GROUNDWATER PROTECTION COUNCIL

Injection Wells:

A Guide to Their Use, Operation, and Regulation

GWPC UIC Underground Injection Control

June 2021

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Background

The purpose of this guide is to provide introductory information about groundwater and the Underground Injection Control (UIC) program. The Guide is intended for a broad audience and avoids the use of technical jargon to the extent possible in describing groundwater and UIC concepts. The Ground Water Protection Council (GWPC)[1] is uniquely positioned to create this guide as the National Association of State Groundwater and Underground Injection Control (UIC) Agencies.

We hope you will find this guide useful as an introduction to the topics of groundwater and underground injection, and we encourage you to learn more by clicking on the links located throughout the Guide. These links will take you to more in-depth information about the specific topic being presented.

The GWPC believes that, based on a long history of demonstrated effective operation, the UIC program is one of the safest and most environmentally protective programs in the U.S.

Disclaimer

This is an informational document and is not intended to offer recommended rules or regulations. The GWPC believes management of the UIC program is best handled at the state level with specific considerations at local, regional, or cross-state levels, due to significant variability in local geology and surface conditions (e.g., population, building conditions, infrastructure, critical facilities, etc.).

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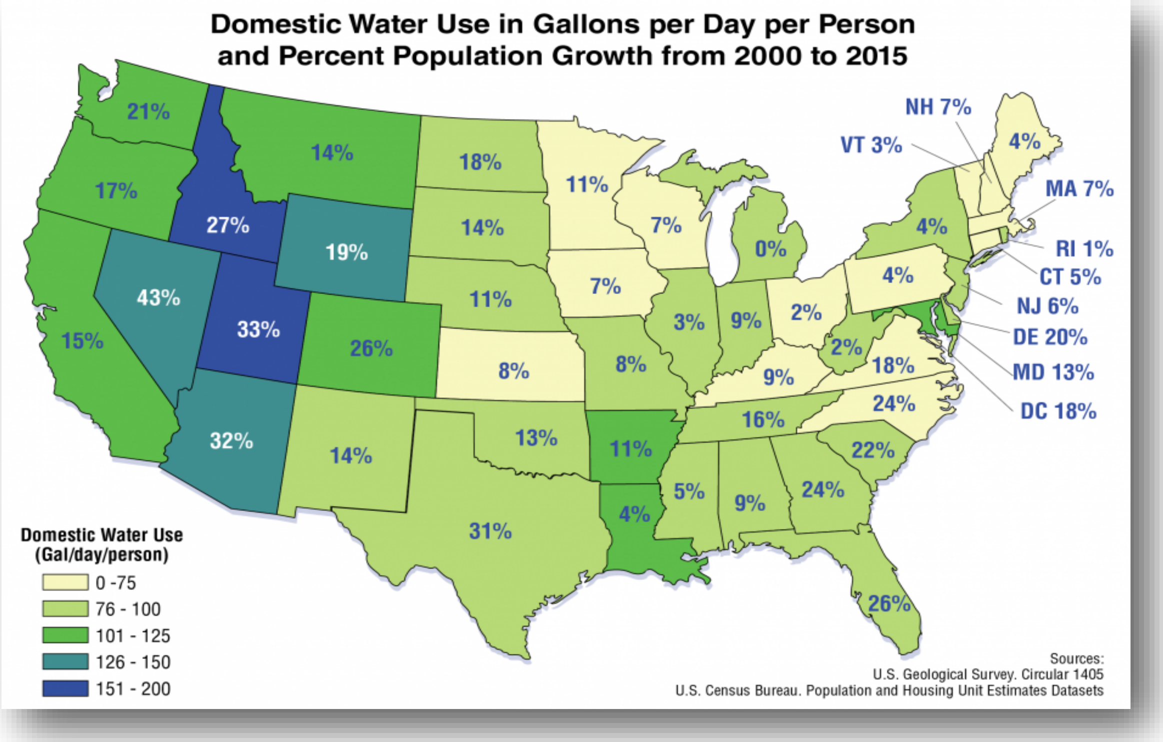
[1] Ground Water Protection Council (GWPC), https://www.gwpc.org

Groundwater Fundamentals

Water is more than just an underappreciated commodity. It is essential to life. Whether your water comes from a public water supply, a private well, a spring, or any other source, everyone must have safe usable and drinkable water. Depending upon where you live, the average American can use as much as 200 gallons of water per day, ***See Figure 1*.**



Domestic Water Use in Gallons per Day per Person and Percent Population Growth from 2000 to 2015

Sources:
U.S. Geological Survey. Circular 1405
U.S. Census Bureau. Population and Housing Unit Estimates Datasets

Figure 1: Domestic Water Use in Gallons per Day per Person and Percent Population Growth from 2000-2015: Source U.S. Geological Survey

According to the Groundwater Foundation 51 percent of people in the U.S. use groundwater as their primary drinking water source and this figure jumps to 99 percent for rural populations.[2] But what exactly is groundwater? Groundwater is water stored beneath the land surface of our local communities in formations of saturated rock, sand, gravel, and in the soil. Unlike surface water, groundwater does not flow in a series of lakes and rivers unless it is part of a karst (cave) system. Instead, the precipitation that seeps into our soil can sometimes follow a torturous journey, eventually filling the pores of these subsurface formations. The amount of water that infiltrates the subsurface varies widely, depending on land use, the type of soil present, and the amount of precipitation that falls.

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[2] Groundwater Foundation, https://www.groundwater.org/get-informed/basics/groundwater.html#:~:text=Groundwater%20supplies%20drinking%20water%20for%2051%25%20of%20the,source%20of%20recharge%20for%20lakes%2C%20rivers%2C%20and%20wetlands. pdf

Groundwater can also be replaced or recharged when rock formations come into contact with surface water bodies such as lakes and rivers. These points of connection can also result in discharge of groundwater to the surface, and are called springs, ***See Figure 2*****.**

Figure 2: Groundwater discharge spring: Source Virginia Department of Environmental Quality

Groundwater is found at various depths and in both confined and unconfined systems. Groundwater is essential to our public water supply systems, economic growth, national agricultural production, and the overall quality of life we all share. This is true regardless of whether or not we are personally dependent upon groundwater for drinking water. Fresh groundwater—that is, water with lower salinities and mineral contents—is usually located nearer the earth's surface, while deeper rock formations often contain water with higher dissolved mineral content limiting its quality or usability. Water with salinities greater than 10,000 parts per million of Total Dissolved Solids (TDS), is considered saline and has not historically been considered a potential source of drinking water ,except where it can be cost effectively treated. However, in recent years there has been an increased focus on brackish groundwater as a potential source of drinking water. This water has higher salinities than fresh groundwater but lower salinities than typically deeper saline water.

MOST AMERICANS ARE SURPRISED TO LEARN THAT: *

- **82 billion gallons of groundwater is used in America each day;**
- **41 percent of the nation's drinking water and over 29 percent of our total fresh water supply comes from groundwater; and**
- **132,200,000 people in the U.S. derive their household water supply from groundwater.**

***Derived from figures in "Groundwater Use in United States of America", National Ground Water Association (NGWA), January 2021** https://www.ngwa.org/docs/default-source/default-document-library/groundwater/usa-groundwater-use-fact-sheet.pdf?sfvrsn=5c7a0db8_4

Formations that contain large enough volumes of groundwater to feed springs or wells are called aquifers. The two principal properties of rock which determine the volume of water that aquifers can provide are called porosity and permeability.

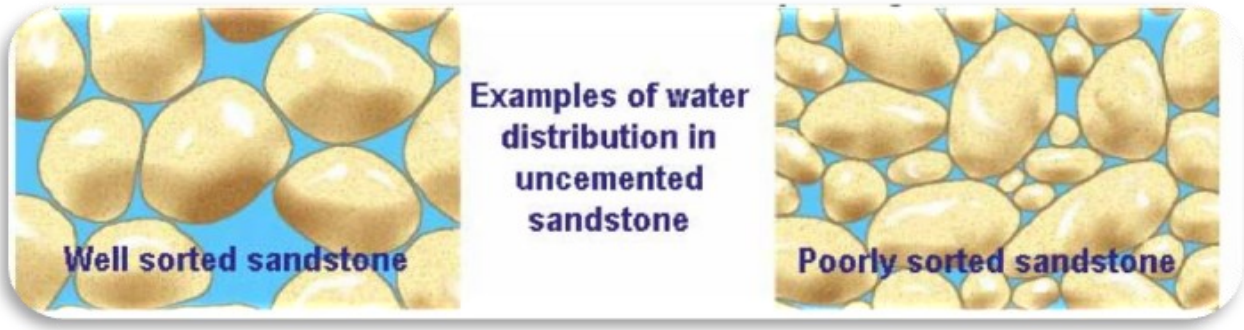

Figure 3: Diagram of a typical groundwater aquifer: Source, National Groundwater Association

Porosity is a measure of the amount of pore space, or holes and cracks, present in a rock. The more pores present, the greater the rock's ability to hold water. A rock with many pores is said to have high porosity, ***See Figure 3*** (Left half).

Figure 4: Shale with horizontal bedding planes and low vertical permeability: Source GWPC

Permeability refers to the degree to which the pores are connected, providing a path for the groundwater to move within the rock. Some rocks, including many shale formations, have very low permeability perpendicular to their bedding planes, ***See Figure 4****.* Other rock types such as sandstone can be highly permeable in multiple directions, allowing water to move through its pores easily regardless of flow direction. If you think of a sponge between two layers of children's clay you can get a sense of a confined aquifer system that has a very porous layer bounded top and bottom by denser, less permeable layers.

A National Geographic Society estimate places U.S. reserves of groundwater at more than 33,000 trillion gallons.[3] However, groundwater can be susceptible to contamination from a variety of common sources, including septic tanks, feed lots, fertilizer applications, highway de-icing, industrial processes, landfills, oil and gas operations and underground storage tanks.

Once a groundwater resource has been contaminated, cleaning it up to make it usable again can be an extremely difficult, costly and, sometimes, infeasible task. That is why it is important that potential sources of contamination be managed in ways which protect groundwater and why deep formations containing highly saline groundwater are ideal locations for disposal or injection of liquids and liquid wastes.

Some wastes generated by industrial processes are difficult or nearly impossible to treat to levels that could make it safe to discharge at the surface. These materials may also cause groundwater contamination if they are not effectively isolated. Assuring the safe isolation of liquids and liquid wastes in the subsurface is the purpose of the UIC program.

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3 "Water map", National Geographic Society, November 1993 (Estimate of U.S. groundwater reserves, National Ground Water Association,), https://www.ngwa.org/what-is-groundwater/About-groundwater/groundwater-facts#:~:text=Hydrologists%20estimate%2C%20according%20to%20the,in%20the%20past%20200%20years.pdf

Underground Injection Control (UIC) Program

Waste is an unavoidable by-product of manufacturing processes that create the thousands of products we use each day. Products such as steel, plastics, gasoline, pharmaceuticals, and many others cannot be made without generating liquid and solid wastes.

Figure 5: UIC Program Well Classes: Source USEPA

Additionally, many millions of gallons of liquid wastes are generated in large municipalities from treated sewage. While industry continues to research and implement ways to reduce waste by recycling and improving processes, generated wastes and waste treatment byproducts still require disposal. Depending upon the type of waste generated, there are many disposal options, including incineration, biological or chemical treatment, and, for solid waste; properly located, constructed, and permitted landfills. While some areas have rivers or other water bodies at the surface that can receive municipally treated waste streams under the National Pollutant Discharge Elimination System (NPDES)[4], others have very sensitive waters that make disposal of these liquid wastes unsafe and/or impractical. An environmentally protective way to deal with liquid waste in many parts of the United States is underground disposal through injection wells which can penetrate thousands of feet below the earth's surface, ***See Figure 5.*** But what is underground injection and how is it regulated by the UIC program[5] ?

Underground injection is the placement of fluids into the subsurface through a properly constructed well. Many of the wells used for injection are "high tech" in their construction and some are used for purposes other than waste disposal such as Enhanced Oil Recovery (EOR) , mineral mining, groundwater sustainability, and others. However, some are very simple, including dug wells, certain septic systems, and other shallow, subsurface, fluid distribution systems. The practice of underground injection has become essential to many of today's industries, including the petroleum industry, chemical industry, food and pharmaceutical industries, geothermal energy industry, and many local small specialty plants and retail establishments.

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4 National Pollutant Discharge Elimination System (NPDES), https://www.epa.gov/npdes

5 Underground Injection Control Program (UIC), https://www.epa.gov/uic

To dispose of fluids safely, injection wells need to be in the right kind of geologic setting, properly constructed, operated, maintained, and checked through different kinds of monitoring. In the late 1960's, the realization that subsurface injection could contaminate groundwater if wells were not properly located and operated prompted many states to develop programs and methods to protect underground sources of usable water. Shortly after the creation of the U.S. Environmental Protection Agency (USEPA) in 1972, a federal UIC program was created to increase groundwater protection when underground injection was used as a method of disposal. This UIC program was established under the authority of the federal Safe Drinking Water Act (SDWA) of 1974.[6]

The goal of the UIC program is the effective isolation of injected fluids from Underground Sources of Drinking Water (USDWs), which are defined as:

> *"an aquifer or its portion:*
>
> *(a)(1) Which supplies any public water system; or*
>
> *(2) Which contains a sufficient quantity of ground water to supply a public water system; and*
>
> *(i) Currently supplies drinking water for human consumption; or*
>
> *(ii) Contains fewer than 10,000 mg/l total dissolved solids; and*
>
> *(b) Which is not an exempted aquifer."*[7]

NOTE: "Exempted aquifer means an "aquifer" or its portion that meets the criteria in the definition of "underground source of drinking water" but which has been exempted according to the procedures in 40 Code of Federal Regulations (CFR) Part 144.7"

Although most groundwater used today as drinking water contains less than 500 Mg/L of TDS, as listed in the USEPA secondary drinking water standards, the UIC Program protects waters with much higher mineral concentrations to ensure that water with the potential to be treated and used as drinking water in the future is protected.

Since the passage of several legislative acts in the 1970's intended to regulate waste disposal into water, air, and landfills, the use of underground injection has grown in importance. In the

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[6] Safe Drinking Water Act (SDWA) of 1974, https://www.epa.gov/sdwa

[7] USEPA Code of Federal Regulations 40 CFR Part 144.3 Definitions
https://www.govinfo.gov/content/pkg/CFR-2014-title40-vol23/xml/CFR-2014-title40-vol23-part144.xml

petroleum industry alone, about 24.4 billion barrels (bbl.), or 1.02 trillion gallons of produced water, are generated each year in the United States from nearly a million oil & gas wells. Of this total about 91.5 percent is reinjected underground for disposal or to enhance oil recovery[8] If improperly discharged at the surface, this water may pose a risk of contaminating surface water and groundwater.

Underground Injection Well Classification Chart

Well Class	Purpose	Active Wells
I	Injection of hazardous, non-hazardous, and municipal wastes below the lowermost USDW	830
II	Injection of fluids associated with the production of oil and natural gas resources for the purposes of disposal or enhanced oil and gas recovery	181,431
III	Injection of fluids for the extraction of minerals	28,327
IV	Injection of hazardous or radioactive wastes into or above a USDW (USEPA prohibited the use of Class IV wells in 1984)	122
V	Injection into wells not included in other well classes but generally used to inject non-hazardous waste	531,536
VI	Injection of supercritical carbon dioxide for storage	2

Figure 6: UIC Well Classes and Purposes including numbers of wells by class: Source USEPA, 2020, https://www.epa.gov/sites/production/files/2020-04/documents/uic_fact_sheet.pdf

According to the USEPA there are over 742,000 injection wells in six well classes in the United States, including over 182,000 Class I and II wells which are used to inject fluids into deep underground rock formations trapped by impermeable layers, keeping the fluids away from USDWs. ***See Figure 6.***

Injection well classes are generally based on the kind of fluid injected and the depth of the fluid injection compared with the depth of the lowermost USDW. For example, Class I wells are used to inject industrial or municipal waste to a depth beneath the lowermost USDW. Class II wells are used to dispose of fluids associated with the production of oil and gas or are used to enhance the production of oil and gas. Both Class I and II wells typically inject into zones well below the lowermost USDW. Class III wells are used to inject fluids to aid in

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[8] J.A. Veil, 2017, Produced Water Volumes and Management Practices in the United State, Ground Water Research and Education Foundation by John Veil, Veil Environmental, https://www.gwpc.org/sites/gwpc/uploads/documents/publications/pw_report_2017___final.pdf

the extraction of minerals such as uranium, potash, and salt. Class IV wells were used to dispose of hazardous or radioactive wastes into or above a USDW or as part of a remediation project. However, these wells have been banned in all 50 states, unless they are part of a contaminated site cleanup. Though Class IV wells have been banned for many years, some are still periodically discovered and must be plugged and properly abandoned. Class V wells are all wells not included in Classes I-IV, and which are used to inject or dispose of non-hazardous liquids into or above a USDW. Class VI wells are used to inject the greenhouse gas carbon dioxide (CO_2); a by-product of fossil fuel use, cement processing, ethanol production and other industrial processes, into deep formations for long term sequestration.

Since the early 1980's the USEPA has routinely delegated primary enforcement authority (Primacy) over underground injection programs to those states with agencies that have demonstrated an ability to implement a UIC Program meeting USEPA's legal requirements. These requirements are contained in Sections 1422 and 1425 of the SDWA, and 40 CFR Parts 144 through 147.

There are currently forty-three states, three territories, and two tribes that have Primacy over one or more well classes.[9] ***See Figure 7***.

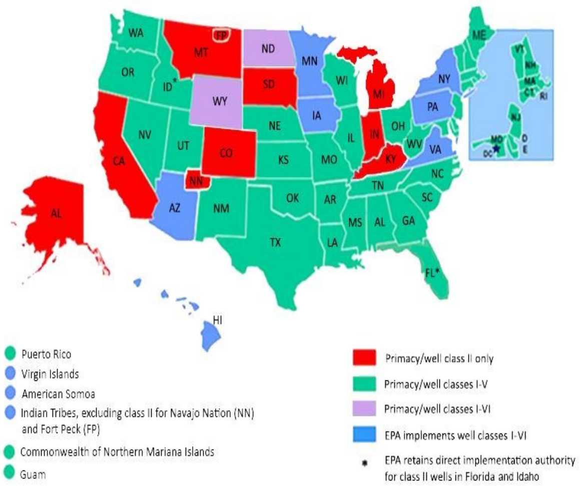

Figure 7: Map of the states with full or partial UIC Primacy: Source USEPA, 2020

In many states, more than one state agency has Primacy for one or more classes of injection well. For instance, one agency may have authority over Class II wells, while another may have authority over Classes I, III, V or VI wells. In states that have not received Primacy over a portion of the UIC program, USEPA remains the responsible regulatory agency for that class or classes of wells. These are referred to as Direct Implementation (DI) programs because USEPA directly implements all or a portion of the UIC program in those states, territories or tribal lands.

In the following pages we will discuss each class of injection well and how it fits into the national picture of the UIC program.

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[9] USEPA list of states, territories and tribes with primary enforcement authority for the UIC program by well class, 2019, https://www.epa.gov/sites/production/files/2019-04/documents/primacy_status_revised_april17_2019_508c.pdf

Class I Wells

Figure 8: Geologic cross section showing Class I wells: Source USEPA

Class I wells are designed to inject hazardous, non-hazardous, municipal, and radioactive wastes into formations located deep beneath the earth's surface, Most geologic formations containing USDWs are relatively shallow, often less than 1000 feet in depth depending upon their location. The suitability of this disposal method depends on the availability of appropriate underground rock formation combinations that have the natural ability to accept and confine the wastes. ***See Figure 8***. It is the long term confinement of fluids that makes deep well injection of this type of waste an environmentally sound disposal method. The ability of some rock formations to accept but confine liquids injected into them is the same characteristic that has held deposits of oil, natural gas, helium and other liquids and gases for millions of years without allowing them to escape.

Because these wells inject waste well below the deepest USDW, there is little chance of negative effects on potentially usable groundwater. In fact, in its March 2001 Study of Class I wells, the USEPA said that "the probability of loss of waste confinement due to Class I injection has been demonstrated to be low" and "existing Class I regulatory controls are strong, adequately protective, and provide an extremely low-risk option in managing the wastewaters of concern."[10] In other words, the deep geologic formations into which the waste in injected, the related confining layers above the injection zone, and the many layers of protection required in the construction, operation, and monitoring of wells, provide many safeguards against upward fluid movement, effectively protecting USDWs.

Class I facility owners are required to apply for and receive a permit from the state or USEPA before constructing or operating any type of Class I well.

[10] USEPA, Class I Underground Injection Control Program: Study of the Risks Associated with Class I Underground Injection Wells, March 2001, https://www.epa.gov/sites/production/files/2015-07/documents/study_uic-class1_study_risks_class1.pdf

As previously stated, Class I wells are subdivided by the types of waste they can inject: hazardous, non–hazardous, municipal, or radioactive. At the time of a 2010 survey conducted by the GWPC, there were 311 active Class I injection facilities in 19 states; which had a total of 523 wells. Of these, 114 wells were listed as hazardous, 305 were non-hazardous and 104 were municipal.[11]

According to the most recent figures available from the USEPA , there are currently a total of 636 Non-hazardous or Municipal Class I wells and 138 Hazardous Class I wells. This represents an 18 percent increase over the past 11 years. As shown in ***Figure 9,*** the greatest numbers of Class I wells are located in the Gulf Coast and Florida.

Hazardous wastes are those industrial wastes that are specifically defined as hazardous in federal laws and regulations[12] (40 CFR Part 261.3 under Section 3001, of Subtitle C of the Solid Waste Disposal Act, as amended by the 1976 Resource Conservation and Recovery Act (RCRA).[13]

Number of Class I Wells by Category

State/ Tribe	Non-hazardous or Municipal	Hazardous
Alaska	23	0
Arkansas	8	3
Colorado	16	0
Florida	251	1
Illinois	9	2
Indiana	0	4
Kansas	56	8
Kentucky	1	0
Louisiana	17	19
Michigan	31	7
Mississippi	8	5
Nebraska	10	0
New Mexico	6	0
North Dakota	8	0
Ohio	5	12
Oklahoma	6	0
Osage Nation	1	0
Seminole Tribe	3	0
Texas	92	77
Wyoming	85	0
Totals	**636**	**138**

Figure 9: Number of Class I wells by location & category: Source USEPA

Only ten states currently have hazardous Class I injection wells. Most of these wells are located along the Texas–Louisiana Gulf Coast. This area has a large number of waste generators such as refineries and chemical plants. This area also has deep geologic formations that are ideal for the isolation of these wastes.

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11 GWPC, Class I Inventory Update, October 2010

12 U.S General Printing Office, 40 CFR Part 261.3, Definition of Hazardous Waste, https://www.ecfr.gov/cgi-bin/text-idx?node=pt40.28.261&rgn=div5#se40.28.261_13

13 Resource Conservation and Recovery Act (RCRA) , https://www.epa.gov/fedfacts/resource-conservation-and-recovery-act-rcra

Non–hazardous wastes are any other industrial wastes that do not meet the legal definition of hazardous wastes, and can include a wide variety of fluids, such as those from food processing. Texas (92) and Wyoming (85) have the greatest number of wells in this category because these states have specific sources that generate significant quantities of non–hazardous, liquid wastes.

Municipal wastes, though not specifically defined in federal regulations, are wastes associated with sewage effluent that has received treatment. With the exception of desalination wastes, disposal of municipal waste through injection wells is primarily practiced in Florida where there are 251 municipal disposal wells. In Florida, this waste disposal practice is often chosen due to a shortage of available land, strict surface water discharge limitations, availability of extremely permeable injection zones, and high cost effectiveness.

At present there are no known authorized radioactive waste disposal wells operating in the U.S.

The process of selecting a site for a Class I disposal well involves evaluating many factors. Paramount in the consideration is the determination that the underground formations possess the natural ability to contain and isolate the injected waste. To determine this, a detailed study is conducted to determine the suitability of the underground formations for disposal and confinement. The receiving formation must be far below the deepest USDW, and be separated from it by confining layers of rock. The injection zone in the receiving formation must be of sufficient size (both over a large area and thickness) and have sufficient porosity and permeability to accept, transmit, and contain the injected wastes. Additionally, the injection zone must be bounded by confining zones that will prevent the migration of injected waste. The region around the well should be geologically stable, and the injection zone should not contain recoverable mineral resources such as ores, oil, coal, or gas.

Another important part of the determination is the evaluation of the history of seismic activity. If a location indicates the possibility of seismicity in the subsurface, it may mean not only that fluids may leave the injection zone, but that injection may have the potential to cause earthquakes. These factors indicate the well should not be drilled in that particular location.

A third important factor is determining if any improperly abandoned wells, mineral resources that provide economic reserves, or underground sources of drinking water are identified in the area. These are evaluated to ensure the injection well will not cause negative impacts to these resources. Abandoned wells of any type, whether oil, gas, or injection that penetrate the proposed injection zone are investigated within a specified distance from the injection well to ensure that they were properly plugged. If they were not, they must be properly re-plugged to prevent them from becoming a means for the fluids injected into the Class I well to escape upward, potentially contaminating a USDW.

In the case of Class I hazardous wells the applicant for a permit must also complete what is known as a *No-migration petition*. This petition contains a requirement that the applicant certify the injectate will not migrate outside of the injection zone for a period of 10,000 years.

The primary concern in the construction of all UIC wells including Class I injection wells is isolation of the injectate from USDWs. This is accomplished by assuring containment of the injected wastes through a multilayer protection system. ***See Figure 10***.

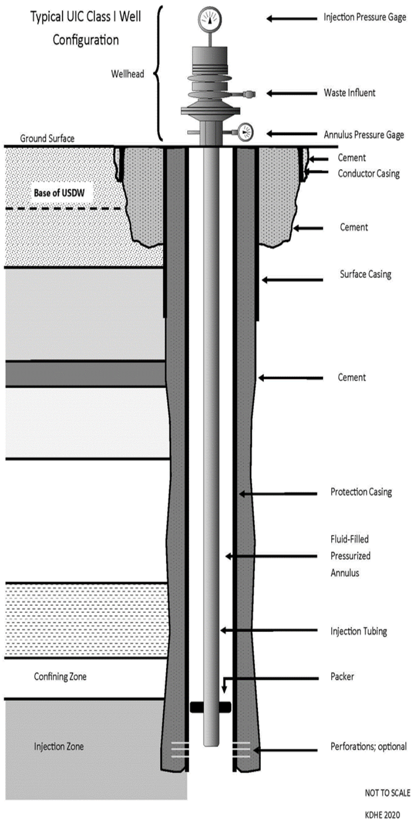

Figure 10: Typical Class I Injection well construction diagram. Source Kansas Department of Health and Environment (KDHE)

Class I injection wells are constructed in stages. The first stage is the drilling of a hole to a depth below the lowermost USDW. A steel pipe called surface casing is installed to cover the full length of the bore hole and cemented from the bottom of the hole to the ground surface. This provides a barrier of steel and cement that protects the groundwater.

After the surface casing is cemented and given time to cure, the second phase is to drill below the surface casing down into or through the intended injection zone. After drilling is complete, an additional protective casing called long string is installed from the surface down to the top of or into the injection zone and, like the surface casing, cemented in place from bottom to top. If the long string was run into or through the injection zone the casing is perforated with several holes to provide a pathway for the injection fluid to enter the formation. Afterwards this casing string and cement combination undergoes mechanical integrity tests (MITs) to assure that the cement has bonded properly to the casing and to the wellbore.

After the long string is tested, an injection packer, which is like a drain plug with a hole in the middle, is placed inside the long string casing above the injection zone or casing perforations and an even smaller pipe known as injection tubing is placed inside the long string and sealed into the packer. The space between the long string and the injection tubing, called the annulus, is filled with a corrosion inhibiting fluid. When the injection packer is expanded tightly against the sides of the injection casing it forms a seal which keeps the annulus fluid in and the injection fluid out of the space above the packer. These components are tested to assure there is no leakage through the tubing, packer, or casing. This test is called a Standard Annulus Pressure Test (SAPT). During injection, the pressure in the annulus is continuously monitored so that any change, indicating a failure of the casing, tubing, or packer would cause the operator to shut down the injection before possible contamination of a USDW could occur.

Wells are also tested regularly, using special tools inserted into the well to record data about the well and surrounding rock formations. These test results tell a geologist or engineer a great deal about conditions in the well. Further tests may also be required upon request of the regulatory agency.

The operating conditions of the well are closely studied and are limited by the permit to ensure:

1. The pressure at which the fluids will be pumped into the subsurface will not initiate fractures in the rock matrix;
2. The rock units can safely receive the volume of fluids to be disposed of; and
3. The waste stream is compatible with all the well components and the natural characteristics of the rocks into which the fluids will be injected.

Class I injection wells are continuously monitored and controlled; usually with sophisticated computers and digital equipment. Thousands of data points about the pumping pressure of fluid disposal, the pressure in the annulus between the injection tubing and the well casing (which indicates there are no leaks in the well components), and data on the fluid being disposed of, such as its temperature and flow rate, are monitored and recorded each day. Alarms are connected to sound if any indication of a component failure or higher pressures than those permitted are sensed by the monitoring equipment. In such cases the well is designed to shut off automatically. Disposal in the well may not resume until the cause of the event is investigated, and the people responsible for operating the well and the regulatory agencies are both assured that no environmental harm has resulted and will not result from further operations.

Regulators review all the data about the well operations; monitoring and evaluating testing frequently, and regularly inspecting the well site to make sure everything is operating according to the requirements put in place to protect USDWs.

When a Class I well is permanently taken out of service, the injection tubing is removed and the well is plugged to prevent any waste movement. Often, a combination of mechanical plugs and cement, are used to seal the wells. The well is then considered to be properly plugged and abandoned (P&A). The plugs in the well ensure that no fluids can move upwards into a USDW. Through years of use and many studies, properly located, designed, constructed, operated, and monitored Class I wells have proven to be a technologically-sound and environmentally safe method of permanent liquid waste disposal.

Class II Wells

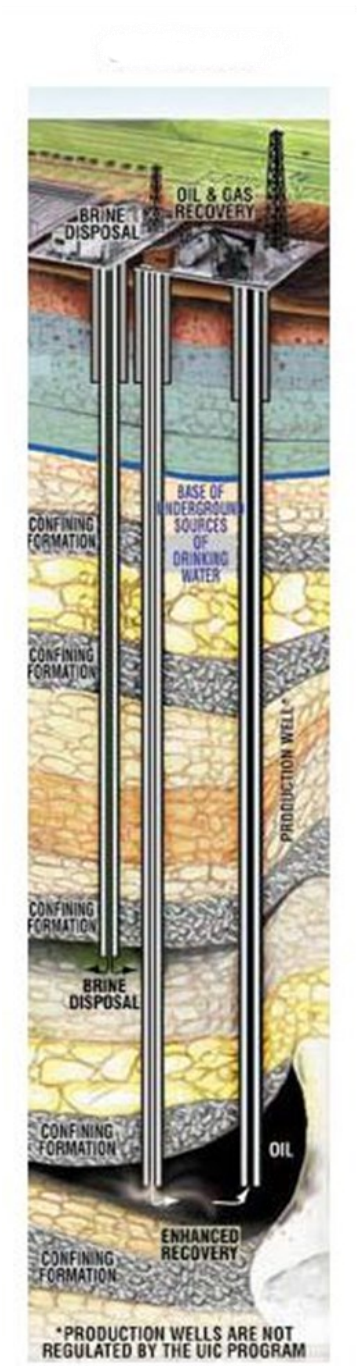

Figure 11: Geologic cross section showing Class II injection wells: Source, USEPA

Class II injection wells have been used in oilfield related activities since the 1930's. As previously shown in *Figure 6*, there are about 181,000 Class II injection wells. These wells are located in 31 states and territories, and on tribal lands. All Class II injection wells are regulated by either a state entity (typically an oil and gas agency, board or commission), or a tribal entity which has been granted Primacy over the program, or by the USEPA. However, some states that do not have Primacy over Class II wells may still have state regulations governing them. A good example of this is Pennsylvania; which is a DI state but requires a state permit in addition to the federal Class II permit.

Much like Class I wells, Class II wells are subject to a regulatory process which requires the administrative review of an application to evaluate financial assurance adequacy and meet other permit requirements, and a technical review to assure adequate protection of USDWs and set operational requirements. The evaluation of the site suitability for a Class II injection well is also very similar to that of a Class I nonhazardous waste injection well. The subsurface conditions of the site are evaluated to make sure the formations will isolate the fluids from non-exempted USDWs. ***See Figure 11***. The wells must be constructed to protect these USDWs, and they are tested and monitored periodically to ensure these USDWs are not being negatively impacted by the injection operations.

Class II wells are categorized into three subclasses: saltwater disposal (SWD) wells, enhanced oil recovery (EOR) wells, and liquid hydrocarbon storage wells.

As oil and natural gas are brought to the surface, they generally are mixed with saltwater (produced water). On average nationally, approximately seven barrels of produced water are co-produced with every barrel of crude oil.[14]

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[14] Ibid, https://www.gwpc.org/sites/gwpc/uploads/documents/publications/pw_report_2017___final.pdf

Figure 12: Typical surface configuration of a Class II injection well: Source, GWPC

The produced water is initially collected at a set of tanks called a tank battery. The produced water is then either piped or trucked to the injection site where it may be further treated to remove suspended solids which may clog the receiving formation. It may also receive additional treatment to assure it has the right composition to be injected into either an EOR or SWD well. It is then transferred to holding tanks and pumped down the well through the injection tubing. ***See Figure 12*.**

The EOR process is commonly referred to as waterflooding or secondary recovery. In this process, produced water is re-injected into the oil-producing formation to drive oil to production wells, resulting in the recovery of additional oil. Tertiary recovery is an EOR process that is used after secondary recovery methods become inefficient or uneconomical. Tertiary recovery methods include the injection of fluids such as gas, water with special additives, CO_2, and steam to maintain or extend oil production. Secondary and tertiary recovery methods allow the maximum amount of oil to be retrieved from the producing formation. Approximately 43.6 percent of the produced water generated with onshore oil and gas production in the United States is injected into EOR wells while nearly all of the remaining water is injected into SWD wells for disposal. A small amount (< 1 percent) is reused outside of the oilfield. [15]

Hydrocarbon storage wells are used to inject hydrocarbons that are liquid at standard temperature and pressure (75° F at 14.7 pounds per square inch). These wells are designed for both injection and removal of the stored hydrocarbons. After being stored underground the hydrocarbons can be pumped back out later for processing and use.

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15 Ibid, https://www.gwpc.org/sites/gwpc/uploads/documents/publications/pw_report_2017___final.pdf

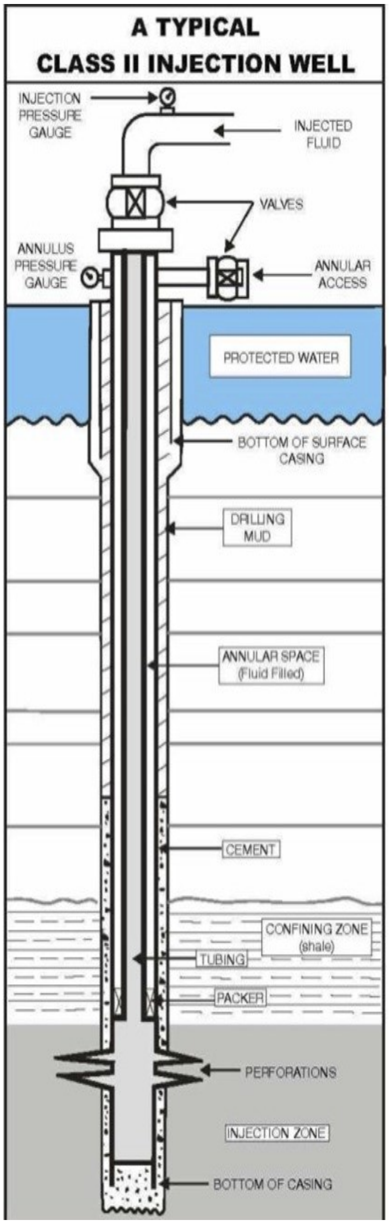

Figure 13 Typical Class II Injection well construction Source, North Dakota Oil and Gas Division

As shown in ***Figure 13***, Class II injection well construction is designed to properly confine injected fluids to the authorized injection zone and prevent the migration of fluids into USDWs.

Class II wells are drilled and constructed using techniques similar to those used for Class I wells, with steel casing cemented in place to prevent the migration of fluids into USDWs. Surface casing in conventionally constructed wells is cemented from below the lowermost USDW up to the surface to prevent fluid movement. Cement is also placed behind the injection casing at critical sections to confine injected fluids to the authorized zone of injection. A typical injection well also has tubing set on a packer, through which the fluids are pumped from the surface down to the receiving formation. The purpose of the packer is to isolate the injection zone from the annular space between the tubing and injection casing above the packer. In some cases, multiple EOR wells may be constructed under one permit to manage the fluids in an entire oil or gas production field. This is commonly referred to as an “area permit”.

Well tests and documentation that demonstrate the conditions of the various well components and the cement in the subsurface are required prior to initial injection and, for well component integrity, no less than once every five years afterward. However, if needed, more frequent testing may be required by regulatory authorities. All tests and test methods are rigorously reviewed by regulatory authority. Test data, as well as data on the volume and characteristics of the fluids injected into the well, are also regularly evaluated by regulatory authorities to make sure USDWs are protected during the operation and maintenance of the wells.

As with construction, Class II well operations are regulated in ways designed to prevent the contamination of USDWs and to ensure fluid placement and confinement within the authorized injection zone. Primacy states or tribes have adopted Class II regulations which have been approved by USEPA to be “as effective as” the USEPA regulation for protection of non-exempt

USDWs. These regulations address items such as financial assurance, injection pressures and volumes, well construction and testing, pressure monitoring, and reporting.

After placing Class II injection wells in service, continued groundwater protection is assured by testing and monitoring the wells on a routine basis. Injection pressures and volumes are also monitored because they provide a valuable indicator of well performance. Effective monitoring is important because it can identify problems in the well so corrective action can be taken quickly to prevent endangerment of non-exempt USDWs.

Closure of Class II wells must be conducted in a manner protective of USDWs. Although regulations vary somewhat from state to state, a cement plug is commonly required to be placed in the well across the injection zone, with additional plugs placed across the base of the lowermost non-exempt USDW and sometimes nearer the surface. In some cases Cast Iron Bridge Plugs (CIPBs) are placed below the cement plugs to provide an additional flow barrier and assure the cement stays in the intended placement intervals inside the well.

Class III Wells

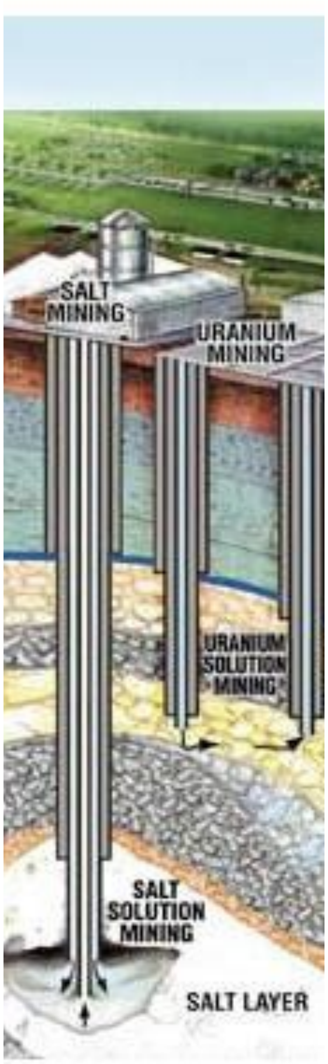

Figure 14: Geologic cross section showing Class III injection wells: Source, USEPA

Class III injection wells are found in 18 states. Every Class III injection well, whether located in a Primacy or DI state, must be permitted through the authorized regulatory authority. The operating permit requires that a well meet any regulations the agency has adopted to ensure the protection of non-exempt USDWs, ***See Figure 14.*** The permits may include specific requirements for well construction, monitoring, mechanical integrity testing, maximum allowable injection pressure, and reporting.

The techniques these wells use for mineral extraction are divided into two basic categories: Solution mining and In–situ (In-place) leaching.

Solution mining: This technique is used primarily for the extraction of salts, sulfur and potash. For example, a common salt solution mining process involves injection of relatively fresh water, which dissolves the underground salt formation. The resulting brine solution is pumped to the surface, either through the space between the tubing and the casing in the injection well, or through separate production wells.

The solution mining technique used for mining sulfur is known as the Frasch process. This process consists of injecting superheated water down the space between the tubing and the casing of the injection well and into the sulfur–bearing formations to melt the sulfur. The molten sulfur is extracted from the subsurface through the tubing in the injection well, with the aid of compressed air, which mixes with the liquid sulfur and airlifts it to the surface.

In-situ leaching: This technique is commonly used to extract minerals such as copper, gold, and uranium. Uranium is the predominant mineral mined by this technique. The uranium in-situ leaching process involves injection of a neutral water solution containing nontoxic chemicals (e.g., oxygen and CO_2) down the well. These injection liquids are circulated through an underground ore body or mineral zone to dissolve the uranium particles that coat the sand grains of the ore body. The resulting uranium rich solution is then pumped to the surface, where the uranium is extracted from the solution and the leaching solution is recycled back into the ore body through the injection well. This same general technology is employed for in-situ leaching of other minerals, the only difference is the type of fluid used in the process. Under normal circumstances, the typical life of a well using in-situ leaching is less than five years. However, at present, many Class III operations have been placed on hold awaiting the price of Uranium to increase. At the end of the leaching operations, state UIC regulations require restoration of the groundwater in the mined zone.

Given the purposes of Class III wells, Class III UIC projects often include many wells that are authorized through an area permit. The standards in this type of permit apply to all of the wells in the project area.

As with other well classes, construction standards for Class III injection wells are designed to confine injected fluids to the authorized injection zone to prevent their migration into non-exempt USDWs. Class III injection wells are typically drilled into mineralized rock formations and casing is cemented in place from top to bottom. Construction materials and techniques vary depending upon the mineral extracted and the nature of the injected fluids.

Well integrity tests are required before initial operation of Class III injection wells to evaluate the condition of the well construction materials and the rock formations. Several different tests have been approved for this purpose. The tests are used to demonstrate there are no leaks in the tubing, casing, or packer and that there is no fluid movement into a non-exempt USDW. UIC regulations also require that the ore body be surrounded by monitoring wells to detect horizontal migration of the mining solutions. Additionally, overlying and underlying aquifers must be monitored to detect any vertical migration of these fluids. This entire network closely monitors the mining activity performed through Class III wells to protect non-exempt USDWs.

As with wells in Classes I and II, Class III wells must be closed or plugged in a manner that protects non-exempt USDWs from potential contamination.

Class IV Wells

Graphic: USEPA

Class IV wells have been identified by USEPA as a significant threat to human health and the environment since they introduce dangerous wastes into or above a USDW. USEPA has banned the use of these wells for many years. However, due to both accidents and illegal intentional acts, Class IV wells are still periodically found at various locations. For example, this well class may include storm drains where spills of hazardous wastes enter the ground or septic systems where hazardous waste streams are combined with sanitary waste. As these wells are identified by state and federal UIC regulatory agencies, their closure becomes a high priority for the UIC program. When they are found, the UIC program staff usually coordinate with the state or USEPA hazardous waste program staff to evaluate site conditions, determine what actions need to be taken to clean up the well and surrounding area, and permanently close the well so additional hazardous wastes cannot enter the subsurface through the well.

Although otherwise banned, there is one instance where Class IV wells are allowed. Class IV wells may be used to help clean up existing contamination. Sites exist across the U.S. where hazardous wastes have entered aquifers due to spills, leaks or similar releases into the subsurface. Under two separate federal laws, the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)[16], regulators require and oversee the clean up of these contaminated sites. Some remediation technologies require the contaminated groundwater to be pumped out of the subsurface, treated at the surface to remove certain contaminants, then pumped back into the contaminated formation. The process essentially creates a treatment loop for the groundwater. However, the water reinjected may still have contaminants at levels that meet the definition of hazardous waste. Until the treatment process has time to remove more contaminants, these wells are technically still Class IV wells. USEPA recognized that these site clean ups needed to occur, and the ban of Class IV wells was hindering the cleanup process. Because these wells are helping the environment, the agency changed the regulations to allow these wells to be used, as long as they are part of an approved regulatory clean up of the site. Regardless, these types of wells are currently being classified as Class V, which we will discuss next.

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16 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), https://www.epa.gov/superfund

Class V Wells

If a well does not fit into Classes I-IV or Class VI it is considered a Class V and must have either an individual permit or be part of a project that is authorized by rule (See Page 30). Class V injection practices recognized by USEPA include several individual types of wells, which range in complexity from simple stormwater drainage wells, to sophisticated geothermal reinjection wells that may be thousands of feet deep, ***See Figure 15.*** However, the number of shallow, relatively simple Class V wells is large, and the subset of sophisticated, deep Class V wells is relatively small in comparison. Recall that injection wells are classified based on the type of waste disposed of and the depth of the disposal zone compared with the deepest non-exempt USDW,

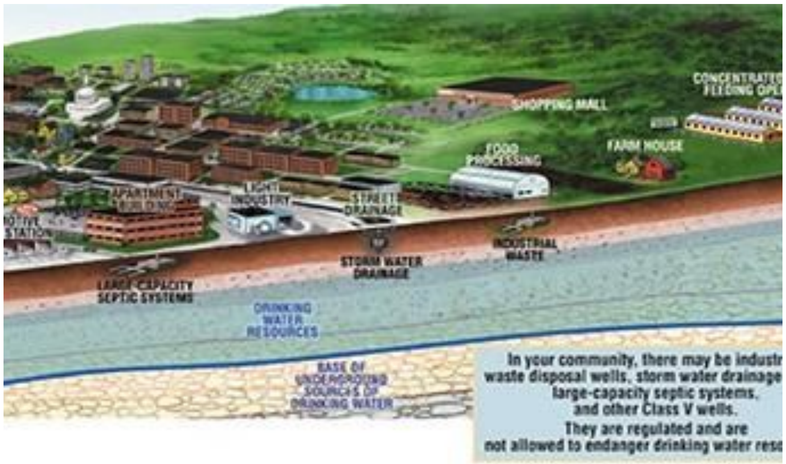


Figure 15: Geologic Cross section showing Class V injection wells: Source USEPA

Class V injection wells can be located anywhere, but they are especially likely to exist in areas that do not have organized wastewater collection and treatment. Unfortunately, these areas are often the same areas where people are most likely to depend on groundwater for their drinking water source, typically from private wells that do not undergo treatment or disinfection, unlike public water supply systems. There are over 30 different types of wells under the UIC Class V category. A survey was conducted in 2016 by a GWPC work group chaired by the Utah Division of Environmental Quality and the Texas Commission of Environmental Quality of 7 states and 3 USEPA regions. This survey found the most labor intensive Class V wells from a regulatory perspective, from most to least, were: stormwater drainage wells, aquifer storage and recovery/ aquifer recharge wells, subsurface environmental remediation wells, motor vehicle waste disposals large capacity septic systems, sewage treatment plant effluent disposal wells, and industrial disposal wells..[17] Not all Class V wells are used for disposal. Examples of Class V practices which are not disposal include: managed aquifer recharge (MAR), aquifer storage and recovery (ASR), and saltwater intrusion control.

[17] Cady, Candace and Council, Lorrie: Presentation at the GWPC Annual Forum, Orlando Florida, 2016

With the increasing need to manage water both at the surface and underground and to develop additional water sources to meet increased demand for drinking water, MAR and ASR wells, along with treated sewage effluent wells and stormwater drainage wells, emplace water underground and are considered to be important tools for water managers.

MAR wells are typically used to prevent land surface subsidence, enhance water storage, prevent saltwater intrusion, or maintain pressure and volume in an aquifer while ASR wells are used to store water underground for future recovery and use, ***See Figure 16.***

The advantages of using ASR to provide for water storage include flexibility, scalability and adjustability because wells can be added as needed to provide for additional storage. The use of ASR can also avoid the potential political, environmental, and economic impacts from the construction and flooding that may occur with new surface water reservoirs. Finally, water stored underground is not as susceptible to contamination from surface sources as reservoirs.

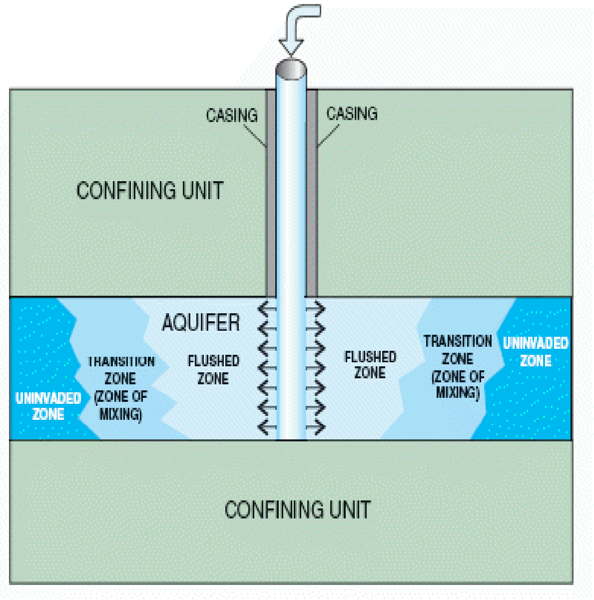


Figure 16: Typical Class V UIC well for an ASR project; Source, USEPA

According to EPA's Class V Fact Sheets, fluids injected into MAR and ASR wells include potable drinking water (from a drinking water treatment plant), groundwater (treated or untreated), and/or surface water (treated or untreated, such as stormwater).[18] However, EPA also notes that the major goal of MAR and ASR wells is to replenish water in aquifers for subsequent use and that the injection fluids typically meet drinking water standards.

Class V wells that inject sanitary wastewater that has received secondary or tertiary treatment, are considered sewage treatment effluent wells. In areas suffering from water scarcity and in areas where rainfall is predicted to decrease, wastewater reuse can stretch existing surface and groundwater supplies. Injection of treated wastewater increases groundwater pressure and volume, enhancing contributions to surface water and providing water for later recovery for drinkable and non-drinkable uses. Additionally, these wells are

[18] Class V Survey of State UIC Agencies, GWPC, 2006

used as plume management wells to prevent saltwater intrusion into non-exempt USDWs. One example of a sophisticated ASR project might be for a large municipality; which starts with high quality effluent from a wastewater treatment plant subjected to more advanced water treatment in a specialized drinking water treatment facility then delivered for injection and underground storage.

Many municipalities use stormwater drainage wells to prevent sanitary sewer overflows and to meet municipal stormwater discharge permit requirements and construction permitting requirements for new land development. According to USEPA, stormwater drainage wells are Class V wells used to remove stormwater or urban runoff from impervious surfaces such as roadways, roofs, and paved surfaces to prevent flooding and related problems including infiltration into basements. Many water resource managers are working on holistically managing the hydrologic cycle (including stormwater harvesting and enhanced aquifer recharge) to address competing and increasing water demands from agriculture, and to augment environmental flows, and municipal and industrial supplies.

Saltwater intrusion control wells are used to increase or maintain aquifer pressure in a fresh water aquifer as a barrier to prevent saltwater from flowing into and contaminating the aquifer. This type of well is commonly used in coastal areas to prevent the intrusion of seawater into drinking water quality aquifers.

Class V wells injecting below the lowermost non-exempt USDW have the least potential for contaminating groundwater. Class V injection directly into or above non-exempt USDWs has a greater potential to cause harm to water quality than discharges below or above the water table. Discharges above the water table may allow some contaminants to be removed from the waste through various chemical and microbial processes in soils and the vadose zone. However, some rock formations and soil types, such as sand, can allow fluids injected above any USDW to move very quickly without much change. In these cases, the effect can be similar to injecting directly into the USDW.

Although the official number of Class V wells is just over 500,000, a survey of the states, conducted by the GWPC in 2008 estimated there may be more than 1.5 million Class V injection wells in the United States and its territories. A review of a series of USEPA Fact Sheets suggests that about 49 percent of all Class V wells belong to three categories:[19] drainage wells (approx. 23 percent), sewage-related wells (approx. 17 percent) and industrial waste (approx. 9 percent).

[19] USEPA Class V Fact Sheets https://www.epa.gov/uic/fact-sheets-class-v-well-types

The USEPA has developed rules and a strategy for regulating Class V injection wells. Involvement by state and local government and the public in implementing the strategy is essential to its success. Many states have also adopted regulations for oversight of certain Class V wells. USEPA targeted those Class V wells which pose the greatest environmental risks as candidates for regulatory development, education and outreach, and enforcement when necessary. The strategy relies on dealing with Class V wells from highest to lowest risk to USDWs.

The USEPA has chosen to highlight the following four subclasses of Class V wells as posing the greatest threat to USDWs.

- Motor vehicle disposal wells;
- Large capacity cesspools;
- Large-capacity septic systems; and
- Stormwater drainage wells;

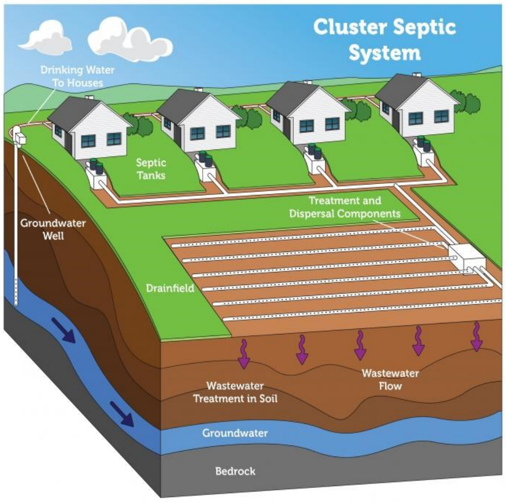
Of these well subclasses large-capacity septic systems and stormwater drainage wells comprise almost 80 percent of the total number of Class V wells nationwide.

Two of the subclasses currently being addressed are automotive waste disposal wells and large capacity septic systems.

Automotive waste disposal wells, like the one shown in ***Figure 17**,* are used by motor vehicle repair or maintenance shops, car dealers, or any operation that disposes of fluids from vehicles (including trucks, boats, trains, planes, tractors, snowmobiles, and other types of vehicles). Motor vehicle waste disposal wells have a high potential to receive spills of vehicle fluids, such as oil, transmission fluid, antifreeze, solvents, degreasers, and other toxic materials. If these fluids enter groundwater, they can create a serious health hazard. USEPA developed a special guide for owners and operators of motor

Figure 17: Typical Class V Motor Vehicle disposal well: Source GPWC

vehicle waste disposal wells, to provide information about how the rule affects them. The document, entitled *Small Entity Compliance Guide: How the New Motor Vehicle Waste Disposal Well Rule Affects Your Business*, https://www.epa.gov/sites/production/files/2015-06/documents/compliance-vehiclewastedisp.pdf is USEPA publication number 816-R-00-018, November 2000. A video describing the regulation and closure of motor vehicle waste disposal wells is available through the GWPC website via a link at https://www.gwpc.org/topics/underground-injection-control/



Please note: Septic systems vary. Diagram is not to scale.

Figure 18: Typical Class V large-capacity septic system Source USEPA

A large capacity septic system (LCSS) is any residential septic system used by multiple dwellings, businesses, or other facilities that are not individual homes (such as schools and commercial buildings). The specific definition of a large capacity septic system can vary from state to state, but environmental regulators can help a facility determine if their system is "large capacity." Large capacity septic systems dispose of treated and untreated sewage into or above a drinking water source, creating a significant risk of introducing bacteria and viruses into drinking water. Fluids injected by an LCSS, including cluster systems, ***See Figure 18***, can also degrade groundwater quality. LCSS wells discharge partially treated sewage.

Stormwater Drainage wells accept and inject waters that may contain contaminants from roadways and other sources of runoff. EPA's Phase I Rules also added and modified several Class V definitions including definitions related to these Class V well types, which increase the numbers and types of facilities requiring Class V regulation. The rules add new definitions including *improved sinkhole*, *point of injection* and *subsurface fluid distribution system*. Importantly the definition of *subsurface fluid distribution system* and *well* expands the "deeper than wide" well definition to include perforated piping and tiles intended to distribute fluids below the surface of the ground.

Additional information about large capacity cesspools, motor vehicle waste disposal wells, and other Class V wells is also available at: https://www.epa.gov/sites/production/files/2015-08/documents/class5_state_imp_guid.pdf

In 1999, the USEPA adopted the Underground Injection Control Regulations for Class V Injection Wells. Revisions, known as the Class V Rule, Phase I, established minimum federal standards for some subclasses of Class V wells. For example, new motor vehicle waste disposal wells were banned, while existing disposal wells in groundwater protection areas and other designated sensitive groundwater areas must either be permanently closed or permitted by the primacy state or USEPA to continue operating under the ban.

Some of the other protective requirements of the Class V Rule, Phase I included a ban on new large-capacity cesspools, like the one shown in ***Figure 19*** and the closure of all existing large capacity cesspools by 2005; although verification of closure for all large capacity cesspools has not been done as of this date.

Figure 19: large capacity cesspool. Source GWPC

Some UIC primacy states have made the updated requirements for existing motor vehicle waste disposal wells apply in the entire state, rather than limiting them to specific sensitive groundwater areas. The owner or operator of a large capacity cesspool or motor vehicle waste disposal well is required to send a notice to the state or USEPA at least 30 days before beginning to close one of these wells. USEPA and the States have established minimum requirements to prevent these injection wells from contaminating a USDW.

In most cases Class V wells are "authorized by rule”; which means an injection well may be operated without a permit as long as the owners or operators:

- Submit inventory information to their permitting authority and verify that they are authorized (allowed) to inject. The permitting authority will review the information to be sure that the well will not endanger a USDW.
- Operate the wells in a way that does not endanger USDWs. The permitting authority will explain any specific requirements.
- Properly close their Class V well when it is no longer being used. The well should be closed in a way that prevents movement of any contaminated fluids into USDWs.
- After reviewing an owner or operator's inventory information the permitting authority may determine that an individual permit is necessary to prevent USDW contamination.

Due to state regulations, the large volume of water being injected into some wells, or the complexity of deeper waste disposal or experimental wells, the regulatory authority may require an individual permit be issued for certain Class V wells.

Class VI Wells

Class VI wells are designed to inject supercritical CO_2 into abandoned oil and gas zones, deep saline aquifers and other potential formations for the purpose of storage. **See *Figure 20.***

NOTE: Wells injecting CO_2 into active oil and gas producing formations for the purpose of EOR remain in the Class II program unless a determination is made by the USEPA, and concurrently for Primacy states or tribes, by the state or tribal program director, that the wells should be transitioned into the Class VI program.

On December 10, 2010 the USEPA finalized the UIC Class VI Rule.[20] The publication of this rule followed a nearly 3 year process of discussions, meetings and hearings with a broad array of stakeholder groups including GWPC and its state members. Special meetings were held on many topics including mechanical integrity, well construction, and monitoring, measuring and verification, and others. The Class VI rule was developed using an iterative process that relied heavily on stakeholder input and feedback.

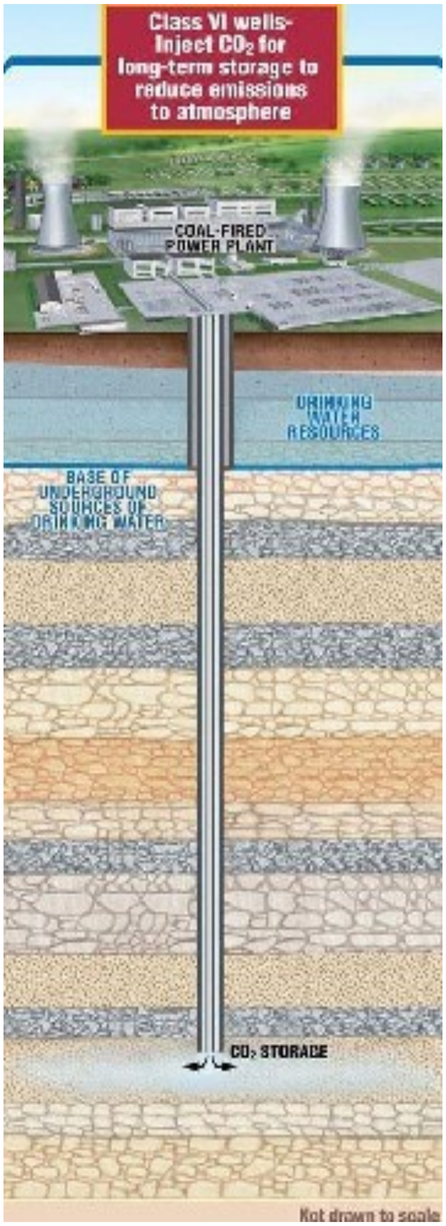


Figure 20: Geologic cross section showing Class VI injection well: Source, USEPA

While the Class VI program most closely resembles the Class I program with respect to its requirements in areas such as well construction, monitoring, and area of review, it is similar to the Class II program in well mechanical integrity and well closure requirements. However, unlike other well classes the Class VI program has unique characteristics in areas like financial assurance, permitting, operations, monitoring, measuring and verification (MMV), and post closure monitoring. Like the Class I, III and V programs it falls under Section 1422 of the SDWA. This means states seeking Primacy for the program must have requirements that are “at least as stringent” as the federal requirements. Although USEPA has chosen to grant Primacy over Class I,III, and V wells only collectively, they have provided a mechanism for separate primacy for the Class VI program.

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[20] USEPA, Class VI Rule, https://www.govinfo.gov/content/pkg/FR-2010-12-10/pdf/2010-29954.pdf

While several states have expressed an interest in obtaining Primacy for the Class VI program, as of May 2021, only two states (North Dakota and Wyoming) have applied for and received Primacy. However, other states have developed authorizing legislation and either have or may submit a Class VI Primacy application.

Whether or not the Class VI program develops into a widespread, state led, regulatory effort depends upon several factors including:

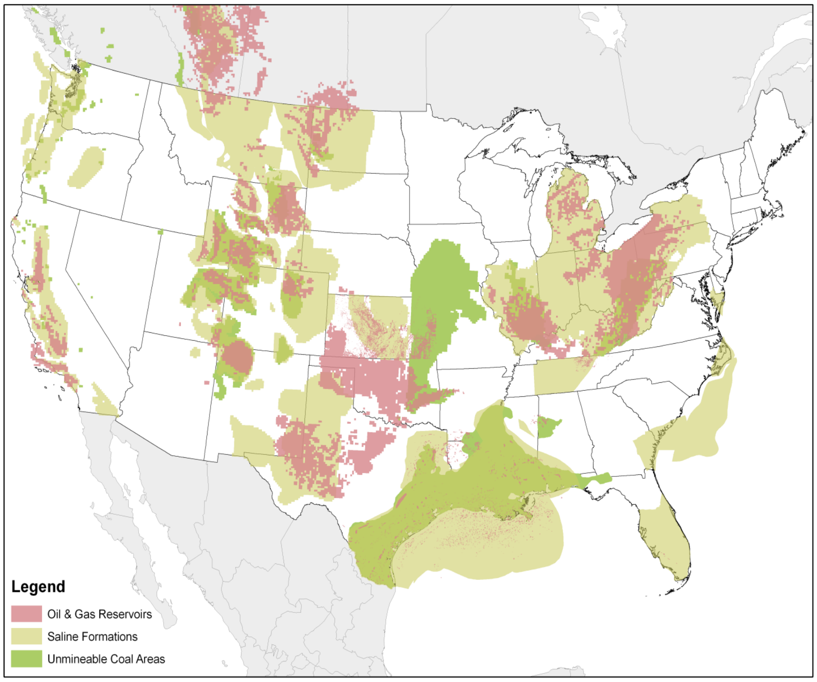

Figure 21: Potential geologic sinks, by type, for underground storage of CO_2, in the coterminous U.S. and southern Canada: Source USEPA

1. The evaluation of potential geologic sinks to store CO_2 ***See figure 21;***
2. The availability of adequate federal/ state funding to implement the program;
3. The need and ability of industries to capture and store CO_2 to address state and federal requirements;
4. The desire of states to seek primacy for the Class VI program;
5. The ability of states and industries to find, hire and train technical staff; and
6. The potential for federal legislation related to carbon management; which could create additional financial mechanisms to encourage Carbon Capture, Use and Storage (CCUS).

Although full implementation of large scale geologic sequestration of CO_2 has not yet occurred, technological and legislative changes taking place with respect to CCUS, such as recent studies of new capture technologies, state interest in primacy, passage of enabling state legislation, and other factors make the need for effective regulatory frameworks to manage underground storage of CO_2 a critical and timely issue.

NOTE: The USEPA has developed a broad set of program guidance related to the Class VI program.[21]

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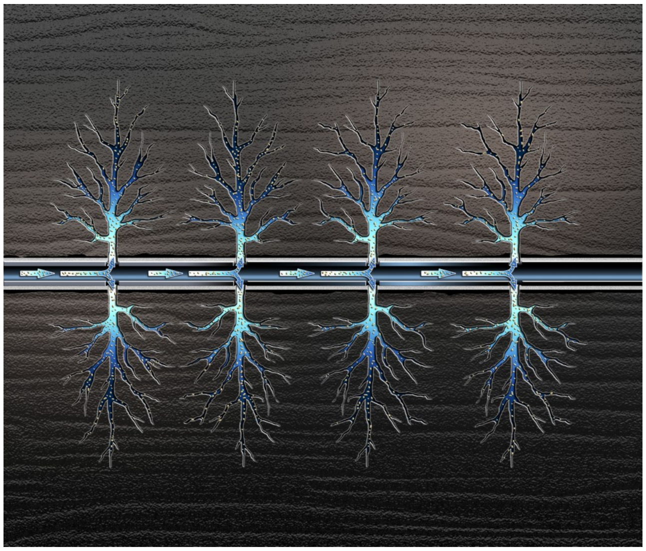
[21] USEPA, Class VI Guidance Documents, https://www.epa.gov/uic/class-vi-guidance-documents

Hydraulic Fracturing and the UIC Program



Diagrammatic representation of a horizontal hydraulic fracturing job: Graphic Courtesy of FracFocus®

In the past 15-20 years, public questions regarding the use and safety of hydraulic fracturing as a means of enhancing oil and gas production have become commonplace. One primary question asked was "Should hydraulic fracturing be considered underground injection" under the SDWA"? While there was no mention of hydraulic fracturing in the original SDWA or its subsequent updates, the question lingered. In 1998 a group called the Legal Environmental Assistance Fund filed a lawsuit in federal court attempting to force the USEPA to withdraw the Class II UIC program from the State of Alabama because it did not regulate the hydraulic fracturing of coalbed methane zones as a Class II UIC activity and the case was adjudicated up through the 11th Circuit Court of Appeals. The court decided that for the purposes of hydraulic fracturing of coalbed methane zones the SDWA UIC Class II provisions applied. Subsequent to the courts determination, the State of Alabama revised its Section 1425 Class II UIC program to include this activity. However, since the court's decision addressed only the Alabama UIC program and then only as it related to hydraulic fracturing of coalbed methane wells, the issue of whether or not hydraulic fracturing, in general, was covered by the UIC program remained unanswered.

In 2005 Congress passed the Energy Policy Act.[22] In the act, Congress clarified its original intent under the SDWA with respect to hydraulic fracturing. The act stated that underground injection "excludes (i) the underground injection of natural gas for purposes of storage; and (ii) the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities" Subsequent to the passage of the act, the USEPA conducted a study to determine the potential impact of hydraulic fracturing on groundwater.[23]

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22 Energy Policy Act of 2005, https://www.govinfo.gov/content/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf

23 USEPA, Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States https://www.epa.gov/sites/production/files/2016-12/documents/hf_final_assessment_fact_sheet.pdf

While the USEPA's hydraulic fracturing study considered issues much broader than the use of diesel fuels, after the findings were published, the USEPA developed an official guidance document regarding the use of only an identified list of five fuels in hydraulic fracturing as being regulated under the UIC Program. This was considered consistent with the 2005 Energy Policy Act language.

The final guidance document (#84)[24] was approved in February 2014. While some adjustments are likely, how each state will respond to this final guidance is still unclear as the guidance was specifically directed at USEPA regions and not states. Regardless, as an informal review of disclosures submitted to the FracFocus® system since the issuance of Guidance #84 demonstrates, the oil and gas industry has substantially decreased the use of the USEPA identified fuels in the hydraulic fracturing process which may, for all intents and purposes, render Guidance #84 moot in many cases.

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[24] USEPA, Permitting Guidance for Oil and Gas Hydraulic Fracturing Activities Using Diesel Fuels: Underground Injection Control Program Guidance #84, February 2014 https://www.epa.gov/sites/production/files/2015-05/documents/revised_dfhf_guid_816r14001.pdf

Final Thoughts

Figure 22: Produced water impoundments: Source, Environmental Defense Fund

Over the years some have questioned the advisability and safety of injecting fluids underground. While there are risks associated with any method of waste disposal it is important to recognize the alternatives to underground injection carry much greater inherent risk because of their proximity to the near surface environment. For example, unlined produced water impoundments, such as the ones shown in ***Figure 22,*** and surface discharges which can cause surface damage from brines, as shown in ***Figure 23*** are much more likely to cause contamination of both surface and groundwater resources than is deep underground injection.

Figure 23: Produced water damaged soil: Source Southwest Indiana Brine Coalition

While new technologies like on-site treatment systems such as those developed at Texas A&M University, ***See Figure 24***, carry the promise of lowering the volumes of fluids that must be injected underground; for now, underground injection is still the safest and most effective means of isolating wastes from the near surface environment and most importantly from groundwater.

Figure 24: Portable produced water treatment system: Source Texas A&M University and John Veil, Veil Environmental

Finally, it could be said that if the success of an environmental protection program is measured by the amount of contamination avoided, the UIC program might be one of the most successful programs ever devised for protecting human health and the environment.

List of Acronyms

ASR	Aquifer Storage and Recovery
CERCLA	Comprehensive Environmental Compensation and Liability Act
CCUS	Carbon Capture, Use, and Storage
CO_2	Carbon Dioxide
DI	Direct Implementation
EOR	Enhanced Oil Recovery
LCSS	Large Capacity Septic System
MAR	Managed Aquifer Recharge
Mg/L	Milligrams per Liter
MIT	Mechanical Integrity Test
MMV	Monitoring, Measuring and Verification
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SWD	Saltwater Disposal
TDS	Total Dissolved Solids
UIC	Underground Injection Control
USDW	Underground Source of Drinking Water
USEPA	U.S. Environmental Protection Agency

Mission Statements

The Ground Water Protection Council is a national association of state groundwater and underground injection control agencies whose mission is to promote the protection and conservation of groundwater resources for all beneficial uses, recognizing groundwater as a critical component of the ecosystem.

The Ground Water Protection Council provides a forum for stakeholder communication and research in order to improve governments' role in the protection and conservation of groundwater.

The Ground Water Research and Education Foundation is a not-for-profit 501 (c) 3 corporation whose mission is to promote and conduct research, education, and outreach, in the areas of development and application of technical systems, and pollution prevention efforts related to ground water protection, underground injection technology, and watershed conservation and protection.