or disasters can happen. Local government officials should be prepared for unforseen circumstances. Emergency response planning or contingency planning is the process of identifying potential threats and formulating response scenarios.
- An emergency response plan is a set of "what ifs" about things that can adversely affect water supplies, and how local government officials would respond.
- Elements of municipal emergency response plans should include information about the water system, potential contamination sources and their locations, fire-fighting plans, needed equipment and supplies, surface spill reporting forms and names and phone numbers of emergency response contacts, and short- and long-term water supply options.
- Business owners may also be required to have emergency response plans on file if, for example, they handle or use hazardous materials and are subject to the Emergency Preparedness and Community Right-to-Know Act (EPCRA) or the Resource Conservation and Recovery Act (RCRA).
- Municipalities should have written emergency response plans on file, and responding parties such as police and fire departments, health officials, and response contractors and public water suppliers should be aware of them.

Source Water Protection Measures for Specific Sources

- This section will discuss protection measures for specific sources:
  - Storm water runoff;
  - Septic systems;
  - Above and underground storage tanks;
  - Vehicle washing;
  - Small quantity chemical use, storage and disposal;
  - Animal waste from livestock, pets, and wildlife;
  - Agricultural application of fertilizers;
  - Turf grass and garden application of fertilizers;
  - Large-scale application of pesticides;
  - Small-scale application of pesticides;
  - Combined and sanitary sewer overflows;
  - Aircraft and airfield deicing operations;
  - Highway deicing operations; and
  - Abandoned wells.
- For each source, we will discuss places where the source can be found; why it should be managed; and best or most-used protection measures.

- ***Storm water runoff*** is rain or snow melt that flows off the land, from streets, roof tops, and lawns. Urban and suburban areas are predominated by impervious cover including rooftops of buildings and other structures; pavement on roads, sidewalks, and parking lots; and impaired pervious surfaces (compacted soils) such as dirt parking lots, walking paths, baseball fields and suburban lawns. Storm water can also be a problem in rural areas if there is not sufficient vegetation or other means of controlling erosion.
- Storm water runoff is a major contamination pathway for many of the specific sources we will discuss in this section. Oil, gasoline, and automotive fluids drip from vehicles onto roads and parking lots. Storm water runoff from shopping malls and retail centers also contains hydrocarbons from automobiles. Landscaping by homeowners, around businesses, and on public grounds contributes pesticides, fertilizers, and nutrients to runoff. Construction of roads and buildings is another large contributor of sediment loads to waterways. In addition, any uncovered materials such as improperly stored hazardous substances (e.g., household cleaners, pool chemicals, or lawn care products), pet and wildlife wastes, and litter can be carried in runoff to streams or ground water. Illicit discharges to storm drains (of used motor oil, for example), can also contaminate water supplies.
- All of this impervious area prohibits the natural infiltration of rainfall through the soil, which could filter some contaminants before they reach ground water, or slow runoff. Development also reduces the amount of land available for vegetation, which can mitigate the effects of rapid runoff and filter contaminants. When the percentage of impervious cover reaches 10 to 20 percent of a watershed area, degraded water quality becomes apparent.
- When runoff is confined to narrow spaces, such as streets, the velocity at which water flows increases greatly. This contributes to erosion and increased flooding (especially in areas without vegetative cover), sedimentation into surface water bodies, and reduced ground water recharge. Sediment deposited in streams can increase turbidity; provide a pathway for pathogens and viruses; decrease reservoir capacity; smother aquatic species, and lead to habitat loss and decreased biodiversity of aquatic species.
- The protection measures that follow can be used to control runoff from the many urban and rural sources of potential source water contamination.

Storm Water Runoff

- Nonstructural measures to control runoff
  - Good housekeeping
  - Public education
  - Roadway maintenance
  - Erosion and sedimentation control measures

Sewer stenciling

- Nonstructural pollution source control and protection measures include ***public education*** to homeowners and business owners on good housekeeping, proper use and storage of household toxic materials, and responsible lawn care and landscaping; storm drain stenciling; hazardous materials collection; and eliminating illegal discharges. ***Building and site-development codes*** should encourage best management practices.
- On roadways, ***proper maintenance of rights-of-way***, including chemical and nutrient control, street cleaning or sweeping, storm drain cleaning, and use of alternative or reduced de-icing products can reduce the pollutant content of runoff.
- Without appropriate ***erosion and sedimentation control (ESC) measures***, construction activities can contribute large amounts of sediment to storm water runoff. Erosion can be controlled by planting temporary fast-growing vegetation, such as grasses and wild flowers. Covering top soil with geotextiles or impervious covers will protect it from rainfall. ***Good housekeeping measures for construction sites*** include construction entrance pads and vehicle washing to keep sediment and soil on-site. Construction should be staged to reduce soil exposure, or timed to coincide with periods of low rainfall and low erosion potential, such as in the fall, rather than during spring rains. Other measures include sediment traps and basins; sediment fences; wind erosion controls; and sediment, chemical, and nutrient control. Ordinances can require plan reviews of construction activities to ensure that erosion is minimized, or require ESC measures during construction. Inspections and repairs will maintain the working order of ESC measures.
- Local governments can use a variety of ***land use controls*** to reduce the flow of contaminants into storm water. For example, subdivision controls help to ensure that expected development will not compromise protection of drinking water. Requiring proper drainage management (e.g., erosion control) in new developments will ensure that runoff does not become excessive as areas of paved surfaces increase. ***Low impact development*** incorporates maintaining pre-development hydrology, considering infiltration technology, re-routing water to recharge the aquifer, and minimize disturbances from development.

Storm Water Runoff

- Engineered devices to control runoff
  - Grassed swales
  - Buffer strips
  - Filter strips
  - Wet ponds
  - Constructed wetlands
  - Infiltration practices
  - BMPs for Class V wells

Porous design minimizes impervious area

- Constructed devices work by encouraging infiltration, or filtration and settling of suspended particles, or a combination of these processes.
- For example, ***minimizing directly connected impervious areas*** is important to reducing the flow and volume of runoff. Planners should direct runoff from roofs, sidewalks, and other surfaces over grassed areas to promote infiltration and filtration of pollutants prior to surface water deposition.
- ***Porous design of parking lots*** also provides places for storm water to infiltrate to soils. Concrete grid pavement is typically placed on a sand or gravel base with void areas filled with pervious materials such as sand, gravel, or grass. Storm water percolates through the voids into the subsoil.
- ***Planting landscaped areas*** lower than the street level encourages drainage.
- It is important when designing these devices to use the right materials and, after construction, to conduct appropriate maintenance.

Storm Water Runoff

Grassed swale

Filter strip

- ***Structural designs*** are used to control runoff or temporarily store storm water on site. A number of structural devices have been developed to encourage filtration, infiltration, or settling of suspended particles.
- ***Grassed swales*** (shown on the left) are shallow, vegetated ditches that reduce the speed and volume of runoff. Soil removes contaminants by infiltration and filtration. Vegetation, or turf, prevents erosion, filters out sediment, and provides some nutrient uptake. Maintenance involves regular mowing, re-seeding, and weed control, along with inspections to check for erosion and ensure the integrity of the vegetative cover. To function appropriately, the inflow to the swale must be sheet flow from a filter strip or impervious surface (not at the end of a pipe). Swales have demonstrated solids removals exceeding 80 percent. Swales should preferably be planted with native plants and regularly maintained to ensure continued proper operation.
- ***Grassed waterways*** are wide, shallow channels lined with sod, used as an outlet for runoff from terraces. They are used to prevent gully erosion, rather than for filtering pollutants. Like swales, they require regular maintenance and should be planted be native plants.
- ***Buffer strips*** are combinations of trees, shrubs, and grasses planted parallel to a stream. Buffer strips should consist of three zones—about four or five rows of trees closest to the stream, one or two rows of shrubs, and a 20 to 24 foot wide grass zone on the outer edge. They decrease the velocity of runoff to moderate flooding and prevent stream bank erosion, but do not necessarily increase infiltration.
- ***Filter strips*** (shown in the right photograph) are areas of close-growing vegetation on gently sloped land surfaces bordering a surface water body. They work by holding soil in place, allowing some infiltration, and filtering solid particles out of the runoff from small storms.

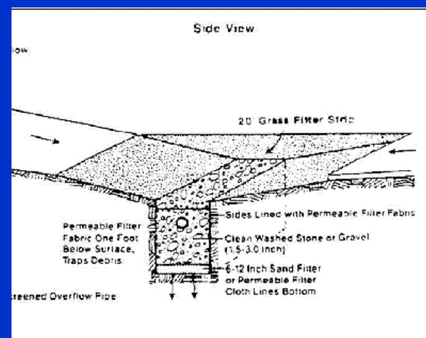
Storm Water Runoff

Photo: Texas Chapter, APWA

Wet Ponds and Constructed Wetlands

- ***Storm water ponds***, or wet ponds (shown above), consist of a permanent pond, where solids settle during and between storms, and a zone of emergent wetland vegetation where dissolved contaminants are removed through biochemical processes.
- ***Constructed wetlands*** are similar to wet ponds, with more emergent aquatic vegetation and a smaller open water area. Storm water wetlands are fundamentally different from natural wetlands in that they are designed to treat storm water runoff, and typically have less biodiversity than natural wetlands. A wetland should have a settling pond, or forebay, if significant upstream soil erosion is anticipated. Coarse particles remain trapped in the forebay, and maintenance is performed on this smaller pool. Wetlands remove the same pollutants as wet ponds though settling of solids and biochemical processes, with about the same efficiency.

Storm Water Runoff



Infiltration Practices

- ***Infiltration practices (basins and trenches)*** are long, narrow stone-filled excavated trenches, three to 12 feet deep. Runoff is stored in the basin or in voids between the stones in a trench and slowly infiltrates into the soil matrix below, where filtering removes pollutants. Infiltration devices alone do not remove contaminants, and should be combined with a pretreatment practice such as a swale or sediment basin to prevent premature clogging. Maintenance consists of inspections annually and after major rain storms and debris removal, especially in inlets and overflow channels. Infiltration devices and associated practices can achieve up to 70 to 98 percent contaminant removal.
- ***Infiltration chambers*** can also be used for septic and storm water management. Infiltration septic chambers replace conventional stone and pipe leach fields. A subsurface infiltration storm water system replaces retention ponds, large diameter pipe and stone, and other storm water designs. Infiltration chambers have been used in drainfield, leach field, mound, and sand filter applications. However, maintenance can be difficult. They are sometimes hard to monitor and to dig up.
- ***Swirl-type concentrators*** are underground vaults designed to create a circular motion to encourage sedimentation and oil and grease removal. The currents rapidly separate out settleable grit and floatable matter, which are concentrated for treatment, while the cleaner, treated flow discharges to receiving waters. Swirl concentrators have demonstrated total suspended solids and BOD removal efficiencies exceeding 60 percent.

Storm Water Runoff

Storm drain

- Storm water drainage wells (Class V)
- Protection measures for Class V wells
  - Siting
  - Design
  - Operation

- Protection measures for Class V storm water drainage wells address siting, design, and operation of these wells.
  - o ***Siting measures*** for storm water drainage wells include minimum setbacks from surface waters, drinking water wells, or the water table. Storm water drainage wells may also be prohibited from areas of critical concern, such as source water protection areas, or from areas where the engineering properties of the soil are not ideal for their performance.
  - o Available ***design measures*** for storm water drainage wells include sediment removal devices (such as oil/grit separators or filter strips), oil and grease separators, and pretreatment devices such as infiltration trenches or wetlands. Maintenance of these BMPs is crucial to their proper operation.
  - o Management measures related to ***operation*** include spill response, monitoring, and maintenance procedures. Source separation, or keeping runoff from industrial areas away from storm water drainage wells, involves using containment devices such as berms or curbs.

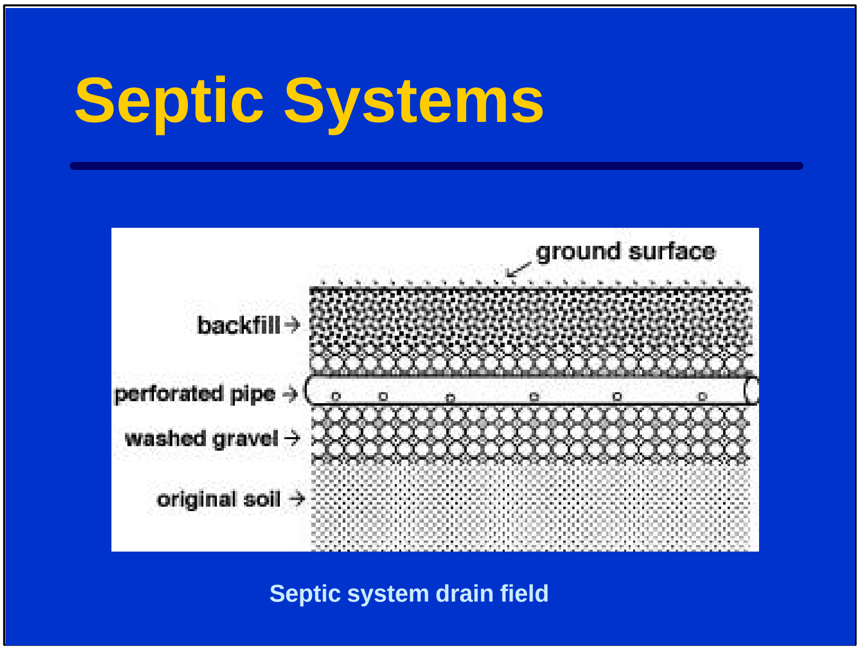
Storm Water Runoff

- Municipal separate storm sewer systems (MS4s)
  - Regulated under the NPDES Program
  - Over 5,000 nationwide

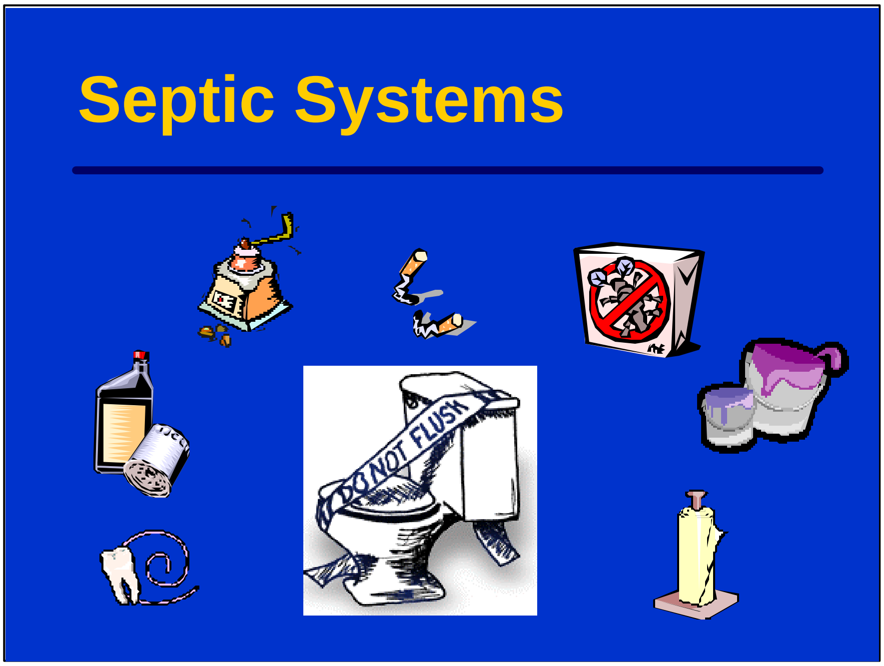
- ***EPA's National Pollutant Discharge Elimination System (NPDES) Permitting Program*** regulates storm water runoff from municipal separate storm sewer systems (MS4s) and industrial activity (including construction). The current rules establish permit requirements for more than 5,000 MS4s nationwide. NPDES storm water permits issued to MS4s require these MS4s to develop the necessary legal authority to reduce the discharge of pollutants in storm water to the maximum extent practicable and to develop and implement a storm water management program that includes:
  - o Structural and source control measures to reduce pollutants from runoff from commercial and residential areas, including maintenance, monitoring, and planning activities;
  - o The detection and removal of illicit discharges and improper disposal into the storm sewer;
  - o Monitoring and control of storm water discharges from certain industrial activities; and
  - o Construction site storm water control.
- In addition, the storm water rule for certain small MS4s requires post-construction storm water management controls. These local controls are in addition to existing federal regulations that require NPDES permits of all construction activities disturbing greater than one acre.
- Recently, EPA developed a menu of BMPs that provides more than 100 fact sheets on measures that small MS4s could use to control urban storm water runoff. The menu is available from EPA's website at www.epa.gov/npdes.

Septic Systems

- ***Septic systems*** are used to treat and dispose of sanitary waste, that is, wastewater from kitchens, clothes washing machines, and bathrooms. When properly sited, designed, constructed, and operated, they pose a minimal threat to drinking water sources. On the other hand, improperly used or operated septic systems can be a significant source of ground water contamination that can lead to waterborne disease outbreaks and other adverse health effects. [Note that large capacity cesspools are not septic systems.]
- A typical household septic system consists of a septic tank, a distribution box, and a drain field. The septic tank is a rectangular or cylindrical container made of concrete, fiberglass, or polyethylene. Wastewater flows into the tank, where it is held for a period of time to allow suspended solids to separate out. The heavier solids collect in the bottom of the tank and are partially decomposed by microbial activity. Grease, oil, and fat, along with some digested solids, float to the surface to form a scum layer.
- The partially clarified wastewater that remains between the layers of scum and sludge flows to the distribution box, which distributes it evenly through the drain field. The drain field is a network of perforated pipes laid in gravel-filled trenches or beds. Wastewater flows out of the pipes, through the gravel, and into the surrounding soil. As the wastewater effluent percolates down through the soil, chemical and biological processes remove some of the contaminants before it reaches ground water.
- Septic systems can be a significant source of ground water contamination leading to waterborne disease outbreaks and other adverse health effects. The bacteria, protozoa, nitrate and viruses found in sanitary wastewater can cause numerous diseases, including gastrointestinal illness, cholera, hepatitis A, blue baby syndrome and typhoid.



- Most jurisdictions require ***minimum horizontal setback distances*** from features such as buildings and drinking water wells and ***minimum vertical setback distances*** from impermeable soil layers and the seasonal high water table. Areas with high water tables and shallow impermeable layers should be avoided because there is insufficient unsaturated soil thickness to ensure sufficient treatment. Soil permeability must be adequate to ensure proper treatment of septic system effluent. If permeability is too low, the drain field may not be able to handle wastewater flows, and surface ponding (thus contributing to the contamination of surface water through runoff) or plumbing back-ups may result. If permeability is too high, the effluent may reach ground water before it is adequately treated. Well-drained loamy soils are generally the most desirable for proper septic system operation.
- Septic tanks and drain fields should be of ***adequate size*** to handle anticipated wastewater flows. In addition, soil characteristics and topography should be taken into account in designing the drain field. Generally speaking, the lower the soil permeability, the larger the drain field required for adequate treatment. Drain fields should be located in relatively flat areas to ensure uniform effluent flow.
- Effluent containing excessive amounts of grease, fats, and oils may clog the septic tank or drain field and lead to premature failure. The installation of ***grease interceptors*** is recommended for restaurants and other facilities with similar wastewater characteristics.
- Construction should be performed by a ***licensed septic system installer*** to ensure compliance with applicable regulations. The infiltration capacity of the soil may be reduced if the soil is overly compacted. Care should be taken not to drive heavy vehicles over the drain field area during construction or afterward. Construction equipment should operate from upslope of the drain field area. Construction should not be performed when the soil is wet, or excessive soil smearing and soil compaction may result.
- Local governments can use a variety of ***land use controls*** to protect source water from potential contamination. For example, subdivision or health regulations can specify the number and size of septic systems allowed in a development, construction and siting standards, maintenance standards, and setback distances. In making siting decisions, local health officials should also evaluate whether soils and receiving waters can absorb the combined effluent loadings from all of the septic systems in the area.



- Inadequate septic system operation and maintenance can lead to failure even when systems are designed and constructed according to regulation. Homeowners associations and tenant associations can play an important role in educating their members about their septic systems. In the case of commercial establishments such as strip malls, management companies can serve a similar role. Septic system owners should continuously monitor the drain field area for signs of failure, including odors, surfacing sewage, and lush vegetation. The septic tank should be inspected annually to ensure that the internal structures are in good working order.
- Many septic systems fail due to hydraulic overloading that leads to surface ponding. Reducing wastewater volumes through ***water conservation*** is important to extend the life of the drain field. Conservation measures include using water-saving devices, repairing leaky plumbing fixtures, taking shorter showers, and washing only full loads of dishes and laundry. Wastewater containing water softeners should not be discharged into the septic system to minimize hydraulic load. In addition, surface runoff from driveways, roofs, and patios should be directed away from the drain field.
- If an excessive amount of sludge is allowed to collect in the bottom of the septic tank, wastewater will not spend a sufficient time in the tank before flowing into the drain field. The increased concentration of solids entering the drain field can reduce soil permeability and cause the drain field to fail. Septic tanks should be ***pumped out*** every two to five years, depending on the tank size, wastewater volume, and types of solids entering the system. Garbage disposals increase the volume of solids entering the septic tank, requiring them to be pumped more often.
- Household chemicals such as solvents, drain cleaners, oils, paint, and pesticides can interfere with the proper operation of the septic system and cause ground water contamination. Grease, cooking fats, coffee grounds, sanitary napkins, and cigarettes do not easily decompose, and contribute to the build-up of solids in the tank. The use of additives has not been proven to improve the performance of septic systems. In fact, additives containing solvents or petrochemicals may actually reduce the septic system's treatment capacity or cause ground water contamination.
- Vehicles and heavy equipment should be kept off the drain field area to prevent soil compaction and damage to pipes. Trees should not be planted over the drain field because the roots can enter the perforated piping and lead to back-ups. Last, ***avoid any type of construction*** over the drain field. Impervious cover can reduce soil evaporation from the drain field, reducing its capacity to handle wastewater.

Above and Underground Storage Tanks

Corroded underground storage tank

- ***Above ground storage tanks*** (ASTs) are tanks or other containers that are above ground, partially buried, bunkered, or in a subterranean vault. ***Underground storage tanks*** (USTs) are tanks and any underground piping that have at least ten percent of their combined volume underground.
- The majority of storage tanks contain petroleum products (motor fuels, petroleum solvents, heating oil, lubricants, used oil, etc.). ASTs are typically found in marketing terminals, refineries, and fuel distribution centers, while most USTs are found at motor vehicle service stations. In fact, the U.S. EPA regulates more than 1.2 million USTs containing petroleum products. Storage tanks may also be found in airports, school bus barns, hospitals, automotive repair shops, military bases, farms, residential areas and industrial plants. Accidental releases of chemicals from storage tanks can contaminate source water. Materials spilled, leaked, or lost from storage tanks may accumulate in soil or be carried away in storm water runoff.
- The major causes for storage tank releases are holes from corrosion, improper installation, failure of piping systems, and spills and overfills. Federal regulations were developed to prevent, detect, and correct UST releases. While most USTs were required to comply with these regulations by December 1998, certain storage tanks were exempted (see 40 CFR 280.10).
- Additionally, large capacity AST and UST owners storing oil products may need to comply with Federal Spill Prevention Control and Countermeasures (SPCC) regulations (see 40 CFR Part 112).
- Local governments can use ***land use controls*** to address some of the potential risks from USTs and ASTs. For example, zoning can restrict these activities to specific geographic areas that are away from drinking water sources. Prohibition of gas stations (which use USTs) in source water protection areas can reduce the risk that harmful contaminants may enter source water. Local governments may also require permits that impose additional requirements such as setbacks, open spaces, buffers, walls and fences; street paving and control of site access points; and regulation of hours and methods of operation.

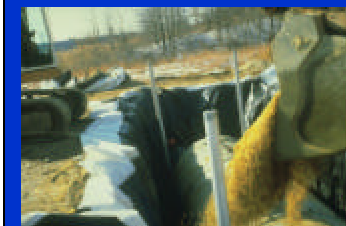
Federal AST Requirements for Tanks Storing Petroleum Products (see 40 CFR Part 112).

- Follow standard tank filling practices when filling tanks to prevent spills and overfills. Furthermore, all ASTs should have a ***secondary containment*** area that contains spills and allows leaks to be more easily detected. The containment area surrounding the tank should hold 110 percent of the contents of the largest tank plus freeboard for precipitation. Secondary containment for ASTs must be impermeable to the materials being stored. Methods include berms, dikes, liners, vaults, and double-walled tanks. A manually controlled sump pump should be used to collect rain water that may accumulate in the secondary containment area. Any discharge should be inspected for petroleum or chemicals prior to being dispensed.
- ***Routinely monitor*** ASTs to ensure they are not leaking. An audit of a newly installed tank system by a professional engineer can identify and correct problems such as loose fittings, poor welding, and poorly fit gaskets. After installation, inspect the tank system periodically to ensure it is in good condition. Depending on the permeability of the secondary containment area, more frequent containment area checks may be necessary. Areas to inspect include tank foundations, connections, coatings, tank walls, and the piping system. Integrity testing should be done periodically by a qualified professional and in accordance to applicable standards.
- If an AST has remained out of service for more a year or more, many States require owners to maintain and monitor the tank, declare the tank inactive, or remove it. If the tank is declared inactive, remove all substances from the AST system (including pipes) and completely clean the inside. Secure tanks by bolting and locking all valves, as well as capping all gauge openings and fill lines. Clearly label tanks with the date and the words “Out of Service.” Samples may be required when removing tanks to determine if any contamination has occurred. Most States require out-of-service tanks to be inspected and meet leak detection requirements before they are put back into service.

Additional AST Protection Measures

- The location of the facility must be considered in relation to drinking water wells, streams, ponds and ditches (perennial or intermittent), storm or sanitary sewers, wetlands, mudflats, sandflats, farm drain tiles, or other navigable waters. The distance to drinking water wells and surface water, volume of material stored, worse case weather conditions, drainage patterns, land contours, soil conditions, etc., must also be taken into account.
- ASTs should have ***corrosion protection*** for the tank. Options include elevating tanks, resting tanks on continuous concrete slabs, installing double-walled tanks, cathodically protecting the tanks, internally lining tanks, inspecting tanks according to American Petroleum Institute standard, or a combination of the options listed above. All underground piping to the tank should be double-walled or located above ground or cathodically protected so you can inspect it when it fails.
- Local jurisdictions may want to implement ***registration programs*** for exempt tanks, in order to exercise some oversight of their construction and operation. Furthermore, most States also require inspections for ASTs by fire marshals. Inspection programs can be expanded to cover water contamination issues. Tier 2 reporting to local fire departments under the Emergency Planning and Community Right-to-Know Act (EPCRA) can be a resource to local jurisdictions.

Underground Storage Tanks



Backfilling an UST installation in a lined pit

- Proper installation
- Corrosion protection
- Spill prevention
- Overfill protection
- Leak detection
- Proper closure

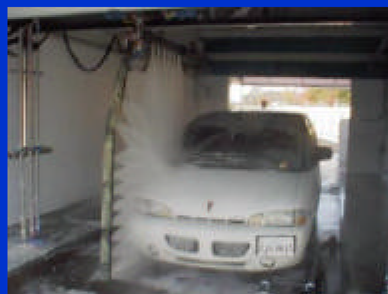
Federal UST Requirements (see 40 CFR Part 280)

- ***Proper installation***. USTs must be installed according to industry standards with great care to maintain the integrity and the corrosion protection of the tank. Tanks must also be ***properly sited*** away from wells, reservoirs, and floodplains. Ideally, all types of USTs should be located outside of source water protection areas.
- ***Corrosion protection.*** UST systems must be made of noncorrodible material, such as fiberglass, or have corrosion protection provided in other ways, such as by being made of externally coated and cathodically protected metal, having double-walls, metal having a thick corrosion resistant cladding or jacket, or having an internal tank lining.
- ***Spill protection.*** USTs must have catchment basins that can catch spills that may occur when the delivery hose is disconnected from the fill pipe. A catchment basin is basically a bucket sealed around the fill pipe.
- ***Overfill protection.*** When an UST is overfilled, large volumes can be released at the fill pipe and through loose fittings on the top of the tank or a loose vent pipe. USTs must have overfill protection devices, such as automatic shutoff devices, overfill alarms, and ball float valves. In addition, proper filling procedures during fuel delivery must be followed to reduce the chance of spills or overfills.
- ***Leak detection.*** Leak detection options include automatic tank gauging, interstitial monitoring, statistical inventory reconciliation, vapor monitoring, and ground water monitoring. All leaks must be detected in a timely manner, before they become big cleanup and liability problems.
- ***Proper closure.*** The regulatory authority needs to be notified 30 days before UST closure, and a determination must be made if any contamination of the environment has occurred. The tank must be emptied and cleaned, after which it may be left underground or removed. Standard safety practices should always be followed when emptying, cleaning, or removing tanks.

Additional protection Measures

- Local governments can use ***land use controls*** to address some of the potential risks from USTs. For example, zoning can restrict these activities to specific geographic areas that are away from drinking water sources. Prohibition of gas stations (which use USTs) or residential heating oil tanks in source water protection areas can reduce the risk that harmful contaminants may enter source water. Local governments may also require permits that impose additional requirements such as setbacks, open spaces, buffers, walls and fences; street paving and control of site access points; and regulation of hours and methods of operation. Local jurisdictions may want to implement ***registration programs*** for exempt tanks, in order to exercise some oversight of their construction and operation.
- Work with your State and local UST regulatory authorities to ensure that ***adequate inspection*** of UST sites takes place regularly — inspections that verify whether USTs are properly equipped, operated, and maintained so they will not pose a threat to your water source.

Vehicle Washing Facilities



- Minimize runoff
- Enclose wash areas and locate them on impervious surfaces
- Use alternative cleaning agents

- Vehicle washing is the cleaning of privately owned vehicles (cars and trucks), public vehicles (school buses, vans, municipal buses, fire trucks and utility vehicles), and industrial vehicles (moving vans or trucks and tractors). Vehicle wash water contains oil, grease, metal (paint chips), phosphates, detergents, soaps, cleaners, road salts, and other chemicals. These chemicals can contaminate source water when they are allowed to enter storm water drains and injection wells, instead of being diverted to treatment plants or transported to vegetative areas, where the grass can filter the contaminants from the water.
- Vehicle washing facilities should be designed and operated to minimize runoff. ***Warning signs*** should be posted for customers and employees instructing them not to dump vehicle fluids, pesticides, solvents, fertilizers, organic chemicals, or toxic chemicals into catch basins. Catch basins are chambers or sumps that channel surface runoff to a storm drain or sewer system. Vehicle wash facilities should ***stencil*** warnings on the pavement next to the grit trap or catch basin. All signs should be in a visible location and maintained for readability.
- ***Wash areas*** should be located on well-constructed and maintained, ***impervious surfaces*** (i.e., concrete or plastic) with drains piped to the sanitary sewer or other disposal devices. The wash area should extend at least an additional four feet on all sides of the vehicle to trap all overspray. Enclosing wash areas with walls and properly grading wash areas prevents dirty overspray from leaving the wash area, and the overspray can be collected from the impermeable surface.
  - The impervious surfaces should be marked to indicate the boundaries of the washing area and the area draining to the designated collection point. Washing areas should not be located near uncovered vehicle repair areas or chemical storage facilities; chemicals could be transported in wash water runoff.
  - Cleaning wash areas and grit traps or catch basins regularly can minimize or prevent debris such as paint chips, dirt, cleaning agents, chemicals, and oil and grease from being discharged into storm drains or injection wells.
- Using ***alternative cleaning agents*** such as phosphate-free, biodegradable detergents for vehicle washing will reduce the amount of contaminants entering storm drains. Cleaning agents containing solvents and emulsifiers should be discouraged because they allow oil and grease to flow through the oil/water separator (see below) instead of being separated from the effluent. In addition, these cleaning agents will remain in the wastewater and can pollute drinking water sources.

Vehicle Washing Facilities

Car wash with vegetated area

- When sanitary sewers are not available for managing wastewater, there are several different approaches that can be taken depending on the size of the site, available resources, and State and local requirements.
- ***Grassed swales and constructed wetlands*** can be used to filter sediment (see slides # 3-5 to 3-7 for more information).
- ***Collection sumps*** are deep pits or reservoirs that hold liquid waste. Vehicle wash water accumulates in the collection sumps, and is pumped or siphoned to a vegetated area (grassed swale or constructed wetland). Sediment traps can also be used to strain and collect the vehicle wash water, prior to pumping or siphoning the wash water to a vegetated area.
- ***Oil/water separators*** are tanks that collect oily vehicle wash water that flow along corrugated plates to encourage separation of solids and oil droplets. The oily solids or sludge can then be pumped out of the system through a different pipe. The sludge can be hauled off site, and the wash water can be discharged to vegetated areas or to a treatment plant. There are two types of oil/water separators, one that removes free oil that floats on top of water, and one that removes emulsified oil, a mixture of oil, water, chemicals, and dirt. Choose the separator that fits the needs of the vehicle wash facility.
- ***Recycling systems*** reduce or eliminate contaminated discharges to storm water drains and injection wells by reusing the wash water until the water reaches a certain contaminant level. The waste water is then discharged to a collection sump or to a treatment facility.
- Local governments can use ***land use controls*** to protect source water from potential contamination from vehicle washing facilities. For example, zoning can restrict this activity to specific geographic areas that are distant from drinking water sources. Localities can also prohibit vehicle washing activities in source water protection areas to reduce the risk that harmful contaminants may enter source water. Local governments may also require permits that impose additional requirements such as setbacks, open spaces, buffers, walls and fences; street paving and control of site access points; and regulation of hours and methods of operation.

Small Quantity Chemical Use, Storage, and Disposal

- ***Small quantity chemical users*** include dry cleaners, beauty shops, photo finishers, vehicle repair shops, printers, laboratories, academic institutions, water supply facilities, nursing homes, medical facilities, and many others. These businesses use solvents, corrosives, dry cleaning agents, heavy metals and inorganics, inks and paint, lead-acid batteries, plating chemicals, cyanide, and wood preserving agents, among other chemicals, in their daily business. These contaminants have a variety of environmental and health hazards. For example, a dry cleaning filtration residue, perchloroethylene, causes kidney and liver damage in both humans and animals. It is among the most common contaminants in ground water and a very small amount can contaminate many thousands of gallons of water. Used cyanide, a common waste product of metal finishing, is considered an acutely hazardous waste and can be toxic in very small doses.
- Improper disposal of chemicals from these users can reach ground or surface water through a number of pathways. If substances from these businesses are accidentally or intentionally discharged into storm drains, contamination of ground and surface waters can occur. Improper disposal into sewers can also endanger the ability of publicly-owned treatment works (POTWs) to properly treat wastewater. Chemicals poured into septic systems or dry wells can leach into ground water or contribute to treatment system failure. Chemical users should always ensure that haulers they hire to carry their waste off-site are properly licensed and that they deliver the waste to appropriate disposal sites.
- A useful tool for making disposal decisions is the ***Material Safety Data Sheet*** (MSDS). These sheets provide important information regarding contents of commercial products and enable a facility to determine whether materials will produce hazardous waste. MSDS data (i.e., chemical name, ingredients, possible carcinogens, and other known hazards) are also important for chemical use, storage and spill control. MSDS documents can be obtained from manufacturers and should be kept readily accessible.

Small Quantity Chemical Use, Storage, and Disposal

Water-based paint

- ***Good waste reduction and management strategies*** can significantly reduce the threat of hazardous materials to drinking water sources. ***Reading the label*** on chemical containers is one of the simplest and most important protection measures. The label provides information on proper use, storage, and disposal and may provide emergency information in the event the product is accidentally spilled or ingested.
- ***Follow the manufacturer's directions*** when mixing or using chemicals to prevent producing large quantities of useless material that must be disposed of as waste.
- ***Responsible purchasing*** can also drastically decrease the amount of hazardous waste for disposal.
  - This includes ordering materials on an as-needed basis and returning unused portions back to vendors.
  - The toxicity of waste can be reduced by purchasing and using the least hazardous or least concentrated products available to accomplish their processes. Such substitutions include the use of water based paints, or high solids solvent based paints when water based paints are not available. Cleaning products and solvents, which can contain highly toxic or harsh chemicals, can be replaced with less hazardous counterparts. Printing businesses can use nontoxic inks that are free of heavy metal pigments.
- Another method of waste reduction is trading waste with other businesses. ***Waste exchanges*** reduce disposal costs and quantities, reduce the demand for natural resources, and increase the value of waste.

Small Quantity Chemical Use, Storage, and Disposal

- Conduct a chemical audit
- Implement a chemical management plan
- Store chemicals properly
- Do not empty in sinks or drains

- Chemical audits are a good starting point. It is important to understand chemical needs for the facility and compare these to the chemical supply on hand. A chemical management plan that includes a list of chemicals used, the method of disposal such as reclamation or contract hauling, and procedures for assuring that toxic chemicals are not discharged into source water should be implemented.
- Proper on-site storage of hazardous substances helps to prevent accidental leaks. Designated storage areas should have paved or impervious surfaces, a protective cover, and secondary containment around all containers. Containers should have clear and visible labels that include purchase date and all information presented on the distributor's original label. Dating materials allows facilities to use older materials first. When not in use, storage containers must be sealed to prevent spills and the loss of chemicals to the air. Storage areas and containers should be thoroughly inspected on a weekly basis and secured against unauthorized entry.
- Hazardous waste should never be discharged into floor drains, storm drains, toilets, sinks, other improper disposal areas, or other routes leading to public sewers, septic systems, or dry wells. Chemical waste should be disposed of according to the manufacturer’s directions and State and local requirements. A facility may unwittingly create excess harmful materials by mixing hazardous with nonhazardous waste. Avoiding this practice can significantly reduce the burden of hazardous waste disposal and increase the possibility of recycling materials. Many local communities sponsor household hazardous waste events to collect and properly dispose of small quantities of chemicals.

Small Quantity Chemical Use, Storage, and Disposal

- Have a spill response plan
- Do not mix hazardous and nonhazardous waste

- When hazardous substances are unintentionally released, the event is considered a spill and must be treated appropriately. A good spill response plan minimizes the risk of bodily injury and environmental impact and reduces liability for clean-up costs and injuries. It is best kept where it can be easily viewed by employees near mixing and storage areas. Besides detailed instructions for staff, a spill response plan includes a diagram showing the location of all chemicals, floor drains, exits, fire extinguishers, and spill response supplies. Spill response supplies (e.g., mop, pail, sponges, absorbent materials) should also be listed. Someone trained in these procedures must be on site or easily reachable during hours of operation.
- Other practices to control spills include the use of funnels when transferring harmful substances and drip pans placed under spigots, valves, and pumps to catch accidental leakage. Sloped floors allow leaks to run into collection areas. Catch basins in loading dock areas, where nearly one third of all accidental spills occur, can help recapture harmful chemicals. All practices should be performed in a way that allows the reuse or recycling of the spilled substance.

Animal Waste

- Livestock
- Pets
- Wildlife

- ***Animal waste*** comes from a variety of sources, the most obvious of which are livestock animals. Estimates indicate that the quantity of animal waste is 13 times greater than human sanitary waste generation in the United States. Livestock waste can be introduced to the environment through direct discharges, open feedlots, land application, animal housing, and pastures.
- Wild birds and mammals can pollute surface waters through direct contact. Gulls and waterfowl commonly visit or inhabit open reservoirs. Birds are widely reported to be one of the most common and significant sources of contamination to open reservoirs.
- Companion animals, particularly dogs, are also significant contributors to source water contamination. Studies performed on watersheds in the Seattle, Washington, area found that nearly 20 percent of the bacteria found in water samples were matched with dogs as the host animals. Horses are also significant sources of waste. The average horse produces 45 pounds of waste each day, which may be difficult for small horse farms to manage properly.
- Probably the greatest health concern from animal wastes is pathogens such as *Cryptosporidium*, *Giardia lamblia*, the more virulent strains of *E. Coli*, and *Salmonella*. They can cause serious gastrointestinal illness lasting 2 to 10 days in healthy individuals, but can be fatal in people with weakened immune systems.
- Animal waste contains many pollutants of concern that affect humans and water quality. Such pollutants include oxygen-demanding substances that can lead to fish kills and degraded water quality; solids that can increase turbidity and decrease the aesthetic value (e.g., taste and odor) of water; and nutrients that can cause algal blooms or methemoglobanemia, Blue Baby Syndrome, in infants. Metals such as arsenic, copper, selenium, and zinc that are added to animal feed can be toxic to humans, plants and animals.

Animal Waste

Hog parlor with lagoon

- Feedlot management
  - Waste lagoons
  - Litter storage facilities
  - Clean water diversion
  - Composting

- Several ***feedlot management measures*** are available to reduce contact between livestock and poultry manure and precipitation or runoff.
- A ***lagoon,*** or waste storage pond, is made by excavating earth fill for temporary storage of animal waste. This practice can reduce the organic, pathogen, and nutrient loading of surface waters but may contaminate ground water if not constructed and maintained properly. Due to the risk to ground water, good planning, siting, design, and maintenance are critical when using a lagoon for animal waste storage.
- ***Poultry litter storage*** facilities are designed to keep rain water and runoff away from poultry house wastes stored for later application to crops. Types of litter storage buildings (ranging from the least to most protective of water sources) include open stockpiles, covered stockpiles, bunker-type storage, and roofed storage structures. The appropriate size of the storage structure will depend on the amount of litter removed and the frequency of poultry house cleanouts.
- ***Clean water diversion*** is an effective protection measure that avoids contamination of precipitation and surface flow as it makes its way to drinking water sources. Rain gutters and downspouts on animal shelter roofs keep runoff clean by directing precipitation away from manure. Another tactic to prevent runoff contamination is to construct superficial diversions, including earthen ridges or diversion terraces built above the feedlot or barnyard to direct surface flow away from waste.
- ***Composting*** can help eliminate pathogens and reduce the volume of manure. Composting is the controlled biological decomposition of organic materials; it can be aerobic (occurring with oxygen) or anaerobic (occurring with little or no oxygen). Compost sites should be located away from drinking water wells and water sources to avoid leaching during heavy rain and on fairly flat sites where water does not collect or run off. Composting should take place at the proper temperature and for an appropriate length of time to kill pathogens in the manure.
- Once runoff becomes contaminated, ***vegetative filter strips*** and other means can be used to control overland flow. Such measures treat runoff from feedlots or grazing areas by absorbing nutrients, bacteria, and chemicals.

- ***Proper land application of manure*** incorporates effective nutrient management to minimize the quantity of nutrients available for loss. This is achieved by developing a ***comprehensive nutrient management plan*** and using only the types and amounts of nutrients necessary to produce the crop, applying nutrients at the proper times and with proper methods, implementing additional farming practices to reduce nutrient losses, and following proper procedures for fertilizer storage and handling.
- ***Correct placement*** of manure in the root zone can greatly enhance plant nutrient uptake and minimize losses. Manure should be incorporated into the subsurface, rather than surface applied, to reduce runoff and production of vapors. Waste should never be applied to frozen, snow-covered, or saturated ground. Good management of irrigation water can help maximize efficiency and minimize runoff or leaching.
- ***Proper manure application rates*** are also important. Applying waste at the time of maximum crop uptake can minimize loss to surface runoff and decrease the amount of manure needed to fertilize crops. Calculating the optimal rate of application also includes ***crediting other sources*** that contribute nitrogen and phosphorus to the soil. Further, appropriate manure application is based on ***realistic yield goals*** established by the crop producers. Yield expectations are established for each crop and field based on soil properties, available moisture, yield history, and management level. ***Soil sampling*** is necessary to determine plant nutrient needs and to make accurate fertilizer recommendations.
- Conservation tillage and buffers can reduce runoff over feeding and grazing lands and transport of livestock wastes to water sources. In ***conservation tillage***, crops are grown with minimal cultivation of the soil. This way, plant residues are not completely incorporated into the soil, providing cover and reducing runoff. ***Buffer strips*** and ***filter strips*** are created by planting dense vegetation near surface water bodies. The vegetation reduces runoff and strains and filters sediments and chemicals.
- Where the amount of animal waste produced is more than can be properly utilized by all the crops in the area, programs to move the excess manure out of the watershed or source water protection area or to develop an alternative use for the manure other than land application may be necessary.
- ***Crop rotation*** can often yield crop improvement and economic benefits by minimizing fertilizer and pesticide needs. Planting legumes as part of a crop rotation plan provides nitrogen for subsequent crops. Deep-rooted crops can be used to scavenge nitrogen left in the soil by shallow-rooted crops.
- Several ***pasture or grazing management*** methods are available to keep livestock away from water bodies. In addition to preventing damage to stream banks, ***fencing*** can be used to keep livestock from defecating in or near streams or wells. Fencing designs include standard or conventional (barbed or smooth wire), suspension, woven wire, and electric fences. Height, size, spacing, and number of wires and posts are a function of landscape topography as well as the animals of concern. Providing ***alternative water sources*** and ***hardened stream crossings*** for use by livestock will lessen their impact on water quality.

Animal Waste

Confined animal feeding operations (CAFOs)

- Under the National Pollutant Discharge Elimination System (NPDES) regulations, concentrated animal feeding operations (CAFOs) are defined as point sources and are subject to permitting where they discharge or have the potential to discharge pollutants (40 CFR 122.23). EPA regulations define a CAFO based on the size of the animal feeding operation or its size in combination with the manner of discharge.
- An animal feeding operation can also be designated a CAFO when the permit authority determines it is a significant source of pollution. A NPDES permit authorizes, and imposes conditions on, the discharge of pollutants. The permit must include technology-based limitations and, if necessary, more stringent water quality-based limitations. EPA has published technology-based limitations (e.g., effluent guidelines) for feedlots at 40 CFR Part 412. The guidelines include numeric limits, non-numeric effluent limitations, and requirements for facilities to use specific BMPs.
- EPA published a proposed rule in the *Federal Register* on January 12, 2001 (66 FR 2960,) that would revise and update both the definition of a CAFO and the effluent guidelines for feedlots. These revisions seek to address water quality issues posed by changes in the animal production industry as well as to more effectively address the land application of CAFO-generated manure and process wastewater. Additional information on this proposed rule can be obtained at http://www.epa.gov/npdes/afo.

Animal Waste

- Managing pet waste
  - Clean up waste
  - Bury waste
  - Keep pets away from streams and lakes

- The most effective way for pet owners to limit their pet's contribution to source water contamination is to simply ***clean up and dispose of pet waste***. As long as the droppings are not mixed with other materials, pet waste should be flushed down the toilet. This allows waste to be properly treated by a community sewage plant or septic system. Also, pet waste can be buried or sealed in a plastic bag and put into the garbage if local law allows it.
- To ***bury pet wastes***, dig a hole at least one foot deep, and place three to four inches of pet waste at the bottom. Use a shovel to chop and mix the wastes into the soil at the bottom, then cover the wastes with at least 8 inches of soil to keep rodents and pets from digging them up. Pet wastes should only be buried around ornamental plants, and never in vegetable gardens or food-growing locations.
- Pet wastes are ***not recommended for back yard compost piles***. While animal manures can make useful fertilizer, parasites carried in dog and cat feces can cause diseases in humans and should not be incorporated into compost piles. Dogs and cats should be kept away from gardens as well.
- ***Pets should not be walked near or allowed to swim in*** streams, ponds, and lakes. Stream banks should not be part of the normal territory of animals. Instead, walk pets in grassy areas, parks, or undeveloped areas. Pet wastes left on sidewalks, streets, or other paved and hard surfaces are readily carried by storm water into streams. Pet wastes should be kept out of street gutters and storm drains.
- Some more advanced practices that can be adopted in public parks are doggy loos and pooch patches. ***Doggy loos*** are disposal units installed in the ground where decomposition can occur. If pets are allowed off-leash, they can be trained to defecate on ***pooch patches***, which are sandy areas designated for that purpose. Special bins can also be provided for the disposal of pet waste. Wherever pets defecate, whether in public parks or backyards, try to have them use areas of long grass. This ***"Long Grass Principle"*** can be used to prevent source water contamination. Not only are dogs readily attracted to long grass, but long grass helps to filter pollutants and the feces can decompose naturally while minimally polluting runoff.

Animal Waste

Snow geese

- Wildlife waste
  - Harassment programs
  - Reducing attractiveness of water supply areas

- While there are a variety of ways to decrease the risk posed by wildlife, by either removing attractants or harassing nuisance species, any such plans should only be implemented with a good understanding of the nuisance wildlife population in question. For example, Federal or State permits may be required for wildlife control harassment programs; additionally some nuisance species, such as Canada geese, are protected by Federal law and harming the birds or their eggs may result in stiff penalties. Consult fish and wildlife agencies regarding the handling of protected species.
- Harassment programs can be implemented to repel birds and wildlife from valuable surface waters. These include habitat modification, decoys, eagle kites, noisemakers, scarecrows or pyrotechnics, plastic owls, dog hazing, and deterrent wires strung across the water source. A daily human presence can keep birds and other wild species away.
- Reducing the attractiveness of water supply areas to wildlife may encourage these species to live elsewhere. Diverting species from sensitive areas can be accomplished using shoreline fencing, mowing, landscaping changes, tree pruning (to reduce bird roosting), or drainage devices (to keep beavers and muskrats from building dams and dens). For example, converting large grassy areas, such as corporate lawns, to native vegetation may make these areas less attractive to Canada geese.
- Keep food sources to a minimum by prohibiting feeding by the public, removing trash, securing poultry, livestock, and pet feed, and reducing palatable plant species.

Agricultural Fertilizer Application

Fertilizer spreader

- Time nitrogen fertilizer applications for maximum uptake
- To minimize phosphorus runoff, control erosion and apply phosphorus based on soil tests

- Fertilizer application is required to replace cropland nutrients that have been consumed by previous plant growth. It is essential for economic yields. However, excess fertilizer use and poor application methods can cause fertilizer movement into ground and surface waters. While fertilizer efficiency has increased, it is estimated that about 25 percent of all preplant nitrogen applied to corn is lost through leaching (entering ground water as nitrate) or denitrification (entering the atmosphere as nitrogen gas).
- The two main components of fertilizer that are of greatest concern to source water quality are nitrogen (N) and phosphorus (P). Nitrogen is used to promote green, leafy, vegetative growth in plants. Phosphorus promotes root growth, root branching, stem growth, flowering, fruiting, seed formation, and maturation.
- ***Time nitrogen fertilizer applications*** to coincide as closely as possible to the period of maximum crop uptake. Fertilizer applied in the fall has been shown to cause ground water degradation in areas with high precipitation in the fall and winter. Partial application of fertilizer in the spring, followed by small additional applications as needed, can improve nitrogen uptake and reduce leaching.
- Phosphorus fertilizer is less subject to leaching, but loss through surface runoff is more common. To minimize losses of phosphorus fertilizer, ***applications*** should only be made ***when needed*** (e.g., determined through soil testing) and at recommended rates.
- The use of organic nutrient sources, such as manure, can supply all or part of the nitrogen, phosphorus, and potassium needs for crop production. However, like inorganic fertilizers, organic fertilizers can also cause excessive nutrient loads if improperly applied.

- One component of a comprehensive nutrient management plan is to determine proper fertilizer ***application rates***. The goal is to limit fertilizer to an amount necessary to achieve a realistic yield goal for the crop. Soil sampling and crediting other sources are part of the concept. ***Yearly soil sampling*** is necessary for determining plant nutrient needs and making accurate fertilizer recommendations. More accurate fertilizer recommendations are made by ***crediting other sources*** that contribute nitrogen and phosphorous to the soil. Previous legume crops, irrigation water, manure, and organic matter all contribute nitrogen to the soil, while organic matter and manure contribute phosphorus.
- Nitrogen fertilizers come in several different forms and applying the appropriate form can reduce leaching.
- ***Inspect fertilizer application equipment*** at least once annually. Application equipment must also be properly calibrated to insure that the recommended amount of fertilizer is spread.
- As with all chemicals, closely ***follow label directions*** for storing and mixing fertilizer and for disposing empty containers. Permanent fertilizer storage and mixing sites need to be protected from spills, leaks, or storm water infiltration. Storage buildings should have impermeable floors and be securely locked. Impermeable secondary containment dikes can also be used to contain liquid spills or leaks. Fertilizer must not be stored in underground containers or pits.
- To prevent accidental contamination of water supplies, mix, handle, and store fertilizers away from wellheads and surface water bodies. Ideally, producers should mix and load fertilizers at the application spot. ***Spills must be recovered immediately*** and reused or properly disposed of. Granular absorbent material can be used at the mixing site to clean up small liquid spills.
- ***Irrigation water*** should be managed to ***maximize efficiency and minimize runoff*** or leaching. Irrigated crop production has the greatest potential for source water contamination because of the large amount of water applied. Both nitrogen and phosphorus can leach into ground water or run off into surface water when excess water is applied to fields. Irrigation systems, such as sprinklers, low-energy precision applications, surges, and drips, allow producers to apply water uniformly and with great efficiency. Efficiency can also be improved by using delivery systems such as lined ditches and gated pipe, as well as reuse systems such as field drainage recovery ponds that efficiently capture sediment and nutrients. Gravity-controlled irrigation or furrow runs should be shortened to prevent over watering at the top of the furrow before the lower end is adequately watered.

- ***Crop rotation*** can often yield crop improvement and economic benefits by minimizing fertilizer and pesticide needs. Planting legumes as part of a crop rotation plan provides nitrogen for subsequent crops. Deep-rooted crops can be used to scavenge nitrogen left in the soil by shallow-rooted crops. Cover crops stop wind and water erosion, and can use residual nitrogen in the soil.
- A complete system is needed to reduce fertilizer loss. Components of this system often include farming practices that are not strictly related to fertilizer, such as conservation tillage and buffers.
- Creating ***buffer strips or filter strips*** can impede runoff and help filter nitrogen and phosphorus from runoff (see slides #3-5 to 3-7 for more information).
- ***Conservation tillage*** is another field management method used to reduce runoff. In conservation tillage, crops are grown with minimal cultivation of the soil. When the amount of tillage is reduced, the plant residues are not completely incorporated and most or all remain on top of the soil. This practice is critical to reducing phosphorus losses because the residue provides cover and thereby reduces nutrient runoff and erosion by water.
- A high-tech way to level or grade a field is to use ***laser-controlled land leveling*** equipment. Field leveling helps to control water advance and improve uniformity of soil saturation in gravity-flow irrigation systems. This improves irrigation efficiency and reduces the potential for nutrient pollution through runoff.
- ***Precision agriculture*** is a suite of information technologies used to monitor and manage sub-field spatial variability. Variable rate application of seeds, fertilizers, pesticides, and irrigation water can enhance producers' profits and reduce the risk to the environment from agricultural production by tailoring chemical use and application more closely to ideal plant growth and management needs.
- Components of a comprehensive precision farming system typically include intensively testing soils or plant tissues within a field; equipment for locating position within a field with the Global Positioning System (GPS); a yield monitor; a computer to store and manipulate spatial data using Geographic Information System (GIS) software; and a variable-rate applicator. More involved systems may also use remote sensing from satellite, aerial, or near-ground imaging platforms during the growing season to detect and treat areas of a field that may need more nutrients.
- Precision farming has the potential to reduce off-site transport of agricultural chemicals from surface runoff, subsurface drainage, and leaching. Two years of Kansas field data indicate less total nitrogen fertilizer use with precision farming than with conventional nitrogen management.
- Several organizations can provide advice to help you select appropriate management practices in agricultural situations. Within the U.S. Department of Agriculture, the Natural Resources Conservation Service and the Cooperative State Research, Education and Extension Service, can provide assistance. Local soil and water conservation districts can also help.

Turf Grass and Garden Fertilizer Application

- The care of landscaped areas can contribute to the pollution of storm water and ground water. Heavily landscaped areas include residential yards, commercial lawns, golf courses, ball fields, and parks. The soil in many of these areas requires frequent fertilization to maintain its turf grass. Because excess fertilizer use and poor application methods can cause fertilizer movement into sources of drinking water, the increased application of lawn and garden fertilizers in recent years has raised concern over the pollution of surface water and ground water.
- Fertilizer applications should be based on soil tests to avoid the economic and environmental costs that can be incurred with excess fertilizer use. A soil test will show the levels of phosphorus and potassium present in the lawn; however, soil tests for nitrogen are rare. Samples can be tested using readily available field kits or submitted to a private laboratory or cooperative extension service for testing and interpretation.

Turf Grass and Garden Fertilizer Application

Composting can supply nutrients to the soil

- ***Selecting the appropriate fertilizer*** is the next crucial step after receiving soil testing results. Most homeowners use blended fertilizers that list percentages of nitrogen, phosphorus, and potassium in the fertilizer. For example, a 100-pound bag of 10-5-10 would contain ten pounds of nitrogen, five pounds of phosphorus, and ten pounds of potassium. If the soil test shows phosphorus is high, then a fertilizer with a low percentage of phosphorus should be chosen (such as 20-0-10 or 24-3-8). Most lawns contain adequate phosphorus, and continuous use of fertilizers high in phosphorus can result in excessive buildups of phosphorus. These lawns are more likely to contribute high levels of phosphorus to surface water during storm runoff events. The use of organic nutrient sources, such as manure, can supply all or part of the nitrogen, phosphorus, and potassium needs for turfgrass and gardens. However, organic fertilizers can also cause excessive nutrient loads if improperly applied.
- To help maintain a healthy lawn it is best to mow frequently at a height of 2.5 to 3 inches. ***Grass clippings should remain*** on the lawn to decompose and recycle nutrients back to the lawn. By leaving grass clippings on the lawn, nitrogen applications can be reduced by 30 to 40 percent.
- Wherever possible, ***plant low maintenance, native plants and grasses*** (for example, xeriscaping is a landscaping method to minimize the use of water in dry climates) to minimize the use of fertilizer. Plants that are adapted to the local soils require less fertilization and watering. In fact, these practices can reduce required lawn maintenance up to 50 percent.
- The use of an ***appropriate form of nitrogen*** fertilizer can reduce the potential for leaching and runoff problems. Quick-release fertilizers should be used on heavy clay or compacted soils, because the longer a fertilizer granule remains intact, the greater the chances it will be washed away into surface water. On sandy soils, however, nitrogen can leach through the soil quickly. On these soils, slow-release nitrogen sources provide soluble nitrogen over a period of time so a large concentration of nitrogen is not made available for leaching.

- While the proper time of year to fertilize varies by location, ***applying a smaller amount of fertilizer*** at a higher frequency is often best. Ideally fertilizer application should be timed to coincide as closely as possible to the period of maximum uptake and growth.
- Core compacted soil before applying fertilizer to insure incorporation. In all types of soil, it is always best to incorporate organic fertilizers into the lawn. When the phosphorus in organic fertilizer remains on top of the soil it has an increased chance of washing away during heavy rains. Fertilizer should never be applied to frozen ground, and also should be limited on slopes and areas with high runoff or overland flow.
- It is important to ***irrigate ¼ to ½ inch of water*** immediately after application of phosphorus or water-soluble nitrogen fertilizer. Afterwards, the key is to add only enough water to compensate for that removed by plant uptake and evaporation; this will minimize potential pollution problems from runoff and leaching.
- To ensure the proper amount of fertilizer is applied, ***properly calibrate spreaders***. As spreaders get older, settings gradually change because of wear and tear. Regular cleaning and lubrication of the spreader will help it perform properly.
- ***Buffer strips or filter strips*** can be created to slow runoff and help filter nitrogen and phosphorus from runoff (see slides #5-7 for more information).
- ***Follow label directions*** when storing and handling fertilizer and disposing of empty containers. Stored fertilizer should be kept covered and on pallets to keep precipitation off and to reduce the possibility of water damage. Spreaders should be filled on hard or paved surfaces where spills can be cleaned up mechanically – sweeping or scooping up the spilled granules.

Large-Scale Pesticide Application

Spraying cotton in Mississippi

- ***Pesticides*** (including insecticides, herbicides, and fungicides) contain a variety of chemicals used to control pests, insects, and weeds. They are used in a variety of applications to reduce damage to plants by insects and other pests, and to control overgrowth of undesirable plant species.
- Pesticides are applied to crops by aerial spraying, topsoil application (granular, dust or liquid formulations, or spray using truck or tractor-mounted equipment), soil injection, soil incorporation, or irrigation. Aerial spraying and topsoil application pose the greatest risks for pesticides to enter surface water bodies from runoff. Soil injection and incorporation pose the greatest likelihood for ground water contamination because pesticides placed in the soil are subject to leaching. The application of pesticides through irrigation (chemigation) can also cause ground water contamination; for example, an irrigation pump may fail while the pesticide-metering equipment continues to operate and cause highly concentrated pesticide levels to be applied to a field. Pesticides can reach ground water through drains, sink holes, and other conduits as well.
- Excess rain or irrigation water can wash pesticides from plants and soil. This can, in turn, run off into streams. Pesticides can leach into the soil if plants are watered or rainfall occurs soon after application. Some pesticides resist degradation by microbes in the soil and will eventually leach into the ground water.
- Pesticides contain a variety of organic and inorganic compounds. By nature, they are poisonous, and while they can be safely used if manufacturers' usage directions are followed, they can, if mismanaged, seep into surface water and ground water supplies. They can be difficult and expensive to remove, and, if inhaled or consumed, be hazardous to human health.
- ***Integrated Pest Management*** (IPM) involves the carefully managed use of three different pest control tactics – biological, cultural, and chemical – to get the best long-term results with the least disruption of the environment. Biological control means using natural enemies of the pest, like lady bugs to control aphids. Cultural or horticultural control involves the use of gardening methods, like mowing high to shade out weeds. Chemical control involves the judicious use of pesticides.
- If pesticides must be used, ***proper handling and application*** according to the EPA-approved label are essential. Select an effective pesticide for the intended use and, where possible, use products that pose lower human and environmental risks. Read the pesticide label for guidance on required setbacks from water, buildings, wetlands, wildlife habitats, and other sensitive areas where applications are prohibited.

Large-Scale Pesticide Application

- Integrated Pest Management combines three pest control tactics
  - Biological
  - Cultural or horticultural
  - Chemical

The leaf beetle *Diorhabda elongata*; first approved biological control agent for salt cedar in the US

- Never start an application if a significant weather event such as rainfall is forecast; the rainfall may cause drift or soil runoff at the application site. Pesticide application just before rainfall or irrigation may result in reduced efficacy if the pesticide is washed off the target crop, resulting in the need to reapply the pesticide.
- ***Crop rotation*** reduces pesticide use by breaking the pest cycle. As crops are rotated, pests such as insects and weeds cannot adapt to the changes in nutrient sources. Insects will move to another location where they can find food. Weeds will become dormant until the right condition returns. ***Pesticide rotation*** reduces the risk of pest-resistant pesticides. As pesticides are used year after year, pests will develop immunities to the pesticide, requiring increased application of pesticides to get the same result.
- ***Soil incorporation*** involves placing the pesticide into the top two inches of soil by tillage, where it is less likely to be removed by surface runoff. Incorporation can reduce runoff by as much as two-thirds compared to surface application.
- Timing of the application of pesticides is important. ***Early pre-plant application*** is the application of pesticides before the plant emerges from the soil. This application, using less than the labeled rate, can reduce potential pesticide runoff by up to one-half. When used in early April, pre-plant applications can provide effective control and the applied pesticides will be less vulnerable to spring and early summer runoff. If additional control is needed with a pre-emerge or post-emerge product, ***spot treatment*** should be practiced.
- ***Post-emergence application*** is the application of pesticides after the plant emerges from the soil. Post-emergence application of pesticides should be done during low periods of rainfall. Post-emergence application can reduce pesticide runoff because a much smaller amount of pesticide (as compared to the labeled rate) is applied.
- ***Split application***, with one-half to two-thirds of the pesticide applied prior to planting and one-half to one-third applied at planting, can reduce pesticide runoff by up to one-third. If good weed control is achieved with the pre-emergence application, the post-emergence application may not be necessary.

Large-Scale Pesticide Application

Ultra low volume herbicide application

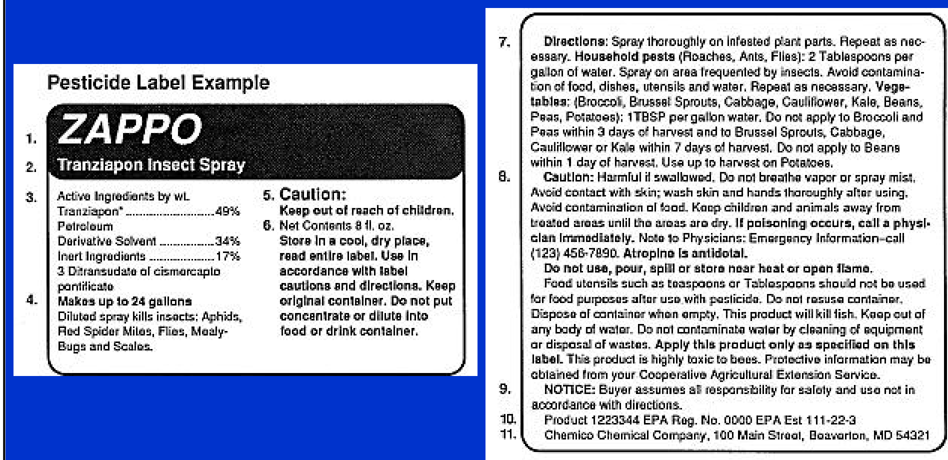
- ***Pesticide storage*** is key to preventing ground water contamination. If pesticides are stored in intact containers in a secure, properly constructed location, pesticide storage poses little danger to ground water. Some States, including Maryland, New Hampshire, North Carolina and Washington, have regulations on the storage of small quantities of pesticides. Nearly half the States have regulations for the storage of large tanks of pesticides. Secondary containment, such as an impermeable (waterproof) floor with a curb and walls around the storage area, will minimize pesticide seepage into the ground or spreading to other areas if a liquid pesticide storage tank leaks. The capacity of liquid tank secondary containment should be sufficient to contain the volume of the largest tank. Dry pesticides should be protected from precipitation. An operator should always be present when pesticide is being transferred.
- ***Proper mixing and loading practices*** can also prevent contamination of ground water and surface water by pesticides. Mixing and loading on an impermeable concrete surface allows most spilled pesticides to be recovered and reused. The impermeable surface, or pad, should be kept clean and large enough to hold wash water from the cleaning of equipment, and to keep spills from moving off-site during transfer of chemicals to the sprayer or spreader. Ideally, the pad should slope to a liquid-tight sump that can be pumped out when spills occur.
- Improper ***disposal of pesticide containers*** can lead to ground water contamination. To prevent ground water contamination, use returnable containers and take them back to the dealer as often as possible. Pressure-rinse or triple-rinse nonreturnable containers immediately after use, since residue can be difficult to remove after it dries, and pour the into the spray tank. Puncture nonreturnable containers and store them in a covered area until they can be taken to a container recycling program or a permitted landfill. Contact the Ag Container Recycling Council at www.acrecycle.org or 877-952-2272 for more on a recycling program near you. Shake out bags, bind or wrap them to minimize dust, and take them to a permitted landfill. Do not bury or burn pesticide containers or bags on private property.

Small-Scale Pesticide Application

- Select disease-resistant plants
- Use plant management techniques
- Use natural biological controls and manual control activities

- ***Pesticides*** are also used in a variety of smaller applications to control insects and other pests, and to control overgrowth of undesirable plant species. They are used by homeowners and lawn care companies for lawn care and gardening activities. Many homeowners plant non-native plant species that require pesticides, fertilizers, and watering to keep them healthy.
- Commercial establishments such as golf courses and cemeteries, and recreational areas such as parks and other open spaces use pesticides for similar purposes. Shorter grasses typical of golf courses are less resistant to insects and require application of pesticides to keep them healthy. Pesticides are also used to maintain lawns in cemeteries and commercial areas. Herbicides are used along roadways and transportation and utility corridors to limit vegetation growth and increase visibility for drivers or access to power lines.
- ***Integrated Pest Management*** (IPM) applies to small-scale use of pesticides as well as large-scale usage.
    - ***Select healthy seeds and seedlings*** that are known to resist diseases and are suited to the climate.
    - ***Alternate your plants*** each year. Insects will move to another location where they can find nutrients, and weeds will remain dormant until their nutrient source is replenished.
    - ***Manual activities*** such as spading, hoeing, hand-picking weeds and pests, setting traps, and mulching are all good ways to get rid of pests without using pesticides.
    - Proper plant management can improve plant health and reduce the need for pesticides. Use ***mowing and watering techniques*** that maintain a healthy lawn and minimize the need for chemical treatment. Maintain ***proper drainage and aeration*** to encourage the growth of microbes that can degrade pesticides. ***Reduce watering*** to control seepage of pesticides to the ground water; this effort conserves water and reduces runoff.
    - Use of ***biological controls*** reduces the need for chemical pesticides. Plants that attract predatory species, such as birds and bats, can enhance landscaping and naturally reduce pests.

Small-Scale Pesticide Application



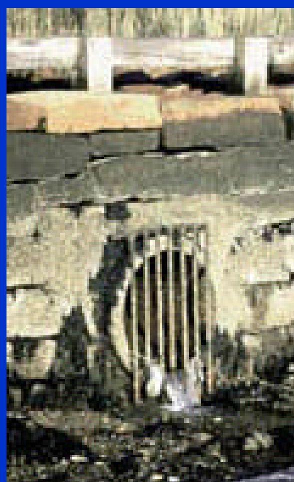
- ***Proper application*** of pesticides reduces the amount of chemicals applied to the ground and saves landowners money by reducing the amount of pesticides purchased. ***Read the label*** for usage, disposal, and emergency information. Calibrate application equipment, follow pesticide manufacturers' directions, and select leaching-resistant or "slow release" pesticides. Application as large droplets could prevent pesticide losses due to wind dispersion. Mix and load pesticides only over impervious surfaces, such as cement, that do not contain floor drains or storm water drain inlets.
- Pesticides should not be applied immediately before or after a rainfall. The rainfall may cause surface runoff at the application site. Pesticide applications just before rainfall also result in reduced efficacy as the pesticide is washed off the target plant, resulting in the need to reapply the pesticide. Also, the soil removed by the runoff can carry the pesticide to the local storm water drain, and contaminate local source waters.
- ***Proper storage*** is important in preventing both surface water and ground water contamination. Store pesticides in intact containers in a shed or covered structure on an impermeable surface such as concrete. You must follow directions for storage on pesticide labels, although the directions are usually general, such as "Do not contaminate food or feed by storage of disposal." Do not store pesticides in areas prone to flooding. Keep pesticides in their original containers; if the label is unreadable, properly dispose of the product.

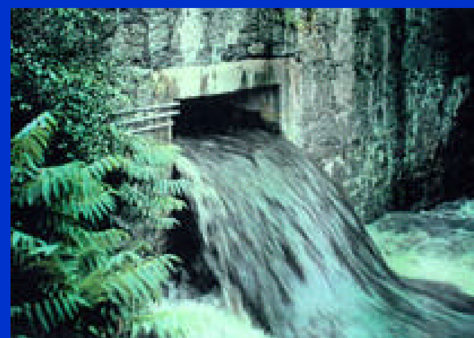
Small-Scale Pesticide Application

- Lady bugs are a natural biological control for aphids

- ***Spill clean up*** is another important protection measure. Promptly sweep up dry spills and reuse the pesticides as intended; dry spills are usually easier to clean. For liquid spills, recover as much of the spill as possible and reuse it as intended. It may be necessary to remove some contaminated soil. Have cat litter or other absorptive materials available to absorb unrecovered liquid from the floor. Be sure to have an emergency contact number to call for help, if necessary. Be sure to check the label for proper handling of the chemicals.
- ***Disposal of pesticide containers*** can lead to ground water contamination if the containers are not stored or cleaned properly. Chemical residues from these containers can leak onto the ground. Homeowners and other users may have smaller quantities of pesticides and empty containers and different disposal options than farmers.
  - Homeowners usually use nonreturnable containers, and have the option of participating in their local community household hazardous waste collection events. Partially-full and empty containers may be given to household hazardous waste collection. Homeowners should only triple rinse pesticide containers if they are able to use the rinse water immediately, e.g., on plants that require pesticides. Rinse water should never be disposed down a drain or into a sewer system. Recycle plastic and metal containers whenever possible, keeping in mind that non-hazardous container recycling programs may refuse to take pesticide containers. Empty containers may be disposed in regular trash. Shake out bags, bind or wrap them to minimize dust, and put them in regular trash. Do not bury or burn pesticide containers or bags on private property. Homeowners may give unused pesticides to a neighbor rather than throw them away.

Combined and Sanitary Sewer Overflows





Combined sewer overflow

Combined sewer outlet

- ***Sanitary sewer overflows*** (SSOs) are discharges of untreated sewage from municipal sanitary sewer systems from broken pipes, equipment failure, or system overload. ***Combined sewer overflows*** (CSOs) are discharges of untreated sewage and storm water from municipal sewer systems or treatment plants when the volume of wastewater exceeds the system's capacity due to periods of heavy rainfall or snow melt. The untreated sewage can be discharged directly into surface waters including streams, lakes, rivers, or estuaries.
- SSOs and CSOs can carry bacteria, viruses, protozoa (parasitic organisms), helminths (intestinal worms), and inhaled molds and fungi directly into source water, and can cause diseases that range in severity from mild gastroenteritis to life-threatening ailments such as cholera, dysentery, infectious hepatitis, and severe gastroenteritis. People can be exposed to the contaminant from sewage in drinking water sources, and through direct contact in areas of high public access such as basements, lawns or streets, or water used for recreation.
- ***Monitoring and maintenance*** programs are key in preventing SSOs and CSOs. Sanitary sewer collection system operators should visually inspect and monitor their sewer lines, service connections, and sewer line joints regularly and develop and use a maintenance plan. Maintenance programs should also include cleaning sewer lines, connections, and pumps. If trash and sediments build up in the sewer lines, they will block the sewage from flowing to the collection system or treatment plant.
- ***Employee training*** is an important tool for preventing contamination from sewer overflows. Employees should be trained on how to run the equipment and shut it down, if necessary, to prevent overflows. Employees should have access to and knowledge of contingency and emergency response plans. If there is an incident, they should know to notify public water suppliers. They should be aware of any potential for overflow events and be prepared to take appropriate action to prevent sewage from entering source water.

Combined and Sanitary Sewer Overflows

Sanitary sewer overflow

- ***Public education*** involves informing the community and developers of how sewer overflows occur, and what they can do to prevent them. Developers should be aware of the sewer collection design capacity, and plan accordingly. As new communities are developed, the additional sewage can overload the collection system. Developers should check to make sure the new sewer lines are compatible with the existing sewer system. If the lines do not fit the joints, then the sewage can leak out of the system, or rain water or snow melt can infiltrate the cracked lines and cause overflows. Developers should also make sure that sewer lines are not placed near trees; the roots can grow into the sewer lines and crack them. The community can help prevent overflows by conserving water and flushing only appropriate items.
- Incorporating ***system upgrades*** is another viable option, but this can be very expensive. As sewer systems become older, sewer lines and connections have to be repaired or replaced. Equipment also has to be replaced or updated as new technology becomes available. As new communities are developed, new sewer lines will be added to the collection system. Eventually the sewer system will reach its design capacity and will have to expand or a new collection system will have to be built.
- Adding a ***"wet weather" storage facility*** such as an overflow retention basin to sewer collection system will reduce SSOs and CSOs by capturing and storing excess flow. The stored volumes of sewage and storm water are released to the waste water treatment plant after the wet weather event has subsided and the treatment plant capacity has been restored.
- ***Eliminating direct pathways*** of sewage overflows to source water is an effective measure to prevent contamination. Regrading areas around pump stations and "vulnerable" manholes can divert overflow sewage from entering surface water directly. In addition, plugging storm water drainage wells (i.e., drywells used to discharge storm water underground) in the vicinity of pump stations and manholes would eliminate conduits for sewage overflow to enter the ground water.
- ***CSO control technologies*** include a number of engineering methods such as deep tunnel storage, in-system control/in-line storage, off-line near-surface storage/sedimentation, vortex technologies, and disinfection. In urban areas, where space constraints are severe, deep tunnel storage can be a viable option for managing CSOs. In-line storage, along with control strategies, can be used to maximize the flows to treatment plants. Vortex separators regulate flow and cause solids to separate out from the combined flow, therefore allowing clarified flow to be discharged to surface water. Disinfection using liquid hypochlorite is the most common practice in treating CSOs, and alternatives such as ultraviolet light, ozone, or gaseous chlorine are also available.

Aircraft and Airfield Deicing

21 million gallons of deicing/anti-icing fluid are discharged to surface waters annually.

- Aircraft surfaces must be deiced and anti-iced to ensure the safety of passengers. Paved areas on airfields must also be kept ice-free. However, prevention measures are necessary to ensure that deicing operations do not contaminate drinking water sources.
- The most common technique for **aircraft** deicing/anti-icing is the application of chemical deicing/anti-icing fluids (ADF), which are composed primarily of ethylene or propylene glycol. Deicing/anti-icing fluids also contain additives, such as corrosion inhibitors, flame retardants, wetting agents, and thickeners that protect aircraft surfaces and allow ADF to cling to the aircraft, resulting in longer holdover times (the time between application and takeoff during which ice or snow is prevented from adhering to aircraft surfaces).
- Chemicals commonly used for deicing/anti-icing of **paved areas** include ethylene or propylene glycol, urea, potassium acetate, sodium acetate, sodium formate, calcium magnesium acetate (CMA), or an ethylene glycol-based fluid known as UCAR (containing ethylene glycol, urea, and water). Sand and salt may also be used.
- EPA estimates that 21 million gallons of ADF are discharged to surface waters annually across the country, and an additional 2 million gallons are discharged to publicly owned treatment works (POTWs). Unless captured for recycling, recovery, or treatment, deicing agents will run off onto the ground where they may travel through the soil and enter ground water, or run off into streams. Unprotected storm water drains that discharge to surface water or directly to the subsurface are also of concern.
- Ethylene and propylene glycol can have harmful effects on aquatic life due to their high biological oxygen demand. Depletion of oxygen, fish kills, and undesirable bacterial growth in receiving waters may result. Although pure ethylene and propylene glycols have low aquatic toxicity, ethylene glycol exhibits toxicity in mammals, including humans (with the potential to cause health problems such as neurological, cardiovascular, and gastrointestinal problems, serious birth defects, and even death when ingested in large doses).
- Additives in deicing/anti-icing fluids can be significantly more toxic to the aquatic environment than glycols alone. Corrosion inhibitors are highly reactive with each other and with glycols; reactions can produce highly toxic byproducts. Additives such as wetting agents, flame retardants, pH buffers, and dispersing agents also exhibit high aquatic and mammalian toxicities.
- Sodium chloride (salt) is applied to paved surfaces to prevent icing. Sodium can contribute to cardiovascular, kidney, and liver diseases, and has a direct link to high blood pressure. Chloride adds a salty taste to water and corrodes pipes.

Aircraft and Airfield Deicing

Infra-red deicing system.

- ***Alternative airfield deicing products*** such as potassium acetate, sodium acetate, sodium formate, potassium formate, or CMA instead of urea or glycol deicers have lower toxicities, are readily biodegradable, and have a lower BOD in the environment. Many of these products can be applied using the same mechanical spreaders used for urea or spray booms used for glycol-based fluids.

Reducing Deicing/Anti-Icing Fluid Usage on Aircraft

- ***Mechanical deicing*** technologies eliminate the need for deicing fluids and reduce the need for anti-icing fluid. Below are some examples of newer technology.
  - ***Boot deicing*** works by inflating a rubber boot located on the leading edge of an aircraft wing. When inflated, the boot causes ice to crack and become dislodged from the surface. Passing air blows the ice away. This method is used primarily on propeller-driven aircraft.
  - For small aircraft, ***infra-red deicing systems*** use natural-gas-fired radiant heaters inside a drive-through hanger.
  - ***Electrical resistive heating*** can remove ice from the surface of small to medium sized aircraft. By applying resistive heating to heating mats located near the skin of an aircraft, ice is melted and is easily dislodged from aircraft surfaces.
  - ***Hot air blast*** deicing systems use heated compressed air to blow snow and ice off of aircraft wings. This may be followed by conventional deicing/anti-icing.
- A ***computerized spraying system*** to apply deicing chemicals may reduce the use of deicing/anti-icing fluids. These systems can reduce both the volume of deicing fluid used and the time needed for deicing, and increase the collection efficiency of runoff. These "car-wash" style systems can be operated by personnel with a minimum of training. This option may be cost-prohibitive for smaller airports, and in some cases, planes may need additional deicing using traditional means (trucks or fixed booms) to deice engine inlets, undercarriages, or the underside of aircraft wings.

Aircraft and Airfield Deicing

- Using ***ice detection systems or sensors***, especially on larger aircraft, can reduce and, in some cases, eliminate application of deicing fluid. Because operators and flight crews often have difficulty detecting ice on aircraft wings, aircraft are deiced whenever ice is suspected to be present. Magnetostrictive, electromagnetic, and ultrasonic devices can detect ice on aircraft surfaces, including areas that are difficult to inspect visually and in cases where ice build-up is not apparent. This allows operators to more accurately determine when deicing is unnecessary and can decrease the amount of ADF used at an airport.
- ***Increase storage for multi-strength glycol solutions***. Using a technique called "blending to temperature," operators can vary the concentration of glycol in deicing fluid. Operators, particularly at small airports, commonly use a fluid with 50 percent glycol, a concentration that is formulated for worst-case cold weather conditions. However, concentrations of 30 to 70 percent glycol may be used in different conditions. Reducing the glycol concentration in deicing fluid decreases the amount of glycol in surface runoff and storm water collection systems.

Reducing Deicing/Anti-Icing Fluid Usage on Pavement Surfaces

- ***Prevent strong bonding of ice to pavement surfaces*** by pre-treating and/or promptly treating pavement using either mechanical methods or chemicals. Pre-treating pavement with chemicals such as aqueous potassium acetate prior to the onset of freezing conditions or a storm event can allow easy removal of snow and ice using sweepers and plows. The FAA estimates that the correct application of pavement anti-icing chemicals can reduce the overall quantity of pavement deicing/anti-icing agents used by 30 to 75 percent.
- ***Use mechanical methods for dry snow removal*** rather than applying chemicals.
- ***Use the proper amount of pavement deicing/anti-icing chemicals*** by following recommendations from the manufacturer, and properly maintaining spreading equipment. This will reduce unnecessary or over-application of chemicals. Avoid applying glycol-based deicers near storm drains, particularly those that are not routed to a publicly-owned sewage treatment plant.

Aircraft and Airfield Deicing

Disposal of spent fluid:

Deicing pads
Vacuum sweeper trucks
Detention basins
Bioremediation systems
Transport to a POTW

Collection and Disposal of Spent Fluid to Reduce Runoff

- ***Centralized deicing pads*** restrict aircraft deicing to a small area, minimizing the volume and allowing for the capture of deicing waste. A deicing pad is specially graded to capture and route contaminated runoff to tanks. If the pads are located near gate areas or at the head of runways, deicing may be completed just prior to takeoff; as a result, less Type IV anti-icing fluid may be necessary. In addition, the fluids recovered from deicing pads may be suitable for reuse.
- ***Vacuum sweeper trucks*** collect spent aircraft and airfield deicing fluids as well as any slush or snow from gate areas, ramps, aircraft parking areas, taxiways, and aircraft holding pads. The recovered fluid may be suitable for recycling.
- ***Detention basins or constructed wetlands*** are open-water ponds that collect ADF runoff from runways and airport grounds. Basins allow solids to settle, and reduce oxygen demand before the runoff is discharged to receiving waters. A pump station can discharge metered runoff by way of an airport storm sewer.
- ***Anaerobic bioremediation systems***, in conjunction with sewage treatment plants or detention basins, can be an effective means to dispose of glycol-contaminated runoff. Bioremediation systems generally consist of a runoff collection and storage system, an anaerobic bioreactor treatment system (one that requires little or no oxygen), and a gas/heat recovery system. These systems can reduce oxygen demand levels sufficiently to permit unrestricted disposal to a sewage treatment plant. Additionally, these systems can remove additives from runoff. An economic benefit to the anaerobic process is that it converts glycol in runoff to methane gas that can be used for heating.
- ***Transport*** of spent fluid to a sewage treatment plant by way of a sanitary sewer is almost always the most economical method of treating deicing fluid, provided that sufficient biological loading capacity is available at the treatment plant. However, many sewage treatment plants will only accept limited quantities of glycol-contaminated runoff; check with the appropriate local agency to verify applicable regulations. Airport maintenance crews should not assume that storm drains are routed to a sanitary sewer. They should be knowledgeable about which drains or collection systems discharge directly to surface waters or to the subsurface, e.g., through a dry well.

Aircraft and Airfield Deicing

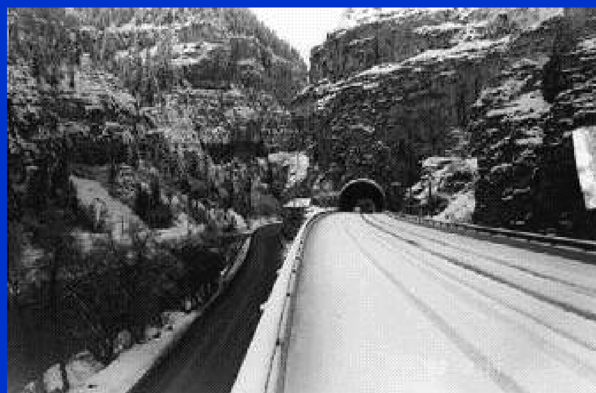
- National Pollutant Discharge Elimination System (NPDES)
- Underground Injection Control (UIC) Program

- Under the National Pollutant Discharge Elimination System (NPDES) Permitting Program, airports are required to obtain permit coverage for storm water discharges from vehicle maintenance, equipment cleaning operations, and airport deicing operations. While specific permit conditions vary from state-to-state, in general, NPDES storm water permits require airports to develop and implement ***Storm Water Pollution Prevention Plans*** (SWPPPs) that include the following elements:
  - Description of potential pollutant sources and a site map indicating the locations of aircraft and runway deicing/anti-icing operations and identification of any pollutant or pollutant parameter of concern.
  - Description of storm water discharge management controls appropriate for each area of operation.
  - Consideration of alternatives to glycol- and urea- based deicing/anti-icing chemicals to reduce the aggregate amount of deicing chemicals used and/or lessen the environmental impact.
  - Evaluation of whether deicing/anti-icing over-application is occurring and adjustment as necessary.
  - Employee training on topics such as spill response, good housekeeping, and material management practices for all personnel that work in the deicing/anti-icing area.
- Many NPDES storm water permits issued to airports also require monitoring to evaluate the effectiveness of storm water controls in preventing deicing/anti-icing activities from impacting receiving water quality. For example, monitoring requirements for airport deicing/anti-icing activities in EPA's Multi-Sector General Permit include monthly inspections of existing storm water controls during the deicing season (weekly if large quantities of deicing chemicals are being spilled or discharged), quarterly visual monitoring of storm water discharges, and periodic effluent monitoring.
- Storm water that discharges directly to the subsurface by way of dry wells, drain fields, or any other type of distribution system is subject to ***Underground Injection Control (UIC) Program*** requirements. These types of drainage systems are regulated as Class V injection wells and operators should contact their state or federal UIC Program authority for information on applicable regulations.

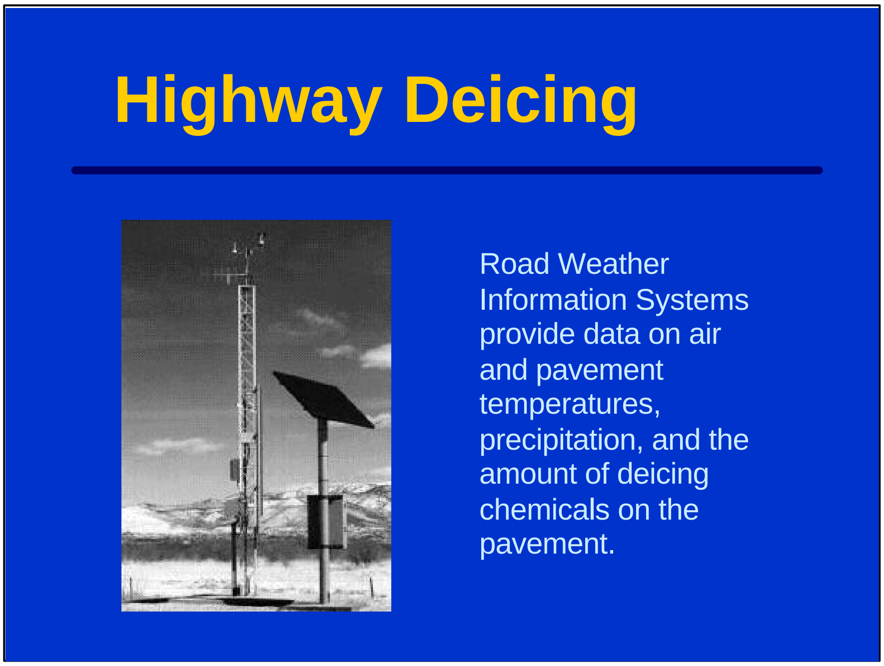
Aircraft and Airfield Deicing

- ***Recycling of glycol*** from spent deicing/anti-icing fluid decreases the amount that reaches and potentially impairs surface and ground waters. The recycling process consists of several steps including filtration, reverse osmosis, and distillation to recover glycol from spent deicing fluid. Technology is available to recycle fluids containing at least 5 percent glycol. Glycol recycling reduces the amount and strength of wastewater, reducing wastewater disposal costs. In addition, the recovered glycol may be sold; the value of recovered glycol depends on the type of glycol and its concentration and purity. Recent developments have made on-site recycling successful at smaller airports; however the volume of fluid used at very small airports may still be insufficient to make recycling economically viable at these facilities.
- ***Employee training*** is an important tool in reducing contaminated runoff. Deicing personnel receive eight hours of FAA-mandated training, but industry sources state that three years of experience is required to become adept at aircraft deicing. Personnel should be trained on proper application techniques and best management practices, and be informed of the presence of any sensitive water areas nearby. Properly trained personnel will also use less deicing/anti-icing fluid, saving money and reducing contamination.
- ***Monitor ground water quality*** and identify the direction of ground water movement on-site through the creation of a water table map. Once the direction of ground water flow is known, annual monitoring up gradient and down gradient of deicing areas should provide early detection of deicing fluid contamination and other harmful impacts.

Highway Deicing



- Deicing chemicals are used to clear roads covered by snow and ice during winter weather to make roadways safe; however, the runoff associated with highway deicing may contain various chemicals and sediment which have the potential to enter surface and ground water sources.
- The most commonly used and economical deicer is sodium chloride, better known as salt, because it lowers the freezing point of water, preventing ice and snow from bonding to the pavement and allowing easy removal by plows. Salt contributes to the corrosion of vehicles and infrastructure, and can damage water bodies, ground water, and roadside vegetation.
- Sodium is associated with general human health concerns. It can contribute to or affect cardiovascular, kidney, and liver diseases, and has a direct link to high blood pressure. Chloride adds a salty taste to water and corrodes pipes.
- These issues have led to the investigation and use of other chemicals as substitutes for and supplements to salt. Other deicing chemicals include magnesium chloride, potassium acetate, calcium chloride, calcium magnesium acetate, and potassium chloride.
- Anti-caking agents are often added to salt, the most common of which is sodium ferrocyanide. There is no evidence of toxicity in humans from sodium ferrocyanide, even at levels higher than those employed for deicing. However, some studies have found that the resulting release of cyanide ions is toxic to fish.



- The goal of prevention measures for roadway deicing is to minimize the loss of deicing chemicals due to overuse and mishandling. Management of deicing chemicals focuses on reducing waste through training and access to information on road conditions through the use of technology. Generally, optimal strategies for keeping roads clear of ice and snow will depend on local climatic, site, and traffic conditions, and should be tailored as such. Road maintenance workers should be trained on these measures prior to the winter season. Personnel should also be made aware of areas where careful management of deicing chemicals is particularly important, e.g., sensitive water areas such as lakes, ponds, and rivers. Similarly, personnel should be aware of runoff concerns from roadways that are near surface water bodies or that drain to either surface water or the subsurface (e.g., through a dry well).
- ***Alternative deicing chemicals*** include calcium chloride and calcium magnesium acetate (CMA). Another alternative, sodium ferrocyanate, should be avoided due to its toxicity to fish. Although alternatives are usually more expensive than salt, their use may be warranted in some circumstances, such as near habitats of endangered or threatened species or in areas with elevated levels of sodium in the drinking water. Other considerations for using alternatives to salt include traffic volume and extreme weather conditions. Each deicer works differently in various climatic and regional circumstances. Combining deicers, such as mixing calcium chloride and salt, can be cost-effective and safe if good information on weather conditions and road usage are available.
- ***Road Weather Information Systems (RWIS)*** help maintenance centers determine current weather conditions in a given location. Since the mid-1980's, increasing numbers of states are using this technology. Sensors collect data on air and pavement temperatures, levels of precipitation, and the amount of deicing chemicals on the pavement. The data are paired with weather forecast information to predict pavement temperatures for a specific area and determine the amount of chemicals needed in the changing conditions. The strategically placed stations are 90 to 95 percent accurate. This information is also used for anti-icing treatment to allow for chemicals to be applied before the pavement freezes, reducing the amount of deicing chemicals used. Several states are developing satellite delivery of this information to maintenance workers.

Highway Deicing

Anti-icing can reduce the amount of chemicals needed to keep roads safe.

- ***Anti-icing or pretreatment*** methods are increasingly being used as a preventative tool. Anti-icing may require up to 90 percent less product than is needed for deicing after snow and ice have settled on road surfaces. Deicing chemicals, often liquid magnesium chloride, are applied to the pavement before precipitation or at the start of a storm to lower the freezing point of water. Timing is everything in the process, and weather reports or RWIS data can assist in determining the best time and place to apply chemicals.
- Some states have installed fixed chemical spraying systems in highway trouble spots, such as on curves and bridges, to prevent slippery roads. Chemicals are dispensed through spray nozzles embedded in the pavement, curbs, barriers, or bridge decks. Though expensive to implement, this technique saves materials and manpower and reduces deicing operations during a storm.
- ***Spreading rates and the amount*** of deicer used are important considerations. Some studies have shown that snow melts faster when salt is applied in narrow strips. In a technique known as windrowing, spreading is concentrated in a four to eight foot strip along the centerline to melt snow to expose the pavement, which in turn warms a greater portion of the road surface, and causes more melting.
- ***Timing of application*** is also an important consideration. It takes time for the chemical reactions of salt and other deicers to become effective, after which a plow can more easily remove the snow. Sand should not be applied to roadways if more snow or ice is expected, as it will no longer be effective once covered. Traffic volume should also be taken into consideration, as vehicles can disperse deicers and sand to the side of the road. The timing of a second application is dictated by the road conditions. For example, while the snow is slushy on the pavement, the salt or deicer is still effective. Once it stiffens, however, plowing should be done to remove excess snow.

Highway Deicing

Plows are a chemical-free option for clearing snow and ice.

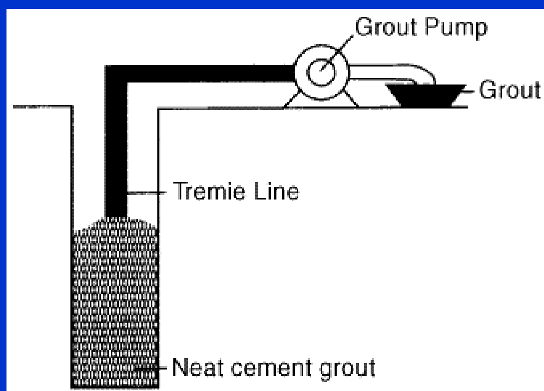
- ***Application equipment*** aids in the proper distribution of deicer chemicals. Many trucks are equipped with a spinning circular plate that throws the chemicals in a semi-circle onto the road. A chute is used to distribute in a windrow, typically near the centerline of the road. Modified spreaders prevent the over-application of materials by calibration or by the speed of the truck and should be used. Spreader calibration controls the amount of chemicals applied and allows different chemicals to be distributed at different rates. Annual equipment maintenance and checks should be conducted to ensure proper and accurate operation.
- ***Plowing and snow removal*** are chemical-free options to keep roads clear of snow and ice. With plowing, less chemicals are needed to melt the remaining snow and ice pack. For specific weather conditions, specialized snow plows may be used. For example, various materials, such as polymers and rubber, can be used on the blade.
- ***Pre-wetting*** of sand or deicing chemicals such as salt can provide faster melting. Salt can be pre-wetted through a spray as it leaves the spreader. Sand is often pre-wet with liquid deicing chemicals just prior to spreading, an effective method for embedding the sand into the ice and snow on the pavement.
- ***Street sweeping*** during or soon after the spring snow melt can prevent excess sand and deicing residue from entering surface and ground waters. Many road departments sweep streets at least once in the spring.
- ***Proper salt storage*** is a key measure to prevent the introduction of potentially harmful contaminant loads to nearby surface and ground waters. It is important to shelter salt piles from moisture and wind, as unprotected piles can contribute large doses of sodium chloride to runoff. Soil type, hydrology, and topography must also be appropriate for the storage area. Any runoff should be cleaned up immediately and the collected brine reused. Spills during loading and unloading should be cleaned as soon as possible. Salt should be stored outside of wellhead and source water protection areas, away from private wells, sole source aquifers (where feasible), and public water supply intakes. ***Ground water quality monitoring*** near salt storage and application sites should be performed annually.

Abandoned Wells

- Locations often unknown
- Common nearby activities may degrade water quality
- Runoff also poses threats

- ***Abandoned wells*** present safety hazards and pose a potential threat to the quality of drinking water. As municipal water supplies reach suburban and rural areas, such as farms and old homestead sites, many older wells are no longer needed and are often neglected or forgotten. In many cases, property owners are not aware that abandoned wells exist on their property. Old and abandoned monitoring, irrigation, pump and treat, and distribution wells can also pose a risk. No one knows how many abandoned wells there are, but estimates for each of the Midwestern States range in the hundreds of thousands.
- Common rural activities that occur in the vicinity of a wellhead may degrade ground water quality. Farmers or landowners mix and apply fertilizers and pesticides on fields and crop lands. Livestock and animal feeding operations produce animal wastes. Rural sites with wells typically have septic systems to treat household wastewater, and faulty septic systems located in areas with thin soil and porous rock can allow wastewater to enter the aquifer and wells. Runoff from vehicle and farm equipment washing carries chemicals and other contaminants. In addition, runoff from waste disposal sites and storage areas carries contaminants that threaten ground water quality.

Abandoned Wells



Graphic: North Dakota State Univ.

- Plug abandoned wells
- Use licensed well drillers

- The most effective way to minimize risks from abandoned wells is to find them and ***properly plug them***.
- While abandoned wells can be anywhere, some indicators that there may be an abandoned well in the area include depressions in the ground surrounded by vegetation, or structures such as hand pumps, pipes in the ground, or old farms that would accompany a well. Historical photographs, land records and permits, and previous land owners are additional sources of information that may yield the locations of abandoned wells.
- In general, plugging a well involves measuring the diameter of the well bore to determine the amount of fill needed, removing debris or obstructing materials, and filling the well with plugging materials and grout. Available fill materials include sand and gravel, clay, sodium bentonite, or cement grout. Specific procedures will vary depending on the well site, depth, and properties.
- State or local health departments may have requirements for proper sealing of a well, and some require that ***licensed well drillers*** do the job.

Class Discussion:

Implementing Source Water Protection Measures

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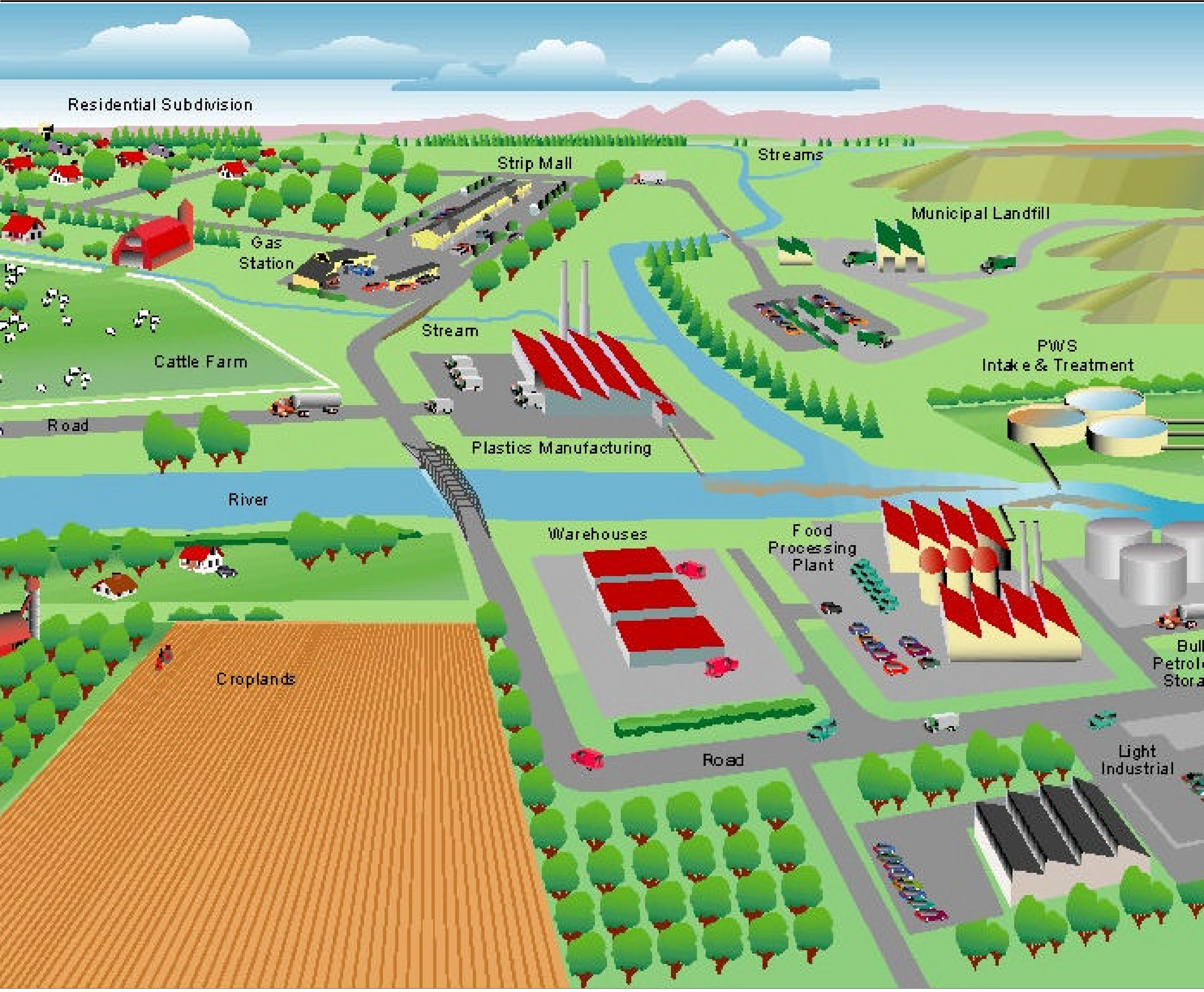

- **Class Discussion:** Students should consider and discuss what actions each of the following entities could take to implement or facilitate implementation of source water protection measures in the community pictured above:
  - o Local government officials
  - o Water systems
  - o Environmental and community groups
  - o Business owners and their trade associations, including farmers
  - o Homeowners
- What types of issues might they face when trying to adopt or implement protection measures?