Injection Wells

An injection well is a vertical pipe in the ground into which water, other liquids, or gases are pumped or allowed to flow. They are used for many purposes.

In the 1930’s oil companies began pumping brine produced from oil and gas production into porous rock formations. This was a way of disposing of wastewater through underground wells. It was more cost effective to do it this way rather than treating and reusing wastewater. It took almost twenty years, but in the 1950’s, injection of hazardous chemical and steel industry wastes began. Then in the 1960’s the practice of injection boomed as the manufacturing of chemicals increased.

When fluids are placed underground in porous formations of rocks, through wells or other similar conveyance systems, this is known as underground injection. Although rocks such as sandstone, shale and limestone appear to be solid, they can contain significant voids or pores that allow water and other fluids to fill and move through them.
Man-made or produced fluids (liquids, gases or slurries) can move into the pores of rocks by the use of pumps or by gravity. The fluids may be water, wastewater or water mixed with chemicals.

Large amounts of waste fluids are generated by Americans. More than 750 billion gallons of hazardous and non-hazardous fluids are disposed of safely through the underground injection system. Over 9 billion gallons of hazardous waste is injected into wells each year in the US.

More than 500,000 injection wells receive a variety of hazardous and non-hazardous fluids in facilities throughout the United States. It would be very costly to treat and release to surface waters the billions and trillions of gallons of wastes that industries produce each year. However, the technology to do so does exist.

If a well is properly sited, constructed and operated, underground injection is an effective and environmentally safe method to dispose of wastes. The agricultural, chemical and petroleum industries all make use of underground injection for waste disposal.

The Environmental Protection Agency (EPA) does everything possible to insure that these fluids are disposed of safely and cost effectively while fulfilling their mission to protect underground sources of drinking water from contamination.
The Federal government as many regulations to prevent contamination of “underground sources of drinking water” (USDW). Underground drinking water is defined as an aquifer. Its purpose is to serve as a source of drinking water for human consumption or to contain a sufficient quantity of water to supply a public water system. It will contain fewer than 10,000 mg/liter of total dissolved solids.

In 1974, the U.S. Environmental Protection Agency became concerned that injected waste could contaminate underground drinking water. Therefore Congress enacted the Safe Drinking Water Act, which required the EPA to set requirements for protecting underground sources of drinking water. It also granted the EPA the power to regulate injection wells and protect our underground sources of drinking water. Then in 1980, the EPA passed its Underground Injection Control regulations. In 1988, these regulations were made stronger to comply with the newly upgraded waste disposal amendments of the Resource Conservation and Recovery Act.

In April, 1968, corrosion caused the casing of Hammermill Paper Company’s No. 1 well to rupture and spent pulping liquor flowed onto the land and entered Lake Erie. A black liquid seeped from an abandoned gas well at Presque Isle State Park five miles away. It was suspected that wastewaters from Hammermill’s injection well migrated up the unplugged, abandoned well bore. This, along with several cases, caused the EPA to get more involved and show their opposition to underground injection.
Another such case was the Velsicol Chemical Company in 1974 and 1976. The Company noted that the pressure in one of their two injection wells was lower than normal and an inspection revealed numerous leaks in the well’s casing. The company decided to plug the well and drill a new one.

As they were abandoning this well they discovered that waste water had leaked to an underground source of drinking water. The wastewater was pumped from the aquifer.

It was in response to events such as those and the growing use of injection wells for waste storage that cause EPA to issue a policy statement in 1974 stating that EPA opposed underground injection”

“without strict control and clear demonstration that such wastes will not interfere with present or potential use of subsurface water supplies, contaminate interconnected surface waters or otherwise damage the environment.”

It was this action by the EPA that resulted in the passage of the Safe Drinking Water Act by Congress in December of 1974 which granted EPA the power to regulate Injection wells and otherwise protect our underground sources of drinking water (USDW). Later acts and regulations have added power to EPA’s ability to protect our groundwater resources including stricter controls over injection wells.

**What is an Injection Well?**

Injection wells are man-made or improved “holes” in the ground, which are deeper than their widest surface dimension. They are used for a variety of purposes, ranging from the disposal

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of various fluids to the extraction of mineral and hydrocarbon resources. When properly sited, constructed and operated, injection wells are an effective tool for safe waste management. The EPA has defined six classes of injection wells, according to the types of fluids injected and how the point of injection relates to an underground source. An injection well is any bored, drilled or a driven shaft or a dug hole, where the depth is greater than the largest surface dimension that is used to discharge fluids underground.

Not all injection wells are waste disposal wells. Some Class V wells inject surface water to replenish depleted aquifers or to prevent salt-water intrusion. Some Class II wells inject fluids for enhanced recovery of oil and natural gas and other inject liquid hydrocarbons that constitute our Nation’s strategic fuel reserves in times of crisis.

**What are injection wells used for?**

Injection wells have a range of uses that include long term Co2 storage, waste disposal, enhancing oil production, mining, and preventing salt water intrusion. Widespread use of injection wells began in the 1930s to dispose of brine generated during oil production. Injection effectively disposed of unwanted brine, preserved surface waters, and in some formations, enhanced the recovery of oil. In the 1950s chemical companies began injecting industrial wastes into deep wells. As chemical manufacturing increased, so did the use of deep injection. Injection was a safe and inexpensive option for the disposal of unwanted and often hazardous industrial byproducts. In 2010, the EPA finalized regulations for geologic sequestration of CO2. This final rule created a new class of wells, Class VI. Class VI wells are used solely for the purpose of long term storage of CO2.
The EPA classifies Injection Wells into six classes:

**Class I Injection Wells** may be permitted to inject hazardous waste into the earth. They are very sophisticated wells and inject both hazardous and non-hazardous wastes below the lowermost underground source of drinking water. Injection occurs into deep, isolated rock formations that are separated from the lower part of the underground source of drinking water by layers of impermeable clay and rock. These wells are strictly regulated.

Class I wells are designated as hazardous or nonhazardous, depending on the characteristics of the wastewaters injected. Wastewaters are considered to be hazardous wastes if they demonstrate a hazardous characteristic of:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity, or are
- A listed waste as determined by EPA

This designation affects the stringency of the requirements imposed on operators of Class I wells. They are sited such that they inject below the lowermost USDW and a confining zone above an injection zone. Injection zone reservoirs typically range in depth from 1,700 to over 10,000 feet below the surface.
The location of the wells is sited so that should any of their components fail, the injected fluids would be confined to the intended subsurface layer. They inject into zones with the proper configuration of rock types to ensure that they can safely receive injected fluids. The geological formation into which the wastewaters are injected is known as the injection zone.

Many geological tests are performed to confirm that the injection zone is of sufficient lateral extent and thickness and is sufficiently porous and permeable so that the fluids injected through the well can enter the rock formation without an excessive build up of pressure and possible displacement of injected fluids outside of the intended zone.

Injection fluids are injected deep into the earth into brine-saturated formations of non-freshwater zones. The typical Class I well injects wastewaters into geologic formations thousands of feet below the land surface.

The failure of Class I wells, both hazardous and non-hazardous, is very low. Early failures were mostly due to historic practices that are no longer permissible under the EPA regulations. Most failures are mechanical failures and the wells are shut down until they are repaired.
Class I wells have many safety systems and several protective layers; an injection well would fail only when multiple systems fail in sequence without detection. If a well were to fail, the geology of the injection and confining zones serves as a final safety net against movement of wastewaters to underground sources of drinking water.

**Class II Injection Wells** are those that are associated with the oil and gas industry. They include wells which inject brine and other fluids associated with oil and gas production. The EPA estimates that there are 147,000 Class II Injection Wells in the United States. At least 700 million gallons of fluids are injected into these wells each year.

Brine is the largest source of liquid that is produced when oil and gas are extracted from the earth. Approximately 10 gallons of brine will be produced for each gallon of oil. Fluids are injected into these wells to enhance oil recovery. Oil is also injected into these wells for the purpose of underground storage.

Protective Regulations for Class II injection Wells include cased and cemented to prevent movement of fluids into the underground drinking water system and construction and design of well casing, tubing and packer.
**Class III Injection Wells** are used for the solution mining of minerals. The EPA estimates that there are 17,000 Class III Injection Wells in the United States. These wells inject superheated steam, water or other fluids into formations in order to extract minerals. Then the fluids are pumped to the surface and the minerals in solution are extracted. Generally the fluid is treated and re-injected into the same formation.

Fifty percent of the salt used in America is extracted through Class III wells. Eighty percent of the uranium is extracted using Class III wells. These wells are also regulated to minimize the environmental impacts from solution mining operations.

Fluids used in the solution mining of various minerals are fresh water to extract salt, sodium bicarbonate to extract uranium salts, steam to extract sulfur and proprietary solutions to extract other minerals and metals.

In general, owners and operators of most new Class I, II and III injection wells are required to:

1. Site the wells in a location that is free of faults and other adverse geological features.
2. Drill to a depth that allows the injection into formations that do not contain water that can potentially be used as a source of drinking water. These injection zones are confined from
any formation that may contain water that may potentially be used as a source of drinking water.

3. To inject through an internal pipe (tubing) that is located inside another pipe (casing). This outer pipe has cement on the outside to fill any voids occurring between the outside pipe and the hole that was bored for the well (borehole). This allows for multiple layers of containment of the potentially contaminating injection fluids.

4. Test for integrity at the time of completion and every five years thereafter (more frequently for hazardous waste wells.)

5. Monitor continuously to assure the integrity of the well.

Class IV Injection Wells are shallow wells used to inject hazardous or radioactive wastes into or above a geologic formation that contains an underground source of drinking water. There are approximately 40 Class IV Injection Wells in the United States according to reports from the EPA. In 1984, the use of Class IV wells to dispose of waste was banned. They were banned under the Environmental Protection Agencies Underground Injection control program because they directly threaten public health.

These wells may be used when operated to inject treated contaminated ground water back into the original aquifer as part of a clean-up effort. They may only be used with State or Federal
approval. An Owner of a Class IV well must still comply with all Environmental Protection Agency requirements.

The difference between Class IV and Class V Injection Wells is the quality of the fluid being injected. Class V wells may only inject non-hazardous fluids that will not endanger USDWs. However, if a Class C well is misused and receives hazardous waste, the well would be considered a Class IV well and therefore be banned.

Class IV wells are prohibited unless the injection wells are used to inject contaminated ground water that has been treated and is being injected into the same formation from which it was drawn. These remediation injection wells are authorized by rule for the life of the well if such subsurface emplacement of fluids is approved by the EPA. Class V Wells may only inject non-hazardous fluids that will not endanger USDWs. If a Class V well is misused and receives hazardous waste, the well would be considered a Class IV well and therefore be banned.

When an unauthorized Class IV well is discovered, the UIC Program coordinates with the Division of Hazardous Waste Management to ensure that they are plugged appropriately and that any necessary corrective actions are taken at the site. All Class IV wells must submit information to the UIC program. In addition, all Class IV wells must be closed per the proper requirements, which includes submitting a closure plan at least 30 days prior to closure and disposing of all waste materials per all applicable laws and regulations.
Class V Injection Wells are used for the shallow injection of non-hazardous fluids only. It is estimated that we have 500,000 to 685,000 Class V injection wells in the United States. These wells are not included in the other classes. Most Class V wells are “low-tech” wells, such as septic systems and cesspools. However, some are technologically advanced wastewater disposal systems used by the industry.

For the most part they are shallow and depend upon gravity to drain or “inject” liquid waste in the ground above or into underground sources of drinking water. There is little or no protection against possible ground water contaminations because of their simple construction. Therefore, it becomes important to control what goes into them.

They are typically shallow, on site-disposal systems, such as floor and sink drains which discharge directly or indirectly to ground water, dry wells, leach fields, and similar types of drainage wells.
The largest number of Class V wells is shallow wells that “inject” non-hazardous fluids into very shallow aquifers that are or can be used as sources of drinking water. The majority of Class V well owners are small business and municipalities. The two most numerous types of Class V wells are storm water drainage and large capacity septic systems.

The government has established guidelines for Class V Injection Wells:

1. The well cannot endanger underground sources of drinking water.
2. Well owners must submit inventory information.
3. There are additional specific requirements for motor vehicle waste disposal wells and large capacity cesspools.

**Class VI Injection Wells**
**What is a Class VI Well?**

Class VI wells are wells used for injection of carbon dioxide (CO2) into underground subsurface rock formations for long-term storage, or geologic sequestration. Geologic sequestration refers to a suite of technologies that may be deployed to reduce CO2 emissions to the atmosphere to help mitigate climate change.

**How do Class VI wells protect drinking water resources?**

Class VI well requirements are designed to ensure that wells are sited, constructed, operated, tested, monitored, and closed in a manner that is protective of underground sources of drinking water (USDWs). The regulations are based on the existing Underground Injection Control (UIC) Program regulatory framework with modifications to address the unique nature of CO2 injection for GS, including: the relative buoyancy of CO2, its mobility in the subsurface, its corrosivity in the presence of water, and the large injection volumes anticipated at GS projects.

**What are the requirements for Class VI wells?**

EPA developed specific criteria for Class VI wells:

- Extensive site characterization requirements
- Well construction using materials that are compatible with and can withstand contact with CO2 over the life of the GS project
• Comprehensive monitoring of all aspects of well integrity, CO2 injection and storage, and groundwater quality during the injection operation and the post-injection site care period
• Wells financial responsibility requirements to assure the availability of funds for the life (including post-injection site care and emergency response) of the GS project.

Waste disposal

One application is waste water disposal, in which treated waste water is injected into the ground between impermeable layers of rocks to avoid polluting fresh water supplies or adversely affecting quality of receiving waters. Injection wells are usually constructed of solid walled pipe to a deep elevation in order to prevent injectate from mixing with the surrounding environment.

Injection wells are widely considered to be the best method for disposal of treated waste water. Unlike outfalls or other direct disposal techniques, injection wells utilize the earth as a filter to further clean the treated wastewater before it reaches the receiving water. This method of wastewater disposal also serves to spread the injectate over a wide area, further decreasing environmental impacts.

Critics of waste water injection wells cite concerns relating to the injectate polluting receiving waters. Most environmental engineering professionals, however, consider waste water
treatment followed by disposal through injection wells to be the most cost effective and environmentally responsible method of waste water treatment. The only known alternatives to injection wells are direct discharge of treated waste water to receiving waters or utilization of the treated water for irrigation. The only known alternatives to injection wells are direct discharge of treated waste water to receiving waters or utilization of the treated water for irrigation. Direct discharge does not disperse the water over a wide area; the environmental impact is focused on a particular segment of a river and its downstream reaches, or on a coastal waterbody. Extensive irrigation is often prohibitively expensive and requires ongoing maintenance and large electricity usage.

Oil and Gas Production

Another use of injection wells is in petroleum production. Steam, carbon dioxide, water, and other substances can be injected into an oil-producing unit in order to maintain reservoir pressure, heat the oil or lower its viscosity, allowing it to flow to a producing well nearby.

Waste site remediation

Yet another use for injection wells is in environmental remediation, for cleanup of either soil or groundwater contamination. Injection wells can insert clean water into an aquifer, thereby changing the direction and speed of groundwater flow, perhaps towards extraction wells downgradient, which could then more speedily and efficiently remove the contaminated groundwater. Injection wells can also be used n cleanup of soil contamination, for example by use of an ozonation system. Complex hydrocarbons and other contaminants trapped in soil and otherwise inaccessible can be broken down by ozone, a highly reactive gas, often with greater
cost-effectiveness than could be had by digging out the affected area. Such systems are particularly useful in built-up urban environments where digging may be impractical due to overlying buildings.

**Regulatory Requirements**

In the United States, injection well activity is regulated by the United States Environmental Protection Agency (EPA) and state governments under the Safe Drinking Water Act. APA has issued Underground Injection Control (UIC) regulations in order to protect drinking water sources.