tion fluids should be of equivalent or better quality (relative to standards of the National Primary or Secondary Drinking Water Standards and RCRA regulations) than the fluids within any USDW in connnection with the injection zone. However, some case studies revealed that injection fluids are of poorer quality (relative to standards of the National Primary or Secondary Drinking Water Standards) than the fluids within any USDW in communication with the injection zone. Based on injectate characteristics and possibilities for attenuation and dilution, injection does occur in sufficient volumes or at sufficient rates to cause an increase in concentration (above background levels) of the National Primary or Secondary Drinking Water Regulation parameters in ground water, or endanger human health or the environment beyond the facility perimeter when contaminants are present in the recharge water.

Ground-water quality may be adversely affected by injection recharge practices if the quality of the injection water is not closely monitored. Serious consequences may result if low quality water is injected directly into utilized underground sources of drinking water. Recharge wells may introduce contaminants to supply aquifers from shallower perched water zones if wells are not properly designed and constructed to prevent communication between zones.

Florida's "connector" wells are specifically designed to allow communication between the surficial perched aquifer and the deeper supply aquifer. A case study on these aquifer connector wells was carried out by the Florida Department of Environmental Regulation, Bureau of Groundwater Protection. This study concluded that 10-20% of the connector wells inject water that greatly exceeds primary drinking water standards for gross alpha radiation, and another 30-40% inject water that slightly exceeds that standard. The concentration of combined radium 226/228 exceeds primary drinking water standards in about 10% of these wells. Injectate consistently exceeds secondary drinking water standards for iron.

Additionally, some of these wells may be located in close proximity to phosphate chemical plant waste disposal areas. These wells may provide a conduit to the water supply aquifer for possible toxic waste plumes originating at chemical plant waste disposal sites. Ground-water samples from the surficial aquifer have been obtained within a contaminant plume from a waste disposal area. Samples taken revealed possibilities of extreme contamination. Records show some cases of sulfate and fluoride concentrations in excess of 5,000 mg/l, sodium concentrations in excess of 2,000 mg/l, chromium concentrations of 2.0 mg/l (forty times the primary drinking water standard), and extremely acidic pH values below 2. Injectate volumes and concentrations will vary according to precipitation amounts and drainage patterns.

Florida receives approximately 53 in/yr precipitation of which approximately 14 in/yr comprises runoff (Pettyjohn, et al., 1979). The case study carried out by the FDER Bureau of Groundwater Protection is listed in Appendix E of this report.

Many inventoried recharge wells in Texas are "dual purpose" irrigation supply/injection wells located on the High Plains. Farmers have been practicing this recharge method for 20-30 years. Recharge wells are also sited in playa lakes in the area. These lakes develop impermeable clay layers along their bottoms from settling solids. Wells are constructed to drain the land and recharge the aquifer. Water injected into "dual purpose" wells and playa lake recharge wells is agricultural runoff. The injection zone is the Ogallala aquifer. Ten wells were inventoried in the High Plains area, and two of these were sampled by the Texas Department of Water Resources for injectate quality. (See Appendix E.) Sampling results indicated that injectate water quality was of higher standards than aquifer water quality at the time the sample was taken (March-April, 1982). This sampling episode may not be representative of typical conditions throughout the year. Nitrate levels in the aquifer water sampled ranged from 8.4 mg/l to 43 mg/l in the two wells (the primary drinking water standard for nitrate is 45 mg/l). This variation raises questions about the origin of nitrate concentrations in the second well. Injectate waters, when sampled and analyzed for nitrate, measured only .04 mg/l. Common chemical contaminants associated with agricultural runoff include nitrates, phosphorus, pesticides, herbicides, pathogens, metals, and total dissolved solids.

Domestic wastewater may contain nitrogen, bacteria, viruses, and organic or inorganic pollutants. Effluent is more susceptible to toxic chemical contaminants if it serves an industrial sector. Refer to Section 4.2.3.3 for more in depth information on domestic wastewater disposal wells.

In summary, the contamination potential of properly designed, constructed, and operated recharge wells is low (proper operation would include careful injectate monitoring to prevent introduction of poor quality fluids). However, many inventoried wells may be improperly designed, constructed, and/or operated and, therefore, must be assessed as a moderate (Texas dual purpose wells) to high (Florida connector wells) contamination threat. Contamination potential is directly dependent upon injectate quality in a properly designed and constructed well.

Current Regulatory Approach

Aquifer recharge wells are authorized by rule under Federally administered UIC programs (see Section 1). State reports were generally not specific with regard to regulatory jurisdiction; however, information from the following States is pertinent. Injection wells in Florida are currently permitted

through the Florida Department of Environmental Regulation. Recharge wells on the High Plains of Texas are permitted by the High Plains Underground Water Conservation Districts in areas where underground water districts have been established. The only permit requirement for these wells is that no pollutants enter the fresh water aquifer through them. A well completion report must also be furnished to the local district by the well owner (Texas DWR, 1986). Arizona has passed regulations for ground-water quality protection and has established an aquifer protection permit program under the Environmental Quality Act of 1986. Arizona House Bill 2209 deals specifically with regulation of aquifer recharge and underground storage projects.

Recommendations

The Florida and Nebraska state reports indicate that major concerns for aquifer recharge injection wells include injectate water quality monitoring, and proper design, construction, and operation of wells. Nebraska recommends that injectate water quality generally be of equivalent or better quality than water contained in the receiving aquifer.

The Arizona report suggests that regulatory personnel should set standards for aquifers on a case by case basis to determine aquifer water quality and allowable quality parameters for injectate waters. For example, if the aquifer serves as a drinking water source, water quality standards should not exceed drinking water standards. Local hydrogeologic information is necessary to adequately assess each site and recharge situation.

Supporting Data

Referenced supporting data for Aquifer Recharge Wells is listed in Appendix E of the report.

4.2.7.2 Salt Water Intrusion Barrier Wells (5B22)

Well Purpose

Artificial recharge is used in many coastal areas to control the intrusion of salt water into fresh water aquifers. Intrusion of salt water is predominantly due to reversal of the ground-water gradient caused by pumping. Over-pumping of fresh water in coastal areas allows salt water to flow inland and contaminate fresh ground water. Since as little as two percent sea water in fresh water can render it unpotable, controlling intrusion has received considerable attention.

Several methods have been proposed to control salt water intrusion. These include: (1) control of pumping patterns; (2) construction of an impermeable subsurface barrier using materials such as sheet piling, puddled clay, emulsified asphalt, [illegible]

grout, bentonite, silica gel, calcium acrylate, or plastics; (3) formation of an extraction barrier whereby a continuous pumping trough is formed by a line of wells adjacent to the ocean, (4) use of combination injection - extraction barriers utilizing injection and extraction wells; (5) direct artificial recharge to raise groundwater levels; and (6) maintenance of fresh water ridge along the coast utilizing artificial recharge (D.K. Todd, 1974). Saline water may also intrude fresh water aquifers in inland areas where fresh and saline waters are in contact. The most usual cause of this problem is overpumping of the fresh water aquifer. This allows upconing of saline water to the pumping well.

Inventory and Location

The inventory data collected by the States, Territories, and Possessions account for a total of 164 saline water intrusion barrier wells. Of this total, 155 wells are located in the state of California. Washington reported a total of 7, and Florida reported 2. Table 4-54 provides a synopsis of information from the State reports.

The West Coast Basin Barrier Project in Los Angeles County, is the first and largest intrusion barrier project in the State of California. This project utilizes 106 injection wells and stretches approximately 10 miles along the coast.

It is certain that uninventoried wells exist. One operation of significance which was not included in inventory numbers is the Palo Alto Intrusion Barrier Project in Santa Clara County, California. This operation is located adjacent to the southern tip of San Francisco Bay. Treated sewage is being injected and extracted at this location to form a fresh water ridge barrier against intruding saline bay waters (see list of applicable Case Studies, Appendix E).

Construction, Siting, and Operation

Utilizing injection wells to control sea water intrusion may be accomplished by utilizing direct recharge, whereby groundwater levels are raised and maintained through injection of high quality water; or by maintaining a fresh water ridge, whereby water is injected through a line of wells near the coast. The most complex method of maintaining a fresh water ridge is an injection-extraction system whereby a ridge and pumping trough is formed (Todd, 1974). This method requires a smaller volume of fresh water for injection than does the system used to maintain a fresh water ridge. However, it also requires twice as many wells.

Wells may be utilized in a variety of ways to form a fresh water barrier against salt water intrusion. Injection or

TABLE 4-54: SYNOPSIS OF STATE REPORTS FOR SALINE WATER INTRUSION BARRIER WELLS(5B22)

REGION & STATES	EPA REGION	Confirmed Presence Of Well Type	Regulatory System	Case Studies/ Info. available	Contamination Potential Rating
Connecticut	I	NO	N/A	NO	N/A
Maine	I	NO	N/A	NO	N/A
Massachusetts	I	NO	N/A	NO	N/A
New Hampshire	I	NO	N/A	NO	N/A
Rhode Island	I	NO	N/A	NO	N/A
Vermont	I	NO	N/A	NO	N/A
New Jersey	II	NO	RULE/PERMIT	NO	N/A
New York	II	NO	N/A	NO	N/A
Puerto Rico	II	NO	N/A	NO	N/A
Virgin Islands	II	NO	N/A	NO	N/A
Delaware	III	NO	N/A	NO	N/A
Maryland	III	NO	N/A	NO	N/A
Pennsylvania	III	NO	N/A	NO	N/A
Virginia	III	NO	N/A	NO	N/A
West Virginia	III	NO	N/A	NO	N/A
Alabama	IV	NO	N/A	NO	N/A
Florida	IV	2 WELLS	PERMIT	NO	N/A
Georgia	IV	NO	N/A	NO	N/A
Kentucky	IV	NO	N/A	NO	N/A
Mississippi	IV	NO	N/A	NO	N/A
North Carolina	IV	NO	N/A	NO	N/A
South Carolina	IV	NO	N/A	NO	N/A
Tennessee	IV	NO	N/A	NO	N/A
Illinois	V	NO	N/A	NO	N/A
Indiana	V	NO	N/A	NO	N/A
Michigan	V	NO	N/A	NO	N/A
Minnesota	V	NO	N/A	NO	N/A
Ohio	V	NO	N/A	NO	N/A
Wisconsin	V	NO	N/A	NO	N/A
Arkansas	VI	NO	N/A	NO	N/A
Louisiana	VI	NO	N/A	NO	N/A
New Mexico	VI	NO	N/A	NO	N/A
Oklahoma	VI	NO	N/A	NO	N/A
Texas	VI	NO	N/A	NO	N/A
Iowa	VII	NO	N/A	NO	N/A
Kansas	VII	NO	N/A	NO	N/A
Missouri	VII	NO	N/A	NO	N/A
Nebraska	VII	NO	RULE	NO	N/A
Colorado	VIII	NO	N/A	NO	N/A
Montana	VIII	NO	N/A	NO	N/A
North Dakota	VIII	NO	N/A	NO	N/A
South Dakota	VIII	NO	N/A	NO	N/A
Utah	VIII	NO	RULE/PERMIT	NO	N/A
Wyoming	VIII	NO	N/A	NO	N/A
Arizona	IX	NO	N/A	NO	N/A
California	IX	155 WELLS	PERMIT	YES	[illegible]
Hawaii	IX	NO	N/A	NO	N/A
Nevada	IX	NO	N/A	NO	N/A
American Samoa	IX	NO	N/A	NO	N/A
Tr. Terr. of P	IX	NO	N/A	NO	N/A
Guam	IX	NO	N/A	NO	N/A
CNMI	IX	NO	N/A	NO	N/A
Alaska	X	NO	N/A	NO	N/A
Idaho	X	NO	N/A	NO	N/A
Oregon	X	NO	N/A	NO	N/A
Washington	X	7 WELLS	PERMIT	NO	[illegible]

extraction wells may be separately, or a combination injection-extraction system may be employed.

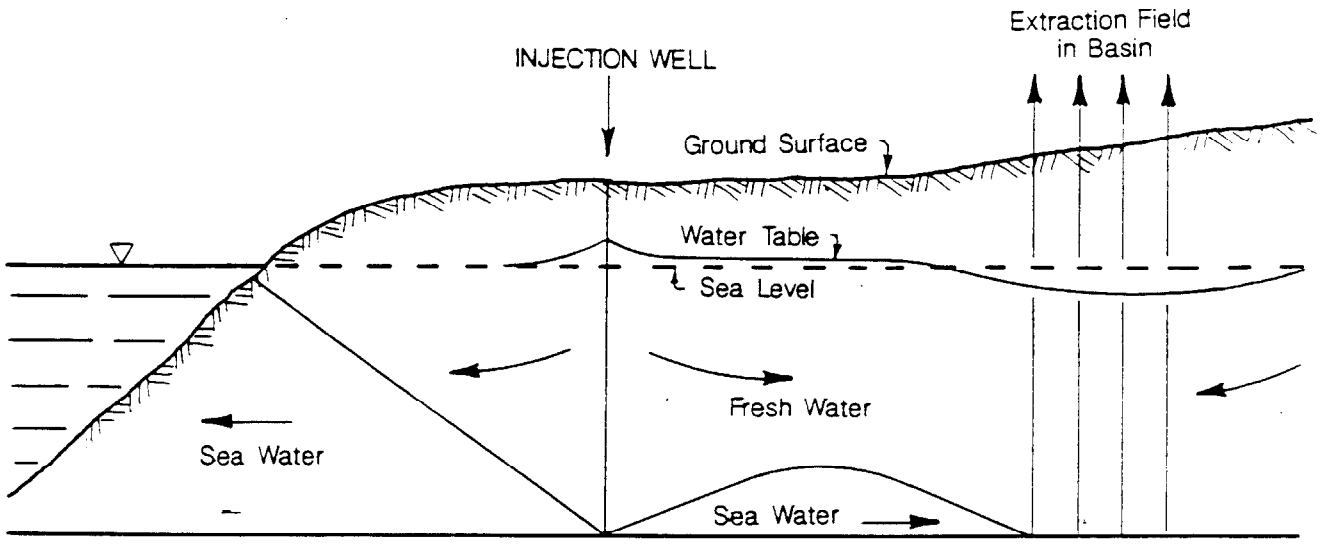
If injection wells alone are utilized, these wells will be sited along the coast, and fresh water will be injected to form a fresh water barrier (see Figure 4-59). If extraction wells alone are utilized, they will be sited along the coast to extract salt water so that it does not further intrude into fresh water aquifers. A combination injection-extraction system may be utlized to extract salt water along the coast when some intrusion has taken place, while simultaneously injecting fresh water further inland (see Figure 4-60). An injection-extraction system may also be utilized to inject water along the coast to form a fresh water ridge, while simultaneously extracting this water further inland. This may prevent aquifer contamination when injectate water quality is low relative to that found within the aquifer. An example of this system exists at Palo Alto, California, and will be discussed further in this report.

Figure 4-61 illustrates construction features of salt water intrusion barrier injection wells used at the Alamitos Project in Los Angeles. These wells utilize 12-inch diameter stainless steel casing and are approximately 300 feet deep. Injection wells for sea water intrusion barriers commonly have injection capacities of 0.5-1.5 cubic feet per second (cfs). Attempts to increase capacities by using high injection pressures may result in problems such as formation fracturing. Cases exist in which the ground surface near the well settled, the well casing buckled, the gravel pack was plugged, and hydraulic communication between aquifers was established due to overpressuring the aquifer (Toups, 1974).

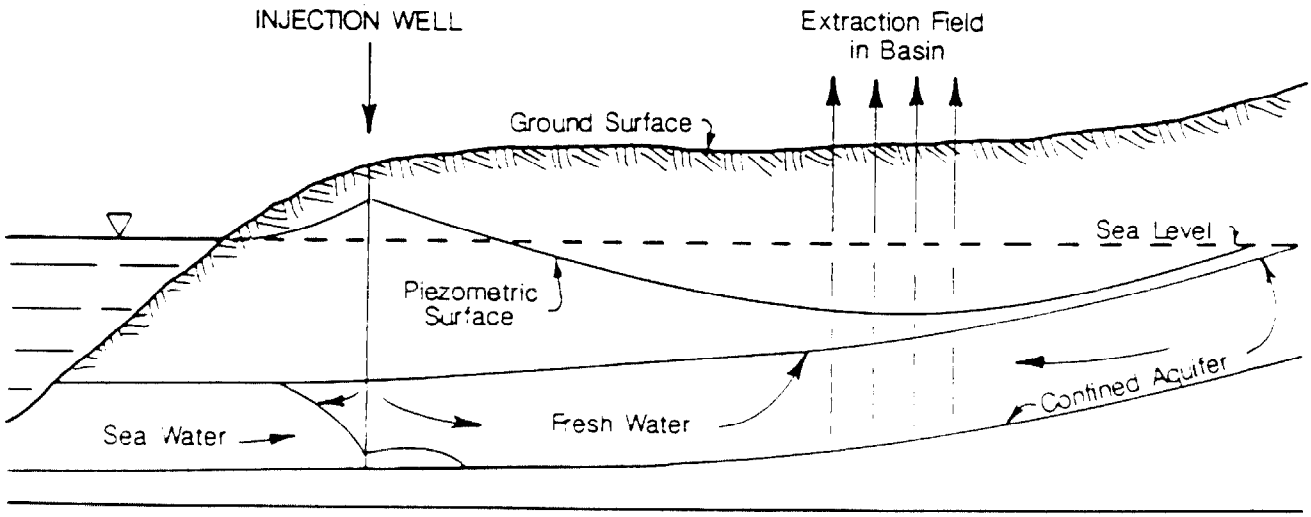
Injected Fluids and Injection Zone Interactions

Characteristics of injection fluids will vary depending upon the source. An intrusion barrier system has been implemented in Palo Alto, California which injects effluent from an advanced sewage treatment plant as fresh water in the injection-extraction system. The effluent is injected along the coast and is later extracted by wells farther inland to prevent contamination of the drinking water supply. After extraction, the diluted effluent is made available for industrial and agricultural purposes (Sheahan, 1977). Examples of other injection fluid sources include surface runoff, which may be comprised of urban and agricultural runoff, and imported surface waters from canals, rivers, and lakes.

Since injected fresh water is less dense than intruding salt water it will overlie the intruded fluid, and a transition zone will exist between fresh and saline waters. The purpose of injected fluid is to keep the transitional and saline waters from intruding into fresh water zones.



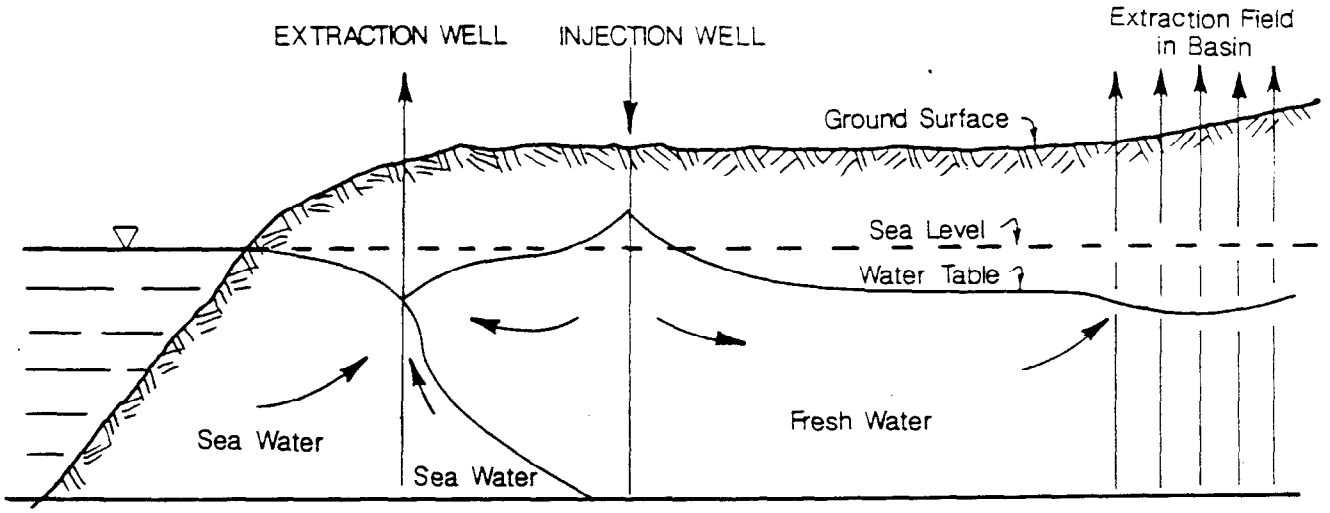
IN AN UNCONFINED GROUNDWATER BASIN



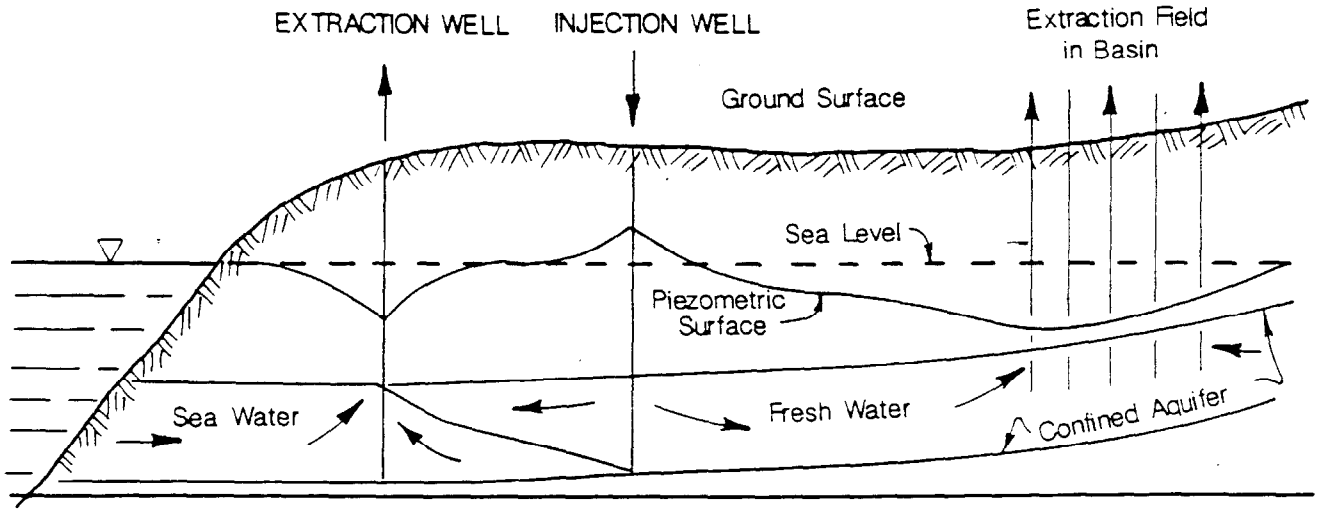
IN A CONFINED GROUNDWATER BASIN

HYDROLOGIC CONDITIONS WITH A
FRESH WATER RIDGE ACTING AS
A SEA WATER BARRIER

Figure 4-59



IN AN UNCONFINED GROUNDWATER BASIN

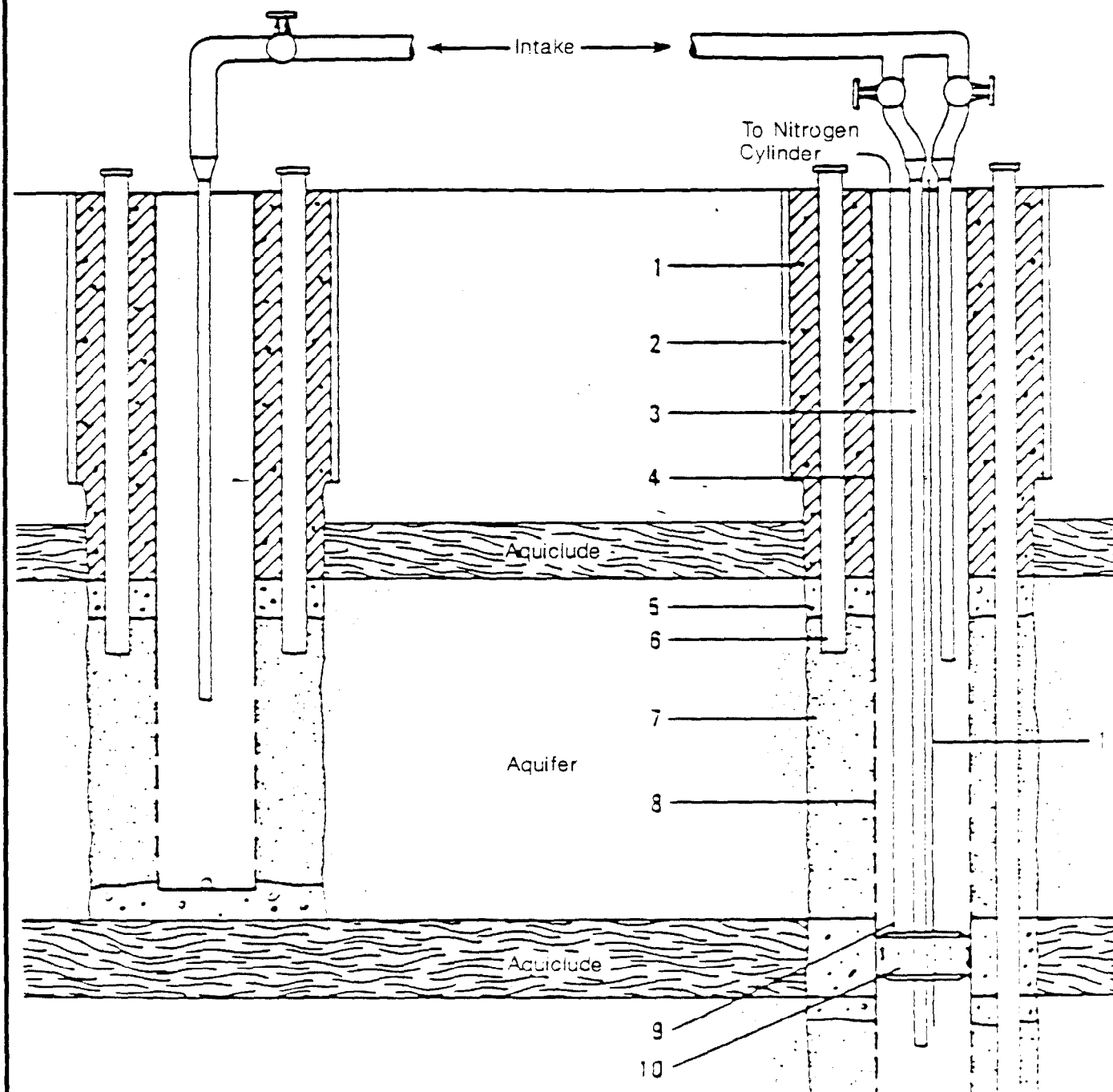


IN A CONFINED GROUNDWATER BASIN

HYDROLOGIC CONDITIONS WITH A COMBINATION INJECTION-EXTRACTION SEA WATER BARRIER

(after Todd, D.K., 1974)

Figure 4-60



EXPLANATION

1 Grout
2 Protective Casing
3 Conductor Pipe
4 Blank Casing
5 Sand Packer
6 Tremie Pipe
7 Gravel Pack
8 Perforated Casing
9 Packer Pressure Line
10 Pneumatic Packer
11 Measuring Pipe

Aquifer

SALT WATER INTRUSION BARRIER WELLS
LOS ANGELES, CALIFORNIA

Figure 4-61

Two major problems can occur within the injection zone as a result of this type of injection, both dependent upon the nature of the injected fluid. The first is that chemical or biological contaminants, associated with agricultural or urban runoff and treated sewage, can be introduced into the injection zone with the recharge water. Second, suspended solids can be introduced with the injected fluid, causing local clogging within the injection zone and contamination due to adsorption and transportation of pollutants. Clogging solids of greatest concern in are colloidal clays. Colloids resist most forms of settling and filtration and are, therefore, difficult to remove from waters prior to injection (Dvoracek, 1971).

Clogging problems may also be caused by recharge with water that is not chemically compatible with receiving water or aquifer material. These problems include precipitation of solids and the swelling of clay particles present in the aquifer. For example, if the water used for recharge has a higher sodium-calcium ratio than the receiving water, and clay particles are present in the formation, swelling can occur. Ion exchange occurs between calcium and sodium ions adsorbed onto clay minerals. The sodium ions hydrate more than the calcium ions which causes the clay particles to swell, resulting in decreased aquifer pore space and permeability. These types of reactions can be prevented by choosing an alternate recharge water or by treating the recharge water prior to injection to bring it into equilibrium with the aquifer system.

There are a variety of reactions that may occur during injection into an aquifer. Among the most notable are adsorption, ion exchange, precipitation and dissolution, oxidation, biological nitrification and denitrification, aerobic and anaerobic degradation of organic substrates, mechanical dispersion, and filtration. The relative influence of reactions such as these must be addressed on a site-specific basis, and will be dependent upon the chemical nature of the fluids involved.

Hydrogeology and Water Use

Studies by the US Geological Survey of saline ground water (1965) indicate that approximately two thirds of the U.S. is underlain by ground water containing more than 1,000 mg/l of dissolved solids. Coastal intrusion has been recognized to occur in almost all of the states bordering the sea. Most serious are those sections where coastal urban areas have led to exploitation of local ground-water resources. The states of California, Texas, Florida, New York (Long Island), and Hawaii have been affected to the largest extent. The problem is also known internationally (Todd, 1974).

The most significant hydrogeologic parameters to address in assessing this well type are the rate at which intrusion is

occurring and the nature of the chemical interactions between sea water and the injection fluid. Increases in intrusion rates are due to decreased hydraulic head resulting from water extraction via wells tapping the fresh water aquifer. Intrusion is also controlled largely by lithologic and structural features within the area and their influence on hydraulic gradients and transmissivities.

Contamination Potential

Based on the rating system described in Section 4.1, salt water intrusion barrier wells are assessed to pose a low potential to contaminate USDW. These wells typically do inject into or above Class I or Class II USDW. Typical well construction, operation, and maintenance would not allow fluid injection or migration into unintended zones. Injection fluids should be of equivalent or better quality (relative to standards of the National Primary or Secondary Drinking Water Standards and RCRA regulations) than the fluids within any USDW in connection with the injection zone. Based on injectate characteristics and possibilities for attenuation and dilution, injection does not occur in sufficient volumes or at sufficient rates to cause an increase in concentration (above background levels) of the National Primary or Secondary Drinking Water Regulation parameters in groundwater, or endanger human health or the environment in a region studied on a group/area basis.

The contamination potential posed by wells of this type depends heavily upon the type of injectate used and treatment provided. Significant variation in sources for injectate water exists. Effluent from advanced sewage treatment plants, surface runoff, and imported surface waters are the most notable sources of injectate. Water from these sources may contain constituents at levels in excess of National Primary and Secondary Drinking Water Standards, especially if injectate is not sufficiently treated. In addition, constituent levels set forth in 40 CFR, Part 261, Subparts C and D may be exceeded owing to the influence of pesticides, agricultural nutrients, and urban chemicals. At the present time, no data exist to substantiate this.

This sort of injection generally occurs within currently or potentially useable drinking water aquifers. Support for this statement stems from an indication that sea water intrusion is most prominent in regions drawing heavily from wells for agricultural and domestic purposes. If contaminants associated with improperly treated domestic wastes or agricultural and urban runoff are injected directly into presently used drinking water supplies, serious health and safety problems could develop. Injectate quality is especially important since salt water intrusion barrier projects inject large volumes of water. Degradation of USDW on a local or regional scale could occur if injectate water quality is poor.

The contamination potential for saline water intrusion barrier wells is considered low, provided the wells are properly designed, constructed, and operated, and injectate quality is adequately monitored. These wells are designed specifically to remediate contamination problems associated with intrusion.

Current Regulatory Approach

Salt water intrusion barrier wells are authorized by rule under Federally-administered UIC programs (see Section 1). The California Regional Water Quality Control Boards regulate saline water intrusion barrier wells in California. A waste discharge permit is required statewide for salt water intrusion barrier wells injecting waste-water, such as sewage effluent. Injection wells in the State of Washington are currently regulated under the nondegradation provisions of the Water Pollution Control Act and the Water Resources Act. Other Washington State laws applicable to Class V wells include Chapter 90 of the Regulation of Public Groundwaters, the Pollution Disclosure Act, and the Planning Enabling Act. The Florida Department of Environmental REgulation permits Class V wells in Florida. Inspection and surveillance of Class V wells is under the jurisdiction of FDER District offices.

Recommendations

The following recommendations regarding saline water intrusion barrier wells appear in the California report. Proper design, construction, and operation is required to prevent possible contamination resulting from communication with surface waters and other penetrated zones. Wells must be properly cased, cemented, and operated to prevent this problem.

Processes and fluids involved with salt water intrusion barrier projects are variable and often site specific. Lithologic and hydrogeologic parameters that influence salt water intrusion in coastal areas should be defined, and coastal USDW should be defined and characterized with regard to water quality in areas experiencing saline water intrusion problems. Interactions of injected fluids with formation fluids also should be characterized for operating barrier projects. If it can be shown that potentially usable USDW are being degraded by this injection, immediate steps toward corrective action should be initiated.

Because these projects are typically of a broad scope, inventory maintenance and update should not be difficult. A regularly updated inventory is fundamental to maintaining proper regulatory authority.

Supporting Data

The referenced supporting data for Saline Water Intrusion Barrier Wells is listed in Appendix E of the report.

4.2.7.3 Subsidence Control Wells (5S23)

Well Purpose

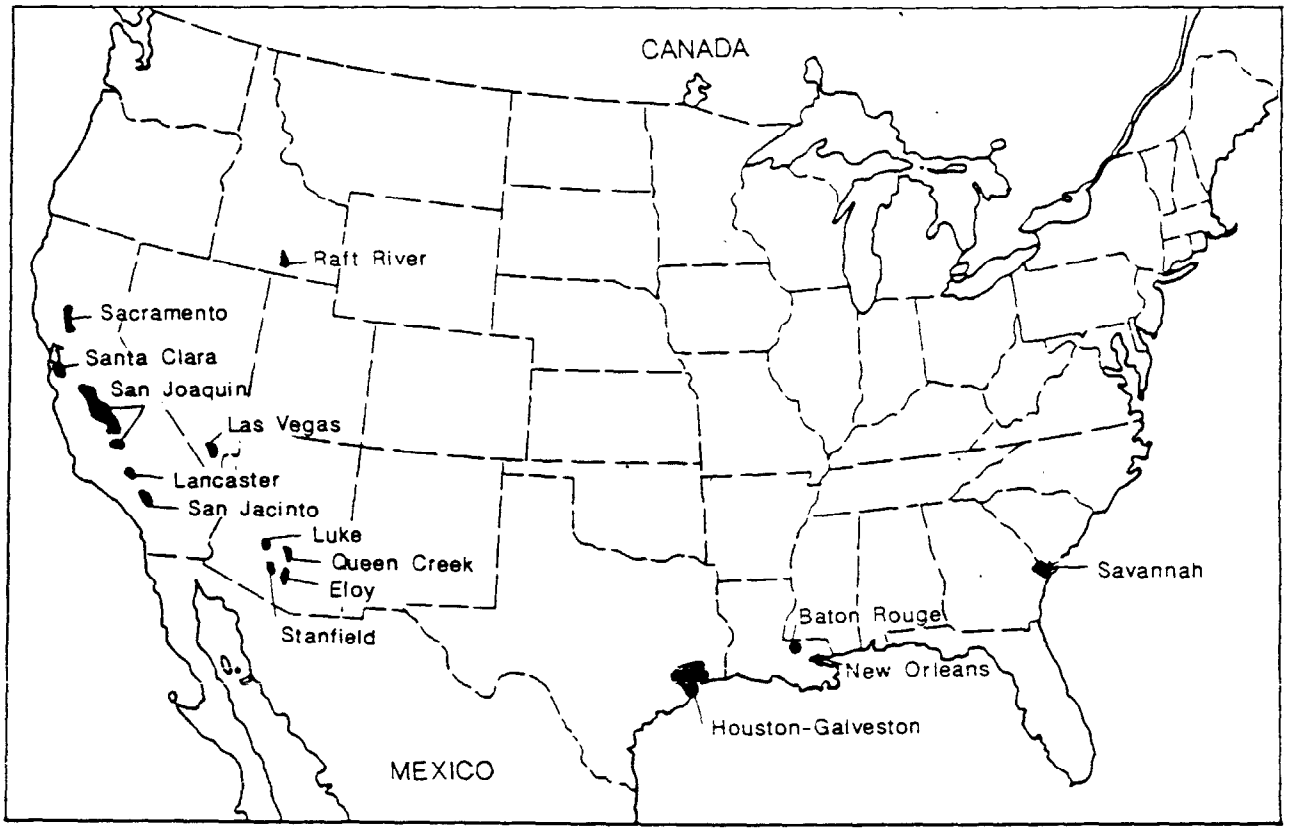
Subsidence control wells are recharge wells employed for the primary purpose of controlling land subsidence. Subsidence is the sudden sinking or gradual downward settling of the earth's surface with little or no horizontal motion. Subsidence may result from a variety of natural geologic or man-induced processes. For purposes of this report and the UIC program, we will limit our discussion to subsidence resulting from excessive ground-water withdrawal.

Problems associated with subsidence include: (1) differential changes in elevation and gradient of stream channels, drainage, and water transport structures, (2) failure of water casings due to compressive stresses generated by compaction of the aquifer system(s), (3) tidal encroachment in lowland coastal areas, and (4) damage to engineering structures (Poland et. al., 1984).

Inventory and Location

The inventory data collected by each State and United States territories and possessions accounts for a total of only 4 wells at one location in Wisconsin. These 4 wells are associated with a construction project. However, problems with subsidence are prevalent in southwestern states, most notably in California, Texas, and Arizona. The Houston-Galveston area of Texas has experienced subsidence which has led to catastrophic flooding along Galveston Bay. Thousands of sinkholes exist in karstic regions from Florida to Pennsylvania. These sinkholes are most often the result of ground-water withdrawal. Some areas of land subsidence resulting from ground-water withdrawal in the United States are depicted in Figure 4-62. Case studies of subsidence problems in Alabama, Texas, and California are listed in Appendix E. Subsidence control wells may be used now or in the future to control problems in these areas. Table 4-55 presents the inventory data from the State reports.

A recharge injection project has been carried out in Long Beach, California for purposes of subsidence control and oil recovery. It is true that this represents a Class II rather than a Class V injection well; however, the same principles would apply for subsidence control purposes.



SOME AREAS OF LAND SUBSIDENCE
RESULTING FROM GROUNDWATER WITHDRAWAL

(after Poland et al, 1984)

Figure 4-62

TABLE 4-55: SYNOPSIS OF STATE REPORTS FOR SUBSIDENCE CONTROL WELLS(5S23)

REGION & STATES	EPA REGION	Confirmed Presence Of Well Type	Regulatory System	Case Studies/ Info. available	Contamination Potential Rating
Connecticut	I	NO	N/A	NO	N/A
Maine	I	NO	N/A	NO	N/A
Massachusetts	I	NO	N/A	NO	N/A
New Hampshire	I	NO	N/A	NO	N/A
Rhode Island	I	NO	N/A	NO	N/A
Vermont	I	NO	N/A	NO	N/A
New Jersey	II	NO	N/A	NO	N/A
New York	II	YES	N/A	NO	N/A
Puerto Rico	II	NO	N/A	NO	N/A
Virgin Islands	II	NO	N/A	NO	N/A
Delaware	III	NO	N/A	NO	N/A
Maryland	III	NO	N/A	NO	N/A
Pennsylvania	III	NO	N/A	NO	N/A
Virginia	III	NO	N/A	NO	N/A
West Virginia	III	NO	N/A	NO	N/A
Alabama	IV	NO	N/A	NO	N/A
Florida	IV	NO	N/A	NO	N/A
Georgia	IV	NO	N/A	NO	N/A
Kentucky	IV	NO	N/A	NO	N/A
Mississippi	IV	NO	N/A	NO	N/A
North Carolina	IV	NO	N/A	NO	N/A
South Carolina	IV	NO	N/A	NO	N/A
Tennessee	IV	NO	N/A	NO	N/A
Illinois	V	NO	N/A	NO	N/A
Indiana	V	NO	N/A	NO	N/A
Michigan	V	NO	N/A	NO	N/A
Minnesota	V	NO	N/A	NO	N/A
Ohio	V	NO	N/A	NO	N/A
Wisconsin	V	4 WELLS	PERMIT	NO	LOW
Arkansas	VI	NO	N/A	NO	N/A
Louisiana	VI	NO	N/A	NO	N/A
New Mexico	VI	NO	N/A	NO	N/A
Oklahoma	VI	NO	N/A	NO	N/A
Texas	VI	NO	N/A	NO	N/A
Iowa	VII	NO	N/A	NO	N/A
Kansas	VII	NO	N/A	NO	N/A
Missouri	VII	NO	N/A	NO	N/A
Nebraska	VII	NO	RULE	NO	N/A
Colorado	VIII	NO	N/A	NO	N/A
Montana	VIII	NO	N/A	NO	N/A
North Dakota	VIII	NO	N/A	NO	N/A
South Dakota	VIII	NO	N/A	NO	N/A
Utah	VIII	NO	RULE/PERMIT	NO	N/A
Wyoming	VIII	NO	N/A	NO	N/A
Arizona	IX	NO	N/A	NO	N/A
California	IX	NO	N/A	NO	N/A
Hawaii	IX	NO	N/A	NO	N/A
Nevada	IX	NO	N/A	NO	N/A
American Samoa	IX	NO	N/A	NO	N/A
Tr. Terr. of P	IX	NO	N/A	NO	N/A
Guam	IX	NO	N/A	NO	N/A
CNMI	IX	NO	N/A	NO	N/A
Alaska	X	NO	N/A	NO	N/A
Idaho	X	NO	N/A	NO	N/A
Oregon	X	NO	N/A	NO	N/A
Washington	X	NO	N/A	NO	N/A

NOTE: SOME NUMBERS IN THIS TABLE ARE ESTIMATED.

Construction, Siting, and Operation

Although the injection wells used in the Wilmington Oil Field subsidence control/enhanced recovery project are not Class V wells, they are illustrative of construction, siting, and operation of subsidence control injection wells (See Figure 4-63). In this particular case, oil production resulted in decreased fluid pressures in the oil saturated sand zone underlying an impermeable shale layer. This shale layer acts as a trapping mechanism, preventing further upward migration of petroleum. As fluid pressures decreased with oil production, water contained in the shale zone was squeezed out by weight of overburden into the zone of lowered pressure. This resulted in compaction of the shale layer, which caused subsidence at the surface.

The water injection well was sited down structural dip to oil production. This allows injection into the water saturated zone of the reservoir rock. Since oil is less dense, injected water acts to push the oil upward toward the producing well, and also to increase reservoir pressures. Increasing reservoir pressures in this case resulted in abatement of the previously described shale dewatering and compaction. This project resulted in reduction of the subsiding area and local land surface rebound of as much as 1 foot (Mayuga and Allen, 1969).

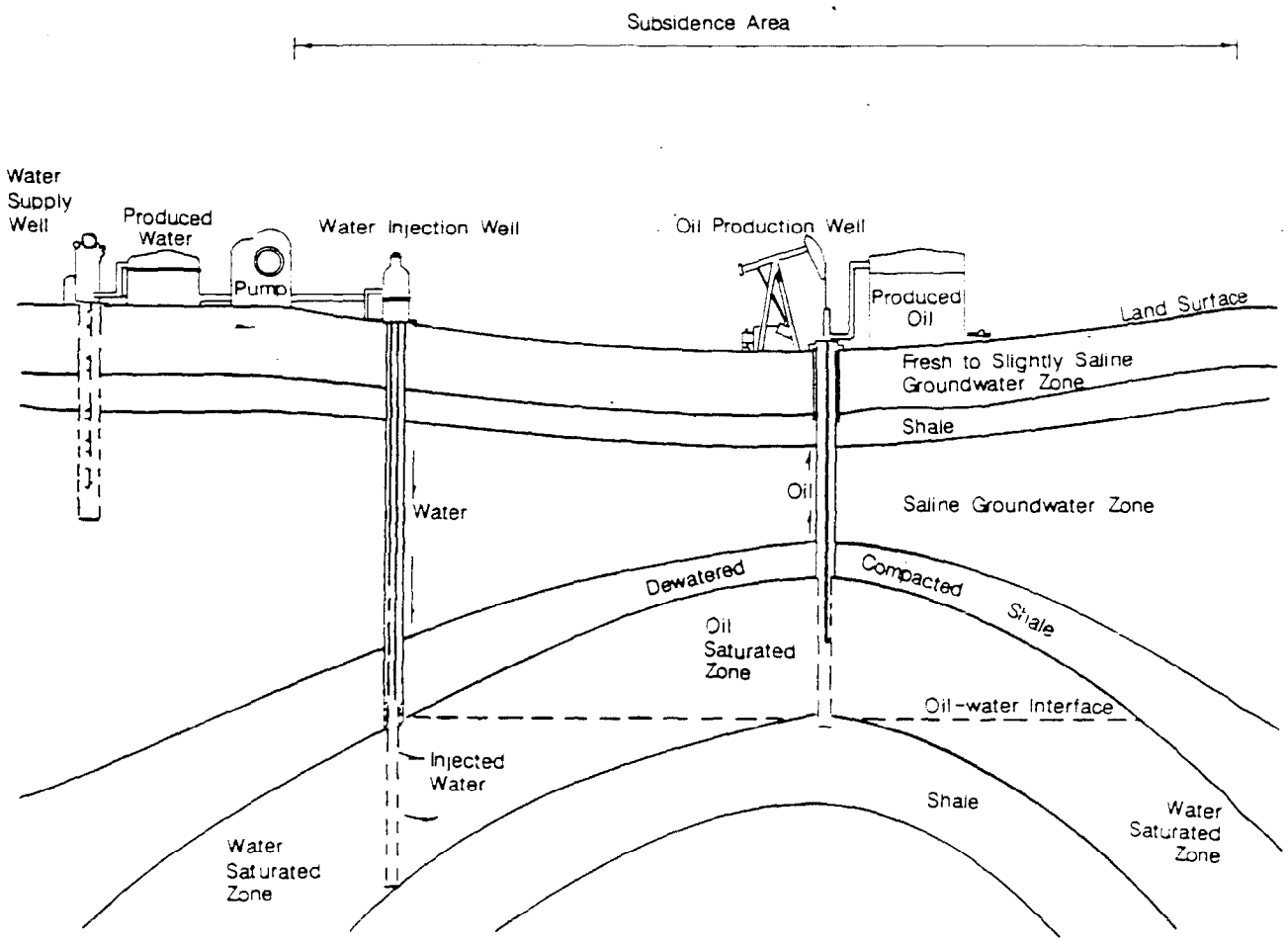
The inventoried wells in Wisconsin are temporary and have been constructed for the purpose of restoring piezometric levels during tunnel construction procedures. This is necessary to minimize damage from settlement during construction of the Milwaukee Tunnel project (Wisconsin DNR, 1986). Construction, siting, and operation practices will vary according to hydrogeologic conditions.

Injected Fluids and Injection Zone Interactions

Injection fluid characteristics and injection zone interactions are discussed in depth under Section 4.2.7.1 (Aquifer Recharge Wells) of the report. The following discussion deals with some physical properties and characteristics of the injection zone with regard to compaction and response to injection.

Water level fluctuations change effective stresses in the following 2 ways (Poland et. al., 1984):

1. A rise in the water table provides buoyant support for the grains within the zone of change while water decline removes buoyant support in this zone. These changes in gravitational stress are transmitted downward to all underlying deposits.



SCHEMATIC DIAGRAM OF SUBSIDENCE CONTROL
(Water Injection) WELL AND OIL WELL
Wilmington Oil Field, Long Beach, CA

after Texas DWR, 1980

Figure 4-63

2. A change in position of the water table or potentiometric surface of the confined aquifer system may induce vertical hydraulic gradients across confining or semiconfining beds and thereby produce a seepage stress. If preexisting seepage stresses are altered in direction or magnitude, a change in effective stress will result.

Since aquitards (composed of clay or shale) are highly compressible in comparison to aquifers (granular porous and permeable media), they may determine by number and thickness the system's susceptibility to compaction. Aquifers themselves are relatively incompressible at low pressures, however compression due to rearrangement of grains will occur at higher pressures (at the effective stress point). Compression may be permanent (inelastic) or recoverable (elastic). If geologic conditions are favorable, injection wells may aid in recovery of compacted strata.

Hydrogeology and Water Use

Subsidence due to ground-water withdrawal develops principally under two contrasting environments and mechanics (Poland et. al., 1984). One environment is that of karst areas where ground water flows through underground cavernous openings. The ground-water body provides buoyant support to overlying material in these areas. When ground-water levels drop, the buoyant support is removed and the hydraulic gradient is increased. This may result in erosion of unconsolidated material overlying the karst material, and also further dissolution of the karst material itself. This process may result in catastrophic collapse of roof material, forming sinkholes.

The second and more prevalent environment of occurrence is that of young unconsolidated, or semiconsolidated elastic sediments of high porosity which were deposited in shallow marine, alluvial, or lacustrine environments. This environment consists of aquifer systems containing aquifers of sand and/or gravel of high permeability and low compressibility, which are interbedded with clayey aquitards of low vertical permeability and high compressibility (Poland et. al., 1984). These aquifer systems compact in response to increased overburden stress. This is caused by decreased fluid pressures in the coarse-grained aquifers resulting from excessive extraction of water from this zone. Clay zones are thus dewatered and compacted as fluids move into the zone of lowered pressure. If overburden pressures continue to increase, aquifers may also compact due to grain rearrangement.

Principle clay minerals of which aquitards are composed belong to the montmorillonite, illite, or kaolin groups. Montmorillonite clays are the most compressible, and are the most

predominant clays in the compacting aquifer systems of the southwestern United States.

Populations in arid climates are generally more dependent upon ground water, as surface water is not readily available in many of these areas. Heavy ground-water demands may cause severe depletion leading to subsidence. High ground-water demand in irrigated agricultural areas of the southwestern United States has caused widespread subsidence problems. Subsidence in Arizona has led to the formation of earth fissures.

Contamination Potential

Based on the rating system described in Section 4.1, subsidence control wells are assessed to pose a low potential to contaminate USDW. These wells typically do inject into or above Class I or Class II USDW. Typical well construction, operation, and maintenance would not allow fluid injection or migration into unintended zones. Injection fluids should be of equivalent or better quality (relative to standards of the National Primary or Secondary Drinking Water Standards and RCRA regulations) than the fluids within any USDW in connection with the injection zone. Based on injectate characteristics and possibilities for attenuation and dilution, injection does not occur in sufficient volumes or at sufficient rates to cause an increase in concentration (above background levels) of the National Primary or Secondary Drinking Water Regulation parameters in ground water, or endanger human health or the environment in a region studied on a group/area basis.

Subsidence control injection wells discharge directly into or above USDW. If subsidence control wells are not properly designed, constructed, and operated contamination may result. Wells must be properly sealed to prevent cross contamination and surface inflow. Special design, construction, and operation problems may arise in subsiding areas, as wells may be subject to casing or seal failures resulting from compressive stresses. Ground-water quality may be adversely affected by subsidence control recharge practices if injectate water quality is not closely monitored. Serious aquifer degradation may result if low quality water is injected directly into drinking water supply aquifers since injected volumes are quite large. Contamination potential for subsidence control wells is considered to be low providing they are properly designed, constructed, and operated. Serious problems may arise with improper practices which may lead to a high contamination potential. Refer to Section 4.2.7.1 for more information on the contamination potential of recharge wells.

Severe land subsidence itself may threaten water quality in some instances. Underground structures such as water and sewer systems, pipelines, and storage tanks may be damaged by land subsidence and earth fissures. There have been some cases in Arizona of people dumping refuse into open fissures. [illegible]

fissures and sinkholes may extend to depths of regional supply aquifers and could provide a conduit for surface pollutants to enter drinking water supply aquifers.

Current Regulatory Approach

Subsidence control wells are authorized by rule under Federally administered UIC programs (see Section 1). The inventoried wells in Wisconsin have been permitted by the Wisconsin Department of Natural Resources (WDNR). These wells will be used temporarily during a construction project and will be properly plugged after the project is completed. The WDNR approved these wells under certain conditions, which include proper construction, operating, and abandonment procedures. The injectate source will be public supply drinking water. The project proposal was found by the WDNR to be consistent with the USEPA UIC regulations and local state regulations.

The Harris-Galveston Coastal Subsidence District was created in May 1975 to provide for the regulation of ground-water withdrawal within district boundaries for the purpose of ending subsidence. In 1978 (Smith-Southwest Industries, Inc. vs. Friendswood Development Company) the Texas Supreme Court ruled that ground-water users were not liable for subsidence damage caused by past actions, but could be held liable for damages due to future negligent or malicious ground-water pumpage (Poland, et. al., 1984).

In 1958 the United States sued oil and gas producers in the previously mentioned Wilmington oil field for damages to the U.S. Naval Base on Terminal Island, and other properties, resulting from subsidence. This was the largest damage suit in United States history for subsidence caused by the pumping of underground fluids. This case was settled out of court and the Anti-Subsidence Act of 1958 compelled Wilmington oil field producers to unitize and repressure the depleted reservoir (Poland, el. al., 1984).

Recommendations

Recommendations for subsidence control wells are similar to those for recharge wells (See Section 4.2.7.1). Injectate quality should be monitored, and proper well design, construction, and operation are most important. Injectate quality should be of equivalent or better quality than fluids in the receiving aquifer. Standards should be set on a case by case basis.

Supporting Data

Referenced supporting data for Subsidence Control Wells is listed in Appendix E of the report.

4.2.8 MISCELLANEOUS WELLS

4.2.8.1 Radioactive Waste Disposal Wells (5N24)

Well Purpose

The purpose of radioactive waste disposal wells is to dispose of wastes containing radioactive materials, in concentrations exceeding those listed in 10 CFR Part 20, Appendix B, Table 2, Column 2, into subsurface formations. These wastes are low level radioactive wastes. This subcategory includes wells that inject heat exchange and cooling water process equipment waste condensate from facilities managing radioactive materials. In addition, non-radioactive wastes from laboratory drains also may be injected into these wells.

Inventory and Location

The inventory data collected by each State, Territory, and Possession, account for a total of approximately 122 radioactive waste disposal wells. There tends to be a hesitancy by the operators of possible radioactive waste disposal wells to identify themselves. However, when this report was coordinated with the Department of Energy, staff at all levels were cooperative and offered full and complete data for this report. It is very possible that the current inventory of known radioactive waste disposal wells constitutes only a percentage of those actually in existence. Table 4-56 indicates where inventoried Class V radioactive waste disposal wells are located.

A major problem in the inventory of radioactive waste disposal wells is determining which wells are Class V injection wells and which wells would meet the criteria for Class IV injection wells, which are banned. Also, wells which have not disposed of radioactive wastes since the inception of the UIC program would not fall under the jurisdiction of the UIC regulations; however, mention of these facilities is included in this inventory for completeness.

The Nuclear Regulatory Commission (NRC) under the Energy Reorganization Act of 1974, licenses and regulates the following facilities according to Section 202:

1. Demonstration Liquid Metal Fast Breeder reactors when operated as part of the power generation facilities of an electric utility system, or when operated in any other manner for the purpose of demonstrating the suitability for commercial application of such a reactor.

TABLE 4-56: SYNOPSIS OF STATE REPORTS FOR RADIOACTIVE WASTE DISPOSAL WELLS(5N24)

REGION & STATES	EPA REGION	Confirmed Presence Of Well Type	Regulatory System	Case Studies/ Info. available	Contamination Potential Rating
Connecticut	I	NO	N/A	NO	N/A
Maine	I	NO	N/A	NO	N/A
Massachusetts	I	NO	N/A	NO	N/A
New Hampshire	I	NO	N/A	NO	N/A
Rhode Island	I	NO	N/A	NO	N/A
Vermont	I	NO	N/A	NO	N/A
New Jersey	II	NO	N/A	NO	N/A
New York	II	NO	N/A	NO	N/A
Puerto Rico	II	NO	N/A	NO	N/A
Virgin Islands	II	NO	N/A	NO	N/A
Delaware	III	NO	N/A	NO	N/A
Maryland	III	NO	N/A	NO	N/A
Pennsylvania	III	NO	N/A	NO	N/A
Virginia	III	NO	N/A	NO	N/A
West Virginia	III	NO	N/A	NO	N/A
Alabama	IV	NO	N/A	NO	N/A
Florida	IV	NO	N/A	NO	N/A
Georgia	IV	NO	N/A	NO	N/A
Kentucky	IV	NO	N/A	NO	N/A
Mississippi	IV	NO	N/A	NO	N/A
North Carolina	IV	NO	N/A	NO	N/A
South Carolina	IV	NO	N/A	NO	N/A
Tennessee	IV	1 WELL(ABD)	N/A	NO	N/A
Illinois	V	1 WELL	RULE	NO	N/A
Indiana	V	NO	N/A	NO	N/A
Michigan	V	NO	N/A	NO	N/A
Minnesota	V	NO	N/A	NO	N/A
Ohio	V	NO	N/A	NO	N/A
Wisconsin	V	NO	N/A	NO	N/A
Arkansas	VI	NO	N/A	NO	N/A
Louisiana	VI	NO	N/A	NO	N/A
New Mexico	VI	1 WELL(ABD)	ILLEGAL	YES	LOW
Oklahoma	VI	1 WELL(ABD)	RULE	NO	N/A
Texas	VI	NO	N/A	NO	N/A
Iowa	VII	NO	N/A	NO	N/A
Kansas	VII	NO	N/A	NO	N/A
Missouri	VII	NO	N/A	NO	N/A
Nebraska	VII	NO	RULE	NO	N/A
Colorado	VIII	NO	N/A	NO	N/A
Montana	VIII	NO	N/A	NO	N/A
North Dakota	VIII	NO	N/A	NO	N/A
South Dakota	VIII	NO	N/A	NO	N/A
Utah	VIII	NO	RULE/PERMIT	NO	N/A
Wyoming	VIII	NO	N/A	NO	N/A
Arizona	IX	NO	N/A	NO	N/A
California	IX	NO	N/A	NO	N/A
Hawaii	IX	NO	N/A	NO	N/A
Nevada	IX	NO	N/A	NO	N/A
American Samoa	IX	NO	N/A	NO	N/A
Tr. Terr. of P	IX	NO	N/A	NO	N/A
Guam	IX	NO	N/A	NO	N/A
CNMI	IX	NO	N/A	NO	N/A
Alaska	X	NO	N/A	NO	N/A
Idaho	X	4 WELLS	PERMIT>1B FT	YES	7TH HIGHEST/14 TYPES
Oregon	X	NO	N/A	NO	N/A
Washington	X	116 WELLS	PERMIT	YES	HIGH

NOTE: SOME NUMBERS IN THIS TABLE ARE ESTIMATES.

2. Other demonstration nuclear reactors when operated as part of the power generation facilities of an electric utility system, or when operated in any other manner for the purpose of demonstrating the suitability for commercial application of such a reactor.

3. Facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under such Act.

The Kerr-McGee facility in Oklahoma falls under the jurisdiction of the NRC. The State of Oklahoma reports a permit request from the Kerr-McGee Corporation for disposal of "very low-level radioactive wastes." Oklahoma reports that these wastes were below the level designated as nuclear waste and, therefore, did not permit the well as a radioactive waste disposal well. The well was plugged in December 1985. Applications for radioactive waste injection at NRC licensed facilities are evaluated on a case-by-case basis and in accordance to EPA regulations.

The Department of Energy (DOE) under the Atomic Energy Act of 1954 regulates the remaining facilities included in the current inventory. At the Hanford Atomic Operations in Richland, Washington, information has been documented concerning the disposal of radioactive wastes; however, available information indicates that the injection wells have not been used to inject fluids containing radioactive materials since the 1950's. Another facility which has injected radioactive wastes, in the form of cement grout, in the past is the Oak Ridge National Laboratory in Oak Ridge, Tennessee. According to State officials, radioactive wastes are no longer injected into those wells, and there are no plans to resume this type of injection due to the difficulties in obtaining a UIC permit. The last reported injection activity there occurred in 1984.

In the State of Idaho, DOE maintains one low-level radioactive waste disposal well at the DOE Idaho Chemical Processing Plant (ICPP) on the Idaho National Engineering laboratory reservation. According to an Idaho assessment of Class V injection wells, this well is maintained as an emergency disposal method to the facility's ongoing waste percolation pond disposal system.

A tile field cooling water disposal system has been reported by the State of Illinois at the Fermi National Accelerator Laboratory in Batavia, Illinois. The radioactive wastes are composed of cooling water with low levels of Beryllium 7, which has an affinity for adhesion to the clay into which disposal occurs. Under current DOE policy, no injection wells are being used to dispose of radioactive materials.

Construction, Siting, and Operation

Construction and operation of radioactive waste disposal wells varies greatly. At Oak Ridge National Laboratory, radioactive wastes were blended with cement to form a slurry which was pumped under pressure through a cased well into subsurface strata.

At the Hanford Facility in Washington, injection has occurred through three distinct methods. The methods include: reverse wells, french drains, and cribs. According to the State of Washington Department of Ecology, the Hanford facility has operated 13 reverse wells, 32 french drains, and 70 cribs since the early 1940's. There is some uncertainty as to which of these disposal methods would fall under jurisdiction of the UIC program. The "reverse wells" undeniably are subject to UIC regulation. Reverse wells are cased wells with a perforated bottom section for disposal of the radioactive materials. A french drain consists of a rock-filled cell with an open bottom that allows liquids to seep into the ground. A crib is an underground structure which consists of a settling tank, diversion box, distribution line, and a perforated drain pipe which allow fluids to seep into the subsurface. The cribs at the Hanford facility, however, did not include a settling tank.

The ICPP low-level radioactive waste disposal well in Idaho is constructed of 12-inch diameter casing which extends from 15 feet below ground surface (base of well pit) to 588 feet, the total depth of the borehole. The borehole encountered approximately 40 feet of unconsolidated materials and penetrated approximately 548 feet of interlayered basalt and sedimentary strata. The lowermost 138 feet of casing (from 450 feet to 588 feet) is perforated. Ground water is encountered in the ICPP emergency injection well at a depth of 440 feet. In 1983, the well was lined with 10-inch diameter PVC casing and back-filled to a depth of 520 feet. No explanation for the casing and backfilling effort was presented in the Idaho report. However, DOE has informed EPA that the PVC casing and backfilling were standard techniques to correct well collapse.

Injected Fluids and Injection Zone Interactions

A variety of radioactive materials reportedly have been injected into radioactive waste disposal wells. Reported wastes include Beryllium 7, Tritium, Strontium 90, Cesium 137, Potassium 40, Cobalt 60, Plutonium, Americium, Uranium, and other Radionuclides.

At the Idaho DOE facility, the ICPP emergency injection well is not utilized for routine injection. The injectate, as demonstrated from fluids disposed in the facility's routine disposal system, would include: heat exchange condensate and cooling water, boiler blowdown, deionizer regeneration solutions,

chemical makeup solutions, process equipment waste condensate, nonradioactive wastes from laboratory drains, and fluids from pilot plant drains.

According to the 1985 records, approximately 136,000 gallons of injectate were disposed through the ICPP emergency injection well. According to the Idaho report, only one injection episode occurred from January 1, 1986 through October 1, 1986. During this injection episode, approximately 850 gallons of injectate were disposed through the ICPP injection well.

Based on water quality data, injectate of the ICPP injection well is not considered hazardous in accordance with the definition of RCRA listed and characteristic hazarous waste under 40 CFR Part 261. In addition, the injectate is in accordance with the Idaho Department of Health and Welfare, Radiation Control Regulation for release to an uncontrolled area. However, the concentrations of radiochemical constituents, as well as nitrates and mercury, have exceeded the USEPA Primary Drinking Water Standards (40 CFR, Part 142). They also exceeded the discharge quality standards of the Idaho Injection Well Regulations.

According to the Washington Department of Ecology report on the Hanford facility, injection fluids originated from a variety of sources which include laboratories and processing areas. The fluids may contain condensates and laboratory wastes.

Hydrogeology and Water Use

Inventoried injection facilities inject wastes which are reported to be confined within the perimeters of the site. There is no expected water usage on these sites; however, the potential transport of these materials off-site needs further evaluation. Since injection occurs at very shallow depths, there still remains the potential for contaminating USDW if transport of these radioactive material occurs. Investigations should be conducted to determine whether these wells are Class V or Class IV injection wells, based on location of USDW with respect to injection zones.

Contamination Potential

With the data available from the State reports, the contamination potential cannot be adequately determined.

Current Regulatory Approach

Radioactive waste disposal wells are authorized by rule under Federally-administered UIC programs (see Section 1). See Table 4-[illegible] for a synopsis of regulatory systems by State.

Recommendations

Washington provided the following recommendations for its Class V program:

1. The Department proposes to use the provision of [the state waste discharge permit program (Chapter 173-216 WAC)] to authorize and take enforcement actions for discharges which do not satisfy the standard of all known available reasonable methods of treatment and control.

2. The disposal standard for cribs and french drains will be to treat the waste before discharge and not to rely soley on evaporation, the soil, and dilution to treat the wastes.

3. The number of permits issued and permit compliance and enforcement actions will be negotiated annually with Environmental Protection Agency through the State/EPA Agreement program planning process.

4.2.8.2 Experimental Technology Wells (5X25)

Well Purpose

These wells are used in experimental or unproven technology. Studies are generally conducted on a pilot scale to assess the economic and technological feasibility of applying such procedures. Most wells of this type have been used in technologies associated with recovering fossil fuels and other minerals. Examples of these technologies include underground coal gasification, in situ oil shale retorting, in situ solution mining, tracer studies, aquifer remediation, and secondary water recovery projects. While underground coal gasification and in situ oil shale retorting are regarded as experimental technologies, projects of this kind have been operated on large scales and associated injection wells are classified as a specific type of Class V well. These technologies are discussed thoroughly in a previous section of this report (See Section 4.2.4.3). In situ solution mining, primarily for uranium and copper recovery, is a specific type of Class V injection and also is discussed in a previous section (See Section 4.2.4.2). Certain of these solution mining facilities are operating at pilot scales and are technically defined as an experimental technology, though little to no difference in procedures exists.

Inventory and Location

Inventory updates, through State reports and other database additions, result in an inventory of 225 experimental technology

wells, located in 17 States. A summary of available inventory, regulatory systems, contamination potential ratings and known case studies is presented in Table 4-57.

Referring to Table 4-57, it will be noted that over half the reported experimental technology wells are located in Wyoming (135). The Wyoming State report indicates that this number represents three well types: underground coal gasification, in situ oil shale retorting, and in situ uranium solution mining. At the present time, none of these facilities is believed to be active, presumably due to economic difficulties plaguing those industries. In addition, the two known experimental technology wells in California, associated with a refinery clean-up project are presently inactive. The Alabama report describes a well used in an "experimental" capacity to dispose of treated domestic wastewater. Another well in that State is used to dispose of wastewater generated by the recovery and treatment of contaminated ground water. The report indicates that both projects are short-term and do not appear to be feasible for continued use. The implication of these reports is that there are actually very few active experimental technology injection operations in the United States at the present time.

Construction, Siting, and Operation

Because of the diverse nature of experimental well types, aspects of construction, siting, and operation will also be diverse. The specific examples provided in State reports are discussed in the following paragraphs. For a description of construction, siting, and operation typical of in situ solution mining, underground coal gasification, and in situ oil shale retorting, see the appropriate sections of this report.

The facility in Alabama disposing of treated domestic wastewater uses an injection well approximately 65 feet deep. Six-inch diameter PVC slotted screen is used for casing and is gravel packed at the borehole annulus for the entire depth of the well. Monitoring is conducted at five wells for total suspended solids, fecal coliform, ammonia, BOD (5-day), and pH. Flow rate averages 43 gallons per minute, and maximum daily volume is 36,000 gallons.

The other experimental facility in Alabama is used to inject wastewater generated by the recovery and treatment of contaminated ground water. Wells are 80 feet deep and screened over the bottom 25 feet. Ten-inch diameter steel casing is secured in the 14-inch borehole with cement grout. Adjacent to the 10-inch diameter wire-wound, stainless steel screen is a gravel pack capped with fine sand. Fluid injected must meet criteria for [illegible] and nitrated organics ([illegible] mg/l and 0.5 mg/l, respectively). Maximum flow rate is 100 gallons per minute.

TABLE 4-57: SYNOPSIS OF STATE REPORTS FOR EXPERIMENTAL TECHNOLOGY INJECTION WELLS(5X25)

REGION & STATES	EPA REGION	Confirmed Presence Of Well Type	Regulatory System	Case Studies/ Info. available	Contamination Potential Rating
Connecticut	I	NO	N/A	NO	N/A
Maine	I	NO	N/A	NO	N/A
Massachusetts	I	NO	N/A	NO	N/A
New Hampshire	I	NO	N/A	NO	N/A
Rhode Island	I	NO	N/A	NO	N/A
Vermont	I	NO	N/A	NO	N/A
New Jersey	II	NO	N/A	NO	N/A
New York	II	NO	N/A	NO	N/A
Puerto Rico	II	NO	N/A	NO	N/A
Virgin Islands	II	NO	N/A	NO	N/A
Delaware	III	NO	N/A	NO	N/A
Maryland	III	NO	N/A	NO	N/A
Pennsylvania	III	NO	N/A	NO	N/A
Virginia	III	NO	N/A	NO	N/A
West Virginia	III	NO	N/A	NO	N/A
Alabama	IV	2 WELLS	PERMIT	YES	MODERATE
Florida	IV	3 WELLS	PERMIT	NO	N/A
Georgia	IV	NO	N/A	NO	N/A
Kentucky	IV	NO	N/A	NO	N/A
Mississippi	IV	5 WELLS	RULE	NO	N/A
North Carolina	IV	8 WELLS	PERMIT	NO	N/A
South Carolina	IV	NO	N/A	NO	N/A
Tennessee	IV	NO	N/A	NO	N/A
Illinois	V	2 WELLS	RULE	NO	N/A
Indiana	V	NO	N/A	NO	N/A
Michigan	V	4 WELLS	N/A	NO	N/A
Minnesota	V	2 WELLS	N/A	NO	N/A
Ohio	V	NO	N/A	NO	N/A
Wisconsin	V	NO	N/A	NO	N/A
Arkansas	VI	NO	N/A	NO	N/A
Louisiana	VI	NO	N/A	NO	N/A
New Mexico	VI	6 WELLS	PERMIT	YES	LOW
Oklahoma	VI	NO	N/A	NO	N/A
Texas	VI	6 WELLS	N/A	NO	LOW
Iowa	VII	NO	N/A	NO	N/A
Kansas	VII	NO	N/A	NO	N/A
Missouri	VII	NO	N/A	NO	N/A
Nebraska	VII	2 WELLS	RULE	NO	N/A
Colorado	VIII	2 WELLS	N/A	NO	LOW
Montana	VIII	NO	N/A	NO	N/A
North Dakota	VIII	NO	N/A	NO	N/A
South Dakota	VIII	NO	N/A	NO	N/A
Utah	VIII	NO	RULE/PERMIT	NO	N/A
Wyoming	VIII	135 WELLS	PERMIT	YES	LOW-HIGH
Arizona	IX	32 WELLS	PERMIT	YES	LOW-MODERATE
California	IX	2 WELLS	PERMIT	NO	UNKNOWN
Hawaii	IX	6 WELLS	PERMIT	NO	LOW-MODERATE
Nevada	IX	5 WELLS	PERMIT	NO	UNKNOWN
American Samoa	IX	NO	N/A	NO	N/A
Tr. Terr. of P	IX	NO	N/A	NO	N/A
Guam	IX	NO	N/A	NO	N/A
CNMI	IX	NO	N/A	NO	N/A
Alaska	X	NO	N/A	NO	N/A
Idaho	X	NO	N/A	NO	N/A
Oregon	X	NO	N/A	NO	N/A
Washington	X	3 WELLS	N/A	NO	N/A

NOTE: SOME NUMBERS IN THIS TABLE ARE ESTIMATES.

Air injection tests have been conducted in Texas as a mode of secondary water recovery. This experimental method is used to determine whether air pressure will force capillary water within the unsaturated zone of the aquifer to migrate down to the saturated zone. A six-inch diameter injection well was completed to 116 feet. Steel casing is seated in or below an impermeable stratum and cemented to surface. Slotted steel tubing is seated to total depth, below the impermeable stratum. A packer isolates the injection zone. The injection well is surrounded in a radial pattern by five monitoring wells. An estimated 12 million cubic feet of air was injected during a 217-hour test.

An experimental procedure tested at the University of Minnesota attempted storing heated ground-water in a confined aquifer. The goal was to recover energy, via heat, from the injected fluid. Four short-term cycles were studied. Wells were constructed of stainless steel casing, screened across permeable intervals of the confined aquifer. This screened casing (6-inch diameter) extended down from 13-3/8-inch steel casing. The lower casing was surrounded by a gravel pack designed to accommodate thermal expansion of the casing. The injection zone was isolated by a packer. Constant speed turbine pumps were seated at about 450 feet. Hot fluid was injected and stored for various lengths of time, then recovered to test the heat content of the fluid. A fixed-bed precipitator using high-purity limestone was used to treat injected fluid to prevent scaling. Similarly, hardness was removed before heating the ground-water using an ion-exchange water softener.

Injected Fluids and Injection Zone Interactions

Each type of experimental injection operation makes use of a different type of injectate. A variety of acidic and basic compounds can be used for in situ solution mining operations. These fluids and their potential interactions with the injection zone are discussed in Section 4.2.4.2. Similarly, fluids used for underground coal gasification and in situ oil shale retorting are reported, along with injection zone interactions, in Section 4.2.4.3.

The Alabama facility injecting treated domestic wastewater has been monitored for total suspended solids, fecal coliform, ammonia, BOD, and pH. The Alabama report stated that there were no permit limitations for those parameters. The permit was for one year, and injectate volumes of 36,000 gallons per day would result in a maximum of over 13 million gallons injected at that facility. No information on the injection aquifer was presented by the Alabama facility.

The other Alabama facility, injecting wastewater associated with treatment of contaminated ground water, was reported to inject up to 100 gallons per minute. On an annual basis, this would result in a maximum of over [illegible] million gallons injected.

This injected fluid was subject to contaminant limits per the operating permit. Again, no information with respect to the injection zone was presented by the facility.

For the secondary water recovery operation in Texas, it was stated that air was injected under pressure to affect movement of capillary water toward the water table. It is believed that this activity results in very little interaction at a molecular level between injected air and formation water. Data regarding hydrogeological character of the injection zone were not reported by the Texas facility.

Finally, the experimental procedure applied in Minnesota for storing injected hot water made use of ground water extracted from the intended injection zone. Before heating, the water was softened by ion exchange. A fixed-bed reactor is part of the injection system and is used to precipitate calcium carbonate, thus preventing scaling within the injection wells. The conclusion is that the injectate was actually of better quality than injection zone water with respect to hardness and total dissolved solids (TDS). The influence of temperature differentials between injectate and injection zone fluids upon lithological parameters was not determined by the facility.

The previous discussions, though not exhaustive, exemplify that no singular or typical description of injection fluids or injection zone interactions can be made. Characterization of these parameters must be conducted on a site-specific basis. Each known facility studied should place emphasis the following parameters:

1. Goal of the operation;
2. Nature and volume of injected fluids;
3. Site hydrogeology; and
4. Construction, operation, and maintenance features.

Hydrogeology and Water Use

It is difficult to make broad hydrogeological generalizations with respect to these wells. Experimental procedures involving injection can vary greatly as can the goals of these projects. Again, it should be emphasized that experimental procedures for in situ solution mining, underground coal gasification, and in situ shale retorting are discussed with respect to hydrogeologic parameters in previous sections.

In general, experimental injection operations reported within the United States are characterized by injection into confined aquifers. Exceptions to this may be the two experimental facilities reported by Alabama where injection wells reach a maximum depth of only 80 feet. Though specific details for these aquifers are not known, the well depths are indicative of unconfined or semi-confined aquifer conditions.

The Wolfforth Air-Injection test, a 1984 experimental secondary water recovery test, was conducted in two unsaturated zones separated by a "bed of hard rock" (High Plains Underground Water Conservation District No. 1, July, 1985). The depth of this well (110 feet) is such that the aquifer beneath the hard rock unit was probably confined, and the zone above this layer was unconfined or semi-confined. Two tests were conducted at the Wolfforth site. The first test was designed to inject air under low pressure (8 psi) at low volumes (300 cubic feet/minute) into the unsaturated zone above the confining layer. Two key results were noted. First, moisture content within the unsaturated zone decreased within a 300-foot radius of the injection well, indicative that the procedure actually could move capillary water. Second, injection actually increased the moisture content within the confined aquifer below the hard rock layer.

A second test conducted at Wolfforth was designed to inject air at low pressures and volumes into the confined zone below the hard rock layer. Results similar to the initial test occurred, namely a decrease in moisture content around the injection well and increased yields within a two-mile radius in irrigation wells during and after the test. Additionally, researchers were able to observe the influence of lateral variations in aquifer characteristics upon capillary water movement induced by air injection. Results of these injection tests conclusively demonstrated that water levels could be significantly raised in radii of several tens of miles using air injection. Other important findings were 1) up to 30 percent of the capillary water in storage can be released under relatively low air pressures and volumes using this procedure, and 2) post capillary water drainage can occur for several months or years after short-term injection.

Another experimental injection operation for which relatively full documentation exists is the aquifer thermal energy storage (ATES) project. These experiments were conducted at the University of Minnesota. The procedure made use of a combination extraction-injection system whereby ground water is heated and injected into a confined aquifer for storage. Results showed that energy recovery via this process was 62 percent of the energy added to the injected ground-water for long-term cycles. Energy recoveries varied from 46-62 percent for the four short-term experiments conducted.

Wells used in this procedure were completed in a highly variable sequence of late Cambrian marine sediments (Franconia-Ironton-Galesville sequence). This is a highly stratified, confined aquifer, present at a depth of about 890 feet. It is approximately 200 feet thick and is under a static head of about 400 feet (Hoyer and Walton, 1984). The aquifer is composed of sandstone interbedded with shale, siltstone, and dolomite. Ground water is calcium-magnesium bicarbonate and is extracted from and injected into the same zones. The upper zone, part of the Upper Franconia, is a fine- to medium-grained sandstone

demonstrating varying concentrations of glauconite. It is confined above and below by relatively impermeable silty dolomites and siltstones, respectively. The lower injection zone is the entire section of Ironton and Galesville rocks. These formations are a sequence of medium quartzose sandstones and fine feldspathic sandstones with shale laminations. Similar to the upper zone, the Ironton-Galesville sequence is a highly permeable aquifer bounded above and below by relatively impermeable silts, fine sands, and silty dolomites.

The foregoing site-specific information on experimental injection operations has been presented to demonstrate parameters important to such operations. Ground-water remediation and recovery, thermal energy storage, and fossil fuel and mineral recovery are known to be major objectives of experimental strategies. Other important aspects of experimental injection include 1) lithologic character of the injection zone (mineralogy, permeability, vertical confinement, and lateral variation), 2) nature of injected fluid, 3) ground-water quality, and 4) injection system design. Each of these aspects will vary, and their influence upon system performance and environmental impact should be evaluated on a site-specific basis.

Contamination Potential

Based on the rating system described in Section 4.1, experimental technology wells inventoried to date are assessed to pose a moderate to low potential to contaminate USDW, but each operation must be assessed individually. These facilities typically do inject into or above some USDW. Typical well construction, operation, and maintenance would not allow fluid injection or migration into unintended zones. Injection fluids typically have concentrations of constituents exceeding standards set by the National Primary or Secondary Drinking Water Regulations. Based on injectate characteristics and possibilities for attenuation and dilution, injection may or may not occur in sufficient volumes or at sufficient rates to cause an increase in concentration (above background levels) of the National Primary or Secondary Drinking Water Regulation parameters in ground water, or endanger human health or the environment beyond the facility perimeter.

Because of the variability exhibited in experimental technologies associated with Class V injection, it is not possible to assign a singular contamination potential. In previous sections, it has been stated that contamination potential attributable to in situ solution mining is generally low and that contamination potential from underground coal gasification and in situ shale retorting is moderate. These results indicate that meaningful assessment of experimental technologies for contamination potential must be system-specific. The following paragraphs contain assessments for the types of experimental injection operations inventoried to date.

Due to the limited data presented for the experimental systems in Alabama, these two facilities are assessed together, using certain broad generalizations. One operation disposes of treated domestic wastewater, and the other injects wastewater produced due to the recovery and treatment of contaminated ground water. Injection at both facilities is relatively shallow, and both injection zones may be USDW. However, from the limited description presented, it cannot be concluded these aquifers are Class IIB quality or better.

Construction designs for the Alabama facilities provide for specific injection intervals. Screened openings are employed, and the up-hole portions of wells at both facilities are cemented and grouted. However, the reported well depths are shallow enough to imply that the injection zones are actually semi- to unconsolidated and are probably not totally confined. As such, it is likely that injection fluids have migrated vertically into other zones.

At the facility disposing of treated wastewater, injectate is monitored for total suspended solids, fecal coliform, ammonia, BOD, and pH, yet no permit limitations exist for these parameters. At the other facility, limitations for chemical oxygen demand (COD) and nitrated organics have been established, but other constituents present within contaminated ground water are not addressed. The conclusion is that there is a strong likelihood that some constituents are present within these waste streams that exceed certain Primary and/or Secondary Drinking Water Regulations.

Finally, injection volumes must be addressed. Maximum injection volumes for these facilities can be several tens of millions of gallons annually. Though specific hydrogeologic conditions for each site have not been ascertained, these volumes could result in contamination of ground water beyond facility boundaries.

In summary, it cannot be concluded that injection at the two Alabama facilities is into Class IIB aquifers. However, construction and operation of the wells is probably resulting in migration of injection fluids into unintended zones. In addition, the possibility exists that certain drinking water regulations are being exceeded for injection fluids and that injection volumes are sufficient to cause increases in these constituents within ground water beyond facility boundaries. It is hereby concluded that injection conducted at these two facilities poses moderate threat of contamination to local USDW. This assessment could be amended to high contamination potential, should further data about USDW in the area become available.

In Texas, the air injection operation for [illegible] recovery was into an aquifer used extensively as a [illegible] water aquifer. That aquifer's potential [illegible]

water supply has not been demonstrated. Injection of air into the unconfined zone actually resulted in changes in moisture content within the confined aquifer. With respect to injectate quality, only compressed air was injected. The composition of air would not be such that any Primary or Secondary Drinking Water Regulations would be exceeded, nor would it cause increases in those constituents within ground-water beyond facility boundaries. Therefore, this particular injection operation poses a low ground-water contamination potential.

At the University of Minnesota facility, injection fluid was merely heated ground water which was returned to the same zones it was extracted from. It could not be determined if the extraction-injection aquifer was of Class IIB quality. Well construction was found to be relatively simple, and the potential for migration of fluids into unintended zones may be considered to exist. Because the same fluid is extracted, heated and injected, increases in constituents of Primary and Secondary Drinking Water Standards may or may not occurr beyond facility boundaries. Therefore, this particular injection operation has presented low potential for contamination to USDW.

To summarize what has been demonstrated in the previous discussion, contamination potentials ranging from low to moderate are possible for experimental injection operations as presently understood. Future data regarding known operations or new inventory information may result in a higher contamination assessment. It will be necessary to evaluate each facility individually.

Current Regulatory Approach

Experimental technology wells are authorized by rule under Federally-administered UIC programs (see Section 1). Review of the various types of experimental injection operations has indicated that in situ solution mining, underground coal gasification, and in situ shale retorting are the most thoroughly regulated. Aspects of regulatory jurisdiction over these well types are discussed in earlier sections of this report.

Data regarding regulatory authority over other representative well types is largely absent. The Alabama facility injecting wastewater generated by recovery and treatment of contaminated ground water operates under concentration limitations for COD and nitrated organics. It is presumed these restrictions are part of waste discharge permit requirements, but the issues of such permits remain in question. Some inventoried facilities may not operate under permit programs at the present time. Refer to Table 4-57 for a synopsis of State regulatory systems.

Recommendations

Experimental technologies involving injection vary greatly. As such, recommendations addressing siting, construction, and operation must be broad and general in nature. Siting injection wells associated with precious metal or fossil fuel recovery will, of course, be dependent upon the location and dimensions of the mineral deposit. The California report recommends that injection wells for other technologies, not location dependent, should not be sited where poor quality fluid injection into a Class IIB aquifer could occur. The report further suggests that detailed ground-water studies should be conducted for any potential injection site. Points to be addressed in such studies might include general ground-water quality, aquifer dimensions, and present ground-water uses, as well as potential for further use.

Additional recommendations from the California report include chemical analysis of the waste stream at regular intervals. Frequency for such analyses will be dictated by the general nature of the waste stream with respect to potentially hazardous or toxic materials, and volumes of injection. Establishment of mechanical integrity at regular intervals should be part of every operational plan, according to both the Arizona and California reports. The type of tests employed will be dependent upon the materials used for casing, and the type of completion (perforations, screened openings, or open hole).

Most of the experimental injection facilities discussed in this report are inactive or have been abandoned. Facilities known to still be active are certain solution mining operations in the southwestern United States. No evidence for USDW contamination exists at the present time. As a result, no recommendations for remedial or corrective action were proposed in the State reports except to continue to identify USDW in areas where experimental injection is occurring. These data could be used to better assess, on a site-specific basis, potential contamination to USDW from this kind of Class V injection.

Supporting Data

Two case studies are listed in Appendix F for Experimental Technology Injection wells. The first is a study of aquifer thermal energy storage conducted on the University of Minnesota campus by the Minnesota Geological Survey. The second case study represents an air-injection test conducted in Texas to attempt enhancement of secondary fresh water recovery. The test was conducted jointly by the Texas Department of Water Resources, the High Plains Underground Water Conservation District Number 1, and the City of Wolfforth, Texas.

4.2.8.3 Aquifer Remediation Related Wells (5X26)

Well Purpose

Aquifer remediation can be defined as the implementation of remedial measures to correct deficiencies, improve selected parameters (such as quality or flow), or to prevent anticipated or possible problems in permeable materials which contain or are capable of containing ground water. The implementation of these programs historically has been in response to problems which have already occurred and, to a much lesser extent in recent years, as a preventive practice.

Recent years have seen the incidence, or at least the recognition, of ground-water contamination on the increase. In light of this, the public awareness and concern have demanded correction of these problems. Remediation programs implemented throughout the United States have many widely varying arrays which normally are a function of several parameters including type and quantity of pollutants, area of contaminated water, hydrogeologic regimens, and others. While aquifer remediation programs are implemented through the use of different tactics, they have certain goals which are common throughout. These goals include, first and foremost, the abatement of contamination, second, the containment of the area of contamination, and last, the restoration of the aquifer. Injection wells quite often are used in these programs for a variety of purposes. They are implemented to achieve one or more of these goals. They can be used to introduce chemicals or microorganisms designed to neutralize the contamination, or they may be used to transport clean waters to the contaminated zones for the purpose of diluting tainted waters and forming hydraulic barriers, or they may be used to return treated waters to the aquifer. Many people refer to wells utilized to return treated water to the aquifer as "recharge wells," or simply "injection wells." Returning treated waters to the aquifer and setting up hydraulic barriers to contain contamination plumes are the most common uses for injection wells in aquifer remediation strategies.

The use of injection wells in some portion of the remedial strategy is almost an absolute. Most of the programs implemented in the past have included the removal of contaminated waters, above ground treatment, and subsequent return of these waters to the production zone. With technological advancements made in recent years, this is not always necessary. In-situ treatment is rapidly becoming a popular and relatively inexpensive remedial tactic. This requires the introduction of some agent or agents which will counteract and eliminate the contaminated waters without removing them from the aquifer. Each of these schemes, in-situ treatment and recovery and treatment, require some sort of injection program. It is these injection wells which are assessed in the following sections.

A specialized type of aquifer remediation related wells, known as hydrocarbon recovery "recharge" wells, is addressed separately in the following section, 4.2.8.4.

Inventory and Location

To date, the inventory of aquifer remediation wells in the United States includes 353 injection wells distributed throughout fifteen States as shown in Table 4-58. Since an abatement and restoration program may require several injection wells at a single contamination site, these wells often are clustered. The 257 injection wells accounted for in the USEPA Underground Injection Control database (known as FURS) are distributed throughout ten States with the majority of these injection wells located in three of those states (81 in Colorado, 59 in Michigan, and 60 in Oklahoma). This clustering is accounted for by concentrations of certain industrial practices which are prevalent in those States such as petroleum refining in oil-rich Oklahoma (refer to Section 4.2.8.4) and the manufacturing of industrial chemicals at a site in Colorado. This is demonstrated by the fact that all 60 injection wells located in Oklahoma are located at various petroleum refineries, and all 81 injection wells in Colorado are at the Rocky Mountain Arsenal which was used by the government during the Second World War for the manufacturing of chemicals used in warfare and later leased by private industry for chemical manufacturing. It should be noted that these wells serve the secondary purpose of aquifer recharge.

Construction, Siting, and Operation

The construction of injection wells used in aquifer remediation programs varies widely throughout the United States. The depths to which these wells are installed is based on the location of the contaminated aquifer. Since most contamination occurs as a result of surface or near surface spills, the depths of injection wells used in aquifer remediation are generally quite shallow. Over 50% of these wells are installed to depths of less than 100 feet (based on available inventory information). Diameters range from 1 to 12 inches for those wells (50%) identified above but also vary widely according to the amount of fluids they must deliver to the subsurface.

Remediation injection wells are screened when completed in sands and gravels. This eliminates or reduces incrustation and facilitates water movement (the latter being of primary concern in aquifer remediation). Furthermore, injection wells used for aquifer remediation are almost always cased, the only exception to this being the "wells" which return fluids through surface introduction (percolation). Casing is constructed of PVC piping and generally is installed from the surface through the top of the injection zone. The casing aids in supporting the walls of the well, helps keep out possible surface contaminants, and

TABLE 4-5B: SYNOPSIS OF STATE REPORTS FOR AQUIFER REMEDIATION(5X26)

REGION & STATES	EPA REGION	Confirmed Presence Of Well Type	Regulatory System	Case Studies/ Info. available	Contamination Potential Rating
Connecticut	I	NO	N/A	NO	N/A
Maine	I	NO	N/A	NO	N/A
Massachusetts	I	NO	N/A	NO	N/A
New Hampshire	I	NO	N/A	NO	N/A
Rhode Island	I	2 WELLS	N/A	NO	HIGH
Vermont	I	NO	N/A	NO	N/A
New Jersey	II	9 WELLS	NJPDES PERMIT	NO	N/A
New York	II	NO	N/A	NO	N/A
Puerto Rico	II	1 WELL	N/A	YES	N/A
Virgin Islands	II	NO	N/A	NO	N/A
Delaware	III	NO	N/A	NO	N/A
Maryland	III	NO	N/A	NO	N/A
Pennsylvania	III	NO	N/A	NO	N/A
Virginia	III	NO	N/A	NO	N/A
West Virginia	III	NO	N/A	NO	N/A
Alabama	IV	1 WELL	PERMIT	NO	VARIABLE
Florida	IV	NO	N/A	NO	N/A
Georgia	IV	NO	N/A	NO	N/A
Kentucky	IV	NO	N/A	NO	N/A
Mississippi	IV	NO	N/A	NO	N/A
North Carolina	IV	12 WELLS	PERMIT	NO	N/A
South Carolina	IV	NO	N/A	NO	N/A
Tennessee	IV	NO	N/A	NO	N/A
Illinois	V	NO	N/A	NO	N/A
Indiana	V	4 WELLS	N/A	NO	N/A
Michigan	V	59 WELLS	N/A	NO	N/A
Minnesota	V	7 WELLS	N/A	NO	N/A
Ohio	V	NO	N/A	NO	N/A
Wisconsin	V	17 WELLS	RULE	NO	LOW
Arkansas	VI	NO	N/A	NO	N/A
Louisiana	VI	NO	N/A	NO	N/A
New Mexico	VI	50 WELLS	N/A	NO	MOD-LOW
Oklahoma	VI	60 WELLS	RULE	NO	N/A
Texas	VI	37 WELLS	N/A	NO	N/A
Iowa	VII	NO	N/A	NO	N/A
Kansas	VII	15 WELLS	N/A	NO	LOW
Missouri	VII	YES	N/A	NO	N/A
Nebraska	VII	YES	PERMIT	NO	N/A
Colorado	VIII	81 WELLS ++	N/A	NO	LOW
Montana	VIII	NO	N/A	NO	N/A
North Dakota	VIII	NO	N/A	NO	N/A
South Dakota	VIII	NO	N/A	NO	N/A
Utah	VIII	NO	RULE/PERMIT	NO	N/A
Wyoming	VIII	NO	N/A	NO	N/A
Arizona	IX	NO	N/A	NO	N/A
California	IX	NO	PERMIT	NO	LOW +
Hawaii	IX	NO	N/A	NO	N/A
Nevada	IX	NO	N/A	NO	N/A
American Samoa	IX	NO	N/A	NO	N/A
Tr. Terr. of P	IX	NO	N/A	NO	N/A
Guam	IX	NO	N/A	NO	N/A
CNMI	IX	NO	N/A	NO	N/A
Alaska	X	NO	N/A	NO	N/A
Idaho	X	NO	N/A	NO	N/A
Oregon	X	NO	N/A	NO	N/A
Washington	X	NO	N/A	NO	N/A

NOTE: SOME NUMBERS IN THIS TABLE ARE ESTIMATES.
\+ PROVIDED PROPER DESIGN, CONSTRUCTION AND OPERATION
++ THESE WELLS SERVE THE SECONDARY PURPOSE OF AQUIFER RECHARGE

maintains the proper integrity between the injected fluids and the contaminated zones. The typical construction of injection wells used in aquifer remediation programs is shown in Figure 4-64.

Siting is a key factor in aquifer remediation strategies. In almost all cases injection wells are located upgradient from any discharge wells and contamination plumes. This facilitates the proper migration of injection fluids with respect to remediation objectives. Different remedial tactics require different arrays of injection wells.

Injection wells used to control hydraulic flow require different orientations in relation to contamination plumes than those injection wells returning treated waters to an aquifer. For instance, some injection strategies utilize two injection wells, a "double-cell containment" array, to contain and facilitate the proper movement of a contamination plume (Figure 4-65). A different strategy might be to utilize a single injection well to facilitate the proper movement and containment of plumes (Figure 4-65).

Isolating contaminants in an aquifer by using these hydraulic "barriers" requires much more precision in the siting of injection wells than does the return of treated waters. Typically, injection wells used to return treated waters simply are located upgradient of any recovery wells in the aquifer.

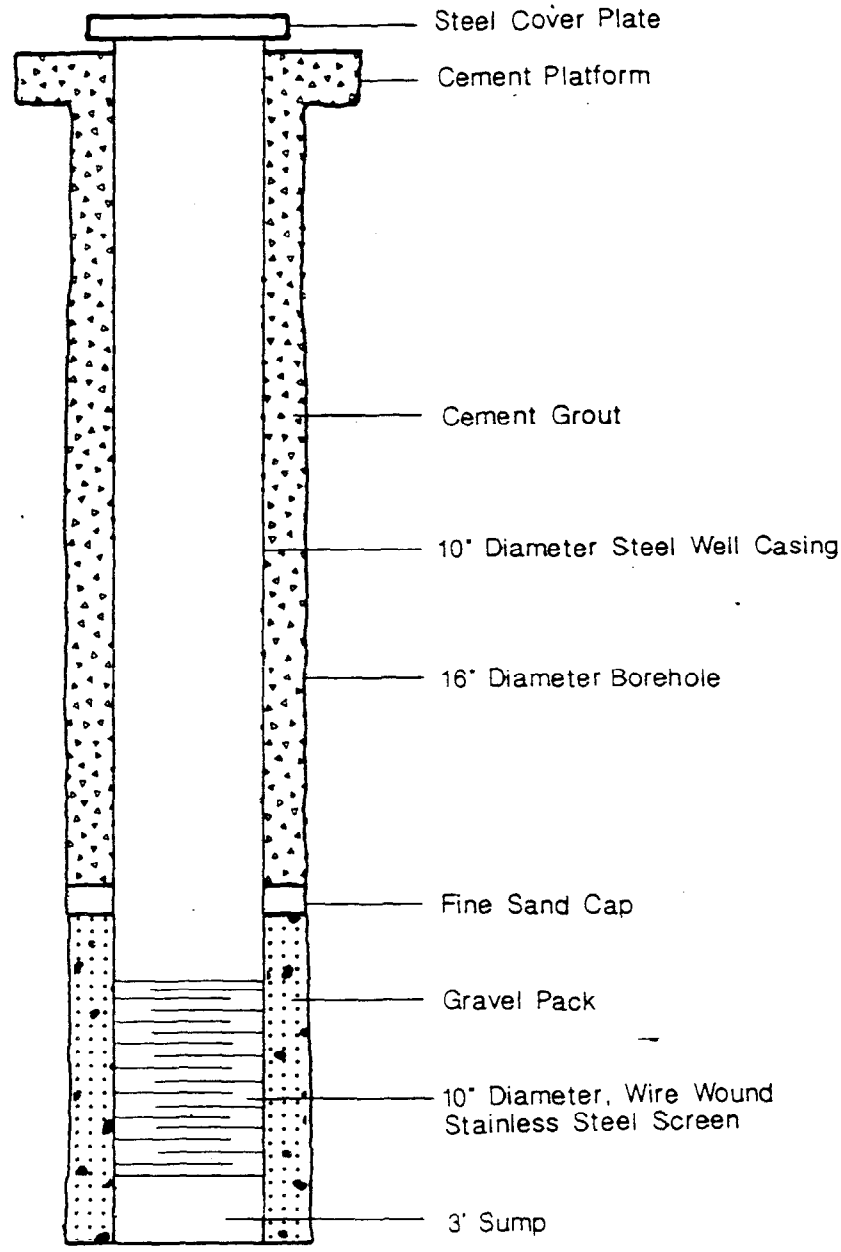
The operation of almost all of the injection wells used for aquifer remediation is by simple gravity flow. To date, there is no inventory information available indicating the use of pressurized injection.

Injected Fluids and Injection Zone Interactions

The primary forms of aquifer contamination which have been addressed in remediation programs are contamination through the introduction of organic compounds (chiefly hydrocarbons), industrial chemicals, and inorganic compounds. Because most contamination occurs as a result of surface or near surface spills, the nature and volume of injected fluids is a function of the hydrogeologic regime, the parameters of the contamination plume, and the design of the remediation program.

Hydrocarbon recovery largely depends on the types of hydrocarbons involved and on the recovery system being used. Pump rates range from a few gallons per minute (gpm) to 100 gpm (refer to Section 4.2.8.4 for more detail). The constituents in the injected stream generally consist of some hydrocarbons recirculated back to the contaminated aquifer.

There is a facility in Alabama currently using two injection wells to recover and treat contaminated ground water. Shallow

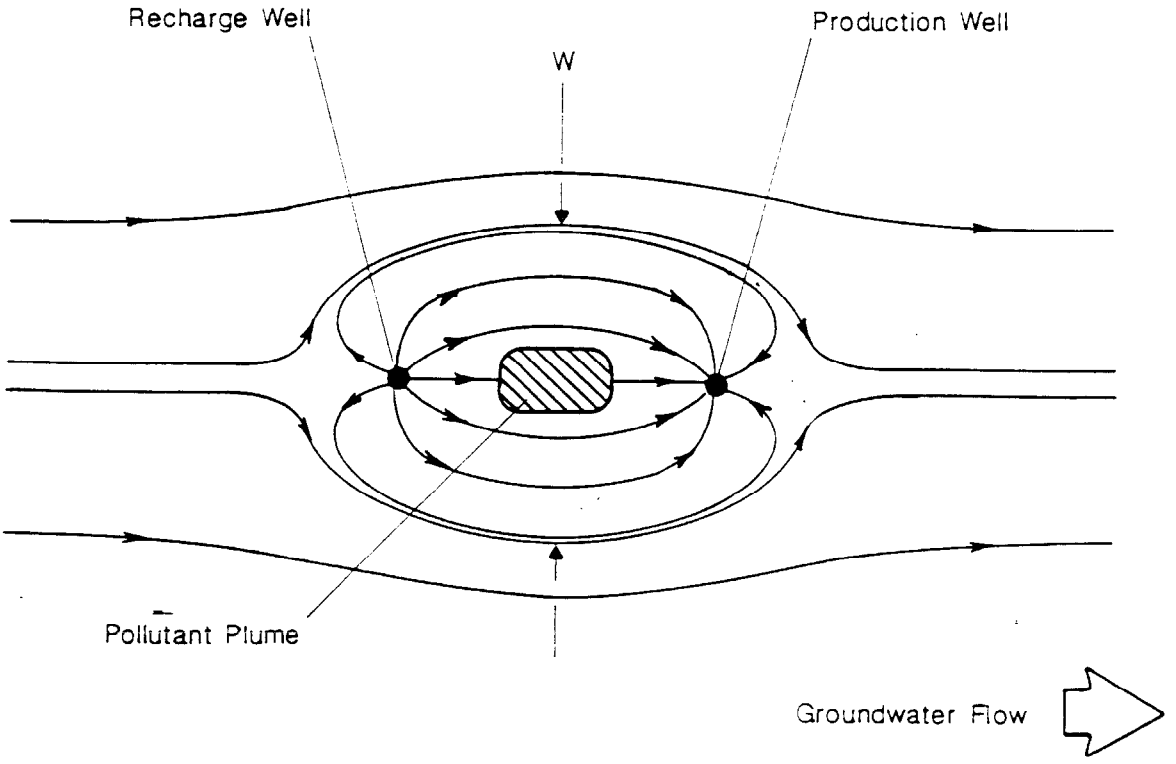


Not To Scale

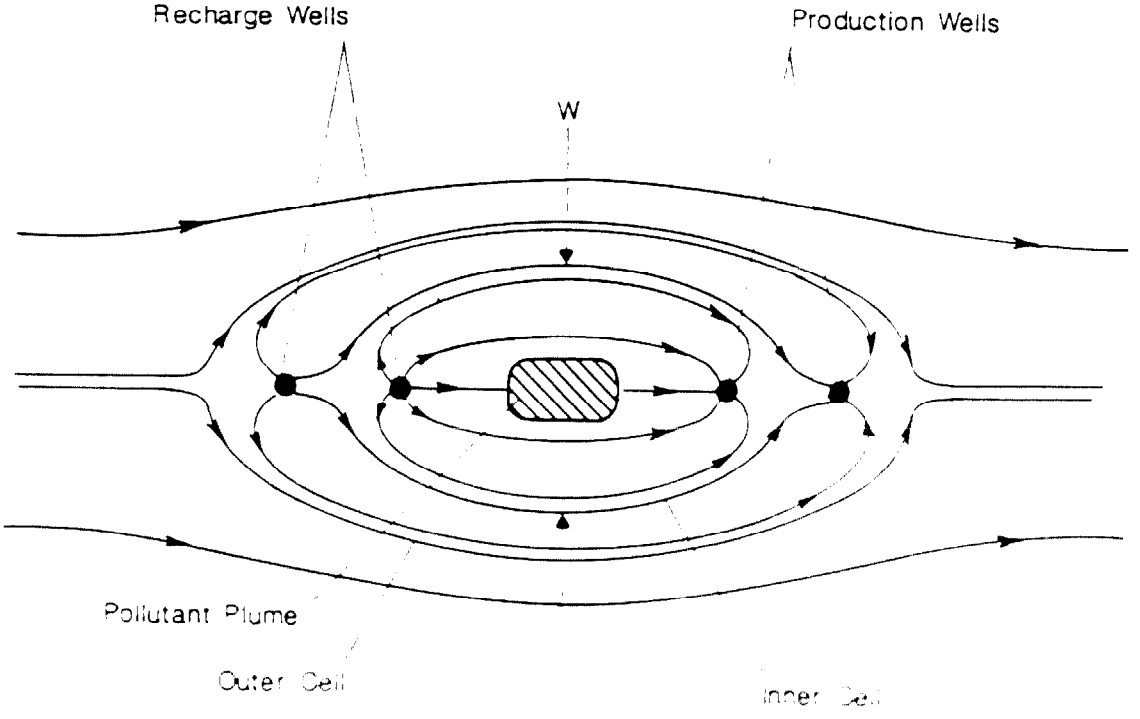
UNIROYAL CHEMICAL INJECTION WELL
USED FOR AQUIFER REMEDIATION

(from Alabama, 1986)

Figure 4-64



A. SINGLE-CELL



B. DOUBLE-CELL

SINGLE CELL AND DOUBLE CELL
HYDRAULIC CONTAINMENT SHOWING FLOW LINES

(from Wilson, 1984)

Figure 4-65

have been set for these injection fluids which must be met. These consist of no more than 100 mg/l COD and no more than 0.5 mg/l of nitrated organics.

Remediation programs for recovery and treatment of ground water contaminated with industrial chemicals most often utilize recovery wells to extract contaminated ground water. The tainted water undergoes above-ground filtering prior to reinjection. In Colorado, the remediation program at the Rocky Mountain Arsenal utilizes injection wells to return water that has been extracted from the contaminated zone and purified by carbon filtering. This method is used to aid in removing industrial chemicals and wastes.

Inorganic chemicals are also often present in unacceptable quantities in many aquifers. New techniques are being developed to treat these waters in situ and include a method called Vyredox which is being used in pilot programs in some areas of the United States to remove iron and manganese. Vyredox treatments involve the injection of degreased, highly oxygenated waters which precipitate out iron and manganese, thus improving water quality.

Hydrogeology and Water Use

Injection wells used in aquifer remediation programs seldom inject fluids into USDW. Their purpose is to restore contaminated aquifers to a condition in which they can provide usable waters. The degree of restoration may differ based on the projected use of the water. Because these remediation programs are generally expensive, aquifers that are easily replaced are seldom restored. This means that, in general, the aquifer might have to be the primary source of water for a variety of users to mandate remediation. The expense of remediation might be undertaken voluntarily by an industry if it can recover significant amounts of leaked product (enough to make it profitable), or it might be mandated by governmental or public demand in an area where users are not able to utilize low quality water.

Contamination Potential

Contamination potential for these wells must be assessed on a site specific basis rather than as a group. Since the goal of aquifer remediation is to increase the quality of an aquifer as a unit, one might jump to the conclusion that as Class V wells they possess a low potential for contamination. This, however, is not always the case. There are injection wells used in aquifer remediation programs which may place uncontaminated zones or other aquifers in the vicinity in jeopardy due to the nature of injected constituents or the hydrogeologic strata. This, however, varies widely from application to application. In accordance with the rating system previously outlined, we can

only say that these wells possess (as a group) an unknown potential for contamination. It is possible to assess any of these wells on a site specific basis with the proper information, and efforts should be made in future work to do so. However, the varying hydrogeology, injection fluid nature, water use, and remediation techniques result in different potentials for contamination at different sites.

Current Regulatory Approach

Aquifer remediation wells are authorized by rule under Federally administered UIC programs (see Section 1). State and local authorities have little to do with the regulation of aquifer remediation. They may require the reporting of these wells for inventory efforts (per USEPA mandates) but seldom monitor these wells. Aquifer remediation programs are generally subject to widespread media attention which may aid State and local governments in monitoring these programs.

Recommendations

The Kansas State report suggests that implementation of a registration and monitoring program is in order. This would allow for site specific evaluations and the subsequent setting, on a site specific basis, of operating conditions which will aid restoration activities and restrict or eliminate any contamination potential. The Oklahoma State report recommends that these wells be constructed to the same set of standards by which discharge wells are constructed to insure the injection wells' integrity and to maintain remediation program standards. At a minimum, injection wells used in remedial programs should be cased from the surface through the top of the injection zone and screened in sands and gravels, and the annulus should be grouted. It is recommended in the Florida State report that injected fluid quality should be required to be better than the quality of the fluid inherent to the injection zone but not necessarily required to meet drinking water standards.

4.2.8.4 Hydrocarbon Recovery Injection Wells (5X26)

Well Purpose

Hydrocarbon recovery injection (recharge) wells are used to return the coproduced water pumped from hydrocarbon recovery wells back into the aquifer. These wells are a specialized type of aquifer remediation related wells (Section 4.2.8.3). The hydrocarbons and water are separated either by the pumping system in the recovery wells or by surface separators.

Hydrocarbons such as gasoline, diesel, fuel oil, and other refined petroleum products may leak into the subsurface from

tanks and pipelines and migrate downward. Most such hydrocarbons are lighter than water and accumulate as a discrete layer of free hydrocarbons floating on the water table. If this hydrocarbon layer is not removed from the water table it will migrate downgradient into streams or move under adjoining properties. In areas where the water table is very shallow (less than about 20 feet) fire and other hazards from fumes are possible in addition to ground-water pollution.

Removal of the free hydrocarbon layer (contamination source) may be accomplished by a variety of remedial methods of which pumping is the most common. In many instances a two-pump system is used. The bottom pump in the recovery well creates a cone of depression in the water table and pumps only water. The hydrocarbon flows down the cone of depression into the well and is pumped out by the upper pump which pumps only hydrocarbons. In other situations, both water and hydrocarbons are pumped from the well by a single pump, and the oil and water are then separated at the surface.

With either rehabilitation system water must be removed from the aquifer in order to remove the hydrocarbons. In many cases the most feasible and environmentally sound method of disposing of the water is to discharge the water back into the aquifer through injection wells.

Inventory and Location

Large-scale hydrocarbon recovery is currently underway at many active and abandoned refineries, tank farms, and terminals across the United States. Such remedial action will become more widely practiced as more of these facilities are investigated. There are approximately 350 active and inactive refinery sites in the United States, and as yet an undetermined number of tank farms and terminals - probably on the order of 1,000 to 5,000. Although no inventory has been made, it is estimated that cleanup of free hydrocarbons may be required at 30 to 50 percent of these sites. Water reinjection wells may be used at approximately 25 percent of the sites anticipated to require remedial action.

Small-scale hydrocarbon recovery will be required at approximately 270,000 underground storage tanks that are estimated to have leaked. However, injection of the water produced in the remedial actions is anticipated at only a small fraction of these sites.

Construction, Siting, and Operation

The design and construction of water injection wells used in hydrocarbon recovery is not sophisticated. These wells are commonly only 20 to 100 feet deep and are constructed with plastic (PVC) casing 2 to 6 inches in diameter. Such wells are

not operated under pressure and the surface seal around the outside of the casing is used only to prevent surface fluids from migrating down the annulus. Figure 4-66 is a typical hydrocarbon recovery injection well schematic. Figure 4-67 is a typical hydrocarbon recovery well. The water produced by the recovery well is piped to the injection well. Maintenance of these water injection wells is limited to periodic well rehabilitation to remove plugging caused by the high iron content commonly associated with hydrocarbon pools.

Injected Fluids and Injection Zone Interactions

No data have been submitted by the States, but it is known that in some instances the injected water contains water soluble fractions from the hydrocarbons such as benzene, toluene, and xylene, commonly referred to as BTX. The BTX content of the injected water may, in some instances, exceed currently recommended drinking water standards. The Oklahoma Water Resources Board (OWRB) put together a list of constituent concentrations both "realistic and representative" for typical injection streams located in remediation areas at certain refineries in Oklahoma. This list is given in Table 4-59.

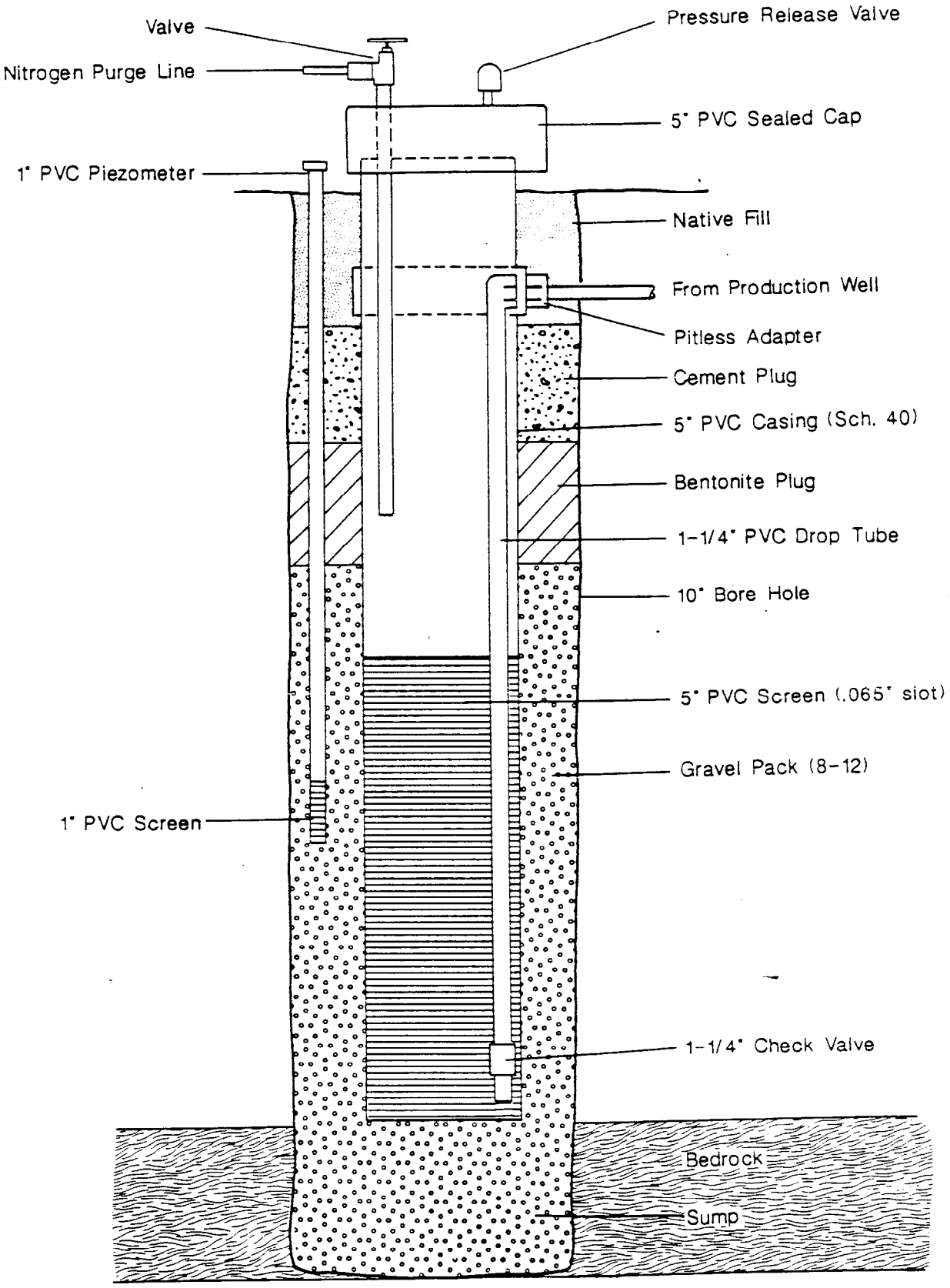
TABLE 4-59

OWRB LIST OF CONSTITUENT CONCENTRATIONS FOR HYDROCARBON RECOVERY INJECTION WELL FLUIDS

Oil/Grease	4.80	mg/l	Lead	0.02	mg/l
Phenols	3.00	mg/l	Iron	8.40	mg/l
Toluene	12.80	mg/l	Total Hardness	86.80	mg/l
Benzene	7.90	mg/l	pH	7.10	
			COD	229.00	mg/l

Normally, water containing BTX would be treated before injection back into the aquifer; however, in many cases involving hydrocarbon recovery, such treatment would be pointless unless the soil is also cleaned or removed. Only 40 to 60 percent of the total amount of hydrocarbons floating on the water table can be recovered. The unrecoverable fraction remains in the soil above the water table and continues to provide a source of BTX into the underlying ground water. Therefore, removing the BTX from the water being pumped from the aquifer and reinjected is useless unless all of the hydrocarbons are removed from the soil or the contaminated soil is excavated.

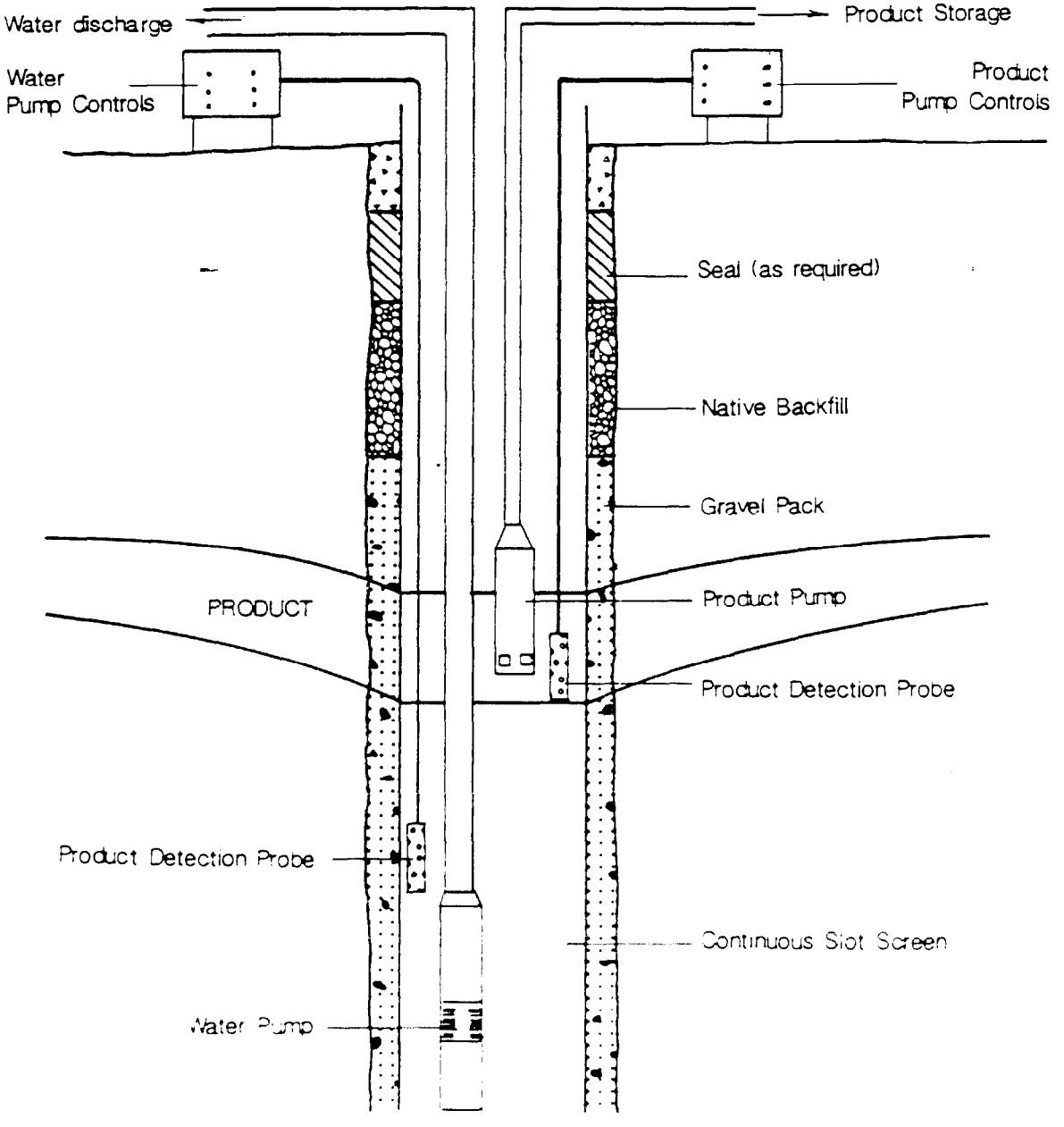
In large-scale hydrocarbon recovery projects, the amount of water injected back into the aquifer may total up to 1,000 gpm. Handling of such volumes by existing on-site treatment is usually not feasible; furthermore, injection of the water can accelerate the cleanup of the free hydrocarbons.



TYPICAL CLOSED RECHARGE WELL COMPLETION
AQUIFER REMEDIATION

(Source: Oklahoma, 1985)

Figure 4-66



SCHEMATIC OF TWO PUMP SYSTEM UTILIZING
ONE RECOVERY WELL FOR AQUIFER REMEDIATION

from Oklahoma, 1985

Figure 4-67

In small-scale rehabilitation efforts, where less than 50 gpm water is produced, alternatives other than injection are more feasible, hence injection is rarely needed.

In all cases, the quality of the water being injected is the same as the quality of the water already in the aquifer, providing, of course, the water is injected into the same geologic horizon and area from which it was originally pumped.

Hydrogeology and Water Use

Hydrocarbon recovery as a form of aquifer remediation may be required in a wide variety of hydrogeological settings. It is considered probable at this time that only a small minority of the large-scale hydrocarbon recovery operations requiring the use of injection wells would be located over an aquifer being used as a water supply. Most refineries and major tank farms are believed to be located on bedrock or over very shallow alluvial geologic environments not being used for water supply.

Contamination Potential

The overall contamination potential of hydrocarbon recovery injection wells is unknown; contamination potential must be assessed on a case by case basis. Recharging water being pumped by a hydrocarbon recovery operation back into the same geologic environment from which the water was originally pumped does not contribute to the contamination of the water already there. In many instances removal of the free hydrocarbons alone accomplishes the objective of the rehabilitation action, i.e. where drinking water supplies are not threatened by the continued presence of BTX.

In those instances where the water in the aquifer contains BTX or other contaminants exceeding drinking water standards and where drinking water supplies are threatened, treatment of the water prior to injection should be accomplished. It must be stressed, however, that cleanup of the water underlying a hydrocarbon pool must be accompanied by complete cleanup of the hydrocarbons remaining in the soil above the water table in order to prevent the water from becoming recontaminated.

Recommendations

No recommendations concerning this type of remediation well were provided in State reports.

4.2.8.5 Abandoned Drinking Water/Waste Disposal Wells (5X29)

Well Purpose

Intentionally or unintentionally, unplugged or improperly abandoned water wells can become receptacles for the disposal of waste. Intentional misuse may involve disposal of hazardous wastes, sewage, or simply household garbage. Improperly abandoned wells can become the conduit by which unintentional disposal occurs. Surface runoff draining into a well and the establishment of a hydraulic connection between aquifers of different water quality are two examples of unintentional misuse.

An important consideration is that surface or near-surface contamination may be transferred to potable aquifers without the benefit of natural clean-up processes. Ground water usually travels very slowly, a few to tens of feet per year, and during that downward movement through unsaturated soils, natural purification occurs. Purification involves filtering, biological, and other chemical changes. Rainfall runoff or spills entering improperly abandoned wells around industrial sites, construction sites, animal feedlots, etc. will be injected directly into an aquifer, circumventing the purification process.

Inventory and Location

A total of 3,050 abandoned drinking water wells have been reported. There is also one such well on the FURS inventory. Documented cases of abandoned drinking water wells used for waste disposal were rarely found in the State reports. Much of the reported inventory represents estimates of improperly abandoned water wells from a few States. Most States reported no such wells exist. This is understandable since most States do not make an effort to check the status of the thousands of private drinking water wells on a periodic basis.

The distribution of reported wells is shown on Table 4-60. In all likelihood there are probably several hundred to many thousands of 5X29 wells in every State. Because of a lack of understanding among the general public as to the nature and occurrence of ground water and its sensitivity to contamination, most disposal is probably unintentional. Eventually some of these wells are discovered after a complaint about poor water quality from a well owner prompts an investigation.

Construction, Siting, and Operation

A vast array of well designs is possible for this well type. Local hydrogeologic conditions, preferences on materials, and construction methods are the sources of variability. Most of these wells are probably shallow wells dug, bored, or drilled for livestock and domestic uses. A lack of understanding, finances,

TABLE 4-60 SYNOPSIS OF STATE REPORTS FOR ABANDONED DRINKING WATER WELLS/WASTE DISPOSAL(5X29)

REGION & STATES	EPA REGION	Confirmed Presence Of Well Type	Regulatory System	Case Studies/ Info. available	Contamination Potential Rating
Connecticut	I	NO	NO	NO	N/A
Maine	I	NO	NO	NO	N/A
Massachusetts	I	NO	NO	NO	N/A
New Hampshire	I	NO	NO	NO	N/A
Rhode Island	I	NO	P&A RULES	NO	N/A
Vermont	I	NO	NO	NO	N/A
New Jersey	II	NO	P&A RULES	NO	N/A
New York	II	NO	NO	NO	N/A
Puerto Rico	II	NO	P&A RULES	NO	N/A
Virgin Islands	II	NO	NO	NO	N/A
Delaware	III	NO	P&A RULES	NO	N/A
Maryland	III	NO	P&A RULES	NO	N/A
Pennsylvania	III	NO	P&A RULES	NO	N/A
Virginia	III	NO	P&A RULES	NO	N/A
West Virginia	III	NO	P&A RULES	NO	N/A
Alabama	IV	NO	P&A RULES	NO	N/A
Florida	IV	YES	P&A RULES	NO	N/A
Georgia	IV	NO	P&A RULES	NO	N/A
Kentucky	IV	NO	NO	NO	N/A
Mississippi	IV	NO	NO	NO	N/A
North Carolina	IV	NO	P&A RULES	NO	N/A
South Carolina	IV	NO	NO	NO	N/A
Tennessee	IV	NO	P&A RULES	NO	N/A
Illinois	V	NO	P&A RULES	NO	N/A
Indiana	V	156 WELLS	NO	NO	N/A
Michigan	V	630 WELLS	P&A RULES	YES	N/A
Minnesota	V	1,309 WELLS	P&A RULES	YES	N/A
Ohio	V	YES	P&A RULES	NO	N/A
Wisconsin	V	NO	P&A RULES	NO	N/A
Arkansas	VI	NO	P&A RULES	NO	N/A
Louisiana	VI	NO	P&A RULES	NO	N/A
New Mexico	VI	NO	NO	NO	N/A
Oklahoma	VI	NO	P&A RULES	NO	N/A
Texas	VI	945 WELLS	P&A RULES	NO	N/A
Iowa	VII	NO	NO	NO	N/A
Kansas	VII	NO	P&A RULES	NO	N/A
Missouri	VII	NO	P&A RULES	NO	N/A
Nebraska	VII	YES	P&A RULES	NO	N/A
Colorado	VIII	YES	P&A RULES	NO	HIGH
Montana	VIII	NO	NO	NO	N/A
North Dakota	VIII	NO	P&A RULES	NO	N/A
South Dakota	VIII	NO	P&A RULES	NO	N/A
Utah	VIII	7 WELLS	BANNED	NO	RANGE 2-7(7=HIGHEST)
Wyoming	VIII	NO	P&A RULES	NO	N/A
Arizona	IX	NO	P&A RULES	NO	N/A
California	IX	NO	P&A RULES	NO	N/A
Hawaii	IX	NO	NO	NO	N/A
Nevada	IX	NO	P&A RULES	NO	N/A
American Samoa	IX	NO	NO	NO	N/A
Tr. Terr. of P	IX	NO	NO	NO	N/A
Guam	IX	NO	NO	NO	NO
CNMI	IX	NO	NO	NO	NO
Alaska	X	3 WELLS	P&A RULES	NO	HIGH
Idaho	X	NO	P&A RULES	NO	N/A
Oregon	X	NO	P&A RULES	NO	N/A
Washington	X	NO	P&A RULES	NO	NO

NOTE: SOME NUMBERS IN THIS TABLE ARE ESTIMATES.

and regulatory oversight contribute to these wells' potential to degrade ground water.

Private, domestic wells are most likely to be found in rural areas. Therefore, chances of locating improperly abandoned drinking water wells are probably highest in rural areas where there is a heavy reliance on ground water. Though fewer in number, such wells located in suburban or urban areas could have a greater adverse impact on ground-water resources. A municipal well field contaminated by such wells would be costly indeed.

Injected Fluids and Injection Zone Interactions

Potentially, a spectrum of contaminants including hazardous chemicals, sewage, and saline water could enter and degrade USDW through these wells. Dilution or other attenuation mechanisms may reduce contaminant levels as the injectate moves away from the well. The areal distribution of contamination is very much case specific. Variables such as the nature of the contaminant (i.e. salt, metals, petroleum products, bacteria), injection rates and volumes, volume of water in the USDW, natural recharge rate, the USDW rock type, background water quality in the USDW, and hydraulic conductivity of the USDW will determine the impact of contamination.

Ground-water contamination caused by faulty well construction has been documented in an 1,100 square mile area of Southeast Nebraska by Exner and Spalding (1985). Nitrate-nitrogen (NO_3 - as N) and coliform contamination were most prevalent in dug (47%) or augered (80%) wells with open-jointed casing. Farms in this rural area are cash grain-livestock operations, and nitrogen fertilizer use is low. Surface and shallow subsurface leakage into improperly constructed wells from barnyards and corrals was primarily responsible for the contamination. Rural water districts have been formed due to the private well contamination problems. Wells abandoned in favor of a public supply add to the problem because they are not being properly abandoned.

The Minnesota State report describes an on-going practice of domestic sewage disposal by 75 homes via old water wells. In this case the area was connected to a city water supply and the private well owners chose not to plug their wells or maintain them as reserve water supplies. Contamination would be in the form of NO_3 and fecal coliform. Other contaminants might be household cleaning agents, paint, and solvents.

Cases of herbicides or pesticides entering USDW through improperly constructed or abandoned water wells are also known. Improperly constructed farmstead water supply wells acting as conduits for herbicide or pesticide contamination are discussed by Jones (1987), and Exner and Spalding (1985).

Hydrogeology and Water Use

Shallow aquifers utilized for private domestic and/or livestock water supplies are probably most affected by these wells. Historically, these aquifers have had some of the best quality ground water available.

In 1980, 97 percent of rural domestic water supplies in the United States was obtained from ground-water sources (USGS, 1985). The word "rural" carries false connotations of "uninhabited". Actually, about 42 million people were served by their own supply of domestic well water in 1975 (Pettyjohn, et. al., 1979).

Problems with the sanitary condition of private domestic wells have been recognized for years. Studies on the condition of individual water supplies provided by wells were conducted in several states including Wyoming, Ohio, Iowa, Georgia, Kentucky, and Tennessee, during the early 1970's. At that time it was estimated that 40 percent of the supplies were polluted by nitrates or coliform bacteria (Whitsell and Hutchinson, 1973). The studies concluded that faulty and inadequate well construction was primarily responsible for the situation (Whitsell and Hutchinson, 1973).

Contamination Potential

Based on the rating system described in Section 4.1, abandoned drinking water/waste disposal wells are assessed to pose a moderate potential to contaminate USDW. These facilities typically do inject into or above Class I or Class II USDW. Typical well construction, operation, and maintenance would allow fluid injection or migration into unintended zones. Injection fluids may or may not have concentrations of constituents exceeding standards set by the National Primary or Secondary Drinking Water Regulations. Based on injectate characteristics and possibilities for attenuation and dilution, injection may or may not occur in sufficient volumes or at sufficient rates to cause an increase in concentration (above background levels) of the National Primary or Secondary Drinking Water Regulation parameters in groundwater, or endanger human health or the environment in a region studied on a group/area basis.

Confirmed incidents of intentional waste disposal via abandoned water wells seem rare. A literature search of two electronic ground-water and environmental databases, Enviroline and Water Resources Abstracts, did not result in a single case study. Such activities were alluded to in a few State reports, but only Minnesota and Michigan had documented occurrences.

The major contamination problem seems to be the unintentional injection caused by faulty or inadequate well construction

and abandonment. The evidence points to a broad scale problem, especially in rural areas. The most significant contaminants are nitrates and coliform bacteria, both health hazards.

This well type is rated as a moderate contamination potential according to the rating scheme. Yes answers can be given to the first three questions under high contamination potential. The fourth question, concerning injection volumes, cannot be answered affirmatively. Exner and Spalding (1985) found that NO_3 contamination varied widely in their study area, indicative of point-source contamination. Contaminant plumes from such wells may have crossed property lines but had not spread to affect all water supplies in the 1,100 square mile study area.

Current Regulatory Approach

Abandoned drinking water wells used for injection are authorized by rule under Federally-administered UIC programs (see Section 1). According to State reports received, the direct implementation States have not issued UIC permits for this injection practice.

According to Gass and others (1977), most States have some regulations dealing with abandonment of water wells. At the time of their investigation, many of the State programs were inadequate. Some of the major reforms suggested in the Minnesota report included:

1. procedures for well abandonment need to be described in detail for each different subsurface environment;

2. provisions need to be made for enforcement of abandonment regulations; and

3. requirements need to be made for permanent plugging and abandonment procedures to be done by licensed water well drillers.

Recommended plugging and abandonment procedures from two organizations, USEPA, and the American Water Works Association are referenced in Appendix E. States having some kind of regulation are indicated on Table 4-63. The regulatory status of fifteen states, the District of Columbia, American Samoa, Guam, the Trust Territories of the Pacific Islands and the Commonwealth of the Mariana Islands is unknown.

Recommendations

Utilization of former water wells for intentional waste disposal requires regulatory oversight. Such wells would be injecting directly into USDW. Years of neglect or inadequate construction standards could result in a well penetrating a

hydraulic connection between aquifers of varying water quality. Limitations on injectate quality and quantity must be imposed to protect USDW if these wells are allowed to operate.

The USEPA Region V DI program stresses that the issue of abandoned drinking water wells should be seriously considered. Abandoned drinking water wells are a prime suspect for surface runoff which is an uncontrolled source of contaminants. Any uncontrolled source of contaminants poses a high potential for contamination of USDW. These wells are completed in zones that are currently being used for drinking water or may be used sometime in the future.

Unintentional injection through improperly plugged and abandoned water supply wells is a widespread problem. Most States already have regulations concerning abandonment, but due to the large numbers of private wells in existence, inspection and enforcement is not feasible. In some cases the plugging and abandonment procedures are not described in sufficient detail in the State regulations to protect USDW. The danger of inadequate plugging and abandonment is also present in several States where persons performing such work do not have to be licensed water well drillers. The USEPA may be able to bring a more standardized approach to plugging and abandoning water wells among the States, Territories, and Possessions.

The problem of locating these improperly plugged and abandoned wells and the question of who will pay to permanently seal the wells will be difficult to resolve. Well owners may not call attention to their abandoned wells because they do not want to pay the $500 - $1,500 fee to plug and abandon the average 4-inch diameter domestic well (Minnesota, 1986). Without well owners' help, State and local officials do not have the personnel, time, or money to perform inspections to locate the wells.

The answer seems to lie in federal support of approved State programs to locate and properly plug and abandon these wells. Puerto Rico, Indiana, Michigan, and Minnesota recommend that better inventories be established. The Minnesota Department of Health has undertaken such a program, although costs are the responsibility of the well owner. The Minnesota program deserves study because (1) it tries to establish the scope of the problem, (2) areas of the State have been prioritized for action, and (3) procedures for plugging and abandonment are described. The USEPA would have to produce a similar guidance document to the States should this approach be taken nationally. The Minnesota Department of Health program is included in the list of supporting data in Appendix E.

Utah suggests that the only corrective alternative for these wells is closure and that this practice must be halted to prevent aquifer contamination. Utah also suggests that sanitary sewer hook-up should be required for domestic waste disposal and dispo-

sal of industrial wastes which have received necessary pretreatment. Hazardous waste should be handled in accordance with RCRA regulations. It appears that the most practical way these wells can be located and closed is to educate the public and personnel in other government programs (i.e., RCRA, NPDES, local environmental and planning/building programs) in how to locate these wells, what they consist of, and the damage they can do to ground water.

SECTION 5
SUMMARY AND CONCLUSIONS

5.1 CURRENT INVENTORY

5.1.1 NATIONAL INVENTORY

The Class V Injection well inventory, based on State reports, is conservatively estimated to be 173,159 wells. Well types have been grouped into seven main categories for the purposes of the National inventory:

1. Drainage Wells;
2. Geothermal Reinjection Wells;
3. Domestic Wastewater Disposal Wells;
4. Mineral and Fossil Fuel Recovery Related Wells;
5. Industrial/Commercial/Utility Disposal Wells;
6. Recharge Wells; and
7. Miscellaneous Wells.

Based on the purpose of the well and the origin of the injection fluids, 30 well types have been identified and inventoried for this report. A summary of the numbers of Class V well types, shown in Table 5-1, indicates over 94 percent of the inventory is from four categories of wells: drainage wells, domestic wastewater disposal wells, geothermal wells (mostly heat pump/air conditioning return flow wells), and mineral and fossil fuel recovery related wells. These four categories are predominantly comprised of low-tech wells. Low-tech wells typically 1) have simple casing designs and well head equipment and 2) inject to shallow formations by gravity flow or low volume pumps. In contrast, high-tech wells typically 1) have multiple casing strings, 2) have sophisticated wellhead equipment to control and measure pressure and volume of injected fluid, and 3) inject high volumes into deep formations.

The Class V injection well inventory is characterized by extreme variations in database completeness and quality. In general, inventories for high-tech Class V wells are more accurate than those for low-tech wells.

Because high-tech Class V injection wells are typically associated with special industries or large scale remediation and disposal projects, they constitute a small proportion of all Class V wells. They also tend to be localized, and are easier for regulatory agencies to inventory and monitor. In addition, several agencies may be involved with these operations and

TABLE 5-1: CLASS V WELL NATIONAL INVENTORY
RANKED BY WELL CLASSIFICATION

WELL TYPE & CATEGORY	TOTAL #WELLS	% OF TOTAL
DRAINAGE	100744	58.2
DOMESTIC	43688	25.2
GEOTHERMAL	10163	5.9
MINERAL	8712	5.0
MISCELLANEO	3754	2.2
RECHARGE	3719	2.1
INDUSTRIAL	2379	1.4
TOTAL	173159	100

drilling and waste discharge permits at local, county, and state levels.

It has also been found that, in general, operators of high-tech wells are more informed about existing regulations and more responsible in reporting activities than are owner/operators of some types of low-tech wells. As a result, files maintained by high-tech well operators tend to be more complete, whereas no such files may exist for many low-tech wells.

A number of inspection programs have been conducted that target high-tech Class V injection wells. These inspections have provided valuable inventory data for facilities inspected, as well as other facilities owned by the same owner/operator. The result of all these factors has been a generally complete inventory database for high-tech wells and a generally poor to nonexistent one for low-tech wells.

The high-tech Class V database is relatively good; however it is certain that uninventoried facilities exist, and files for certain other high-tech facilities are lacking in technical data.

The data summarized in this section were submitted by 56 States, Territories, or Possessions of the United States. The inventory data reveal that Class V wells are not distributed evenly among the ten USEPA Regions. In fact, four Regions contain over 80 percent of the Class V wells inventoried. Region IX alone accounts for 37 percent of Class V wells. Table 5-2 summarizes the distribution of wells by USEPA Region.

Several well types have very incomplete inventories. In general, the well types which have been most difficult to inventory are those for which records are kept only at a local level or registration or permitting of the wells has not been required. The well types most seriously impacted by these limitations are:

1. All types of drainage wells (5F1, 5D2, 5D3, 5D4);

2. All types of domestic wastewater disposal wells (5W9, 5W10, 5W11, 5W12, 5W31, 5W32);

3. Industrial disposal wells (5W20);

4. Automobile service station disposal wells (5W24); and

5. Abandoned drinking water waste wells (5X24).

TABLE 5-2: CLASS V NATIONAL WELL INVENTORY
RANKED BY USEPA REGION

EPA REGION	TOTAL #WELLS	% OF TOTAL
IX	64214	37.1
X	29826	17.2
IV	27911	16.1
V	17772	10.3
VIII	9015	5.2
II	8950	5.2
VII	6675	3.9
III	4589	2.7
VI	3843	2.2
I	364	0.2
TOTAL	173159	100

5.2 ASSESSMENT OF WELL TYPES

5.2.1. REVIEW OF RATING SCHEME

The available data were used in Section 4 to qualitatively assess the consequences of injection on current or potential beneficial uses of USDW. Four major criteria entered into the assessment of contamination potential:

1. The identification and potential usability of USDW (water quality parameters);

2. The typical well construction, operation, and maintenance as they relate to injection or migration of injectate into unintended zones;

3. The Injection fluid characteristics with regard to the water quality parameters; and

4. The estimated degree and areal extent of contamination based on injection rates and volumes, and contaminant transport and fate in the USDW.

The rating system consists of a series of questions based on the four major criteria which produce "YES" or "NO" answers. Section 4.1 fully describes the methods used in assessing contamination potential.

5.3 SUMMARY OF WELL TYPE ASSESSMENTS

Application of the rating system resulted in each well type being rated as having a high, moderate, low, or unknown contamination potential. For some well types, one typical injection situation was difficult to establish. In these cases, a range of contamination potentials is indicated. The well types are listed below under all the appropriate contamination potential headings. In all following tables, the well type is listed under the highest contamination potential ascribed in a range. Stricter State regulation of some well types rated high or moderate may lower the assessment of their contamination potential. Table 5-3 lists the number of wells by contamination potential for each State. Table 5-4 summarizes by Region the numbers of wells reported. Figures 5-1 through 5-4 illustrate the distribution of wells by contamination potential and Region.

<u>High Contamination Potential</u>

- Agricultural drainage wells, 5F1;

- Improved sinkholes, 5D3 (high to moderate);

Table 5-3: DISTRIBUTION OF CLASS V WELLS BY CONTAMINATION POTENTIAL

REGION & STATES	TOTAL # WELLS	HIGH POTENTIAL											MODERATE POTENTIAL											LOW POTENTIAL					UNKNOWN POTENTIAL	
		5F1	5D3	5A9	5A10	5W11	5W31	5W32	5W12	5W20	5X28	5X21	5D2	5D4	5S30	5A5	5A6	5A8	5X13	5X15	5A19	5X25	5X29	5A7	5X14	5X16	5X22	5S23	5N24	5X26
REG 1	264	0	3	0	0	57	0	0	72	99	14	1	22	16	0	0	0	0	0	0	14	0	0	24	0	0	0	0	0	2
Connecticut	84	0	0	0	0	57	0	0	0	6	1	0	3	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0
Maine	15	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Massachusetts	132	0	0	0	0	27	0	0	72	1	0	0	19	0	0	0	0	0	0	0	3	0	0	10	0	0	0	0	0	0
New Hampshire	38	0	3	0	0	0	0	0	0	13	0	1	0	16	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0
Rhode Island	80	0	0	0	0	8	0	0	0	59	3	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	2
Vermont	15	0	0	0	0	0	0	0	0	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REG 2	8950	150	10	5	68	1260	85	63	22	401	21	3000	2504	1116	0	0	0	0	0	0	6	0	0	181	48	0	0	0	0	10
New Jersey	379	0	0	0	1	143	0	0	0	20	18	0	1	1	0	0	0	0	0	0	5	0	0	181	0	0	0	0	0	9
New York	7172	150	0	0	x	x	x	x	21	350	3	3000	2500	1100	0	0	x	0	0	0	0	0	0	x	48	x	0	x	0	0
Puerto Rico	1352	x	10	5	67	1073	85	63	1	28	0	0	3	15	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Virgin Islands	47	0	0	0	0	44	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REG 3	4597	0	0	0	0	6	903	0	5	30	1	0	273	6	0	0	0	0	1070	0	0	0	0	2291	0	2	0	0	0	0
Delaware	164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	164	0	0	0	0	0	0
Maryland	1271	0	0	0	0	0	890	0	0	9	0	0	0	3	0	0	0	0	1	0	0	0	0	368	0	0	0	0	0	0
Pennsylvania	1026	0	0	x	0	0	13	0	4	19	0	0	155	0	0	0	0	0	811	0	x	0	0	24	0	0	0	0	0	0
Virginia	1864	0	x	0	0	6	0	[illegible]	1	2	1	0	116	3	0	0	0	0	0	0	x	0	0	1735	0	0	0	0	0	0
West Virginia	264	x	x	0	0	2	0	0	0	0	0	0	2	x	0	0	0	0	259	0	0	0	0	0	0	2	0	0	0	0
REG 4	27911	43	81	0	0	19001	736	200	556	318	0	349	2072	2	1385	0	0	0	61	0	75	18	0	2998	0	0	2	0	1	13
Alabama	144	0	0	0	0	1	0	0	0	98	0	0	9	0	0	0	0	0	x	0	33	2	0	0	0	0	0	0	0	1
Florida	22557	x	x	0	0	19000	0	0	553	20	x	349	1537	x	1385	0	0	0	0	0	33	3	x	2671	0	0	2	0	0	0
Georgia	163	43	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	5	0	0	111	0	0	0	0	0	0
Kentucky	1360	x	76	0	0	0	736	0	3	0	0	0	464	x	0	0	0	0	61	0	0	0	0	x	0	0	0	0	0	0
Mississippi	12	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	7	0	0	0	0	0	0
North Carolina	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	79	0	0	0	0	0	12
South Carolina	493	0	0	0	0	0	0	200	0	200	0	0	31	0	0	0	0	0	0	0	2	0	8	60	0	0	0	0	0	0
Tennessee	83	0	x	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	x	0	0	0	0	70	0	0	0	0	1	0
REG 5	17772	147	135	959	65	4537	2635	0	41	577	34	2	4987	191	0	0	0	0	5	2	90	8	2095	1164	15	41	0	4	1	47
Illinois	1764	6	0	916	0	0	0	0	1	16	5	1	697	47	0	0	0	0	5	0	10	2	0	57	0	0	0	0	1	
Indiana	3816	72	26	22	22	895	105	0	27	30	2	1	2190	8	0	0	0	0	0	1	22	0	156	236	0	8	0	0	0	
Michigan	7575	15	103	11	18	2693	2511	0	2	9	27	0	623	9	0	0	0	0	0	1	52	4	630	760	15	33	0	0	0	
Minnesota	2106	54	6	10	25	588	16	0	11	1	0	1	30	8	0	0	0	0	0	0	4	2	1309	34	0	0	0	0	0	
Ohio	2360	0	x	0	0	361	0	0	x	467	0	0	1341	115	0	0	0	0	0	0	x	0	x	73	0	0	0	0	0	0
Wisconsin	151	0	0	0	0	0	3	0	0	4	0	0	116	1	0	0	0	0	0	0	2	0	0	4	0	0	0	4	0	17
REG 6	3843	108	0	10	30	66	0	0	0	4	0	74	57	5	1	0	3	0	26	0	7	12	945	1146	1073	77	0	0	2	147
Arkansas	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	70	0	0	0	0
Louisiana	11	0	0	0	0	x	0	0	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
New Mexico	1237	0	0	0	14	10	0	0	0	2	0	30	5	0	0	0	2	0	11	0	6	6	0	27	1073	0	0	0	1	50
Oklahoma	168	x	0	0	0	x	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	100	0	7	0	0	1	60
Texas	2356	108	0	10	16	56	0	0	0	2	0	44	52	0	0	x	1	0	65	x	0	6	945	1014	0	0	0	0	0	37
REG 7	6675	230	250	0	0	5	0	0	0	0	6	8	10	0	0	0	0	0	4326	0	16	2	0	1802	0	0	0	0	0	15
Iowa	262	230	0	0	0	3	0	0	0	0	1	0	6	0	0	0	0	0	0	0	5	0	0	17	0	0	0	0	0	0
Kansas	419	0	0	0	0	0	0	0	0	0	0	4	3	0	0	0	0	0	0	0	3	0	0	394	0	0	0	0	0	15
Missouri	5324	x	250	0	0	2	0	0	0	0	5	0	0	0	0	0	0	0	4326	0	0	0	0	741	0	0	0	0	0	x
Nebraska	670	5	0	0	x	x	0	0	0	0	0	4	1	0	0	0	0	0	0	0	8	2	x	650	0	0	0	0	0	x
REG 8	9015	1	0	0	3	422	0	0	0	36	2	7	7250	321	55	0	3	0	386	64	6	137	7	219	14	1	0	0	0	81
Colorado	115	x	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	2	23	1	2	x	2	0	0	0	0	0	81
Montana	4587	0	0	0	0	2	0	0	0	0	0	0	4500	0	55	0	0	0	10	0	x	0	0	20	0	0	0	0	0	0
North Dakota	438	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300	0	1	0	0	135	0	1	0	0	0	0
South Dakota	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	46	0	0	0	0	0	0
Utah	3088	0	0	0	0	x	0	0	0	4	2	0	2743	321	0	0	1	0	0	0	3	0	7	7	0	0	0	0	0	0
Wyoming	728	0	0	0	3	420	0	0	x	32	0	7	5	0	0	0	0	0	74	41	0	135	0	7	14	0	0	0	0	0
REG 9	64214	0	0	3	120	1313	73	1279	358	209	0	103	59483	4	1	91	7	25	1	0	26	45	0	57	875	0	155	0	0	0
Arizona	51207	0	0	0	17	143	18	3	1	72	0	51	50000	x	0	0	0	0	0	0	0	37	0	x	870	0	0	0	0	0
California	12178	0	0	0	46	1165	48	1276	22	93	0	52	9175	x	0	65	1	0	0	0	20	2	0	53	5	0	155	0	0	0
Hawaii	617	0	0	3	57	0	7	0	335	44	0	0	129	4	1	0	0	25	0	0	6	6	0	0	0	0	0	0	0	0
Nevada	46	0	0	0	0	3	0	x	0	0	x	0	15	x	0	16	6	0	1	0	0	5	0	x	0	0	0	0	0	0
American Samoa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tr. Terr. of P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Guam	164	0	0	0	0	0	0	0	0	0	0	0	164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CNMI	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REG 10	29825	654	0	3	6556	60	3	2241	45	365	21	14	16910	2141	115	8	8	0	575	0	51	3	3	150	0	0	0	0	120	0
Alaska	2542	0	0	3	79	8	3	2133	4	220	0	0	66	0	0	4	0	0	0	0	2	0	3	7	0	0	0	0	0	0
Idaho	2503	571	0	0	0	52	0	0	9	46	21	7	1165	0	7	4	2	0	575	0	49	0	0	20	0	0	0	0	4	0
Oregon	7120	16	0	0	6257	0	0	0	32	20	0	0	776	0	0	0	6	0	0	0	0	0	0	13	0	0	0	0	0	0
Washington	17621	66	0	0	0	0	0	108	0	69	0	7	14903	2141	108	0	0	0	0	0 x		3	0	110	0	0	0	0	116	0
TOTAL	170159	1328	479	980	6622	26769	4435	3783	1099	1999	99	3558	93566	3802	1557	89	21	25	6500	66	291	225	2250	10028	2025	121	157	4	124	335

NOTE: Some numbers in this table are estimated. "X" indicates well type reported; no numbers are available.

TABLE 5-4: CLASS V INJECTION WELL INVENTORY BY REGION

REGION	HIGH	MODERATE	LOW	UNKNOWN	TOTAL
I	286	52	24	2	364
II	5085	3626	229	10	8950
III	947	1349	2293	0	4589
IV	21284	3613	3000	14	27911
V	9082	7378	1224	88	17772
VI	292	1106	2296	149	3843
VII	504	4354	1802	15	6675
VIII	471	8229	234	81	9015
IX	3458	59673	1083	0	64214
X	9742	19814	150	120	29826
TOTAL	51151	109194	12335	479	173159

BAR GRAPH ILLUSTRATING
HIGH CONTAMINATION POTENTIAL
DISTRIBUTION BY USEPA REGION

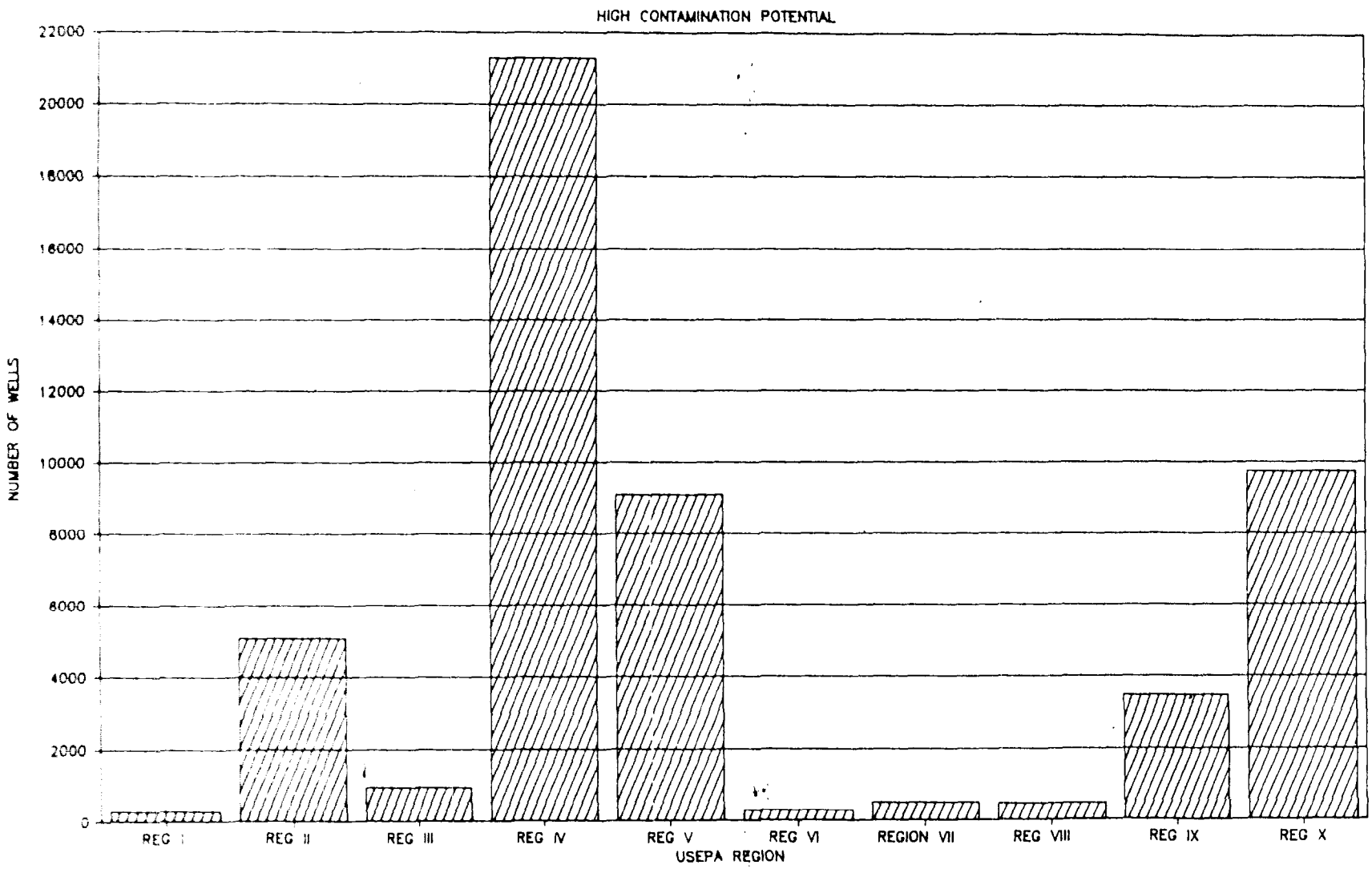
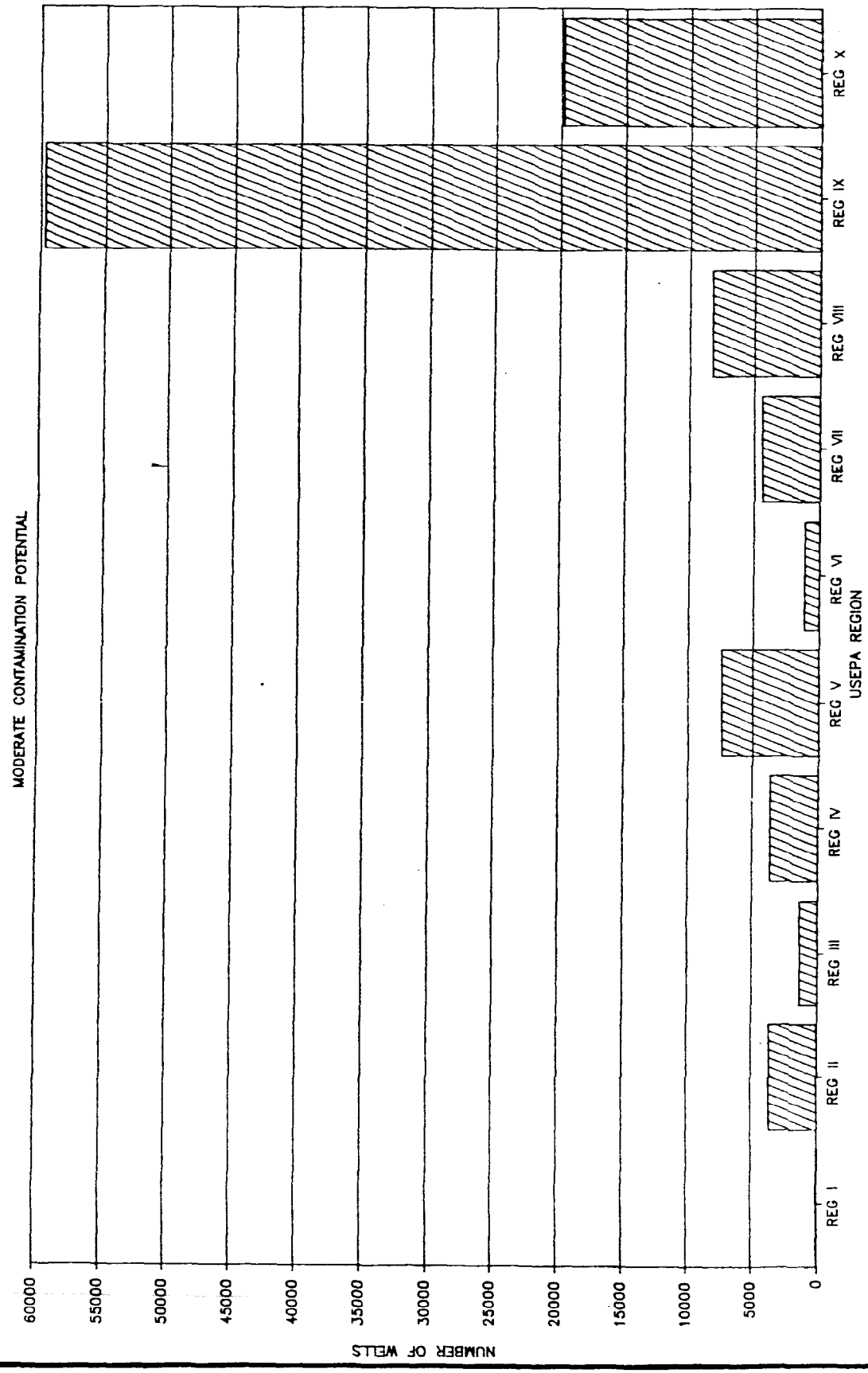


Figure 5-1



BAR GRAPH ILLUSTRATING
MODERATE CONTAMINATION POTENTIAL
DISTRIBUTION BY USEPA REGION

Figure 5-

BAR GRAPH ILLUSTRATING
LOW CONTAMINATION POTENTIAL
DISTRIBUTION BY USEPA REGION

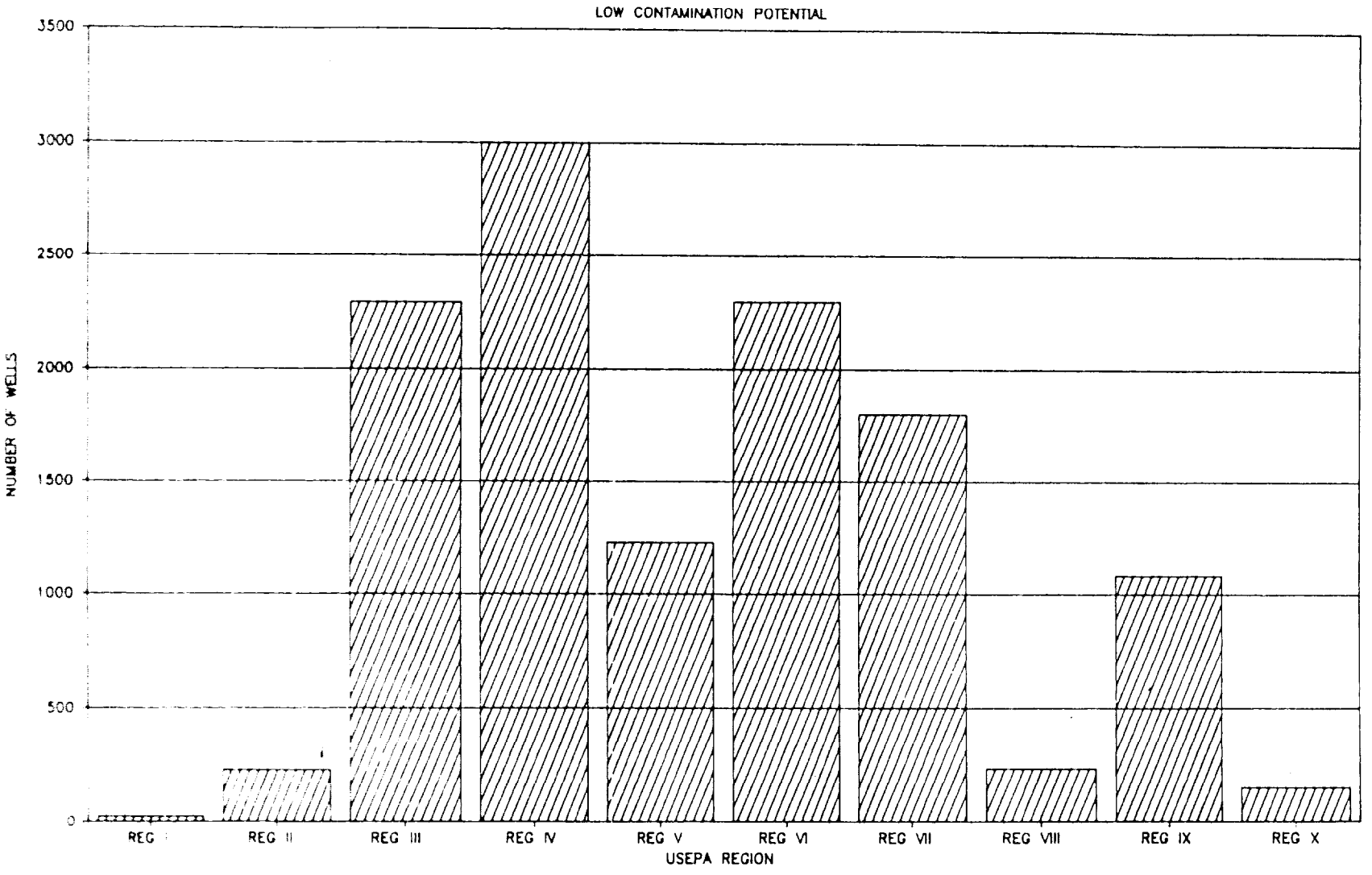
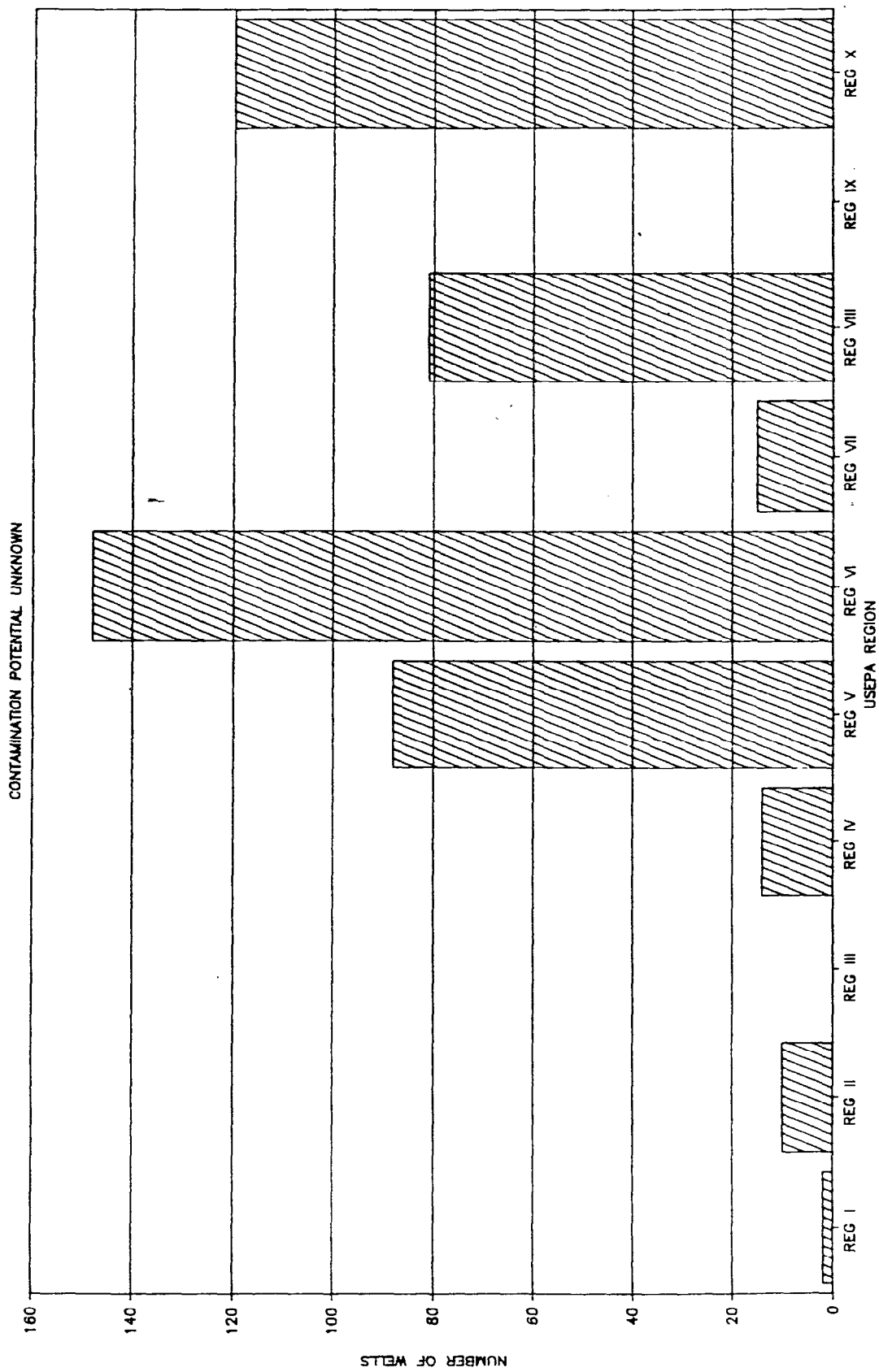


FIGURE 5-3



BAR GRAPH ILLUSTRATING
CONTAMINATION POTENTIAL UNKNOWN
DISTRIBUTION BY USEPA REGION

Figure 5-4

- Raw sewage waste disposal wells, 5W9, and cesspools, 5W10;
- Septic systems, 5W11, 5W31, 5W32;
- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);
- Industrial process water and waste disposal wells, 5W20;
- Automobile service station disposal wells, 5X28; and
- Aquifer recharge wells, 5R21 (high to low).

Moderate Contamination Potential

- Storm Water drainage, 5D2, and industrial drainage wells, 5D4;
- Improved sinkholes, 5D3, (high to moderate);
- Special drainage wells, 5G30 (moderate to low);
- Electric power, 5A5, and direct heat reinjection wells, 5A6;
- Aquaculture return flow wells, 5A8;
- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);
- Mining, sand, or other backfill wells, 5X13;
- In-situ fossil fuel recovery wells, 5X15;
- Cooling water return flow wells, 5A19, (moderate to low);
- Aquifer recharge wells, 5R21 (high to low);
- Experimental technology wells, 5X25 (moderate to low); and
- Abandoned drinking water/waste wells disposal wells, 5X29.

Low Contamination Potential

- Special drainage wells, 5G30 (moderate to low);
- Heat pump/air conditioning return flow wells, 5A7;
- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);
- Solution mining wells, 5X14;
- Spent brine return flow wells, 5X16;
- Cooling water return flow wells, 5A19 (moderate to low);
- Aquifer recharge wells, 5R21 (high to low);
- Saline water intrusion barrier wells, 5B22;
- Subsidence control wells, 5S23; and
- Experimental technology wells, 5X25 (moderate to low).

Unknown Contamination Potential

- Radioactive Waste Disposal Wells, 5N24; and
- Aquifer remediation related wells, 5X26 (including hydrocarbon recovery related injection wells).

5.3.1 REGIONAL BREAKDOWN OF INVENTORY ACCORDING TO CONTAMINATION POTENTIAL

A series of tables have been compiled to indicate the breakdown of well types in each USEPA Region. The well types and numbers are listed in Tables 5-5 to 5-14 under headings which group well types by contamination potential. The tables are useful tools for prioritizing additional Class V inventory and assessment efforts in the various Regions.

5.3.2 SUMMARY OF REGULATORY SYSTEMS CURRENTLY KNOWN TO BE IN EFFECT

Class V injection wells are authorized by rule under the Federally-administered UIC programs (Section 1). Several States, however, implement their own methods of regulating Class V wells. Table 5-15 lists and Figure 5-5 illustrates the known regulatory systems in effect.

TABLE 5-5: WELL TYPES IN REGION I
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL # S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Improved Sinkholes (5D3)	3	0.8
Septic Undifferentiated(5W11)	97	26.6
Domestic WW Treatment Plant Effluent(5W12)	72	19.8
Industrial Process Water & WW(5W20)	99	27.2
Automobile Service Station(5X28)	14	3.8
Aquifer Recharge Wells(5R21)	1	0.3
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	22	6.0
Industrial Drainage(5D4)	16	4.4
Cooling Water Return Flow Wells(5A19)	14	3.8
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	24	6.6
CONTAMINATION POTENTIAL UNKNOWN		
Aquifer Remediation Related Wells(5X26)	2	0.5
TOTAL	364	100.0

TABLE 5-6: WELL TYPES IN REGION II
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL #'S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Agricultural Drainage(5F1)	150	1.7
Improved Sinkholes (5D3)	10	0.1
Untreated Sewage Disp(5W9)	5	0.1
Cesspools(5W10)	68	0.8
Septic Undifferentiated(5W11)	1260	14.1
Septic with Well(5W31)	85	0.9
Septic with Drainfield(5W32)	63	0.7
Domestic WW Treatment Plant Effluent(5W12)	22	0.2
Industrial Process Water & WW(5W20)	401	4.5
Automobile Service Station(5X28)	21	0.2
Aquifer Recharge Wells(5R21)	3000	33.5
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	2504	28.0
Industrial Drainage(5D4)	1116	12.5
Cooling Water Return Flow Wells(5A19)	6	0.1
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	181	2.0
Solution Mining Wells(5X14)	48	0.5
CONTAMINATION POTENTIAL UNKNOWN		
Aquifer Remediation Related Wells(5X26)	10	0.1
TOTAL	8950	100.0

TABLE 5-7: WELL TYPES IN REGION III
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL #'S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Septic Undifferentiated(5W11)	8	0.2
Septic with Well(5W31)	903	19.7
Domestic WW Treatment Plant Effluent(5W12)	5	0.1
Industrial Process Water & WW(5W20)	30	0.7
Automobile Service Station(5X28)	1	0.0
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	273	5.9
Industrial Drainage(5D4)	6	0.1
Mining Sand/Other Backfill Wells(5X13)	1070	23.3
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	2291	49.9
Spent-Brine Return Flow Wells(5X16)	2	0.0
CONTAMINATION POTENTIAL UNKNOWN		
None		
TOTAL	4589	100.0

TABLE 5-8: WELL TYPES IN REGION IV
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL #'S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Agricultural Drainage(5F1)	43	0.2
Improved Sinkholes (5D3)	81	0.3
Septic Undifferentiated(5W11)	19001	68.1
Septic with Well(5W31)	736	2.6
Septic with Drainfield(5W32)	200	0.7
Domestic WW Treatment Plant Effluent(5W12)	556	2.0
Industrial Process Water & WW(5W20)	318	1.1
Aquifer Recharge Wells(5R21)	349	1.3
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	2072	7.4
Industrial Drainage(5D4)	2	0.0
Special Drainage Wells(5G30)	1385	5.0
Mining Sand/Other Backfill Wells(5X13)	61	0.2
Cooling Water Return Flow Wells(5A19)	75	0.3
Experimental Technology Wells(5X25)	18	0.1
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	2998	10.7
Saline Water Intrusion Barrier Wells(5B22)	2	0.0
CONTAMINATION POTENTIAL UNKNOWN		
Radioactive Waste Disposal Wells(5N24)	1	0.0
Aquifer Remediation Related Wells(5X26)	13	0.0
TOTAL	27911	100.0

TABLE 5-9: WELL TYPES IN REGION V
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL #'S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Agricultural Drainage(5F1)	147	0.8
Improved Sinkholes (5D3)	135	0.8
Untreated Sewage Disp(5W9)	959	5.4
Cesspools(5W10)	65	0.4
Septic Undifferentiated(5W11)	4537	25.5
Septic with Well(5W31)	2635	14.8
Domestic WW Treatment Plant Effluent(5W12)	41	0.2
Industrial Process Water & WW(5W20)	527	3.0
Automobile Service Station(5X28)	34	0.2
Aquifer Recharge Wells(5R21)	2	0.0
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	4987	28.1
Industrial Drainage(5D4)	191	1.1
Mining Sand/Other Backfill Wells(5X13)	5	0.0
In-situ Fossil Fuel Recovery wells(5X15)	2	0.0
Cooling Water Return Flow Wells(5A19)	90	0.5
Experimental Technology wells(5X25)	8	0.0
Abandoned Drinking Water wells(5X29)	2095	11.8
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	1164	6.5
Solution Mining wells(5X14)	15	0.1
Spent-Brine Return Flow Wells(5X16)	41	0.2
Subsidence Control Wells(5S23)	4	0.0
CONTAMINATION POTENTIAL UNKNOWN		
Radioactive Waste Disposal wells(5N24)	1	0.0
Aquifer Remediation Related wells(5X26)	67	0.3
TOTAL	17772	100.0

TABLE 5-10: WELL TYPES IN REGION VI
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL #'S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Agricultural Drainage(5F1)	108	2.8
Untreated Sewage Disp(5W9)	10	0.3
Cesspools(5W10)	30	0.8
Septic Undifferentiated(5W11)	66	1.7
Industrial Process Water & WW(5W20)	4	0.1
Aquifer Recharge Wells(5R21)	74	1.9
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	57	1.5
Industrial Drainage(5D4)	5	0.1
Special Drainage Wells(5G30)	1	0.0
Direct Heat Reinjection Well(5A6)	3	0.1
Mining Sand/Other Backfill Wells(5X13)	76	2.0
Cooling Water Return Flow Wells(5A19)	7	0.2
Experimental Technology Wells(5X25)	12	0.3
Abandoned Drinking Water Wells(5X29)	945	24.6
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	1146	29.8
Solution Mining Wells(5X14)	1073	27.9
Spent-Brine Return Flow Wells(5X16)	77	2.0
CONTAMINATION POTENTIAL UNKNOWN		
Radioactive Waste Disposal Wells(5N24)	2	0.1
Aquifer Remediation Related Wells(5X26)	147	3.8
TOTAL	3843	100.0

TABLE 5-11: WELL TYPES IN REGION VII
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL #'S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Agricultural Drainage(5F1)	235	3.5
Improved Sinkholes (5D3)	250	3.7
Septic Undifferentiated(5W11)	5	0.1
Automobile Service Station(5X28)	6	0.1
Aquifer Recharge Wells(5R21)	8	0.1
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	10	0.1
Mining Sand/Other Backfill Wells(5X13)	4326	64.8
Cooling Water Return Flow Wells(5A19)	16	0.2
Experimental Technology Wells(5X25)	2	0.0
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	1802	27.0
CONTAMINATION POTENTIAL UNKNOWN		
Aquifer Remediation Related wells(5X25)	15	0.2
TOTAL	6675	100.0

TABLE 5-12: WELL TYPES IN REGION VIII
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL #'S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Agricultural Drainage(5F1)	1	0.0
Cesspools(5W10)	3	0.0
Septic Undifferentiated(5W11)	422	4.7
Industrial Process Water & WW(5W20)	36	0.4
Automobile Service Station(5X28)	2	0.0
Aquifer Recharge Wells(5R21)	7	0.1
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	7250	80.4
Industrial Drainage(5D4)	321	3.6
Special Drainage Wells(5G30)	55	0.6
Direct Heat Reinjection Well(5A6)	3	0.0
Mining Sand/Other Backfill Wells(5X13)	386	4.3
In-situ Fossil Fuel Recovery Wells(5X15)	64	0.7
Cooling Water Return Flow Wells(5A19)	6	0.1
Experimental Technology Wells(5X25)	137	1.5
Abandoned Drinking Water Wells(5X29)	7	0.1
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	219	2.4
Solution Mining Wells(5X14)	14	0.2
Spent-Brine Return Flow Wells(5X16)	1	0.0
CONTAMINATION POTENTIAL UNKNOWN		
Aquifer Remediation Related Wells(5X26)	81	0.9
TOTAL	9015	100.0

TABLE 5-13: WELL TYPES IN REGION IX
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL # S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Untreated Sewage Disp(5W9)	3	0.0
Cesspools(5W10)	120	0.2
Septic Undifferentiated(5W11)	1313	2.0
Septic with Well(5W31)	73	0.1
Septic with Drainfield(5W32)	1279	2.0
Domestic WW Treatment Plant Effluent(5W12)	358	0.6
Industrial Process Water & WW(5W20)	209	0.3
Aquifer Recharge Wells(5R21)	103	0.2
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	59483	92.6
Industrial Drainage(5D4)	4	0.0
Special Drainage Wells(5G30)	1	0.0
Electric Power Reinjection Well(5A5)	81	0.1
Direct Heat Reinjection Well(5A6)	7	0.0
GW Aquaculture Return Flow Well(5A8)	25	0.0
Mining Sand/Other Backfill Wells(5X13)	1	0.0
Cooling Water Return Flow Wells(5A19)	26	0.0
Experimental Technology Wells(5X25)	45	0.1
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	53	0.1
Solution Mining Wells(5X14)	875	1.4
Saline Water Intrusion Barrier Wells(5B22)	155	0.2
CONTAMINATION POTENTIAL UNKNOWN		
None		
TOTAL	64214	100.0

TABLE 5-14: WELL TYPES IN REGION X
CLASSIFIED BY CONTAMINATION POTENTIAL

WELL TYPE & CLASSIFICATION	WELL #'S	% OF TOTAL
HIGH CONTAMINATION POTENTIAL		
Agricultural Drainage(5F1)	654	2.2
Untreated Sewage Disp(5W9)	3	0.0
Cesspools(5W10)	6336	21.2
Septic Undifferentiated(5W11)	60	0.2
Septic with Well(5W31)	3	0.0
Septic with Drainfield(5W32)	2241	7.5
Domestic WW Treatment Plant Effluent(5W12)	45	0.2
Industrial Process Water & WW(5W20)	365	1.2
Automobile Service Station(5X28)	21	0.1
Aquifer Recharge Wells(5R21)	14	0.0
MODERATE CONTAMINATION POTENTIAL		
Storm Water Drainage(5D2)	16910	56.7
Industrial Drainage(5D4)	2141	7.2
Special Drainage Wells(5G30)	115	0.4
Electric Power Reinjection Well(5A5)	8	0.0
Direct Heat Reinjection Well(5A6)	8	0.0
Mining Sand/Other Backfill Wells(5X13)	575	1.9
Cooling Water Return Flow Wells(5A19)	51	0.2
Experimental Technology Wells(5X25)	3	0.0
Abandoned Drinking Water Wells(5X29)	3	0.0
LOW CONTAMINATION POTENTIAL		
Heat Pump/AC Return Flow Wells(5A7)	150	0.5
CONTAMINATION POTENTIAL UNKNOWN		
Radioactive Waste Disposal Wells(5N24)	120	0.4
TOTAL	29826	100.0

SUMMARY OF STATE'S REGULATORY SYSTEMS
OF CLASS V WELLS (PART ONE)
AUGUST 1987

STATES BY REGION	EPA REGION	DRAINAGE					GEOTHERMAL				DOMESTIC WASTEWATER					
		5F1	5D2	5D3	5D4	5G30	5A5	5A6	5A7	5A8	5W9	5W10	5W11	5W31	5W32	5W12
Connecticut	I	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	PERMIT>5K GPD	N/A	N/A	N/A
Maine	I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Massachusetts	I	N/A	EXEMPT	N/A	N/A	N/A	N/A	N/A	PERMIT>15K GPD	N/A	N/A	N/A	PERMIT>15K GPD	N/A	N/A	PERMIT>15K GPD
New Hampshire	I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rhode Island	I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vermont	I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
New Jersey	II	N/A	NJPDES PERMIT	N/A	NJPDES PERMIT	N/A	N/A	N/A	RULE/PERMIT	N/A	N/A	NJPDES PERMIT	NJPDES PERMIT	N/A	N/A	N/A
New York	II	SPDES PERMIT	PERMIT>1K GPD	N/A	PERMIT>1K GPD	N/A	N/A	N/A	PERMIT	N/A	N/A	PERMIT>1K GPD	PERMIT>1K GPD	PERMIT>1K GPD	PERMIT>1K GPD	PERMIT
Puerto Rico	II	N/A	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT
Virgin Islands	II	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Delaware	III	N/A	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Maryland	III	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A
Pennsylvania	III	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Virginia	III	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
West Virginia	III	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Alabama	IV	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A
Florida	IV	PERMIT	PERMIT	PERMIT	PERMIT	PERMIT/RULE	N/A	N/A	PERMIT	N/A	N/A	N/A	PERMIT	N/A	N/A	PERMIT
Georgia	IV	BANNED	BANNED	BANNED	BANNED	N/A	N/A	N/A	BANNED	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kentucky	IV	N/A	LOCAL	LOCAL	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	RULE	N/A	ELIMINATE
Mississippi	IV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
North Carolina	IV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A
South Carolina	IV	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	RULE	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A
Tennessee	IV	N/A	PERMIT	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Illinois	V	RULE	RULE	N/A	RULE	N/A	N/A	N/A	RULE	N/A	BANNED	N/A	N/A	N/A	N/A	RULE
Indiana	V	N/A	N/A	NONE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT
Michigan	V	N/A	N/A	NONE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT
Minnesota	V	N/A	N/A	NONE	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	RULE	N/A	N/A	N/A
Ohio	V	N/A	N/A	NONE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wisconsin	V	N/A	NONE	N/A	RULE	N/A	N/A	N/A	RULE	N/A	N/A	N/A	N/A	RULE	N/A	N/A
Arkansas	VI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Louisiana	VI	N/A	N/A	N/A	CLASS II	CLASS II	N/A	N/A	PERMIT	N/A	N/A	N/A	RULE	N/A	N/A	N/A
New Mexico	VI	N/A	REGISTRATION	N/A	N/A	N/A	N/A	PERMIT	REGISTRATION	N/A	N/A	BANNED	REGISTRATION	N/A	N/A	N/A
Oklahoma	VI	RULE	RULE	N/A	N/A	N/A	N/A	N/A	RULE	N/A	N/A	N/A	RULE	N/A	N/A	N/A
Texas	VI	N/A	N/A	N/A	N/A	N/A	PERMIT	PERMIT	RULE	N/A	N/A	RULE	LOCAL	N/A	N/A	RULE/PERMIT
Iowa	VII	DIVERSION PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kansas	VII	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Missouri	VII	NONE	N/A	NONE	N/A	N/A	N/A	N/A	REGISTRATION	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A
Nebraska	VII	RULE	RULE	N/A	RULE	RULE	RULE	RULE/PERMIT	RULE	RULE	RULE	RULE	RULE	RULE	RULE	RULE
Colorado	VIII	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Montana	VIII	N/A	PERMIT	N/A	N/A	PERMIT	N/A	N/A	NONE	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A
North Dakota	VIII	N/A	N/A	N/A	N/A	N/A	N/A	N/A	RULE	N/A	N/A	N/A	RULE	N/A	N/A	N/A
South Dakota	VIII	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Utah	VIII	RULE	RULE	N/A	RULE	N/A	PERMIT	PERMIT	PERMIT	PERMIT	BANNED	BANNED	PERMIT	PERMIT	PERMIT	PERMIT
Wyoming	VIII	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	PERMIT	PERMIT	N/A	N/A	N/A
Arizona	IX	PERMIT	REGISTRATION	N/A	REGISTRATION	N/A	N/A	N/A	NONE	N/A	N/A	PERMIT	PERMIT	PERMIT	PERMIT	PERMIT
California	IX	N/A	RULE	N/A	RULE	N/A	PERMIT	PERMIT	PERMIT	N/A	N/A	BANNED	N/A	PERMIT	PERMIT	PERMIT
Hawaii	IX	N/A	PERMIT	N/A	PERMIT	PERMIT	N/A	N/A	N/A	PERMIT	PERMIT	PERMIT	N/A	PERMIT	N/A	PERMIT
Nevada	IX	N/A	N/A	N/A	N/A	N/A	PERMIT	PERMIT	N/A	N/A	BANNED	BANNED	PERMIT	BANNED	PERMIT	BANNED
American Samoa	IX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Trust Terr. of P.I.	IX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Guam	IX	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CNMI	IX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NONE	N/A	N/A	N/A
Alaska	X	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A	PERMIT OR RULE	PERMIT OR RULE	PERMIT OR RULE	PERMIT OR RULE	PERMIT OR RULE	PERMIT OR RULE
Idaho	X	PERMIT>18 FT	PERMIT>18 FT	N/A	N/A	PERMIT>18 FT	PERMIT	PERMIT	PERMIT	N/A	N/A	N/A	PERMIT>18 FT	N/A	N/A	RULE
Oregon	X	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT>5K GPD	PERMIT>5K GPD	PERMIT>5K GPD	RULE	RULE	N/A	N/A	PERMIT>5K GPD	N/A
Washington	X	UNDECIDED	NONE	N/A	NONE	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	PERMIT/RULE	N/A	PERMIT	RULE

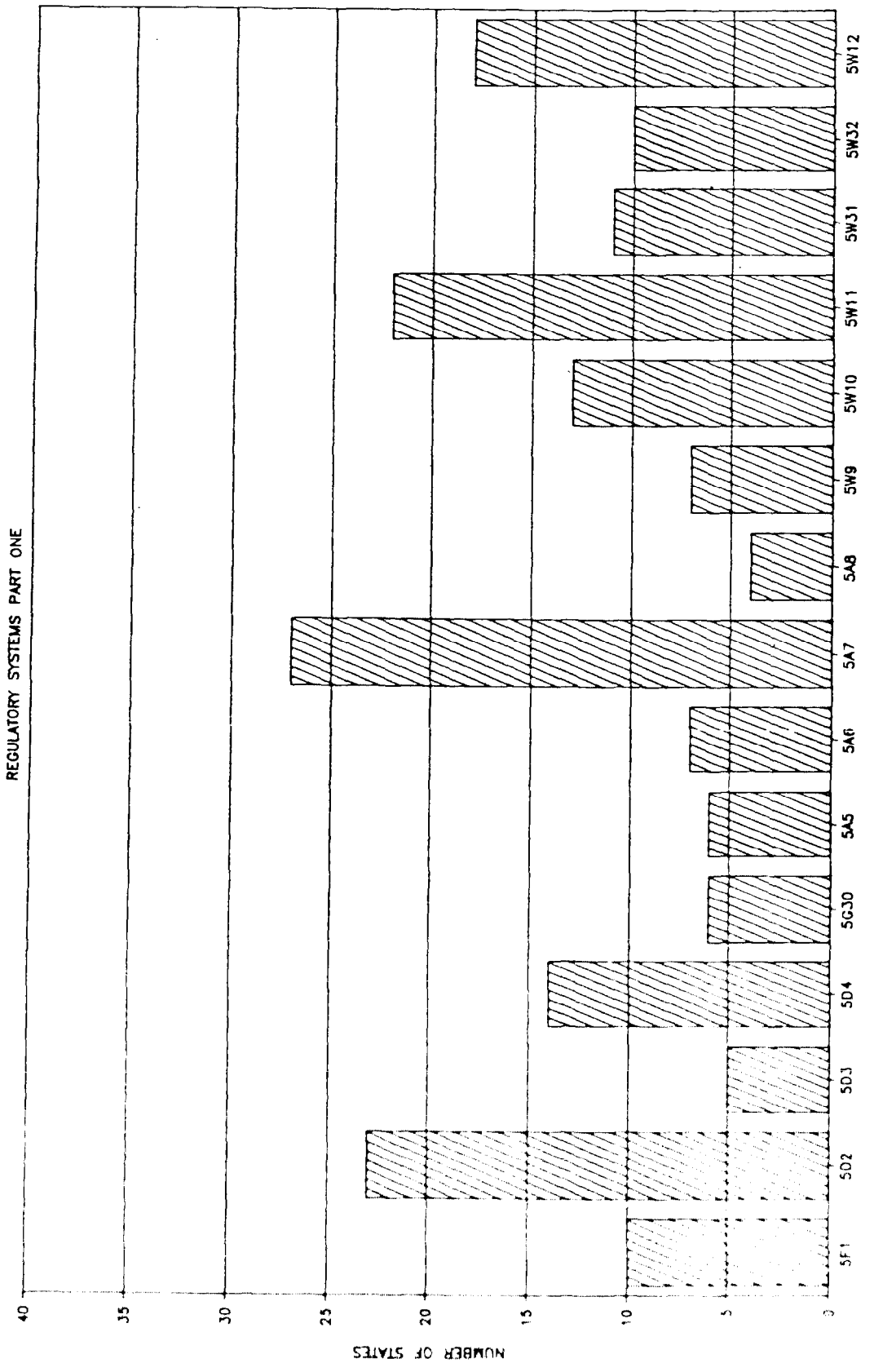
TABLE 5-15A

SUMMARY OF STATE'S REGULATORY SYSTEMS OF CLASS V WELLS (PART TWO)

AUGUST 1987

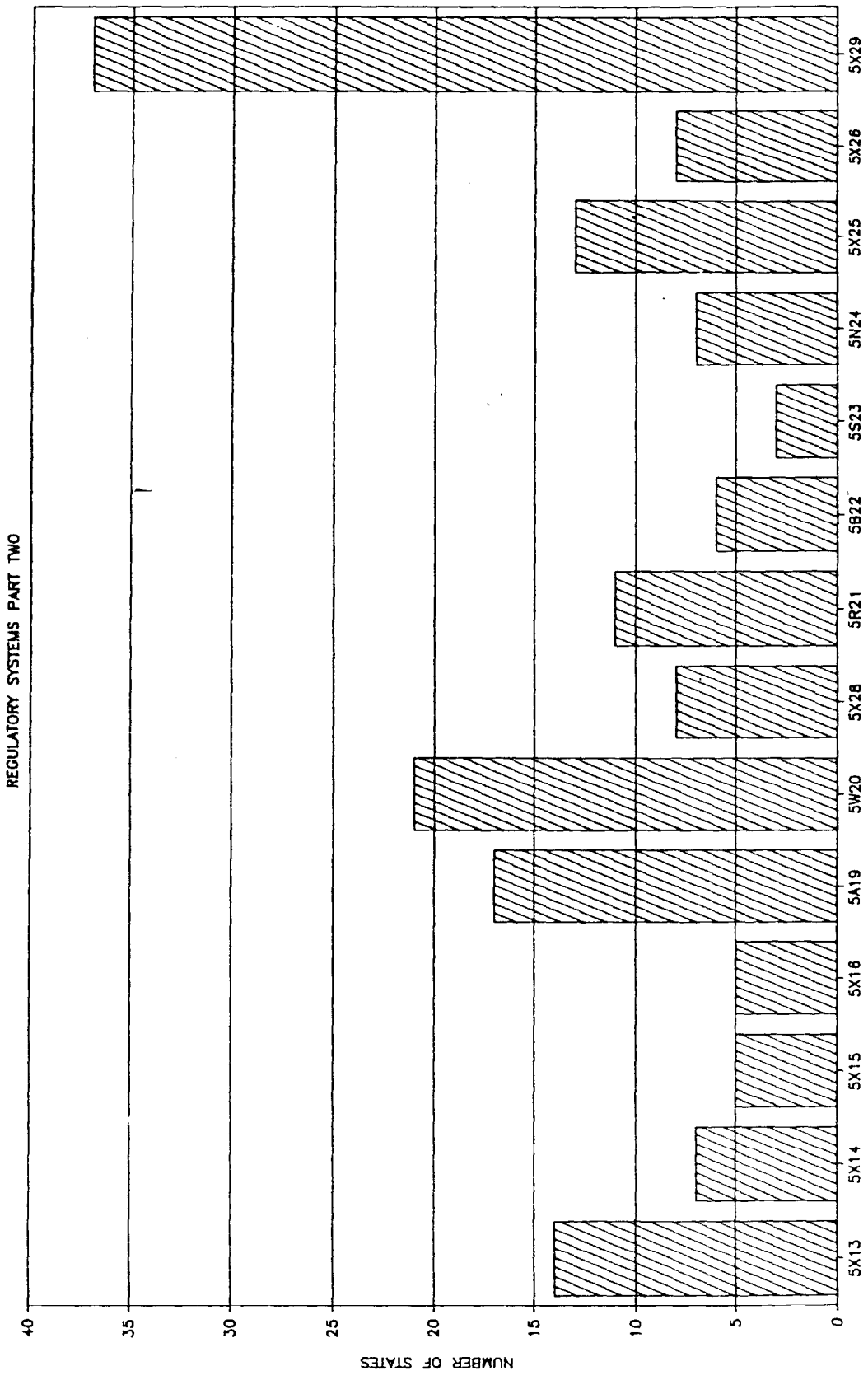
STATES BY REGION	EPA REGION	MINERAL & FOSSIL FUEL				INDUSTRIAL			RECHARGE			MISCELLANEOUS			
		5X13	5X14	5X15	5X16	5A19	5W20	5X28	5R21	5B22	5G23	5N24	5X25	5X26	5X29
Connecticut	I	N/A	N/A	N/A	N/A	N/A	PERMIT	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	NO
Maine	I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Massachusetts	I	N/A	N/A	N/A	N/A	PERMIT>2K GPD	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
New Hampshire	I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Rhode Island	I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Vermont	I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
New Jersey	II	N/A	N/A	N/A	N/A	NJPDES PERMIT	NJPDES PERMIT	NJPDES PERMIT	RULE/PERMIT	RULE/PERMIT	N/A	N/A	N/A	NJPDES PERMIT	P&A RULES
New York	II	N/A	PERMIT	N/A	PERMIT	N/A	PERMIT	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	NO
Puerto Rico	II	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Virgin Islands	II	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Delaware	III	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Maryland	III	PERMIT	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Pennsylvania	III	MINE OPERATION	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Virginia	III	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
West Virginia	III	MINE OPERATION	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Alabama	IV	PERMIT	N/A	N/A	N/A	PERMIT	PERMIT	N/A	N/A	N/A	N/A	N/A	PERMIT	PERMIT	P&A RULES
Florida	IV	N/A	N/A	N/A	N/A	PERMIT	PERMIT	PERMIT	PERMIT	PERMIT	N/A	N/A	PERMIT	N/A	P&A RULES
Georgia	IV	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Kentucky	IV	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Mississippi	IV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	RULE	N/A	NO
North Carolina	IV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT	PERMIT	P&A RULES
South Carolina	IV	N/A	N/A	N/A	N/A	RULE	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Tennessee	IV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Illinois	V	RULE	N/A	N/A	N/A	RULE	RULE	RULE	RULE	N/A	N/A	RULE	RULE	N/A	P&A RULES
Indiana	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Michigan	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Minnesota	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Ohio	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Wisconsin	V	N/A	N/A	N/A	N/A	RULE	PERMIT	N/A	N/A	N/A	PERMIT	N/A	N/A	RULE	P&A RULES
Arkansas	VI	N/A	N/A	N/A	PERMIT	NONE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Louisiana	VI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
New Mexico	VI	N/A	PERMIT	N/A	N/A	REGISTRATION	N/A	N/A	REGISTRATION	N/A	N/A	ILLEGAL	PERMIT	N/A	NO
Oklahoma	VI	N/A	N/A	N/A	RULE	N/A	N/A	N/A	N/A	N/A	N/A	RULE	N/A	RULE	P&A RULES
Texas	VI	RULE	N/A	PERMIT	N/A	N/A	CLASS I	N/A	PERMIT +	N/A	N/A	N/A	N/A	N/A	P&A RULES
Iowa	VII	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Kansas	VII	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Missouri	VII	NONE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Nebraska	VII	RULE	PERMIT	RULE	RULE	RULE	RULE	RULE	RULE	RULE	RULE	RULE	RULE	PERMIT	P&A RULES
Colorado	VIII	RULE	N/A	RULE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Montana	VIII	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
North Dakota	VIII	RULE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
South Dakota	VIII	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Utah	VIII	RULE	PERMIT	PERMIT	RULE	PERMIT	BANNED	BANNED	RULE/PERMIT	RULE/PERMIT	RULE/PERMIT	RULE/PERMIT	RULE/PERMIT	RULE/PERMIT	BANNED
Wyoming	VIII	PERMIT	PERMIT	PERMIT	N/A	N/A	PERMIT	N/A	PERMIT	N/A	N/A	N/A	PERMIT	N/A	P&A RULES
Arizona	IX	N/A	PERMIT	N/A	N/A	N/A	PERMIT	N/A	PERMIT	N/A	N/A	N/A	PERMIT	N/A	P&A RULES
California	IX	N/A	PERMIT	N/A	N/A	PERMIT	PERMIT	N/A	PERMIT	PERMIT	N/A	N/A	PERMIT	PERMIT	P&A RULES
Hawaii	IX	N/A	N/A	N/A	N/A	PERMIT	PERMIT	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A	NO
Nevada	IX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	PERMIT	N/A	P&A RULES
American Samoa	IX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Tr. Terr. of P	IX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Guam	IX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
CNMI	IX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO
Alaska	X	N/A	N/A	N/A	N/A	PERMIT	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Idaho	X	RULE	N/A	N/A	N/A	PERMIT	PERMIT>18 FT	RULE	PERMIT>18 FT	N/A	N/A	PERMIT>18 FT	N/A	N/A	P&A RULES
Oregon	X	N/A	N/A	N/A	N/A	PERMIT>5K GPD	PERMIT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P&A RULES
Washington	X	N/A	N/A	N/A	N/A	PERMIT	N/A	N/A	N/A	PERMIT	N/A	PERMIT	N/A	N/A	P&A RULES

ABLE 5-15B



NUMBER OF STATES WITH KNOWN IN-PLACE
REGULATORY SYSTEMS FOR CLASS V WELLS
(PART ONE)
AUGUST 1987

Figure 5-6a



NUMBER OF STATES WITH KNOWN IN-PLACE
REGULATORY SYSTEMS FOR CLASS V WELLS
(PART TWO)
AUGUST 1987

Figure 5-5b

Several items should be clearly understood when interpreting this information. First, these data are based on information reviewed to date (5-15-87) as provided by State Class V reports. Second, it is very likely that many additional regulatory systems are currently in effect, but the State reports have not completely addressed them, in many cases.

In describing States' regulatory systems, the intent was to use one of the following words: Permit, Rule, Banned, None, or Information Not Available (N/A). However, many States use these systems in conjunction with a multitude of qualifiers and/or exemptions. For example, Idaho regulates some well types by permit if the wells are deeper than 18 feet but regulates by rule if they are shallower than 18 feet. Several States regulate by permit only when the amount of injection fluid exceeds a set volume (i.e., Oregon 5A6-8 are permitted if injecting more than 5,000 (5K) gallons per day). In the case of abandoned drinking water wells (5X29), most States appear to have existing rules for proper plugging and abandonment (P & A) procedures. Utah specifically indicated that injection into abandoned drinking water wells is illegal. Kentucky could not identify State systems in effect for drainage wells (5D2, 5D3) because they are regulated locally.

In general, few States regulate all well types, since many well types are highly dependent on the geology of the area (5D3, 5A6-8). The fact that some States do not have a regulatory program for a particular well type does not mean that those wells are not adequately regulated. In actuality, many States have not regulated some well types because these well types are not located in their States.

In spite of some of the pitfalls, the effort to identify current regulatory systems will help simplify the task of identifying future actions necessary for an effective National Class V program.

5.3.3 SUMMARY OF CLASS V INJECTION WELL DATA

Table 5-16 presents a summary of available inventory data, types of fluids injected, contamination potentials, recommendations, and State regulatory systems for each well type.

TABLE 5-16

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Drainage Wells					
Agricultural Drainage Wells (5F1)	Nationwide: 1,338 wells New York: 150 wells Puerto Rico: no numbers West Virginia: no numbers Florida: no numbers Georgia: 43 wells Kentucky: no numbers Illinois: 6 wells Indiana: 72 wells Michigan: 15 wells Minnesota: 54 wells Oklahoma: no numbers Texas: 108 wells Iowa: 230 wells Missouri: no numbers Nebraska: 5 wells Colorado: no numbers North Dakota: 1 well Idaho: 572 wells Oregon: 16 wells Washington: 66 wells Potentially many times this figure in areas typified by irrigation.	Varies due to differing farming practices and soil types; potential agricultural contaminants include sediment, nutrients, pesticides, organics, salts, metals, and pathogens in some cases.	High	New York - SPDES Permit Florida - Permit Georgia - Banned Illinois - Rule Oklahoma - Rule Iowa - Diversion Permit Missouri - None Nebraska - Rule Utah - Rule Arizona - Permit Idaho - Permit if deeper than 18 feet Washington - Undecided	- Improvement of inventory efforts is essential. (PR, GA, IN, MI, MN, CO, OR) - Locate and properly plug all abandoned wells near Agricultural Drainage Wells. (IA) - Close surface inlets to allow infiltration through soil. (MO) - Raise the inlets above maximum ponding levels. (IA) - Require that injection fluids meet all or some drinking water standards. (NE, OR) - Require irrigation tailwater recovery and pumpback. (OR) - Use only necessary amounts of irrigation water and applied chemicals. (CA) - Require frequent monitoring of drinking water wells in surrounding areas. - Require detailed map with all well locations. (NE) - Require diagram of injection well construction. (NE) - Require siting of wells at least 2,000 ft. away from any stock, municipal, or domestic well. (NE) - Discourage use and encourage elimination of agricultural drainage wells by developing alternate methods. (IA)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
[illegible]	Nationwide: [illegible] wells reported for [illegible] States.	Herbicides, pesticides, fertilizers, deicing salts, asphaltic sediments, gasoline, grease oil, tar and residues from roofs and paving, rubber particulates, liquid wastes and industrial solvents, heavy metals and coliform bacteria.	Moderate	Information applies to both 5D2 and 5D4 unless otherwise specified. Connecticut-Permit (5D2) Massachusetts-Exempt (5D2) New Jersey-NJPDES Permit New York-Permit if injected volume exceeds 1,000 GPD Maryland-Permit (5D4) Alabama-Permit (5D2) Florida-Permit Georgia-Banned Kentucky-Local (5D2), Permit (5D4) South Carolina-Permit (5D2) Tennessee-Permit (5D2) Illinois-Rule Wisconsin-None (5D2) Rule (5D4) Louisiana-Class II Regulations (5D4), Registration of Class V wells not required New Mexico-Registration Oklahoma-Rule Nebraska-Rule Montana-Permit (5D2) Utah-Rule Wyoming-Permit (5D2) Arizona-Registration California-Rule Hawaii-Permit Guam-Permit (5D2) Alaska-Permit (5D2) Idaho-Permit if deeper than 18 feet (5D2) Washington-None	Apply to both storm water and industrial drainage wells: - New wells should be investigated and added to FURS. (KY, UT, WA) - Construction of new industrial drainage wells should be limited or discouraged; storm water sewers, detention ponds, or vegetative basins are preferred. (OR, IL, KY, TN, UT). - Sand and gravel filters should be added to wells. (KY, TN) - Stand pipes should be constructed at the openings of wells. (KY, TN) - Limit future construction to residential areas. (IL) - All spills should be diverted away from industrial drainage wells (OR, UT, WA) - New construction of wells in areas served by storm water sewers should be prohibited. (CA, AZ) - Drainage wells should not be constructed within 200 ft. of water supply wells which tap lower water-bearing aquifers. (CA) - Deep wells should be plugged or cemented to avoid mixing between aquifers. (KY, TN) - Depth to water data should be made available to well drillers. (AZ) - Additional studies including use of monitoring wells should be conducted to study possible pollution sources and prolonged effect of industrial drainage wells on ground water. (FL, WI, KS) - An assessment of the effects of storm drainage wells should be conducted prior to completing an inventory because the inventory would be time-consuming and costly. (MT, OR) - Sediments extracted from drainage wells, catch basins, or sediment traps should be disposed in an appropriate landfill. (AZ) A public awareness program should be implemented. (AZ) All drainage wells should be identified and plugged. (WV)
[illegible]	Nationwide: 3,802 wells reported for 23 States.	Similar constituents to those found in Stormwater Drainage Wells, though generally present in higher concentrations. Heavy metals such as lead, iron, and manganese. Organic compounds.			

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Improved Sinkholes (5D3)	Nationwide: 479 wells New Hampshire: 3 wells Puerto Rico: 10 wells Kentucky: 76 wells Tennessee: 5 wells Indiana: 26 wells Michigan: 103 wells Minnesota: 6 wells Missouri: 250 wells Virginia, West Virginia, Florida, and Ohio: numbers not yet confirmed. Potentially in all areas with limestone and dolomite lithologies at relatively shallow depths.	Runoff, from paved areas, containing lead and petroleum products from automobiles, pesticides from horticulture and lawn care, nitrates from fertilizers, and fecal material from wild and domestic animals; normal fallout from air pollutants may also be present.	High to Moderate	Puerto Rico-Permit Florida-Permit Georgia-Banned Kentucky-Local Tennessee-Permit Indiana-None Michigan-None Minnesota-None Ohio-None Missouri-None	- Training should be required for engineers and drillers in the proper construction of wells with special emphasis on sanitary sealing and protection against corrosion. Training should be slanted toward construction in Karst or limestone formations. (PR) - Careful dye trace studies should be run on any existing or improved sinkhole drainage systems, and occasional monitoring of both entering and exiting fluids should be run after the system is in operation. (MO)
Special Drainage Wells (5G30)	Nationwide: 1,557 wells Florida: 1,385 wells Louisiana: 1 well Montana: 55 wells Hawaii: 1 well Idaho: 7 wells Washington: 108 wells. Potentially present in all Regions.	Highly variable, depending on system design; for landslide control, ground water is generally used; swimming pool drainage fluid may contain lithium hypochlorite, calcium hypochlorite, sodium bicarbonate, chlorine, bromine, iodine, cyanuric acid, aluminum sulfate, algaecides, fungicides, and muriatic acid.	Moderate to low	Florida-Permit/Rule Louisiana-Class II Regulations, Registration of Class V wells not required Nebraska-Rule Montana-Permit Hawaii-Permit Idaho-Permit if deeper than 18 feet.	- Random sampling and analysis of swimming pool wastewater for possible contaminants should be required. (FL)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OF POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
[illegible]					
[illegible]	Nationwide: [illegible] wells Texas: [illegible] California: [illegible] wells Nevada: [illegible] wells Idaho: 4 wells Alaska: 4 wells	Vapor-Dominated Resource Heavy metals (arsenic, boron, selenium), sulfates, and dissolved solids. Hot Water-Dominated Resource Heavy metals (arsenic, boron, selenium), chlorides, dissolved solids, and acidic pH.	Moderate	Texas-Permit Nebraska-Rule Utah-Permit California-Permit Nevada-Permit Idaho-Permit	Apply to both electric power and direct heat reinjection wells: - Detailed study on the types of MIT available for geothermal systems and the resolution of each method. (NV) - Initial analysis of injectate and injection zone water conducted prior to full-scale injection operations; parameters of concern are temperature, inorganic constituents of Primary and Secondary Drinking Water Regulations, alkalinity, hardness, silica, boron, and ammonia nitrogen. (CA, NV) - Injection into non-thermal reservoirs if the thermal injection fluids meet drinking water requirements or if the receiving fluids are of equal or lesser quality. (ID)
[illegible]	Nationwide: 21 wells New York: no numbers New Mexico: 2 wells Texas: 1 well Colorado: 2 wells California: 1 well Nevada: 6 wells Idaho: 2 wells Oregon: 6 wells Utah: 1 well	Arsenic, boron, fluoride, dissolved solids, sulfates, chloride.	Moderate	New Mexico-Permit Texas-Permit Nebraska-Rule/Permit Utah-Permit California-Permit Nevada-Permit Idaho-Permit Oregon-Permit if injected volume exceeds 5,000 GPD	

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Heat Pump/Air Conditioning Return Flow Wells (5A7)	Nationwide: 10,028 wells. Potentially present in all regions; more expected in areas characterized by climatic extremes. Reported in all States except the following: Maine, Rhode Island, Vermont, Puerto Rico, Virgin Islands, West Virginia, Alabama, Arkansas, Hawaii, American Samoa, TTPI, Guam, CNMI.	Primarily thermally altered ground water; additives designed to inhibit scaling, corrosion and incrustation when water high in metals and salts, or demonstrating high or low pH, is used.	Low	Connecticut-Permit Massachusetts-Permit if injected volume is greater than 15,000 GPD New Jersey-Rule/Permit New York-Permit Delaware-Permit Maryland-Permit Florida-Permit Georgia-Banned North Carolina-Permit South Carolina-Rule Illinois-Rule Minnesota-Permit Wisconsin-Rule Louisiana-Permit New Mexico-Registration Oklahoma-Rule Texas-Rule Missouri-Registration Nebraska-Rule Montana-None North Dakota-Rule Utah-Permit Wyoming-Permit Arizona-None California-Permit Alaska-Permit Idaho-Permit Oregon-Permit if injected volume is greater than 5,000 GPD Washington-Permit	- More research is needed on the theoretical environmental effects of heat pumps. (MO, AZ, SC) - Authorization by rule is appropriate for properly spaced and operated systems. (SC) - New regulatory programs should be directed at large-scale systems rather than at systems for single-family dwellings. (LA, OK, TX) - Records should be maintained by counties and periodically up-loaded to State databases in order to monitor well densities. (WA) - The State permitting agency should set construction standards and ensure that wells are constructed and operated properly. (FL, KS, MO, NE, SC, WA) - Permits for commercial developments should include requirements for water quality characterizations of both source and receiving water. (WA) - Return wells should be cased through top of injection zone. (IA) - Annular space should be cemented or grouted. (IA, KS, NE, TN) - Adequate spacing between production wells should be practiced. (KS, NE, SC) - Discharge should be into or above the supply aquifer. (LA, IA, KS, SC) - Closed loop systems should be required. (UT, TN) - Discharge should be to the surface rather than to an injection well. (LA) - The waste product should contain no additives or only approved additives (LA, KS, NE) - Volumes and temperatures of injection fluids should be monitored. (NC) - Analyses of receiving fluids should be conducted periodically. (KS, WA) - A licensed water well driller should be employed to install, rework, and/or plug and seal the well. (IA, IL) - New well installation in known or suspected contaminated aquifers should be prohibited. (WA)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OF POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
[illegible]	Hawaii: 7 active wells 3 standby wells 15 proposed wells Potentially found wherever marine or fresh water organisms are cultured in large quantities.	Large volumes of wastewater composed of essentially salt water with added nutrients, bacteriological growth, perished animals, and animal detritus. Effluent typically contains nitrates, nitrites, ammonia, high BOD, and orthophosphate.	Moderate	Nebraska-Rule Utah-Permit Hawaii-Permit Oregon-Permit if injected volume exceeds 5,000 GPD	- Regular sampling and analysis of injection fluid and injection zone fluid should be required (semi-annually). (HI) - Water to be disposed should be filtered and appropriately treated prior to injection. (HI) - Return waters should be carefully monitored at a point before and after treatment to ensure the measures being employed are sufficient to allow the water to be injected. (HI)
[illegible]					
Raw Sewage Disposal Wells (RSWS)	Nationwide: 980 wells Puerto Rico: 5 wells Pennsylvania: no numbers Illinois: 916 wells Indiana: 22 wells Michigan: 11 wells Minnesota: 10 wells Texas: 10 wells Hawaii: 3 wells Alaska: 3 wells	Generally poor quality, including high fixed volatiles, BOD, COD, TOC, nitrogen (organic, and free ammonia), chloride, alkalinity and grease.	High	Illinois-Banned Nebraska-Rule Utah-Banned Hawaii-Permit Nevada-Banned Alaska-Permit or Rule Oregon-Rule	No recommendations concerning raw sewage disposal wells and cesspools were provided in State reports. However, the use of such disposal methods has been banned in several States.
[illegible]	Nationwide: 6,6[illegible] wells New Jersey: [illegible] New York: [illegible] Puerto Rico: [illegible] wells Indiana: [illegible] wells Michigan: 15 wells Minnesota: 2[illegible] wells New Mexico: 14 wells Texas: 16 wells Nebraska: no numbers Wyoming: [illegible] wells Arizona: 1[illegible] wells California: 46 wells [illegible] [illegible] [illegible]	Same as for Raw Sewage Disposal Wells.	High	New Jersey-NJPDES Permit New York-Permit if injected volume exceeds 1,000 GPD New Mexico-Banned Texas-Rule Nebraska-Rule Utah-Banned Wyoming-Permit Arizona-Permit California-Banned Hawaii-Permit Nevada-Banned Alaska-Permit or Rule Oregon-Rule	

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Septic Systems (5W11, 5W31, 5W32)	5W11: 26,769 inventoried wells in 31 States 5W31: 4,435 wells in 13 States 5W32: 3,783 wells in 8 States	Varies with type of system; fluids typically 99.9% water (by weight) and .03 suspended solids; major constituents include nitrates, chlorides, sulfates, sodium, calcium, and fecal coliform.	High	Connecticut-Permit if volume injected exceeds 5,000 GPD Massachusetts-Permit if volume injected exceeds 15,000 GPD New Jersey-NJPDES Permit New York-Permit if volume injected exceeds 1,000 GPD Maryland-Permit (5W31) Alabama-Permit Florida-Permit Kentucky-Rule (5W31) South Carolina-Permit (5W32) Minnesota-Rule Wisconsin-Rule (5W31) Louisiana-Rule New Mexico-Registration Oklahoma-Rule Texas-Local Missouri-Permit Nebraska-Rule Montana-Permit North Dakota-Rule Utah-Permit Wyoming-Permit Arizona-Permit California-Permit Hawaii-Permit (5W31) Nevada-Banned (5W31), Permit (5W32) CNMI-None Alaska-Permit or Rule Idaho-Permit if deeper than 18 feet Oregon-Permit if injected volume exceeds 5,000 GPD (5W32) Washington-Permit/Rule	- Further study is recommended. (FL, MT, OR) - Proper construction and installation guidelines should be developed. (MO) - Ongoing training programs for sanitarians is recommended; should include hydrogeology, ground-water flow, theory of septic system operation, and potential risks to human health. (PR, MD, MN) - Siting should be conducted so as not to endanger water wells. (KS, NE) - All systems should be sited and designed individually. (TX) - Local planning groups should be encouraged to establish septic tank density limits. (NE) - Sewage disposal wells for private facilities should be phased out and replaced by alternate methods of treatment and disposal. (TX) - Well constructions should be investigated. (KS) - Statewide monitoring systems should be established and should include inventory methodology and database updates. (WA)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OF POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
[illegible]	[illegible]	Injected fluid, after secondary or tertiary waste treatment, believed to be generally compatible with receiving formation; may contain high nitrates and fecal coliform if improperly treated.	High to Low	Massachusetts-Permit if injected volume exceeds 15,000 GPD New York-Permit Puerto Rico-Permit Florida-Permit Kentucky-Eliminate Illinois-Rule Indiana-Permit Michigan-Permit Texas-Rule/Permit Nebraska-Rule Utah-Permit Arizona-Permit California-Permit Hawaii-Permit Nevada-Banned Alaska-Permit or Rule Idaho-Rule Washington-Rule	- Operation should ensure that injection is restricted to rates and pressures dictated by site-specific hydrogeologic conditions (should involve monitoring). (WY, AL, HI). - Alternative methods of disposal and feasibility of upgrading existing plants should be evaluated. (VA) - In some cases, wells should be plugged. (KY)
[illegible]					
[illegible]	[illegible]	Hydraulic or pneumatic slurries - Solid portion of slurries may be sand, gravel, cement, mill tailings/refuse, or fly ash. - Slurry waters may be acid mine water or ore extraction process wastewater.	Moderate	Maryland-Permit Pennsylvania-Mine operation West Virginia-Mine operation Alabama-Permit Kentucky-Permit Illinois-Rule New Mexico-Unknown Texas-Rule Missouri-None Nebraska-Rule Colorado-Rule Montana-Permit North Dakota-Rule Utah-Rule Wyoming-Permit Idaho-Rule	- Siting, design, construction, and operation should be specified in permit requirements. (IL) - Slurry injection volumes should be monitored and compared to calculated mine volume to prevent catastrophic failure. (WV) - Ground-water monitoring in areas containing potable water. (MO) - Site-specific study is necessary to determine the nature and extent of degradation from mine backfill wells. (MT) - Authorization of mine backfill wells without permits should continue where tailings are injected into formations that are effectively isolated from USDW. (ID)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Solution Mining Wells (5X14)	Nationwide: 2,025 wells New York: 48 wells Michigan: 15 wells New Mexico: 1,073 wells Wyoming: 14 wells Arizona: 870 wells California: 5 wells Potentially in other mining districts.	Weak acid solutions (sulfuric and hydrochloric) Ammonium carbonate Sodium carbonate/bicarbonate Ferric cyanide	Low	New York-Permit New Mexico-Permit Nebraska-Permit Utah-Permit Wyoming-Permit Arizona-Permit California-Permit	- Network of injection wells should not extend beyond surface projection of ore body. (CA) - New types of mechanical integrity tests for implementation with this well type should be studied. (AZ) - Hydrologic monitoring should be conducted to determine a water budget. (AZ)
In Situ Fossil Fuel Recovery Wells (5X15)	Nationwide: 66 wells Colorado: 23 wells Indiana: 1 well Michigan: 1 well Wyoming: 41 wells Potentially in other areas wtih relatively shallow, organic rich sub strata.	Underground coal gasification: - air, oxygen, steam, water, igniting agents such as ammonium nitrate-fuel oil (ANFO) or propane. In situ oil shale retorting: - air, oxygen, steam, water, sand, explosives, igniting agents (generally propane) Purpose in both cases is to initiate and maintain combustion. Combustion products include polynuclear aromatics, cyanides, nitrites, phenols.	Moderate	Texas-Permit Nebraska-Rule Colorado-Rule Utah-Permit Wyoming-Permit	- Conduct complete geologic and hydrogeologic investigations prior to system implementation. (WY) - Remediate zone fluids to minimize future contamination. (WY)
Spent Brine Return Flow Wells (5X16)	Nationwide: 121 wells New York: no numbers West Virginia: 2 wells Indiana: 8 wells Michigan: 33 wells Arkansas: 70 wells Oklahoma: 7 wells North Dakota: 1 well Potentially in Regions having commercially recoverable halogen deposits.	Limited to brines from which halogens or salts have been extracted; Potential for addition of other undefined constituents into waste stream.	Low	New York-Permit Arkansas-Permit Oklahoma-Rule Nebraska-Rule Utah-Rule	Technical requirements specified in permits should be similar to those for oilfield brine injection wells or solution mining wells. (WV, AR) - Construction requirements should be developed based upon well operating parameters. (AR) - Mechanical integrity tests should be required. (AR) - Semi-annual comprehensive sampling and analysis of fluid and comparison of produced vs. injected fluid should be required. (AR)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
[illegible]					
[illegible]	241 wells inventoried nationwide; potentially [illegible] this number; and would be located in all [illegible]	Dependent upon type of system, type of additives, and temperature of water; open pipe systems may expose ground water to accidental introduction of surface contaminants, industrial spills, or unauthorized disposal of wastes.	Moderate to Low	Massachusetts-Permit if injection volume exceeds 2,000 GPD New Jersey-NJPDES Permit Alabama-Permit Florida-Permit Georgia-Permit South Carolina-Rule Illinois-Rule Wisconsin-Rule Arkansas-None New Mexico-Registration Iowa-Permit Nebraska-Rule Utah-Permit California-Permit Hawaii-Permit Alaska-Permit Idaho-Permit Oregon-Permit if injected volumes exceed 5,000 GPD Washington-Permit	- Minimum locating requirements for the injection well relative to any nearby municipal supply wells should be established. (NE, SC) - Wells should be grouted from at least 20 feet below land surface to land surface or to the water table. (NE) - Wells should be cased from surface to the top of the uppermost supply and injection zone. (AR) - Cemented annulus from surface to supply/injection zone. (AR) - Require minimum of 2 wells: supply well and return well. (AR, SC) - Wells should be constructed such that spent fluids are injected into source aquifer. (AR) - Open loop return flow wells should be prohibited. (FL, AR, NE, UT) - Wells should be plugged with cement upon abandonment. (AR) - Permit specifications needed: Detailed map showing all area wells. Diagram of injection well design. Diagram of entire system. Type and volume of injectate. (AR, NE)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Industrial Process Water and Waste Disposal Wells (5W20)	1,989 inventoried wells in 33 States.	Potentially any fluid disposed by various industries; can have high dissolved solids, suspended solids, alkalinity, chloride, phosphate, sulfate, total volatiles.	High	Connecticut-Permit Massachusetts-Permit New Jersey-NJPDES Permit New York-Permit Maryland-Permit Pennsylvania-Permit Alabama-Permit Florida-Permit South Carolina-Permit Illinois-Rule Wisconsin-Permit Texas-Class I Regulations Nebraska-Rule Utah-Banned Wyoming-Permit Arizona-Permit California-Permit Hawaii-Permit Alaska-Permit Idaho-Permit if deeper than 18 feet Oregon-Permit	- Inventory efforts should continue with high priority on identifying industrial disposal facilities. (PR, IN, WI, AK, WY) - Assume all industrial waste disposal has a deleterious effect on USDW, warranting immediate action. (PA) - Extensive ground-water evaluation studies should be conducted to identify areas which would be vulnerable to contamination by industrial waste disposal. (PR, AL) - Drainage areas surrounding industrial facilities should be studied and all possible pollution sources noted. (KS) - Inspection of these facilities should be mandatory, and conducted by teams backed by chemical or industrial engineers. (PR) - Monitoring programs should be required and sampling specifications should be tightened. (PR, MD, FL, KS) - Ground-water monitoring should be conducted using a minimum of one upgradient and two downgradient wells. (AZ) - Practice of injecting industrial process water and waste should be discouraged, and wastes routed to on-site treatment facilities or municipal sanitary sewer systems. (FL) - Discharge of industrial process wastes to septic systems should be discouraged. (PR, NE) - These wells should be permitted only when injection is into ground water containing greater than ten-thousand mg/l TDS. (FL)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OF POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
[illegible]	Nationwide: 89 wells [illegible] [illegible] [illegible] New Jersey: 18 wells New York: 3 wells Virginia: 1 well Florida: no numbers Illinois: 5 wells Indiana: 2 wells Michigan: 27 wells New Mexico: no numbers Iowa: 1 well Missouri: 5 wells Utah: 2 wells Nevada: no numbers Idaho: 21 wells	Waste oil, antifreeze, floor washings (including detergents, organic, and inorganic sediment) and other petroleum products.	High	Connecticut-Permit New Jersey-NJPDES Permit New York-Permit Florida-Permit Illinois-Rule Nebraska-Rule Utah-Banned Idaho-Rule	- Inventory update is vital. Guidelines for construction, operation, and overall regulation of these wells need to be established. (NY, PR) - Permits should show construction features, a plan to utilize separators and holding tanks, and a plan to sample and analyze injected fluids. (IA) - Underground holding tanks should be required. (UT) - Local building code and sewer pretreatment inspection should identify areas where discharge to sewers is prohibited. (UT)
[illegible]					
[illegible]	Nationwide: 3,558 wells New Hampshire: 1 well New York: 3,000 wells Florida: 349 wells Illinois: 1 well Minnesota: 1 well New Mexico: 30 wells Texas: 44 wells Kansas: 4 wells Nebraska: 4 wells Wyoming: 32 wells Arizona: 51 wells California: 52 wells Idaho: [illegible] wells Washington: [illegible] wells Potentially found in areas characterized by large withdrawals for [illegible] water [illegible] for [illegible]	Dependent upon source; water quality changes noted include adsorption, ion exchange, precipitation and dissolution, chemical oxidation, biological nitrification and denitrification, aerobic or anaerobic degradation, mechanical dispersion, and filtration.	High to Low	New Jersey-Rule/Permit Florida-Permit Illinois-Rule New Mexico-Registration Texas-Permit Nebraska-Rule Utah-Rule/Permit Wyoming-Permit Arizona-Permit California-Permit Idaho-Permit if deeper than 18 feet	- Injection fluid should be of generally equivalent or better quality than injection zone fluid. (NE) - Standards for injectate quality must be on a case by case basis. (AZ) - Regular injectate sampling should be conducted. (NE) - Use of proper design, construction and operation is essential. (FL, NE)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Saline Water Intrusion Barrier Wells (5B22)	California: 155 wells Florida: 2 wells Potentially found in coastal areas typified by abundant fresh water withdrawals for irrigation and/or drinking water.	Varies with type of source; examples include advanced treated sewage, surface urban and agricultural runoff, and imported surface waters.	Low	New Jersey-Rule/Permit Florida-Permit Nebraska-Rule Utah-Rule/Permit California-Permit Washington-Permit	- Pilot studies to define lithologic and hydrogeologic parameters influencing salt water intrusion should be conducted on site-specific basis. (CA) - Characterization of interaction of injectate and formation fluids is necessary. (CA)
Subsidence Control Wells (5S23)	4 wells inventoried for Wisconsin from state reports; it is believed inventory is incomplete; potentially present in desert and coastal areas typified by large, long-term ground-water withdrawals; areas having carbonate aquifers are particularly susceptible to subsidence.	See 'Aquifer Recharge Wells'	Low	Wisconsin-Permit Nebraska-Rule Utah-Rule/Permit	- Injectate quality should be monitored. (CA) - Proper well design, operation, and construction practices should be implemented. (CA) - For additional recommendations, see 'Aquifer Recharge Wells'
Miscellaneous Wells					
Radioactive Waste Disposal wells (5R24)	Unknown number, but existence confirmed for Tennessee, New Mexico, Idaho, and Washington in State reports.	Variety of radioactive materials, including Beryllium 7, Tritium, Strontium 90, Cesium 137, Potassium 40, Cobalt 60, beta particles, Plutonium, Americium, Uranium, and radionuclides.	Unknown	Illinois-Rule New Mexico-Banned Oklahoma-Rule Nebraska-Rule Utah-Rule/Permit Idaho-Permit if deeper than 18 feet Washington-Permit	- Discharges should satisfy all known, available, reasonable treatment and control methods. (WA) - Discharge to cribs and french drains should be pretreated prior to disposal. (WA) - Permits, permit compliance, and enforcement actions should be negotiated annually with EPA through the State/EPA Agreement Program. (WA)
Experimental Technology Wells (5X25)	225 wells in State reports; Potentially located in every Region.	Wide variety of injected constituents: highly acidic or basic compounds for solution mining; domestic wastewater containing high total suspended solids, fecal coliform, ammonia, BOD, pH; air is used in certain water recovery projects.	Moderate to Low	Alabama-Permit Florida-Permit Mississippi-Rule North Carolina-Permit Illinois-Rule New Mexico-Permit Nebraska-Rule Utah-Rule/Permit Wyoming-Permit Arizona-Permit California-Permit Hawaii-Permit Nevada-Permit	- Wells should not be sited and operated so as to permit injection into Class IIB aquifers. (CA) - Detailed hydrogeological studies should be conducted prior to any proposed injection. (CA) - Chemical analysis of waste stream periodically. (CA) - Mechanical integrity tests should be developed and conducted regularly. (CA, FL)

TABLE 5-16, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OF POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
[illegible]	[illegible]	Dependent upon hydrogeologic setting, parameters of the contamination plume, and design of the remediation program; for refinery projects, typical injectate constituents are oil/grease, phenols, toluene, benzene, lead, iron.	Unknown	New Jersey-NJPDES Permit Alabama-Permit North Carolina-Permit Wisconsin-Rule Oklahoma-Rule Nebraska-Permit Utah-Rule/Permit California-Permit	- Implementation of registering and monitoring programs. (KS) - Construction standards should be similar to those established for discharge wells. (OK) Cased from surface through the top of the injection zone. (OK) Screened intervals through sands and gravels. (OK) Annulus should be grouted. (OK) - Injected fluid quality should be better than that of the fluid in the contaminated aquifer but not necessarily of drinking water standards. (FL)
[illegible]	[illegible] wells inventoried. Potentially present in all areas having shallow fresh water aquifers.	Potentially any kind of fluid, particularly brackish or saline water, hazardous chemicals and sewage; documentation of nitrate and coliform contamination documented in Nebraska (Exner and Spalding, 1985); Domestic sewage disposal via these wells documented for 75 homes in Minnesota; also documentation for disposal of pesticides within agricultural runoff (Creek, 1973; Exner and Spalding, 1985).	Moderate	Utah-Banned The following states have plugging and abandonment regulations for water wells: Rhode Island, New Jersey, Puerto Rico, Delaware, Maryland, Pennsylvania, Virginia, West Virginia, Alabama, Florida, Georgia, North Carolina, Tennessee, Illinois, Michigan, Minnesota, Ohio, Wisconsin, Arkansas, Louisiana, Oklahoma, Texas, Kansas, Missouri, Nebraska, Colorado, North Dakota, South Dakota, Wyoming, Arizona, California, Nevada, Alaska, Idaho, Oregon, and Washington	- Must establish a better inventory of wells. (PR, IN, MI, MN) - Wells should be properly plugged using cement. (MN)

SECTION 6
RECOMMENDATIONS

6.1 INVENTORY DATABASE

6.1.1. PRIORITIES

The inventory database is based on reports submitted by the State UIC programs. Inventory data on most of the low-tech well types has been described in this report as generally poor. Both the completeness (inventoried vs. existing) and the quality (level of detail) of the database are poor for the low-tech wells. The lack of inventory information is reflected in the extremely low number of detailed case studies of low-tech wells. Case studies of low-tech well types, including site investigations, will need to be conducted if appropriate policy is to be set concerning their siting, construction, and operation.

Several States recommended that, based on numbers and contamination potential, all types of drainage wells and domestic wastewater disposal wells are appropriate candidates for further study. States also recommended that the inventory and contamination potential of the two well types listed as unknown contamination potential be clarified by further study.

6.1.2 INVENTORY DATABASE UPDATE

Some States recommended that the inventory of newly constructed wells also be tracked along with status changes for inventoried wells. Successful inventory methods and a consistent approach to updating the Class V inventory are discussed below.

6.1.2.1. Inventory Methods

Lessons learned to date on effective inventory methods should be built upon. Some of the more successful techniques and sources of information are listed below.

1. Survey efforts involving questionnaires are an appropriate first step in building an inventory database. A minimum of actual facility information should be requested initially. This may improve inventory response since volunteering lengthy or technically sensitive data goes against human nature.

2. Personal, follow-up telephone calls to respondents for data verification and to explain the UIC program have been especially useful in obtaining cooperation when a more detailed questionnaire or report is needed later. Personal follow-up is also a very good technique for producing new inventory leads.

3. Federal, State, and local government agencies are storehouses of information on Class V injection wells. Much of the current inventory information was provided by these sources. Indications are that these sources have not been fully utilized. There are problems associated with information accessibility because it has not been filed according to Class V well types. Many agencies have indicated they do not have the manpower or finances to sort through files and determine which wells meet Class V criteria.

4. Visits to regulatory agencies and site inspections are invaluable for in-depth investigations and new inventory leads.

Details on compiling mailing lists and agencies which have information on specific well types and other inventory strategy can be found in Section 3, Class V Injection Well Inventory.

6.1.2.2. Mechanism for Updating the Class V Inventory Database

Presently, there is not a well defined, consistent approach among USEPA Regions or State and local governments to locate additional inventory and report it. This has seriously hampered inventory and assessment efforts to date. Consequently, a mechanism or system for passing along information needs to be developed. Ideally, one designated State agency would interface between the USEPA Region and other agencies in the same State. The interface would pass along new inventory information and be a directory for additional information requests. At least an annual update to the Class V injection well inventory database is needed in order to prioritize USEPA efforts. Some confusing inventory information could be eliminated if the database used the new well type codes (Table 1-1).

In order to enhance obtaining a more complete inventory database for all Class V wells, concerted effort on the part of agencies at all levels of government will be required. It will be necessary to redefine areas that may have Class V wells present and initiate a new questionnaire mailing. Historically, this has been best accomplished at the local or State levels by water resource and waste management agencies. These authorities seem to be most familiar with potential Class V injection facilities, and should be able to follow up questionnaire mailings with personal contact or provide more intuitive [illegible]

that replies be received for each questionnaire issued. It should not be assumed that no reply indicates there are no Class V wells at a given location.

Another essential element in building a more complete inventory database for Class V wells is the development of a more thorough public awareness about these wells and appropriate regulations. Many owners of private, small-scale domestic, or commercial facilities probably are not aware that they need to report their injection systems. A campaign must be conducted to promote public knowledge of potential contamination to major drinking water supplies as a result of unregulated Class V injection. The public must be made aware that valuable groundwater supplies are limited and susceptible to irreversible degradation.

6.2 CLASS V WELL TYPES

6.2.1 SITING, CONSTRUCTION, OPERATION, CORRECTIVE AND REMEDIAL ACTIONS

The following sections contain a discussion of recommendations for siting, construction, and operation of existing and future Class V injection wells. Recommendations are made for groups of well types established on the basis of contamination potential.

While certain recommendations are unique to specific Class V well types, many States made some general recommendations that apply to all well types, regardless of the rated contamination potential. These recommendations address the need for:

1. continued inventory efforts;

2. in-depth hydrogeologic studies for active and potential areas of Class V injection;

3. periodic comprehensive sampling and analysis of injected fluids and injection zone water;

4. protection of USDW by adequate construction and operational monitoring;

5. maintenance and verification of mechanical integrity; and

6. proper plugging and abandonment of wells upon termination of injection activities.

Certain well types are not characterized by a single contamination potential. Because of a wide disparity in State report assessments and case study data, some well types were found to

pose low or moderate contamination potential in certain areas and high potential in others. For the purpose of the subsequent recommendations summary, well types will be discussed under the highest contamination potential ascribed in a range. State reports containing applicable recommendations are indicated in parentheses.

6.2.1.1 High Contamination Potential Well Types

Well types assessed as having high contamination potential are:

- Agricultural drainage wells, 5F1;
- Improved sinkholes, 5D3 (high to moderate);
- Raw sewage waste disposal wells, 5W9, and cesspools, 5W10;
- Septic systems, 5W11, 5W31, 5W32;
- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);
- Industrial process water and waste disposal wells, 5W20;
- Automobile service station waste disposal wells, 5X28; and
- Aquifer recharge wells, 5R21 (high to low).

Agricultural Return Flow Wells (5F1)

Locating and properly plugging all abandoned wells within the immediate area of agricultural drainage wells would significantly aid in protecting USDW (IA). Injected fluids should be required to meet all or some National Drinking Water Regulations (NE, OR). Recovery and pumpback of irrigation tailwater should be required (OR). Water from drinking water supply wells near agricultural drainage wells should be sampled and analyzed frequently to detect any contaminant mobility (NE).

A detailed map of the location of injection wells and all municipal, domestic, and stock wells within one mile of the injection wells should be required. A diagram showing construction features of injection wells should also be required, and all ADW should be sited at least 2,000 feet away from any stock, municipal, or domestic well (NE).

Closing surface inlets in order to allow infiltration through the soil would decrease the transport of bacteria, pesticides, and sediment to the aquifer (NE). [illegible]

inlets to the injection wells should be raised above ponding levels.

The volume of irrigation return flow would be reduced by applying only the quantity of water necessary and only the amounts of chemicals necessary to meet crop requirements and maintain correct soil balances (CA). Use of ADW should be discouraged and elimination should be encouraged: alternative drainage methods should be developed (IA).

Improved Sinkholes (5D3)

Little is currently understood about these wells, and few recommendations were provided in the State reports. The Puerto Rico report suggests that well construction training should be required for engineers and drillers, with special emphasis on sanitary sealing and protection against corrosion. Missouri suggests running careful, dye trace studies on improved sinkhole drainage systems.

Raw Sewage Disposal Wells and Cesspools (5W9, 5W10)

Assessments for these well types found within State reports indicate that the construction of any such wells should be strictly prohibited. Regional ground-water contamination resulting from cesspools and raw sewage disposal wells has been documented. Recommended on-site disposal systems for domestic wastewater would be septic systems with drainfields or septic tanks with absorption mounds.

Septic Systems (5W11, 5W31, 5W32)

Septic systems are a widely varied group of Class V facilities, and include undifferentiated systems, well disposal systems, and drainfield disposal systems. Because of the variabilites noted for disposal methodology, construction design, and operation, large variations in contamination potential are recognized.

Of extreme importance is that national continuing public education programs be implemented, with specific emphasis toward septic system owners. A key aspect to continued education about septic systems and their potential threat to USDW will be ongoing training programs for sanitarians at local and State levels. This training should include hydrogeology, ground-water flow, theory of septic system operation, and potential risks to human health (PR, MD, MN).

Kansas and Nebraska suggested that septic systems be sited in well-studied drainage areas to avoid endangering water wells. Present local regulations may ignore hydrogeology and allow

migration to the owner's and/or neighbor's wells. Septic systems which dispose without adequate treatment should be eliminated. Nebraska further recommended that the density of septic systems and total loading to ground water be studied.

Three States (Florida, Montana, and Oregon) recommended that further study is required. Missouri recommended that proper construction guidelines be developed, and Kansas suggested investigating facilities to ensure quality well construction.

Washington identified a critical need to establish a statewide monitoring system, inventory methodology, and database in order to evaluate design for existing systems, establish ambient water quality in vulnerable aquifer regions, and be able to quantify changes in critical parameters.

Texas recommended that systems be individually sited and designed and that sewage disposal wells for individual facilities be phased out.

Domestic Wastewater Treatment Plant Disposal Wells (5W12)

This is another well type that demonstrates much variability in design and operation, resulting in wide variations in assessed contamination potential. Operation should ensure that injection is restricted to rates and pressures dictated by site-specific hydrogeologic conditions. This will involve continuous monitoring of operations, assuring that injectate does not exceed standards set forth in waste disposal permits (WY, HI, AL). Alternative methods of disposal and feasibility of upgrading existing plants should be evaluated (VA). In some cases, wells should be plugged (KY).

Industrial Process Water and Waste Disposal Wells (5W20)

Inventory efforts must be continued with high priority placed upon identifying industrial disposal facilities (PR, IN, WI, AK, WY). It is believed that some industrial disposal into or above USDW will have a deleterious effect upon those aquifers, warranting immediate remedial or corrective action (PA). The practice of injecting these wastes in the future should be discouraged, and wastes should be routed to on-site treatment facilities or municipal sanitary sewer systems (FL). The discharge of these wastes to septic systems should be discouraged (PR, NE). Extensive ground-water evaluation studies should be conducted to identify areas potentially vulnerable to contamination by industrial disposal. This study would include an analysis of drainage areas surrounding industrial facilities, noting all possible sources of pollution (KS, PR, AS).

Periodic site inspections should be mandatory for these facilities, and inspections should be conducted by trained [illegible]

ical and industrial engineers (PR). Monitoring programs should be specifically required and should include sampling and analysis of ground water. A minimum of one upgradient and two downgradient wells for monitoring ground water are recommended, and the well pattern should be sufficient to detect any migration of injected fluid into USDW (PR, MD, FL, KS, AZ).

The NPDES program could be more effective in helping the UIC program by requiring sewer improvement districts to inventory all industrial users of their systems and to review details of each user's waste stream(s) (NY). The issue of reluctance of operators to report their wells can be overcome by presenting a coordinated program (about waste streams that are allowed) through a multi-media approach (States in Region V).

All non-hazardous industrial process water and waste disposal wells shown to have a high contamination potential should be phased out. These wells should be required to inject below USDW as Class I wells in the future. Other 5W20 wells should be periodically checked for injection rate and fluid quality (States in Region VI).

The policy of prohibiting the installation of septic tank/drainfields for treating embalming fluids should be continued. (Current practice requires holding facilities and periodic removal and proper disposal.) (SC).

Until additional data are at hand to define the fate of industrial wastes in the saturated zone, it is prudent to take extraordinary precautions to minimize the potential for aquifer degradation via injection of highly toxic substances. Alternatives to land disposal such as recycling or resource recovery, reduction of wastes generated through process modification, and improved methods of hazardous waste neutralization should be actively pursued (WA).

Automobile Service Station Disposal Wells (5X28)

As with most Class V well types, continued inventory update is vital to continued monitoring and regulation of these wells. In general, guidelines for construction, operation, and overall regulation of these wells do not exist and must be established immediately (NY, PR). Iowa suggests requiring a permit to operate which would include information on construction features, a plan to utilize separators and holding tanks, and a plan to sample and analyze the injected fluids.

Utah suggests that these wells can be corrected by providing underground holding tanks (total containment) for the waste oils/fluids. These tanks would require regular off-loading to waste oil reclaimers. In Utah, there is economic incentive for a service station to sell waste oil to a reclaimer. The management of these wells would best be accomplished at the local government

level because they already enforce their building and sewer ordinances. Any inspections by State or Federal staff would be a duplication of effort.

Utah continues that communities with a water reclamation system commonly prohibit oil and grease discharges to their sewer. Consequently, some operators opt to discharge to dry wells as a "loophole" to the environmental regulations. Local building code and sewer pretreatment inspection should be able to locate and manage these wells.

Finally, Utah states that the UIC program has not been effective in controlling this problem, but local government has. The UIC program can be more effective by educating those local government staff who conduct building and environmental inspections. This training will help locate these violators and hopefully solve the problem.

Aquifer Recharge Wells (5R21)

Design, construction and operation features will vary, depending upon the type of project, but it is essential that high standards be set and strictly enforced by regulatory agencies for these parameters. Again, because operations can vary so widely, standards for injectate quality must be determined on a case-specific basis (AZ). In general, injection fluids should be of equivalent or better quality than injection zone fluids, and periodic sampling and analysis of injectate and injection zone fluids should be required (NE). Certain wells of this type have been assessed as having high contamination potential (FL), whereas others have been rated moderate (TX). It is believed that properly designed, constructed, and operated wells may be assessed as low potential for contamination.

6.2.1.2 Moderate Contamination Potential Well Types

Well types assessed as having a moderate contamination potential include:

- Storm water drainage, 5D2, and industrial drainage wells, 5D4;
- Improved sinkholes, 5D3 (high to moderate);
- Special drainage wells, 5G30 (moderate to low);
- Electric power, 5A5, and direct heat reinjection wells, 5A6;
- Aquaculture return flow wells, 5A8;

- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);

- Mining, sand, or other backfill wells, 5X13;

- In-situ fossil fuel recovery wells, 5X15;

- Cooling water return flow wells, 5A19 (moderate to low);

- Aquifer recharge wells, 5R21 (high to low);

- Experimental technology wells, 5X25 (moderate to low); and

- Abandoned drinking water/waste disposal wells, 5X29.

Stormwater and Industrial Drainage Wells (5D2, 5D4)

Inventory efforts should continue and newly located wells should be investigated and added to FURS (KY, UT, WA). The construction of new industrial drainage wells should be severely limited (OR, IL). Storm water sewers, detention ponds, or vegetative basins are the preferred alternatives (UT). If sewers are cost prohibitive, on-site vegetated basins with fine-grained sand beds should be constructed (Grass swales have been discovered in the NURP study to provide moderate improvements in runoff quality). Retention basins might be planned so runoff can be released slowly into the sanitary sewer or treated before entering the well (KY, TN). Sand and gravel filters should be added to wells (KY, TN). Stand pipes should be constructed, several feet in height, at the opening of wells (KY, TN).

Future construction should be limited to residential areas (IL). All spills should be diverted away from industrial drainage wells (PA, IA, OR, KY, UT, WA). The construction of new storm water and industrial drainage wells in areas served by storm water sewers should be prohibited (CA, AZ). Drainage wells should not be constructed within 200 feet of water supply wells which tap lower water-bearing aquifers (CA). Deep wells should be plugged or cemented to avoid mixing between aquifers (KY, TN).

Depth to ground water information should be made readily available to drainage well drillers and land planning engineers. Separation distances between the depths of storm water drainage wells and ground-water tables should be maximized. Proposed wells which would penetrate perched ground water or water tables should not be constructed (AZ).

Additional research should be conducted to study the prolonged effect of industrial drainage wells on ground-water quality. Additional research relating to the attenuation of

metals and organics under long term discharge conditions from industrial and storm water drainage wells should be conducted (States in Region VIII). Ground-water monitoring programs in industrial areas with many industrial drainage wells are advisable (FL, WI, KS). Sediments extraced from drainage wells catch basins, or sediment traps should be disposed in an appropriate landfill. Due to possible metal concentrations, these sediments may be considered as hazardous materials (AZ).

Assessment of the effects of drainage wells should be conducted prior to completing an inventory because the inventory would be time-consuming and costly (MT, OR). A public awareness program should be implemented (AZ).

Special Drainage Wells (5G30)

Certain wells that fall under this classification probably have been inventoried as other well types. Other inventoried well types should be cross-checked for special drainage wells.

In sensitive hydrogeological areas, continual monitoring of injection fluid volume and quality should be conducted. Florida recommended that random sampling and analysis of swimming pool waste fluids be conducted to define possible contaminants.

Electric Power and Direct Heat Reinjection Wells (5A5, 5A6)

Most recommendations for electric power and direct heat reinjection wells are derived from the California and Nevada reports. These wells are characterized by generally high volumes of disposed fluids. More work is necessary in the near future in determining what surveys will be the most reliable indicators of mechanical integrity.

It is essential that accurate characterization of injection fluids be conducted not only before operations begin but also periodically during the life of the facility. Parameters of concern in physical and chemical analyses of injection fluids include temperature, inorganic constituents of National Primary and Secondary Drinking Water Regulations, alkalinity, hardness, boron, silica, and ammonia nitrogen.

Geothermal fluids should not be injected into non-thermal reservoirs unless the receiving fluids are of equal or lesser quality or the thermal injection fluids meet drinking water standards (ID). Besides temperature pollution, concentrations of most other dissolved solids would be increased. Beneficial uses of most non-thermal waters with TDS <1,000 mg/l could be seriously altered if heat spent geothermal fluids from high temperature reservoirs were injected. Even heat spent geothermal fluids from low temperature resources should not be injected into non-thermal waters without carefully considering water quality.

Most drinking water quality aquifers in the western United States would be negatively impacted by such a practice.

Aquacultural Return Flow Wells (5A8)

All recommendations for aquaculture return flow wells are derived from the Hawaii report. Wells of this type located in Hawaii should always be sited outside the UIC Line, as defined by the Hawaii Department of Health, and should be located as close to the coast as possible, where applicable. Injection well casing should be constructed of lightweight steel or Schedule 40 PVC. The annulus should be filled with rock packing across the injection zone and cement grout between the surface and the rock packing. An extremely important recommendation is that injection wellheads should not be open at the surface so as to allow disposal of unauthorized liquid wastes.

Regular comprehensive sampling and analysis of injectate and injection zone fluids should be required. Because injection volumes are typically high and waste streams are characteristically variable, semi-annual sampling is recommended.

Mining, Sand, or Other Backfill Wells (5X13)

Siting, design, construction, and operation of these wells should be specified in permit requirements (IL, KY, ID). Slurry injection volumes should be monitored continually and compared to calculated mine volumes to prevent catastrophic failure due to over-injection (WV). Regular analysis during injection operations should continue. It will be important to monitor ground water regularly in areas containing potable water (MO). Site-specific studies should be conducted to determine the nature and extent of degradation due to mine backfill wells (MT). Authorization without permits of mine backfill wells should be continued where tailings are injected into formations that are effectively isolated from USDW (ID).

In Situ Fossil Fuel Recovery Wells (5X15)

As part of any in situ fossil fuel recovery program utilizing injection wells, complete geologic and hydrogeologic investigations should be conducted prior to system implementation. All operations should have a well-defined remediation program for injection zone fluids to minimize future ground-water contamination after operations are terminated (WY).

Cooling Water Return Flow Wells (5A19)

Many States regulate cooling water return flow wells under a permit system. Permit specifications for these wells are not

consistent. It is recommended (IA, NE) that all permit applications include the following material:

1) detailed map showing all wells in the area;

2) a diagram of the injection well system;

3) a diagram of the entire operational system; and

4) detailed chemical and physical analysis of the injectate.

All injection wells of this type should be constructed such that injection of spent fluids is into the source aquifer. In addition, wells should be cased from the surface to the top of the uppermost supply and injection zone. Open loop return flow wells should be prohibited (FL, AR, NE).

Cooling water return flow systems should have a minimum of two wells: one supply well and one injection well. No additives should be used (AR). Upon abandonment, all wells should be plugged with cement (AR).

Experimental Technology Wells (5X25)

All recommendations for experimental technology wells are derived from the California and Arizona reports. Before operations for any experimental technology facility can commence, detailed hydrogeologic studies should be conducted for the area of interest. Of primary importance in such a study will be to determine the occurrence of USDW and, more importantly, the occurrence of aquifers of Class IIB or better quality. Injection into any Class IIB or better aquifer should be strictly prohibited.

Chemical analysis of the injection fluid should be conducted periodically, and the frequency should be dependent upon such factors as potential toxicity of the fluid and the consistency of the injected stream. Finally, a system of mechanical integrity testing applicable to these wells needs to be developed, and those tests should be conducted regularly. Annual mechanical integrity testing would be sufficient.

Abandoned Drinking Water/Waste Disposal Wells (5X29)

Because these wells are potentially located in all regions of the nation, it is critical that a better inventory database is established (IR, IN, MI, MN). This will require efforts at all regulatory levels. Wells of this type that are located should be properly plugged using high-quality cement (MN).

6.1.2.3 Low Contamination Potential Well Types

Wells rated in this assessment as having low potential for contamination are:

- Special drainage wells, 5G30 (moderate to low);
- Heat pump/air conditioning return flow wells, 5A7;
- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);
- Solution mining wells, 5X14;
- Spent brine return flow wells, 5X16;
- Cooling water return flow wells, 5A19 (moderate to low);
- Aquifer recharge wells 5R21 (high to low);
- Saline water intrusion barrier wells, 5B22;
- Subsidence control wells, 5S23; and
- Experimental technology wells, 5X25 (moderate to low).

Heat Pump/Air Conditioning Return Flow Wells (5A7)

As with most Class V injection systems, it is essential that characteristics of the production/injection aquifer system be thoroughly understood. In addition, inventory updates must be continually conducted.

Adequate spacing between production and injection wells must be maintained (KS, NE). This will serve to enhance system efficiency and limit thermal interactions between injected fluids and fluids near the production wellbore. Return wells should be cased through the top of the injection zone, and the annular space should be grouted or cemented (IA, KS, NE).

It is important that the injection zone be the same as the production zone from water quality and availability standpoints. If injection must occur into a zone other than the production zone, the injectate should be of equal or better quality than water in the injection zone (LA, KS, IA). Volumes and temperatures of return fluids should be monitored continually, and comprehensive sampling and analysis of both injection and receiving fluids should be conducted periodically (KS, NC).

g Wells (5X14)

injection wells should not extend beyond the of the ore body (CA). It is also important ıducted to determine what types of mechanical ›uld be implemented for testing these wells.

:urn Flow Wells (5X16)

tions for spent brine return flow wells are :ate report. Technical requirements specified se wells should be similar to those for oil ›n wells. Construction and operation designs scope of operations and should be developed operation parameters of interest. Mechanical uld be required periodically. In addition, hensive sampling and analysis of injection :on of produced and injected fluids, should be on of fluids other than spent brine (e.g. d be prohibited.

trusion Barrier Wells (5B22)

ions for saline water intrusion barrier wells › California report. These wells are usually e to heavy ground-water withdrawals for king water in coastal areas. Intrusion of to zones of high discharge by wells, thus p intrusion barriers must be into the same ; injection is typically into Class IIB or t is essential that studies precede any ›f this type. These studies should address thologic and hydrogeologic parameters influ- intrusion and the impact of proposed injec- ection aquifers. Delineation of USDW within be a goal of such studies.

rol Wells (5S23)

for this well type are generally consistent ; previously for "Aquifer Recharge Wells." ed to that section for recommendations.

:amination Potential Well Types

l types have been assessed as having unknown al, based upon broad-scale lack of knowledge ence and operation. These well types are:

- Radioactive waste disposal wells, 5N24

- Aquifer remediation wells, 5X26 (incl
  recovery injection wells).

Radioactive Waste Disposal Wells (5N24)

Since the current inventory may constitute
of existing wells, it is recommended that in
radioactive waste disposal practices be conducte
of facilities in Tennessee, New Mexico, Wa
Oklahoma, and Illinois has been confirmed.

Washington provided the following recomme
discharges should satisfy all known availa
treatment and control methods. Second, discha
french drains should be pretreated prior to
permits, permit compliance, and enforcement a
negotiated annually with EPA through the Sta
Program.

Aquifer Remediation Wells (Including Recovery Injection Wells) (5X26)

Because projects of this type are believe
in many, if not all, of the regions, the i
registering and monitoring programs must be
Construction standards for these wells should b
established in permitting requirements for othe
Wells should be cased from the surface throug
injection zone. Screened intervals should
injection zones are sands and gravels. Perfo
used in less permeable injection lithologi
between wellbore and casing should be grouted
some type of cement (OK).

APPENDIX A

State Report Summary Sheets

Region I State Report Summaries

Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Prepared: 5-15-87
Updated: 8-14-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Connecticut **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: State of Connecticut UIC Class V Assessment

AUTHOR: Water Compliance Unit of the Department of Environmental Protection

DATE: 4-87 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): Water Compliance Unit DEP

HYDROGEOLOGY: N/A

INVENTORY AND ASSESSMENT: 84 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5A7	12	None	Yes	Permit
5W20	6	Moderate	Yes	Permit
5W11	62	High	Yes	Permit (75000 gpd)
5X28	1	High	Yes	Permit
5D2	3	N/A	No	Permit

Strategy	Rating/Response
N/A	N/A

RECOMMENDATIONS:

To address the concern about 5X28 wells, the following strategy will be used by the Connecticut DEP:

Task I - Continue the existing program of inspection by existing field and engineering staff of facilities that could discharge to the groundwaters of the state with emphasis placed on facilities that could contaminate underground sources of drinking water.

Task II - Contact the owners and/or operators if the facilities that discharge to the ground via letter informing them of the need to apply for and obtain a permit for these discharges and the Department's policy of not granting discharge permits in GA or GAA and GB groundwater classification areas.

Task III- Contact the Directors of Health of each of the 169 towns in Connecticut informing them of:

1. The potential for groundwater contamination from unpermitted discharges to the groundwater from floor drains at gas stations and auto repair shops.

2. The department's program of permitting and enforcement actions for groundwater discharges from floor drains under the Connecticut Water Pollution Control Statutes.

Prepared: 1-28-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report additional correspondence, and verbal communication)

STATE: Maine **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: Revised Interim Report: Maine's UIC Program

AUTHOR: Maine Department of Environmental Protection

DATE: 12-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
Maine Department of Environmental Protection

HYDROGEOLOGY:
Areas with rocky outcrops tend to be characterized by highly or moderately fractured bedrock relatively near the surface. In most such instances, the fissures are saturated with groundwater. The pumping of liquid wastes into the ground requires the displacement of the groundwater in these fissures.

Other areas of Maine consist of sand and gravel aquifers, usually overlying marine clays or bedrock zone. In such areas, forcible injection is feasible, yet the costs are still high relative to other disposal techniques. Also, most of Maine's sand and gravel aquifers are in moderately to heavily populated areas and are valued water supplies. This has discouraged the development of injection facilities within those areas.

INVENTORY AND ASSESSMENT: 15 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5W20	15	Variable	9 facilities	N/A

Strategy	Rating/Response
N/A	N/A

RECOMMENDATIONS:

N/A

Prepared: 12-4-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report additional correspondence, and verbal communication)

STATE: Massachusetts **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Underground Injection Control in the Commonwealth of Massachusetts

AUTHOR: Division of Water Pollution Control

DATE: 7-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES): Division of Water Pollution Control (DWPC)

HYDROGEOLOGY: No overview of general hydrogeology of the state is provided. However, site-specific hydrogeology is addressed in case study assessments.

INVENTORY AND ASSESSMENT: 131 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies*	Regulatory System
5D2	19	Low	Yes	Exempt from permit if area is separated from industrial activities.
5A7	10	Low	Yes	Permit if discharge exceeds 15,000 GPD.
5W11	27	Low	No	Permit if discharge
5W12	72	Low	Yes	exceeds 15,000 GPD.
5A19	3	Low	Yes	Permit if discharge exceeds 2,000 GPD or temp. of inj. fluid exceeds 40°C.
5W20	1	Moderate	Yes	Discharge permit required.

* Those provided are very brief but well summarized.

Strategy (Date)	Rating/Response
N/A	N/A

RECOMMENDATIONS:
N/A

Prepared: 12-12-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report additional correspondence, and verbal communication)

STATE: New Hampshire **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: Inventory of Class V Injection Wells in New Hampshire (Plus additional correspondence)

AUTHOR: New Hampshire Water Supply and Pollution Control Commission

DATE: ? **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES): New Hampshire Water Supply and Pollution Control Commission

HYDROGEOLOGY: N/A

INVENTORY AND ASSESSMENT: 38 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies*	Regulatory System
5D3	3	N/A	Yes	N/A
5D4	16	N/A	Yes	N/A
5A7	2	N/A	Yes	N/A
5A19	3	N/A	Yes	N/A
5W20	13	Variable	Yes	N/A
5R21	1	Low	Yes	N/A

* Specific data are provided on each individual well but no studies were conducted over any lenth of time. Perhaps these should be termed "skeleton" case studies.

Strategy (Date)	Rating/Response
N/A	N/A

RECOMMENDATIONS:
N/A

Prepared: 5-15-87
Updated: 8-14-87

STATE REPORT SUMMARY
(All information recorded as described in state report additional correspondence, and verbal communication)

STATE: Rhode Island **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: State of Rhode Island Underground Injection Control Program Class V Well Assessment

AUTHOR: Department of Environmental Management, Division of Water Resources

DATE: 7-87 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): Department of Environmental Management, Division of Water Resources, Groundwater Protection Program

HYDROGEOLOGY: Groundwater is utilized by 24% of the population and is derived from two formations: consolidated paleozoic bedrock and unconsolidated pleistocene glacial deposits. Three specific geographical regions were studied. (1) Block Island, a sole source aquifer, glacial washout and till. (2) Southern portion of state, similar to geohydrological formations as in Number 1. (3) Central portion of state, sand and gravel aquifer.

INVENTORY AND ASSESSMENT: 80 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5A19	8	High	Yes	N/A
5W11	8	Low	Yes	N/A
5W20	59	Mod./High	Yes	N/A
5X28	3	Low	Yes	N/A
5X26	2	High	No	N/A

* Some facilities reported lagoons as Class V wells.

Strategy		Rating/Response
Task 1.	Identify UIC Class V injection wells, review the chemical analysis of waste streams and register them with the state UIC program.	N/A
Task 2.	Segregate specific Class V wells having highest potential for contamination which could impact groundwater aquifers supplying public and privately-owned wells.	N/A

Task 3. Eliminate or modify Class V well discharges which are impacting underground drinking water supplies to comply highest attainable groundwater quality. NOV's and order are issued against those facilities that are not in compliance. Fines issued with Administrators' Order are based upon established penalty matrix.	N/A

RECOMMENDATIONS:

N/A

Prepared: 5-15-87
Updated: 8-14-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Vermont **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Vermont Class V Injection Well Inventory and Assessment

AUTHOR: Ground Water Management Section, Dept. of Water Resources and Environmental Engineering

DATE: N/A **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): Vermont Agency of Environmental Conservation, Water Quality Division, Groundwater Management Section

HYDROGEOLOGY: Shallow unconsolidated groundwater aquifers

INVENTORY AND ASSESSMENT: 15 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5X28	10	Mod./High	Yes	N/A
5W20	5	Mod.	Yes	N/A

Strategy	Rating/Response
(All well types)	
-Contractor mailed over 1,000 surveys to town clerks, health officers, planning commissions, water well drillers, septic system contractors, consulting engineers, industrial and environmental groups.	28% response 1 well located
-Published public notice in 16 newspapers.	No response
-Conducted file reviews (storage, transport, treatment, and disposal facilities-hazardous waste).	5 wells located
-Act 250 Review (plans submitted for new or renovated developments-reviewed weekly).	No wells located
(Sewage related wells)	
-Surveyed 53 septage haulers	22 responses

-Conducted 450 file reviews (mobile home parks, public buildings, campgrounds, and subdivisions).	No wells located
(Agricultural drainage wells-5F1) -Contacted Public Facilities Division of the Agency of Environmental Conservation	No wells located
(Heat pump return flow-5A7) -Sent public notice to 20 heat pump installers	7 responses
(Auto service stations-5X28) -Contacted 68 automotive repair stations	10 wells located

RECOMMENDATIONS:

1. The database of injection wells is small, and updating the inventory can be accomplished by site visits coupled with a telephone survey of the injection well operators.

2. Other methods of updating and future surveying of injection wells will continue through the Act 250 inter-agency communications.

3. Methods of remedial action have not been specifically addressed as there are no contaminating injection wells.

4. The injection well location, nature of establishment, type of fluid being discharged, and volume of fluid may be of critical importance to the emergency response program in case of accidents.

Region II State Report Summaries

New Jersey
New York
Puerto Rico
Virgin Islands

Prepared: 4-28-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: New Jersey **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: Underground Injection Control (UIC) Program Inventory and Assessment of Class V Wells Statewide

AUTHOR: New Jersey Department of Environmental Protection

DATE: ? **REPORT STATUS:** ?

HYDROGEOLOGY: New Jersey is divided into two distinct geographic provinces. The Appalachian Province consists of Paleozoic strata, Pre-Cambrian metamorphic rock, and Mesozoic sediments interbedded with intrusive igneous sills. This region is extensively folded and faulted and has two separate groundwater systems (consolidated bedrock and unconsolidated glacial sediments). The Atlantic Coastal Plain consists of unconsolidated, stratified and unstratified, Mesozoic and Cenozoic Sediments underlain by Pre-Cambrian basement-rock complex.

INVENTORY AND ASSESSMENT: 379 wells identified (3000-6000 estimated) **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	1	N/A	No	NJPDES Permit
5D4	1	N/A	No	NJPDES Permit
5A7	181	N/A	Yes	Rule/Permit
5W10	1	N/A	No	NJPDES Permit
5W11	143	N/A	No	NJPDES Permit
5A19	5	N/A	No	NJPDES Permit
5W20	20	Variable	Yes	NJPDES Permit
5R21	0	N/A	No	Rule/Permit
5B22	0	N/A	No	Rule/Permit
5X26	9	N/A	No	NJPDES Permit
5X28	18	N/A	Yes	NJPDES Permit

Strategy (date)		Response/Rating
(12-86)	File search of NJPDES permits.	N/A
(1981)	Preliminary survey obtained from state records and questionnaires mailed to various institutions and organizations	1024 facilities identified
(?)	Mailed permit application to 339 facilities (from preliminary survey).	31%

RECOMMENDATIONS

1. More NJPDES/DGW-UIC permits need to be issued to existing facilities to determine any impact on existing groundwater quality;

2. All new or proposed facilities desiring to utilize subsurface disposal as their primary means of waste management must provide adequate pretreatment of effluent sufficient to meet the State's groundwater quality standards at a pre-determined point of compliance;

3. All existing or abandoned Class V wells which cannot meet the groundwater quality standards must implement a detection monitoring program, pursuant to an order to permit, and enter into remedial mitigation concerning groundwater quality enhancement;

4. Funding from U.S. Environmental Protection Agency must be significantly increased from its present level ($81,800) just to fulfill the minimum reporting requirements of the UIC program. Additional resources are currently needed by NJDEP if it is to perform the required enforcement and permit administration activities to meet EPA's expectations.

5. In terms of groundwater quality, protection and preservation, increased emphasis needs to be placed on creating new treatment facilities, in addition to upgrading existing ones, which are capable of achieving current drinking water or surface water standards.

Prepared: 1-28-87
Updated: 5-05-87

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: New York **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Class V Injection Well Inventory and Assessment: State of New York

AUTHOR: SMC Martin

DATE: 9-83 **REPORT STATUS:** ?

RESPONSIBLE AGENCY(IES):
New York Department of Environmental Conservation

HYDROGEOLOGY:
New York consists of several different provinces controlled by bedrock geology. Each province is blanketed by unconsolidated deposits in the form of glacial drift or coastal plain sediments underlain by consolidated bedrock. Unconsolidated deposits concentrating in stream valleys and Long Island have the highest permeabilities and serve as the principal aquifers but also serve as efficient zones for injection.

INVENTORY AND ASSESSMENT: 7,172 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	150**	Variable	No	SPDES permit
5D2	2,500	Positive	No	SPDES permit (>1000 gpd)
5D4	1,100	N/A	No	SPDES permit (industrial)
5A6	X	N/A	No	N/A
5A7	X	Low	No	Permit
5W10	X	Significant	No	Permit (>1000 gpd)
5W11	X	Significant	No	Permit (>1000 gpd)
5W12	21	N/A	No	SPDES permit
5X14,16	48	N/A	No	Permit
5W20	350	Significant	Yes	SPDES permit
5R21	3,000 basins	N/A	No	N/A
5S23	X	N/A	No	N/A
5X28	3	Highest	No	Permit
5W31	X	N/A	No	Permit (>1000 gpd)
5W32	X	N/A	No	Permit (>1000 gpd)

* "X" indicates well type is believed to exist; no numbers available
** May discharge to either surface or groundwater

Strategy	Rating/Response
1. Review preliminary report completed by the NYSHD on Class V injection wells.	Incomplete
2. Contact state and federal agencies and conduct library research to obtain information on geology, contamination from Class V wells, and regulations.	N/A
3. Contact county health officials with a letter of introduction and a questionnaire concerning the inventory, contamination, and local aquifers.	Limited
4. Contact county health officials and New York Department of Environmental Conservation with a follow-up telephone survey.	100%

RECOMMENDATIONS:

1. Further regulatory control of Class V injection wells.
   a. Type and degree of regulation would most efficiently be developed and implemented by local agencies with respect to specific and potential contamination problems, geology, and pre-existing injection well concentrations.
   b. Such regulation should inventory and classify existing and proposed Class V injection wells for further site specific contamination assessment and permitting.
2. Further study into Class V wells covered by the SPDES program since several county health officials felt the SPDES permit file was not complete or up to date.
3. Further study into the assessment of area of high contamination potential rather than an assessment covering the whole state. Such areas should be chosen with respect to known contamination from Class V injection wells, high injection well concentrations, and geology.
4. Further study into the Smithtown, Suffolk County area, and continuation of the preliminary report.
5. Investigation of other areas of high Class V well contamination potential using a methodology similar to the Smithtown study.

Prepared: 1-30-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Puerto Rico **STATUS:** DI **BIBLIOGRAPHY:** No

TITLE: Report on Inventory and Assessment of Class V Injection Wells in Puerto Rico

AUTHOR: Engineering Enterprises, Inc.

DATE: 12-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCIES:
Puerto Rican Environmental Quality Board (EQB) -- the agency expected to assume "primacy" for continuation of the UIC program.

HYDROGEOLOGY:
Limestones and overlying alluvial deposits make up the most productive aquifers of Puerto Rico. The most extensive and thickest ones underlie the northern coastal area. While the high permeabilities developed in the limestone (due to development of solution cavities) have produced highly productive aquifers, they have also rendered the more shallow aquifers vulnerable to pollution. An additional threat to productive aquifers along the north coast is the intrusion of sea water.

INVENTORY & ASSESSMENT: 1,356 facilities **FURS COMPATIBLE:** No (8-20-86)

Type	Number*	Contamination Potential	Case Studies**	Regulatory System
5F1	-X-	-	No	-
5D2	3	-	2	-
5D3	10	Mod./High	Yes	Permit
5D4	15	-	13	-
5W9	5	-	No	-
5W10	67	-	1	-
5W11	1073	-	No	N/A
5W12	1	High	2	Permit
5A19	1	-	3	-
5W20	28	-	7	-
5X26	1	-	1	-
5X27	4	-	5	-
5W31	85	-	No	-
5W32	63	-	9	-

* "X" indicates well type is known to exist; no numbers available

** Number of inspection reports included in appendix

Strategy (Date)	Response/ Rating
Not addressed directly. There is evidence in the state report that an initial inventory was conducted and later updated.	N/A

RECOMMENDATIONS:

1. Future work:
   a. Look for 5X28's - service stations
   b. Look for 5X29's - probably present

2. Use revised form for pre-inspection mailing and for inventory.

3. Hire inspection personnel with training and experience in engineering geology, or groundwater, or equivalent; or train present employees in those subjects.

4. Set up system of periodic (or continuous) updating of inventory.

5. Inspect remaining industrial UIF's (not inspected in 1986 assessment).

6. Provide training for industrial personnel with responsibility for protecting the environment: geology; hydrogeology; groundwater occurrence and movement; groundwater protection; hydraulics of wells and aquifers; governmental (state and federal) agencies involved in groundwater development and protection.

7. Conduct groundwater studies to define better the direction and rate of groundwater movement in the principal aquifers; and to establish baseline values for key water quality parameters.

8. Training for engineers and drillers in the proper construction of water wells, with special emphasis on sanitary sealing and protection against corrosion. Training to be slanted toward construction in Karst or limestone formations.

9. Training for EQB personnel in those seminars provided by EPA and applicable to Puerto Rico.

10. Priority: study the Florida area to determine the seriousness of the existing threat to the groundwater-using communities in the vicinity.

11. Provide adequate financing for EQB's UIC staff--sufficient to permit routine and emergency field inspections.

12. Agricultural drainage wells--follow up on this, get the information from the Puerto Land Authority.

13. Follow up on the UIF's that have not provided the information requested of them -- Glamourette Fashion Mills in particular.

14. Continue the search for unreported industrial UIF's.

15. Follow up on the school districts that have not responded to the CFO letter requests for information on the schools and their septic tanks.

16. Request all industries to conduct a monitoring program of their injectate. Results should be provided to EPA or to EQB in case Puerto Rico assumes "primacy."

17. Study, in more detail, Sterling, RCA Del Caribe, Lotus, Digital, Upjohn and Flor Quim, (1) to assess the impact each one of these discharges has on the quality of groundwater and on its present and future uses; (2) to delineate remedial actions, including costs and benefits of each alternative.

18. USGS reports existence of numerous water wells that are not within the PRASA water supply network. These should be checked to see if any are supplying water for human consumption.

19. Get injectate analyses with parameters selected according to kind of industries, chemicals or substances used, and the probability or possibility of accidental releases of given materials.

20. Tighten up sampling/monitoring requirements to assure their being representative of materials reaching the injection well. (First part of rain, last part, after a release, etc.)

21. Pre-treatment facilities on industrial plant grounds should be examined critically to see if they may be leaking. The potential for groundwater contamination from these facilities may be much more serious than storm water runoff to sinkholes.

22. Inspection teams should be reinforced by chemical or industrial engineers whose familiarity with the industrial processes would permit a more independent assessment of the impact the industry might have on the environment.

Prepared: 10-2-86
Updated: 1-30-87

STATE REPORT SUMMARY
(All information recorded as described in state report additional correspondence, and verbal communication)

STATE: Virgin Islands **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Class V Well Inspection Program: U.S. Virgin Islands

AUTHOR: Geraghty and Miller

DATE: 9-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
DPW: as part of the well permitting process, collects geologic and well construction data, installs and reads water meters, and requires submission of regular pumpage information from ground water consumers.
DCCA: responsible for collecting ground water quality data.

HYDROGEOLOGY:
Extensive geologic descriptions resulting from Geraghty and Miller's 1983 study of groundwater conditions in the U.S. Virgin Islands for the U.S. Virgin Islands Department of Conservation and cultural affars are included in the state report.

INVENTORY AND ASSESSMENT: 47 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5W11	44	N/A	24 facility investigations	N/A
5W20	3	N/A		N/A

Strategy (Date)	Rating/Response
1. DCCA personnel in charge of the UIC program were contacted to determine if any records or previous reports were available for each facility on the FURS inventory.	N/A
2. An attempt was made to contact each facility listed on the FURS inventory by telephone to check the accuracy of the information on the inventory.	N/A
3. 24 facilities were selected for site inspections based on their proximity to public supply wells and the type of waste generated.	N/A

RECOMMENDATIONS:

1. A waste oil management program should be developed, and all existing underground fuel storage tanks should be inventoried and tested for leaks.

2. To evaluate the extent of septic tank usage on the islands, the DPW records should be inspected to determine which facilities are hooked to the public sanitary sewer system.

3. Records of the companies that clean and install septic systems on the islands should be inspected in order to determine which facilities still utilize septic tanks for waste disposal.

4. Expansion and upgrading of existing public domestic waste collection and disposal systems on St. Croix and St. Thomas would greatly reduce the potential for ground water contamination.

5. More manpower and equipment should be committed to DPW and DCCA in order to implement data-collection programs, coordinate the data-collecting functions of the two organizations, and store the data so that they can be easily retrieved.

6. The three 5X (5W20 above) wells should be investigated in more detail.

Region III State Report Summaries

Delaware
Maryland
Pennsylvania
Virginia
West Virginia

Prepared: 1-30-87
Updated: 5-15-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Delaware **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Underground Injection Control Program Class V Well Assessment

AUTHOR: Philip J. Cherry

DATE: 12-86 **REPORT STATUS:** Final

RESPONSIBLE AGENCY: Department of Natural Resources and Environmental Control, Water Supply Branch

HYDROGEOLOGY: Delaware is divided into two physiographic provinces: (1) Piedmont Province underlain by crystalline bedrock; and (2) Coastal Plain underlain by unconsolidated sedimentary deposits (most important aquifers in the state). Groundwater is the primary source of public, rural, and industrial water supply in 94% of the state; 60% of the population is served by groundwater.

INVENTORY & ASSESSMENT: 164 Wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5A7	164	Little to None	No	Permit

Strategy (Date)	Response/ Rating
All Class V wells must be permitted; records are kept in a powerful computer system. Compilation of inventory information requires listing all permitted Class V wells on the system	N/A

RECOMMENDATIONS:

1. The UIC database inventory, as well as Delaware's well and water allocation database, should be transferred to a more interactive in-house computer-based data system for better data accessibility and reduction in cost.

2. The regulations governing installation of Class V injection facilities, while adequate at the present time, should be updated as the need occurs.

3. The mandatory injection well construction inspections should continue and be supplemented by annual inspections for continued adherence to appropriate regulations.

Prepared: 1-30-87
Updated: 4-2-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Maryland **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: State of Maryland Class V Injection Well Inventory and Assessment

AUTHOR: N/A

DATE: 12-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES): Department of Health and Mental Hygiene (DHMH), Office of Environmental Programs

HYDROGEOLOGY: Maryland is divided into five ground water provinces: (1) unconfined aquifers of the eastern portion of the Coastal Plain Physiographic Province; (2) confined aquifers of the western portion of the Coastal Plain; (3) crystalline rock aquifers of the Piedmont and Blue Ridge Provinces; (4) sedimentary rock aquifers, exclusive of the carbonate rocks, of the Valley and Ridge and the Appalachian Plateau Provinces; and (5) carbonate rocks of the Appalachian Plateau, the Great Valley in the Valley and Ridge Province, and the Frederick Valley in the Piedmont Province.

INVENTORY & ASSESSMENT: 1,271 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number*	Contamination Potential**	Case Studies	Regulatory System
5D4	3	N/A	1 facility	Individual Permit
5A7	368	(3) Low	No	General Permit
5W31	890	(2) Minimal	No	Individual Permit
5X13	1	N/A	No	Individual Permit
5W20	9	(1)	3 facilities	Individual Permit

* "X" indicates well type is known to exist; no numbers available.
** Well types are ranked according to contamination potential; 1 = highest, 3 = lowest.

Strategy (Date)	Response/ Rating
1. Well owners listed on the FURS printout provided 8/85 were surveyed by mail.	39% (poor)
2. Files of state and county records were searched.	N/A
3. Telephone inquiries were made of state agencies that kept records of Class V wells.	N/A

RECOMMENDATIONS:

1. Continue an active program of monitoring well drilling and sampling at industrial Class V well facilities.

2. Maintain an active monitoring presence at those industrial sites where groundwater quality is threatened. If groundwater quality is threatened due to a State permitted Class V discharge, actions should be taken to alleviate the contamination potential.

3. Maintain communications with Local Health Departments in order to disseminate information on current State actions and to solicit comments for future recommendations.

4. Develop a training and guidance program to be made available to local health departments in order to assist in the future protection of groundwater supplies. This program should be supported by the State's UIC grant that is administered by the EPA through the Office of Environmental Programs.

5. Solicit EPA to set aside additional monies in future grant years to assist the State in developing the training and guidance program.

6. Develop a factsheet of standard information to be obtained and guidelines to follow when drafting Class V industrial drainage and waste disposal wells.

7. Maintain an accurate UIC Class V data base. The Class V data base has been accomodated for in the Waste Management Administration's Consolidated Waste Mangement Information System (CWMIS). This effort has already been partially funded by EPA using State UIC carry over money.

Prepared: 1-30-87
Updated: 5-15-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Pennsylvania **STATUS:** DI **BILIOGRAPHY:** Yes

TITLE: Underground Injection Control Program Class V Well Assessment

AUTHOR: U.S. EPA Region III

DATE: 1-87 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY: Pennyslvania Department of Environmental Resources (DER), Bureau of Water Quality Management (BWQM)

HYDROGEOLOGY: There are two major types of groundwater flow or aquifer systems within the Commonwealth of Pennsylvania: (1) unconsolidated alluvial fluvial deposits from which most ground waters used for public water supplies are derived due to their high transmissivities and geographic relationship to high population density areas; and (2) fractured sedimentary bedrock which often serve as the only source of water for individual domestic needs in rural Pennsylvania. Most Class V operations inject directly into or above underground sources of drinking water.

INVENTORY & ASSESSMENT: 1,026 wells **FURS COMPATIBLE:** No(8-20-86)

Type	Number*	Contamination Potential**	Case Studies	Regulatory Systems
5D2	155	(2) High	No	
5A7	24	(6) Low	No	
5W9	X	N/A	No	
5W12	4	(4) Unknown	No	N/A
5X13	811	(5) Low	Yes	Mine Operation
5A19	X	N/A	No	
5W20	19	(1) Deleterious	4 facilities	Permit
5W31	13	(3) Pending	No	

* "X" indicates well types known to exist; no number available

** Well types are ranked according to contamination potential (1 = highest, 6 = lowest)

Strategy (Date)		Rating/ Response
(1979-81)		
1.	Manual search of the ground water file at BWQM	N/A
2.	Review of industrial waste files ("case files")	N/A
3.	Review of solid waste files	N/A
4.	Review of mine permit files	N/A

	Strategy (cont.)	Rating/ Response
5.	Personal contacts and telephone interviews with government agencies	not significant
6.	Survey questionnaire sent to Mayors or Burough Council Presidents, Township Chairmen or Commission Presidents, County Commissioners, County Health Departments, and water well drillers	50%
7.	Department of Transportation survey (4 offices)	30 sites located
8.	RCRA hazardous waste notification survey	2 located of 77 inquiries
9.	Survey of heat pump manufacturers and distributors	14 responses of 26 inquiries
(1983) 1.	EPA sent questionnaires requesting verification of and updates to the database to each Class V well operator on the previous inventory	N/A
2.	Placed public notices of UIC requirements in each of Pennsylvania's major newspapers	N/A
3.	(5A7) Responses were reviewed for completeness and cross-checked against existing inventory	N/A
4.	(5D2) Each of the 11 Department of Transportation offices were surveyed	N/A
5.	(5X13) Personal visits made to Bureau of Abandoned Mine Reclamation (3 offices), Penn. Dept. of the Interior (Office of Surface Mining (2 offices)	N/A
6.	(5W11 & 5W20) Contacted personally or by phone: state and regional DER, BWQB offices; state DER office; all owners/operators of commercial or industrial waste facilities and some owners/operators of sanitary sewage disposal systems with wells; and county health departments	N/A

RECOMMENDATIONS:

Specifics as to recommended future federal action is premature at this time.

Prepared: 11-26-86
Updated: 5-15-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Virginia **STATUS:** DI **BIBLIOGRAPHY:** No

TITLE: 1. Assessment of Selected Class V Wells in the State of Virginia
2. Assessment of Class IV Wells in Saltville, VA
3. Virginia Class V UIC Assessment

AUTHOR: 1. CH2M Hill
2. SMC Martin
3. USEPA Region III

DATE: 1. 4-83 **REPORT STATUS:** 1. Final
2. 12-84 2. Final
3. 5-86 3. Final

RESPONSIBLE AGENCY(IES): USEPA Region III

HYDROGEOLOGY: Five physiographic regions (from east to west) are recognized: Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian (Cumberland) Plateau. Almost half of the state's groundwater occurs in the Coastal Plain. Eighty percent of the population relies either partly or entirely on groundwater for their water supply. Approximately 400 million gallons of groundwater are used every day.

INVENTORY AND ASSESSMENT: 1,864 Wells **FURS COMPATIBLE:** NO(8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	116	Low	Yes	N/A
5D3	X**		No	N/A
5D4	3		No	N/A
5A7/19	1735	N/A	Yes	N/A
5W11	6		No	N/A
5W12	1		No	N/A
5W20	2	Variable	Yes	N/A
5X27*	8		No	N/A
5X28	1		No	N/A

* Propane storage wells (should be Class II)
** "X" indicates well type is believed to exist; no numbers available

Strategy (Date): N/A **Response/Rating** N/A

RECOMMENDATIONS:
N/A

Prepared: 1-28-87
Updated: 5-15-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: West Virginia **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: State of West Virginia Underground Injection Control Program, Class V Injection Well Inventory and Assessment

AUTHOR: D.W. Long, J.M. King, K.W. Ellison

DATE: 1/87 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES): West Virginia Division of Water Resources (DWR), Department of Natural Resources (DNR).

HYDROGEOLOGY: West Virginia is divided into 3 physiographic provinces: Appalachian plateaus, Blue Ridge, and Valley and Ridge. Precipitation is the main source of recharge to groundwater systems. The two principle types of aquifers are unconsolidated alluvial deposits and sedimentary bedrock aquifers (Pennsylvanian and Mississippian). Pennsylvanian rocks are likely to host mining activities while Mississippian rocks are susceptible to contamination due to sinkholes and large solution openings. Abandoned underground mines are an important source of ground water for public supply and industrial use.

INVENTORY AND ASSESSMENT: 83 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	X	High	No	.
5D2	2+	High	No	.
5D3	X	High	No	.
5D4	X	High	No	N/A
5W11	2	N/A	No	.
5X13	268	Low	No	Mine Operation
5X16	2	N/A	No	.

* "X" indicates well type is known to exist; no numbers available.

Strategy

5D2-4: Prepared news release announcing DNR's intent to assess this well type.

5W11: Ground water discharge survey conducted by State Water Resources Division Inspectors.

Strategy (cont.)

5X13: In-depth study by graduate student including permit file reviews, questionnaires, memos, letters of inquiry, and telephone contacts.

5X16: Information was submitted along with applications for Class III permits for solution mining operations.

RECOMMENDATIONS:

(5X13) 1. In instances where Coal Slurry Disposal and Acid Mine Drainage Precipitate Wells may have detrimental effects on USDWs, it would seem prudent to regulate injection fluid composition, quantity, injection rate, injection well construction and operation, hydrogeologic transport, and exposure risk, among other factors, as needed.

2. Regulation of AMWT injection wells is not warranted at this time.

(5W11) If contamination potential were to be detected and more information on these wells cannot be produced to facilitate regulation and/or remedial action, then the wells should be plugged, and alternate sources of waste disposal should be found.

(5D2-4) These wells should all be identified and plugged within the shortest possible time frame.

(5X16) These types of wells could be incorporated into a Class III solution mining permit, or a new permit could be created which closely approximates the conditions set forth in a Class III permit, to initiate regulation.

Region IV State Report Summaries

Alabama
Florida
Georgia
Kentucky
Mississippi
North Carolina
South Carolina
Tennessee

Prepared: 7-28-86
Updated: 4-23-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Alabama **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE:
1. Alabama Class V Injection Well Assessment Report
2. Evaluation of Storm Water Drainage (Class V) Wells, Muscle Shoals, Alabama
3. Response to Comments on Alabama's Class V Assesment

AUTHOR:
1. Alabama Department of Environmental Management (ADEM)
2. Geological Survey of Alabama, Water Resources Division
3. Laura E. Ming, ADEM

DATE: 1. 6-86 2. 8-86 3. 2-87

REPORT STATUS: 1. Draft 2. Final 3. Not Applicable

RESPONSIBLE AGENCY(IES): Alabama Department of Environmental Management

HYDROGEOLOGY:

Northern province: Consolidated rocks formed before and during the Appalachian orogeny. Resistant sandstones and metamorphic rocks form ridges and plateaus while valleys are cut into limestones. Water table depths range from 10 to 50 feet.
Southern province: Unconsolidated sediments deposited during coastal plain development. Abundant sand units provide shallow water table aquifers.

About 45-55% of the population of Alabama depend on groundwater as a source of drinking water; 85% of the public water supply systems use groundwater for part of their supply. The principal withdrawal areas for groundwater are the Coastal Plain and the Tennessee Valley areas. Industry also uses groundwater for their process needs, but these wells are not regulated.

INVENTORY AND ASSESSMENT: 144 facilities **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5D2	9	Varies according to site-specific details	Several cases presented. More information needed on each facility	Permits required for all Class V operations
5W11	1			
5X13	X**			
5A19	33			
5W20	99			
5X25	2			
5X28	1			

* These numbers represent facilities rather than wells
** Wells believed to exist; no numbers available

Strategy (Date)		Rating/Response
(6-82)	Notice placed in newspaper informing owners of Class V wells that they were obligated to apply for a UIC permit	30%
(-85)	Owners of facilities were notified to determine whether they were still in operation	?
(?)	Notified State and County Health Departments and State funeral home licensing agency	?

RECOMMENDATIONS:

1. Facilities which operate Class V injection wells and are not a potential threat to the groundwater could be controlled without requiring a permit. Construction requirements could sufficiently protect the groundwater from contamination.

2. EPA should ensure that State programs will address the potential impact on groundwater by Class V operations. "One means of accomplishing this goal may be a revised formula for grant computation which assigns more weight to Class V wells."

Prepared: 1-28-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Florida **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Florida Underground Injection Control Class V Well Inventory and Assessment Report

AUTHOR: Bureau of Groundwater Protection, Florida Dept. of Environmental Regulation

DATE: 12/86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCIES: Department of Environmental Regulation (DER): 1) Division of Environmental Programs; 2) Division of Environmental Permitting. Often a Class V well will be permitted by both DER and the appropriate water management district (of which there are five).

HYDROGEOLOGY: The Floridan (north & central) and Biscayne (southeast) aquifers are the primary aquifers receiving water injected through Class V wells in Florida. Because of high transmissivites, the sole hindrance to the volume of water a well receives in some areas is the physical size and condition of the well (possibilities range up to hundreds or thousands of gallons per minute into the receiving aquifer).

INVENTORY AND ASSESSMENT: 25,573 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number*	Contamination Potential**	Case Studies	Regulatory System
5F1	X	N/A	No	A permit must
5D2	1539+	1	Yes	be obtained to
5D3	X	1	No	construct all
5D4	X	1	No	Class V wells
5A7	2671	7	No	with the except-
5W11	19000	N/A	No	ion of air con-
5W12	553	2	Yes	ditioning return
5A19	35	5	Yes	flow and swimming
5W20	20	4	Yes	pool drainage
5R21	349	3	Yes	wells which are
5B22	2	N/A	No	issued a general
5X25	3	N/A	No	permit.
5X27	16	N/A	No	
5X28	X	N/A	No	
5X29	X	N/A	No	
5G30	1385	6	Yes	

*"X" indicates well type is known to exist, no numbers available.
**Well types are ranked according to contamination potential; 1 = highest, 7 = lowest

STRATEGY (Date)

(1970) First inventory conducted by Florida Dept. of Air and Water Pollution Control - obtained information from State Board of Health permit files which date back to 1937.

(1977) Inventory updated by Florida DER - used permit files dated 1950 to 1976.

(1980) Class V inventory was compiled for the UIC program - 1977 inventory was on wells drilled between 1977 and 1980. Telephone surveys and a mail survey were also conducted. 6,684 wells were identified.

(1982-83) Owner notification program was conducted. 7,000 questionnaires were mailed out and 2,973 wells were identified (many duplicates of previous inventories).

(1984) Inventory updated and duplications eliminated. 9,602 wells were identified.

(1986) FDER Groundwater Management System (GMS) identifies 6,564 wells. Not all wells in 1984 inventory have been entered into the GMS.

RECOMMENDATIONS:

(5W12) Should further monitoring show that the sewage treatment plant is, in fact, discharging effluent that results in drinking water standard violations in the effluent discharged to the drainage wells, some type of action will be required by FDER. Such corrective action will probably be directed toward modifying the sewage treatment plant.

(5W11) Further study is required.

(5R21) 1. To minimize the occurrence of connector wells draining water with high levels of radionuclide parameters, ground water in the surficial aquifer should be thoroughly analyzed in advance of connector well construction and all new connector wells should be properly constructed and routinely sampled. More attention to well construction and maintenance would also improve well performance and prevent suspended solids from entering connector wells.

2. Areas of shallow ground water contamination should be avoided in siting connector wells.

(5D2-4) 1. Monitoring wells located to specifically monitor certain of the injection wells should be constructed and sampled.

Recommendations (cont.)

2. Monitoring wells should be constructed using information on casing depth and permeable zones intercepted by the injection well.

3. Monitoring wells should be constructed to monitor all the permeable zones that are suspected of being connected to the injection well.

4. Ground water hydrographs and precipitation records should be used to demonstrate hydraulic connection between the monitor and injection wells before samples are collected.

(5A7) The state permitting agency should insure that the wells be and are constructed and operated properly. This effort will entail a review of well construction data by the state, as well as probably requiring permit language that assures that any ground water heat pump system that is damaged or otherwise malfunctions will be promptly repaired.

(5A19) The several systems which place additives in the cooling water should not be allowed to operate.

(5W20) These wells should be permitted only when injection is into ground water containing greater than 10,000 mg/l TDS. If a USDW is present above the injection zone, on-site well monitoring should be required which is capable of detecting the migration of effluent in the direction of the USDW. This practice should be discouraged and these wastes should be routed to on-site treatment systems or municipal sanitary sewer systems if possible.

(5W20) Class V reverse osmosis reject water wells should be permitted using extreme caution. The supply water should be analyzed for primary and secondary water quality parameters and a projection should be made as to the expected reject water quality before a well is permitted. If the projected reject water quality is as good or better than the ambient water quality in the injection zone, a Class V well may be permitted if the applicant can demonstrate that the injected fluids will remain in the injection zone.

(Regs) 1. Change the regulations in order to exempt fluids being injected in a Class V aquifer remediation well (5X26) from having to satisfy the drinking water quality standards or be of a quality equal to, or better than, the natural unaffected background water quality. This requirement should be replaced with one that requires the injected fluid to be better than that in the contaminated aquifer undergoing remediation. The fluids injected would also have to be completely captured by the nearby withdrawal wells. A very stringent monitoring program would also be required.

Recommendations (cont.)

2. Changes should be made in the UIC regulations which would specifically require mechanical integrity testing for Class V wells which inject poor quality fluids, under pressure, into a non-USDW located between two USDW or below a USDW.

3. Construction requirements should be left as is due to the great variety of possible Class V well designs. More stringent construction requirements should be emphasized when poor quality effluent is injected into non-USDW zones located below a USDW or between two USDWs. There should be a range of requirements for these wells, determined by the quantity and quality of effluent injected and the quality of the USDWs below and/or above, with the most stringent requirement being the Class I injection well standards. The proximity of drinking water supply wells should also be taken into account when considering construction requirements for Class V wells.

Prepared: 1-13-87
Updated: 4-24-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Georgia **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: 1. Inventorying and Assessing Class V Injection Wells
2. An Assessment of Class V Injection Wells in Georgia

AUTHOR: 1. J.C. Adams, Ralph M. Lamade
2. Patricia Franzen

DATE: 1. 4-86 **REPORT STATUS:** 1. Draft
2. 12-86 2. Final

RESPONSIBLE AGENCY(IES): Geologic Survey Branch of the Environmental Protection Division (EPD) of the Georgia Department of Natural Resources

HYDROGEOLOGY: Georgia is characterized by the absence of oil and gas production, mineral resources that are not amenable to solution or well-slurry mining techniques, fresh water aquifers to depths of 2000 feet, thick clayey residual soils that protect the bedrock aquifers of north Georgia, and multiple confining units that protect the aquifers of south Georgia. Drainage wells represent the type of injection well most likely to adversely affect water quality in USDW. The geologic character of the state is not conducive to injection well technology.

INVENTORY AND ASSESSMENT: 163 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5F1	43	Low/Unknown	No	Banned
5D2	2	None (Plugged)	No	Banned
5D3	0	None	No	Banned
5D4	2	None (Plugged)	No	Banned
5A7	111	Low	No	Banned
5A19	5	Low	No	Permit

Strategy	Rating/Response
1. General Assessment--mail survey--Univ. of Ga. contacted licensed well drillers, HVAC contractors, county health and public work departments, U.S. Soil Conservation Service field offices, city engineers.	GSS

Strategy (cont.)	Rating/Response
2. Specific Assessment--verification--GTRC	
a. mail survey: Phase 1; Phase 2	25%, 43%
b. telephone and personal interviews	N/A
c. verification of initial survey	N/A
3. Follow-up Assessment - EPD	
visited water well drillers, personal contacts	Best

RECOMMENDATIONS

1. Additional efforts should be made to identify agricultural drainage wells.
2. Wells identified should be plugged and water samples should be checked for contamination within the corresponding well region.
3. Suspend or revoke the license of any driller who constructs an illegal well. Loss of license represents loss of income to the well driller.
4. Prohibit new ground water heat pumps.

Prepared: 4-20-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Kentucky **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: An Assessment of Class V Injection Wells in Kentucky

AUTHOR: USEPA Region IV

DATE: ? **REPORT STATUS:** Draft?

RESPONSIBLE AGENCY(IES): USEPA Region IV

HYDROGEOLOGY: Groundwater serves 31% of the population in Kentucky. Excluding withdrawals for thermoelectric power, groundwater use is 22% of total (water) use. Recharge is primarily from precipitation. Principal aquifers include the Alluvial, Tertiary and Cretaceous, Pennsylvanian Sandstone, and Mississippian and Ordovician Limestone Aquifers.

INVENTORY AND ASSESSMENT: 1360 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	X	N/A	No	N/A
5D2	484+	Smallest °	Yes	Local/City/None
5D3	76	Smallest °	Yes	Local/City/None
5D4	X	Smallest °	No	KPDES Permit
5A7	X	N/A	No	N/A
5W12	3	Serious	No	To be eliminated
5X13	61	Serious	No	Permit
5W31	736	Unknown	No	Rule (Health Dept.)

* "X" indicates well type may exist
\+ Estimated additional 100 wells not inventoried
° Or dependent on land use in the drainage area

Strategy		Rating/Response
(1983)	LOE Contract with SMC Martin (5D2,3)	Located 47 wells
(1984)	Grant with Western Kentucky Univ. (5D2,3)	Located 567 wells
(?)	Environmental Impact Study, Jefferson County (5W11)	Located 736 wells
(?)	Region IV Staff (5X13)	Located 61 wells

RECOMMENDATIONS:

(5D2-4)

1. New wells should be investigated and added to FURS.

2. Identify wells draining contaminated runoff from commercial or industrial areas. Where possible, the contaminants should be prevented from entering the storm water.

3. Retention basins might be planned so runoff can be released slowly into the sanitary sewer or treated before entering the well.

4. Plug or cement deep wells which may cause mixing between aquifers.

5. Construct a stand pipe, several feet in height, at the opening of the well.

6. Add a sand and gravel filter to the well.

(5W12) All three wells are scheduled to be plugged in 1988 when the regional treatment plant and interceptor sewer is completed.

(5X13) Require owners/operators to submit permit applications.

Prepared: 4-22-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Mississippi **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: State of Mississippi Class V Injection Well Inventory

AUTHOR: Mississippi Dept. of Natural Resources, Bureau of Pollution Control

DATE: 3-87 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): Mississippi Dept. of Natural Resources, Bureau of Pollution Control

HYDROGEOLOGY: Geologic and hydrologic conditions and quality of groundwater vary throughout the state. The state is divided into six groundwater areas: 1) far northeast; 2) northeast; 3) north central and central; 4) northwest-Mississippi Delta; 5) central; and 6) south.

INVENTORY AND ASSESSMENT: 14 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5A7	7	N/A	No	N/A
5W11	X+	N/A	No	N/A
5X25*	5	N/A	No	Rule
5X27**	2	N/A	No	Rule

* Groundwater solute transport studies
** Temporary injection of drlg. fluids at gas well sites
\+ "X" indicates well type believed to exist; no numbers available

Strategy	Rating/Response
(?) Telephone survey conducted to determine which governmental agencies permit or keep records on Class V wells. Contacted MS district offices, water management district offices, local environmental programs, and county health departments.	Poor
(?) Mail survey conducted. Contacted all licensed well drillers in the state.	Poor

RECOMMENDATIONS:

N/A

Prepared: 1-16-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: North Carolina **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: North Carolina Class V Injection Well Inventory Assessment Report

AUTHOR: NC Department of Natural Resources and Community Development, Division of Environmental Management, Groundwater Section

DATE: 12-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY: Division of Environmental Management in the Department of Natural Resources and Community Development.

HYDROGEOLOGY: North Carolina can be divided into 7 major hydrogeologic units: (1) Great Smokey Mountain Belt (2) Blue Ridge - Inner Piedmont Belt (3) Charlotte Belt (4) Carolina Slate Belt (5) Triassic Basins (6) Sand Hills, and (7) Coastal Plain Sediments. Known Class V injection wells are primarily located in four of the most productive units: (2), (3), (4), and (7). Groundwater usage within the state as a whole accounts for more than 60 percent of total water required, and in the coastal plain, usage exceeds 90 percent of total water required.

INVENTORY AND ASSESSMENT: 99 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System*
5A7	79	low	No	Monitoring & Permit Required
5X25	8	N/A	No	Permit Required
5X26	12	N/A	No	Permit Required

* "a permit shall be obtained from the director prior to constructing, operating, or using any well for injection."

Strategy (Date)	Response/ Rating
Contacts made by phone, letter, or visit with:	
Regional drilling contractors, heating and air conditioning contractors	least helpful
Building inspectors	most helpful

Also: Realtors, housing developments, country clubs, funeral homes, mortuaries, dry cleaners, county health departments, local governmental departments, lending institutions, individual well owners

RECOMMENDATIONS:

1. Every injection well contact must be covered and informed of state statutes and regulations. After the education is complete, inventory upkeep is relatively easy.

2. The FURS system should be implemented in North Carolina. Upkeep of the present system by sending in inventory forms is inadequate and not the most efficient method of inventory upkeep.

3. Regulating heat pump facilities is best accomplished by monitoring the effluent and system configuration. The permit allows UIC staff access to the facility and effluent sampling port. Thus, samplings and inspections are usually continued after permitting in North Carolina.

4. Should remedial action become necessary at an unpermitted site where ground water has become polluted, the recommended procedure would be to close down the facility, and take steps to neutralize the contaminant plume.

Prepared: 4-20-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: South Carolina **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: An Assessment of Class V Injection Wells in South Carolina

AUTHOR: Sofge, G.M., C.M. Livingston, and M.A. Williams

DATE: 12-86 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): South Carolina Dept. of Health and Environmental Control (SCDHEC)

HYDROGEOLOGY: The SCDHEC has classified and designated the aquifers within South Carolina into nine systems (briefly described in state report). All Aquifers in South Carolina meet the definition for USDW.

INVENTORY AND ASSESSMENT: >493 **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential*	Case Studies	Regulatory System
5D2	31	1 (high)	2 facilities	Permit
5A7	>60	2 (low)	3 wells	Rule
5A19	2 facilities	2 (low)	1 facility	Rule
5W20	>200 drainfields	3	4 facilities	Permit
5W32	>200 drainfields	3	No	Permit

* Contamination Potential is ranked from highest to lowest; 1=highest, 3=lowest

Strategy (Date)	Rating/Response
(?) Field inspections. Mailed questionnaires to architects, engineers, municipalities and well drillers. Reviewed state project files. Contacted State and Federal personnel. Mailed news letters.	N/A

RECOMMENDATIONS:

(5A7/19) 1) The policy prohibiting injection into an aquifer or zone different from the source should be continued.

2) Proper distances between return and production wells should be maintained.

Recommendations (cont.)

3) Extending the return line below water level and installing a back pressure valve at the end of the discharge line is neceessary.

4) Cavitation of the pump within the production well should be avoided.

5) Temperature and pressure shut-off sensors within the heat pump units should remain in proper operation.

6) Authorization by rule is appropriate for properly spaced and operated systems.

7) Additional funding to support State evaluations of groundwater impact from high density situations involving 5A7 wells should be provided.

(5W20) 1) Embalming fluid wastes (volatiles and base neutral and acid extractables) are inherently unsuitable for biological treatment and disposal via septic tanks and drain fields.

2) The policy of prohibiting the installation of septic tank/drain field for treating embalming fluids (current practice requires holding facilities and periodic removal and proper disposal) should be continued.

Prepared: 4-20-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Tennessee **STATUS:** D.I. **BIBLIOGRAPHY:** Yes

TITLE: An Assessment of Class V Injection Wells in Tennessee

AUTHOR: USEPA Region IV

DATE: ? **REPORT STATUS:** Draft?

RESPONSIBLE AGENCY(IES): USEPA Region IV

HYDROGEOLOGY: Groundwater serves 51% of the population in Tennessee. Excluding withdrawals for thermoelectric power, groundwater use is 21% of total (water) use. Recharge is primarily from precipitation. Principal aquifers include Alluvial, Tertiary, Cretaceous Sand, Pennsylvanian Sandstone, Mississippian and Ordovician Carbonate, Knox, Cambrian and Ordovician Carbonates, and Crystalline Rock Aquifers.

INVENTORY AND ASSESSMENT: 82 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	7	N/A	Yes	New wells require a permit.
5D3	5	N/A	Yes	
5A7	70*	Low	No	N/A
5X13	X	N/A	No	N/A

* Estimated 700 to 1000 wells

Strategy (Date)			Rating/Response
(1980-81)	1.	Identified areas of Karst landscape.	N/A
	2.	Mailed letter requesting information to 300 organizations and individuals (mailing list obtained from telephone books).	45%
	3.	Interviewed landowners, residents of flood-prone areas, city officials, and people on the street.	Most Successful
	4.	Interviewed state government officials in Nashville, TN.	Helpful

Strategy (Date) - cont.			Rating/Response
(1982)	1.	Made contacts with several groups to locate wells: industries - 5A19 & 5X13; TN Dept. of Health - 5W9, 10, 11, & 12.	Poor
	2.	Contacted 1/3 of the registered water well drillers in the state - 5A7.	Located 70 wells

RECOMMENDATIONS:

(5D2,3) 1. Plug deeper wells which may cause mixing between aquifers.

2. Direct runoff in commercial and industrial areas to sanitary sewers, or retain and treat storm water before releasing it to drainage wells.

3. Construct a stand pipe, several feet in height, at the opening to the well.

4. Add a sand and gravel filter to the well.

(5A7) 1. Contamination can be prevented by requiring closed loop systems.

2. Wells should be properly constructed, with cement behind the casing, to prevent surface runoff from running down the backside of the casing into USDW.

Region V State Report Summaries

Illinois
Indiana
Michigan
Minnesota
Ohio
Wisconsin
Indian Lands

Prepared: 11-24-86
Updated: 8-24-87

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Illinois **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE:
1. Class IV and Class V Injection Well Inventory.
2. An Assessment of Class V Underground Injection in Illinois, Interim Report. Phase One: Assessment of Current Class V Activities in Illinois.
3. An Assessment of Class V Underground Injection in Illinois, Interim Report. Phase Two: Identification of Possible Action Options.
4. An Assessment of Class V Underground Injection in Illinois

AUTHOR:
1. Stephen Davis and Monte Nienkirk;
2. Stephen L. Burch, and Bruce R. Hensel, Illinois State Water Survey Division, Illinois State Geological Survey;
3. Same as 2.
4. Stephen L. Burch, Bruce R. Hensel, John S. Nealon, and Edward C. Smith

DATE:	**REPORT STATUS:**
1. 5-84	1. Final
2. 7-86	2. Draft
3. 12-86	3. Draft
4. 6-87	4. Final

RESPONSIBLE AGENCY(IES): Illinois Environmental Protection Agency (IEPA); Illinois Pollution Control Board (IPCB)

HYDROGEOLOGY: Most groundwater in Illinois is obtained from unconsolidated sand and gravel, sandstone, or fractured limestone and dolomite. Brine and brackish aquifers are found below 2000 feet in the northern part and 100 feet in the southern part of the state. Injection is generally to zones with high hydraulic conductivity and to open caverns (both abandoned mines and sinkholes). Very good site-specific information is included in the state report.

INVENTORY AND ASSESSMENT: 1,766 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	6	N/A	Yes	All Class V
5D2	697	High	Yes	operations are
5D4	47	Moderate	Yes	authorized by
5A7	57	N/A	No	rule until
5W9	915	Moderate	Yes (illegal)	assessments are
5W12	1	N/A	No	completed and
5X13	5	N/A	No	recommendations
5A19	13	N/A	No	are made.
5W20	16	Moderate	Yes	
5R21	1	N/A	No	
5D24	1	N/A	No	
5X25	2	N/A	No	
5X26	1	N/A	No	
[illegible]	2	N/A	No	

* "X" [illegible]

Strategy			Rating/Response
(1984)	1.	Mailed questionnaire to well drillers, engineers, private companies, statewide associations, and U.S. Professional Services.	37%
	2.	Telephone survey - 270 contacts made (cities and counties).	Invaluable
	3.	Press release in state and local newspapers.	0

RECOMMENDATIONS:

1. Use of storm water drainage wells should be discouraged.

2. Location of storm water drainage wells should be emphasized.

3. UIC manager should use zoning ordinances to limit future construction of stormwater drainage wells to residential areas.

4. Use of detention ponds should be promoted.

5. Policies should prohibit injection wells near or in flow paths toward public water supply wells.

Prepared: 12-17-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Indiana **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Inventory and Assessment of Class V Injection Wells in Indiana

AUTHOR: Geraghty and Miller

DATE: 12/86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
Department of Natural Resources (DNR)
Department of Environmental Management (DEM)

HYDROGEOLOGY: Indiana has been divided into four regions on the basis of the principal source of water supplies used in each region. With the exception of several areas in the southern part of the state, surficial deposits consisting of Pleistocene-aged glacial drift, alluvium, and lake deposits blanket the State. Groundwater resources are derived from both surficial unconcolidated aquifers and bedrock aquifers.

INVENTORY AND ASSESSMENT: 3816 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Type	Number
5F1	72	5W11	895
5D2	2180	5W12	27
5D3	26	5X15	1
5D4	8	5X16	8
5A5*	1	5X18*	3
5A6*	3	5A19	22
5A7	236	5W20	30
5A8*	3	5X26	4
5W9	22	5X28	2
5W10	22	5X29	156
		5W31	105

No information was provided on contamination potential, case studies, or regulatory systems.

* Verification efforts proved these wells do not exist.

Strategy	Response/ Rating
1. Questionnaire packages containing a stamped, addressed return envelope, a cover letter describing the program, and a request for collect telephone calls to G&M concerning questions were mailed to:	
a. county health department sanitarians.....	7%
b. county agricultural extension agents.....	39%
c. soil conservation service district representatives	31%
d. director of public works of all cities in the state.....	25%
e. drilling companies listed in the 1986 NWWA directory, and selected drilling companies from the listing of registered water well drillers in the state.....	17%
2. Telephone interviews.....	?
3. Personal interviews.....	?

Recommendations:

1. Additional resources must be allocated to this program in order to meet the UIC mandates.

2. Additional work is needed in order to expand and refine the assessment report by incorporating more specifics and case studies.

3. Additional work is needed in order to refine procedures for determining the degree-of-risk.

4. Additional work is needed to develop options for corrective actions and regulations of various well types.

5. Additional work is needed toward development of implementation steps.

6. The Class V inventory and assessment reports must be updated annually.

Prepared: 12-17-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Michigan **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Inventory and Assessment of Class V Injection Wells in Michigan

AUTHOR: Geraghty and Miller

DATE: 12/86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
Department of Natural Resources (DNR)
Department of Public Health (DPH)

HYDROGEOLOGY: The state has been divided into seven hydrogeologic regions. Most of Michigan is blanketed by glacial drift composed of till, outwash, and morainal material. Groundwater resources are derived from both surficial unconsolidated aquifers and bedrock aquifers. Bedrock aquifers normally have the largest well yields and best water quality where they subcrop directly beneath and are hydraulically connected with the glacial drift.

INVENTORY AND ASSESSMENT: 7575 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Type	Number
5F1	15	5X15	1
5D2	623	5X16	33
5D3	103	5X17*	1
5D4	9	5A19	52
5A6*	3	5W20	9
5A7	760	5X25	4
5W9	11	5X26	59
5W10	18	5X28	27
5W11	2693	5X29	630
5W12	2	5W31	2511
5X14	15		

No information on contamination potential, case studies, or regulatory systems was provided.

* Verification efforts proved these wells do not exist.

Strategy	Response/ Rating
1. Questionnaire packages containing a stamped, addressed return envelope, a cover letter describing the program, and a request to call G&M collect with any questions were mailed to:	
a. county health department sanitarians.....	77%
b. county agricultural extension agents.....	35%
c. soil conservation service district representatives	48%
d. director of public works in cities whose population is > 2000.....	29%
e. drilling companies listed in the 1986 NWWA directory, and selected drilling companies from the listing of registered water well drillers in the state.....	11%
2. Telephone interviews.....	N/A
3. Personal interviews.....	N/A

RECOMMENDATIONS:

1. Additional resources must be allocated to this program in order to meet the UIC mandates.

2. Additional work is needed in order to expand and refine the assessment report by incorporating more specifics and case studies.

3. Additional work is needed in order to refine procedures for determining the degree-of-risk.

4. Additional work is needed to develop options for corrective actions and regulations of various well types.

5. Additional work is needed toward development of implementation steps.

6. The Class V inventory and assessment reports must be updated annually.

Prepared: 12-17-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Minnesota **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Inventory and Assessment of Class V Injection Wells in Minnesota

AUTHOR: Geraghty and Miller

DATE: 12/86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
Minnesota Pollution Control Agency (MPCA)
Minnesota Department of Health (MDH)

HYDROGEOLOGY: Most of the state is covered by varied thicknesses of glacial drift, lake deposits, peat, and alluvium. Groundwater resources are derived from both surficial unconsolidated aquifers and bedrock aquifers. The major aquifers, and the most favorable units for well injection in terms of permeability and porosity, are located in the southeastern part of the state. This part of the state also is the most heavily populated.

INVENTORY AND ASSESSMENT: 2107 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5F1	54	N/A	N/A	N/A
5D2	30	N/A	N/A	N/A
5D3	6	N/A	N/A	N/A
5D4	8	N/A	N/A	N/A
5A7	34	N/A	N/A	Permit by MDH
5W9	10	N/A	N/A	N/A
5W10	25	N/A	N/A	N/A
5W11	588	N/A	N/A	MN Regulation Chp. 7080
5W12	11	N/A	N/A	N/A
5A19	4	N/A	N/A	N/A
5W20	1	N/A	N/A	N/A
5R21	1	N/A	N/A	N/A
5X25	2	N/A	N/A	N/A
5X26	7	N/A	N/A	N/A
5X27	1	N/A	N/A	N/A
5X29	1309	N/A	N/A	N/A
5W31	16	N/A	N/A	N/A

Strategy	Response/ Rating
1. Questionnaire packages containing a stamped, addressed return envelope, a cover letter describing the program, and a request to call G&M collect with any questions were mailed to various government agencies and private companies:	
a. county health department sanitarians.....	51%
b. county agricultural extension agents.....	23%
c. soil conservation service district representatives	59%
d. director of public works in cities whose population is > 2000.....	48%
e. drilling companies listed in the 1986 NWWA directory.....	9%
f. selected drilling companies from the listing of registered water well drillers in the state	N/A
2. Telephone interviews with state government personnel and selected city and county officials.....	?
3. Personal interviews.....	?

RECOMMENDATIONS

1. Additional resources must be allocated to this program in order to meet the UIC mandates.

2. Additional work is needed in order to expand and refine the assessment report by incorporating more specifics and case studies.

3. Additional work is needed in order to refine procedures for determining the degree-of-risk.

4. Additional work is needed to develop options for corrective actions and regulations of various well types.

5. Additional work is needed toward development of implementation steps.

6. The Class V inventory and assessment reports must be updated annually.

Prepared: 11-12-86
Updated:

STATE REPORT SUMMARY

(All information recorded as described in the state report, additional correspondence, and verbal communication)

STATE: Ohio **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: Class IV and V Injection Well Inventory for Ohio Environmental Protection Agency

AUTHOR: Malcolm Pirnie

DATE: 6-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
Ohio Department of Natural Resources (ODNR); Ohio Environmental Protection Agency (OEPA).

HYDROGEOLOGY:
Groundwater sources (1) buried valleys of glacial outwash, and stream valleys with thick alluvial deposits; (2) porous bedrock: open textured limestones and dolomites; (3) sandstones, conglomerates, and well-sorted glacial material beneath till. Confining units (1) Till and glacial lake deposits; (2) dense shales and limestones.

INVENTORY AND ASSESSMENT: 2360 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5D2	1341	High	N/A	N/A
5D3	X	N/A	N/A	N/A
5D4	118	High	N/A	N/A
5A7	73	Low	N/A	N/A
5W11	361	High	N/A	N/A
5W12	X	N/A	N/A	N/A
5W20	467	High	N/A	N/A
5X27	X	N/A	N/A	N/A
5X29	X	N/A	N/A	N/A

* "X" indicates well types known to exist; no number available

Strategy	Rating/Response
Personal visits to County health or environmental departments; City, State agencies	+
Press release - newspapers and professional associations	?
Telephone interviews	?
General mailing	[illegible]
Industry mailing	[illegible]
Hazardous Materials Facility Mailing	[illegible]
Field site visits	?

RECOMMENDATIONS:

1. Unverified wells should be verified.
2. All ODNR well logs be required to state the intended use of each well being drilled.
3. Further publicize legal requirement to register Class V wells with the OEPA.

Prepared: 1-5-87
Updated: 5-17-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Wisconsin **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: Wisconsin Class V Injection Well Inventory

AUTHOR: Wisconsin Department of Natural Resources (WDNR) Central Office

DATE: 9-86 **REPORT STATUS:** Final

RESPONSIBLE AGENCY (IES): Wisconsin Department of Natural Resources (WDNR)

HYDROGEOLOGY: Five ground water provinces are defined according to the principal aquifers: (1) valley alluvium, (2) central sand plain, (3) glacial, (4) western paleozoic, (5) eastern paleozoic. Seventy-five percent of the state is covered by permeable, glacial deposits. All areas, except the dense crystalline rocks in the northwest third of the state, are capable of accepting injected wastes.

INVENTORY AND ASSESSMENT: 151 Wells **FURS COMPATIBLE:** NO(6-10-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	116	in question	No	None
5D4	1	minimal	No	Bur. Waste Water Mgmt.
5A7	4	minimal	Yes	Bur. of Water Supply
5A19	2	N/A	No	Bur. Waste Water Mgmt.
5W20	4	unknown	No	WPDES permits
5S23	4	negligible	No	Bur. Water Supply
5X26	17	negligible	No	Bur. Water Supply
5W31	3	negligible	No	Bur. Waste Water Mgmt.

Strategy	Rating/Response
1. Examined state's hydrogeologic factors to identify areas favorable for injection	---
2. Recorded field observations and investigated complaints from the public	N/A
3. Reviewed WPDES permit files; then facilities were contacted by phone	N/A
4. Sent questionnaires re: sanitary and stormwater collection systems to 695 municipalities. Followed up with phone contact for qualifying systems	82%

Strategy (cont.)	Rating/Response
5. Contacted DILHR, Division of Safety, Bureau of Plumbing - accessed facilities permitted since 1981.	N/A
6. Sent questionnaires re: "seepage pits" to county zoning administrators.	86%
7. Review Bureau of Water Supply and Bureau of Solid Waste Management Files.	N/A

RECOMMENDATIONS:

1. Further evaluation of industrial seepage pits and municipal storm drainage seepage pits is necessary.

2. Groundwater monitoring programs, in addition to current statewide monitoring, could be established for those nonpermitted Class V injection wells.

3. Increased effluent monitoring could be required in any permitting process for permitted Class V injection wells.

Prepared: 4-15-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Region V - Indian Lands **STATUS:** DI **BIBLIOGRAPHY:** No

TITLE: Survey of Class V Injection Wells

AUTHOR: Larry W. Bailey, Minnesota Rural Water Association

DATE: 3-87 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): N/A

HYDROGEOLOGY: N/A

INVENTORY AND ASSESSMENT: 45 wells **FURS COMPATIBLE:** N/A

Type	Number	Contamination Potential	Case Studies	Regulatory System
5W32	39	N/A	N/A	N/A
5X28	2	N/A	N/A	N/A

Strategy	Rating/Response
Interviewed water system operators, Tribal officials, Tribal and Indian Health Service (IHS) Sanitarians, IHS Engineers, Tribal Housing Authority personnel, and Tribal Environmentalists.	N/A
Interviews confirmed by personal inspection of all Reservations.	N/A
Telephone follow-ups conducted to determine existence of septic systems.	N/A

RECOMMENDATIONS:

1. Follow-up is needed to secure additional maps of reservations.
2. Follow-up will be needed if more detail is required on the wells located to date.
3. Inventory activity should continue to determine whether the data gathered to date is all-inclusive.

Region VI State Report Summaries

Arkansas
Louisiana
New Mexico
Oklahoma
Texas

Prepared: 9-18-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Arkansas **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: Final Design for Arkansas' Class V Injection Well Inventory and Assessment

AUTHOR: Arkansas Dept. of Pollution Control and Ecology

DATE: 9-85 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
The Arkansas Oil and Gas Commission (AO & GC) regulates the subsurface portion, and the Arkansas Department of Pollution Control and Ecology (ADPCE) has regulatory authority over the above ground portion of Class V brine disposal injection wells. The APDCE has complete regulatory authority over all other types of Class V injection wells in Arkansas.

HYDROGEOLOGY:
The principal Class V brine disposal injection formation is the Smackover Limestone which ranges from 7000 to 9000 feet in South Arkansas. Other formations used include: the James Member (limestone) of the Glen Rose Formation, the Tokio Formation (sandstone), the Blossom Formation (sandstone lateral equivalent of the Brownstone Marl), and the Graves Member (sandstone) of the Ozan Formation.

INVENTORY AND ASSESSMENT: 71 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5X16	70	Mod-Low	Yes	AO & GC (permits)
5A19	1	Low	N/A	none

Strategy (Date)	Rating/Response
N/A	

RECOMMENDATIONS:

(5X16)
1. The proposed injection formation must be separated from USDW's by one or more confining zones which meet the approval of the Director
2. Casing and cement must be designed to protect USDWs (see state report for detailed considerations).

Recommendations: (cont.)

3. The casing above the injection zone shall be sufficiently cemented by circulating cement with returns to the surface. Good quality cement is imperative to assure against fluid migration into untargeted zones. The quality should be sufficient to withstand the maximum operating pressure and should be resistant to degradation by native formation fluids and the injection fluids.
4. On all newly drilled or converted, and all existing Class V brine disposal wells, injection must be through tubing set on a packer unless exception is granted by the Director. Packers shall be set no higher than 100 feet above the top of the injection zone.
5. Well use may not begin until an appropriate permit is issued. After permit issuance, any proposed change or alteration to construction plan and specifications described in the application must be approved by the Director before being incorporated.
6. All phases of well construction and testing must, if possible, be supervised by a qualified person who is knowledgeable and experienced in practical drilling engineering and who is familiar with the special conditions and requirements of injection well construction.
7. During the drilling and completion of Class V brine disposal injection wells, appropriate logs will be obtained and tests conducted as set forth in the mechanical integrity guidelines.
8. The operation of a new as well as existing Class V brine disposal injection wells should be regulated according to the same operating requirements by which Class II injection wells are regulated.

(5A19)

Because of the shallow depths of these wells (only fresh water bearing formations are penetrated) and the simpleness of the system in which the water is being used, the Department sees no need for complicated regulations governing this type well except to maintain that no intermingling of the system's water with foreign substances occurs between the supply well and the return well. Specifically, all Class V cooling water return flow wells shall be constructed using the following construction requirements:

1. Both the supply well(s) and the return well(s) shall be cased at least from the surface down through the top of the uppermost supply and injection formation.
2. The casing shall be cemented in place from the top of the uppermost supply and injection formation to the surface.
3. A cooling water return flow well system shall, at a minimum, consist of two wells, a supply well and a return well.
4. The supply and return well system shall be constructed so that the formation from which the cooling water was extracted is the same formation into which the cooling water is reinjected.
5. There shall be no "open-loop" cooling water return flow wells.
6. All cooling water return flow system wells shall be plugged upon abandonment by filling the well with cement.
7. Cooling water return wells shall receive nothing other than the used cooling water which originated at the cooling water supply well(s).

Prepared: 10-16-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Louisiana **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Louisiana Class V Assessment Reports

AUTHOR: Louisiana Department of Natural Resources (DNR), Office of Conservation (OC), and Louisiana Geological Survey

DATE: 3-85 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): Louisiana Department of Natural Resources (DNR), Office of Conservation (OC)

HYDROGEOLOGY: N/A

INVENTORY AND ASSESSMENT: 11 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number+	Contamination Potential	Case Studies	Regulatory* System
5D4	5	N/A	N/A	Class II regulations
5A7	5	Low	N/A	Permitted by OC, DNR
5W11	X	N/A	N/A	Regulated by Dept. Health and Human Resources
5G30	1	N/A	N/A	Class II regulations

+ "X" indicates that well type is known to exist; no number available
* Presently Louisiana does not require the registration of any Class V wells

Strategy	Rating/Response
1. Louisiana Geological survey mailed letters to all the well water contractors in the state requesting information on heat pumps and associated problems	100%
2. Department of Health and Human Resources helped Geological Survey in mailing letters to parish sanitarians requesting information about septic systems	100%
3. Letters were sent to each state requesting information on heat pumps	80%

RECOMMENDATIONS: (Concerning heat pump systems only)

1. Discharge should be to the surface rather than to an injection well.

2. The waste product from ground-water source heat pumps for a single family residence should be returned or injected into or above the supply aquifer without prior review by the State and without a State permit. The installation shall conform with Section 20.03E and 20.04C of Statewide Order 29-N-1, with the following provisions.

   A. The ground water/heat pump installation or system shall be limited to a single family residence.

   B. The owner of an injection/return well, or the licensed water well contractor who installs it, shall be required to register the injection/return well with the Office of Conservation, DNR, within 30 days after the well's completion. The supply well should be registered with the Office of Public Works DOTD. The Office of Public Works Water-Well Registriation Form GW-1) can be used to register the wells. This form has been in use by water-well contractors since 1976.

   C. If pollution of ground water should occur, the well owner or land leassee is responsible for immediately informing the appropriate State and local officials so that the "spread" of polluted water can be prevented and the cause of pollution eliminated. The owner should be made aware that he may be liable for any damage to the property and water of others.

   D. The waste product shall contain no additives, such as chlorine, etc.

   E. A licensed water-well contractor should be employed to install the return/injection well, to rework the well, whenever necessary, and to provide the necessary maintenance.

   F. If the injection/return well becomes inoperative and must be abandoned, a licensed water-well contractor shall be employed to plug and seal the well. When a well is plugged and sealed this action should be reported to the Office of Conservation, DNR and Department of Transportation and Development using Louisiana Office of Public Works Plugging and Abandonment Form (GW-2).

3. The Office of Conservation, DNR, should establish a permit system for an injection well used by an installation for a multiple dwelling, office building, commercial and industrial establishment, or institution. The permit review process should include rules and/or guidelines to provide for the review of plans.

Prepared: 2-13-87
Updated: 8-24-87

STATE REPORT SUMMARY
(All information recorded as described in the state report, additional correspondence, and verbal communication)

STATE: New Mexico **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Underground Injection Control Class V Inventory

AUTHOR: G. Koschal, K. Lambert, S. Sares

DATE: 3-87 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): (1) New Mexico Environmental Improvement Division, (2) Environmental Improvement Division, (3) Ground Water/Hazardous Waste Bureau

HYDROGEOLOGY: Wide variety of geologic settings. Eastern plains are sedimentary sequences; western areas are mountainous. The state is divided into four physiographic provinces: Colorado Plateau, Great Plains, Basin and Range, and Southern Rocky Mountains. Major aquifers are in Tertiary and Quaternary alluvium, Mesozoic sandstones, and Paleozoic limestones.

INVENTORY AND ASSESSMENT: 1237 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5D2	5	Low	No	Registration/Rule
5A6	2	Low	No	Permit
5A7	27	Low	No	Registration/Rule
5W10	14	Moderate	No	ILLEGAL
5W11	10	Moderate	No	Registration/Rule
5X13	11	Low	Yes	N/A
5X14	1073	Low	Yes	Permit
5A19	6	Low	No	Registration/Rule
5W20	2	Moderate	Yes	N/A
5R21	30	Low	No	Registration/Rule
5N24	1 (abd)	Low	Yes	ILLEGAL
5X25	6	Low	Yes	Permit
5X26	50	Mod-Low	No	N/A

Strategy	Rating/Response
1. Preliminary assessment of Class V wells prioritizing subclasses.	
2. Assemblage of potential well owner/operators using permit database, notice of intent database, and knowledge of city, county, and state offices, well drillers, and the general public.	
3. Target surveys mailed.	
4. Follow up letters and telephone calls.	

RECOMMENDATIONS:

1. Need some control over agricultural drainage wells (not in inventory; specifically exempted from WQCC control).

2. Regulations needed to control abandoned injection wells.

3. If abandoned wells have contaminated groundwater, procedure is needed for remediation.

4. Existing notification requirements should be improved (rewrite portions of regulations).

5. Definitions for well type classes and subclasses should be provided in the regions.

Prepared: 9-18-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Oklahoma **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Oklahoma Class V Well Study and Assessment

AUTHOR: Oklahoma Industrial Waste Division, State Department of Health

DATE: 7-85 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
Oklahoma Industrial Waste Division

HYDROGEOLOGY:
N/A

INVENTORY AND ASSESSMENT: 167 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	X	N/A	N/A	All Class V facilities are required to register with the Division
5D2	X	N/A	N/A	
5A7	100's	Low	N/A	
5W11	X	N/A	N/A	
5X16	7	N/A	N/A	
5N24 (Plugged)	X	N/A	N/A	
5X26	60	N/A	N/A	

*"X" indicates this well type is known to exist; no number available

Strategy (Date)		Rating/Response
(1980)	1.a. Department sent questionnaire with a cover letter explaining the purpose of the survey to all County Health Departments, rural water districts, and county/district sanitarians.	0%
	b. Press releases were placed in local newspapers requesting public assistance	0%
	2. Second mailing and follow-up phone calls to county sanitarians	0%
(1982)	Pilot study of Class V wells in Cleveland Co., OK by University of Oklahoma	poor

RECOMMENDATIONS:

1. Oklahoma needs a cooperative system among state agencies to record all drilling activity that exactly defines what each well is intended to be used for.
2. (5X26)
   a) During drilling, machinery capable of producing heat or a spark that could ignite flammable vapors should be kept up-wind and as far removed from the wellsite as possible.
   b) Air rotary drilling should be avoided since the injection of air into the hydrocarbons can produce an extremely flammable mixture.
   c) Registration of wells and a description of construction features and well locations should be mandatory.
   d) The Division should have an opportunity to examine well proposals and set permit conditions as they see fit, including the quality of fluid to be reinjected.
   e) Federal or State regulatory standards and limitations would be extremely difficult to enforce as well as hinder activity. Permit conditions should be defined on a case by case basis.
3. (5A7)
   a) Any new regulatory program for air conditioning/heat pump return flow wells should mainly be directed at large scale systems designed for commercial buildings, such as office complexes and manufacturing facilities.
   b) A system is needed to register, inventory, and maintain opportunity for review of air conditioning/heat pump return flow wells.
   c) Renewable permits and periodic inspections would help prevent groundwater contamination problems due to these return-flow wells.
4. With a registration and tracking mechanism the Division would have the opportunity to review well site conditions and construction, set permit standards where needed, and better assess possible groundwater contamination from Class V wells.
5. Before stringent state and federal regulation is imposed, further study of Class V wells is advisable.
6. Recommendations from the Cleveland County pilot study:
   a) A public awareness, public relations program should be instituted concerning these wells. The program should be conducted using a sound, positive approach which emphasizes that while most of these wells probably pose no pollution problems, they must be reported in an ongoing effort to assess their significance to possible groundwater contamination.
   b) Since the state already has an effective working network of Professional Sanitarians and Environmental Specialists at the city and county levels, this group should have the primary responsiblity for data gathering and inspection of Class V wells.
   c) The Class V well inventory and permitting information should be compiled and stored in a databank which has capability for future expansion.

Prepared: 11-13-86
Updated:

STATE REPORT SUMMARY
(All Information is recorded as described in state report, additional correspondence, and verbal communication)

STATE: Texas **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Underground Injection Operations in Texas: A Classification and Assessment of Underground Injection Activities, Report 291

AUTHOR: Texas Department of Water Resources, Ben K.Knape

DATE: 12-84 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES): Texas Department of Water Resources (now Texas Water (Commission); Texas Railroad Commission

HYDROGEOLOGY: Most significant structures: (1) fault zones of central Texas, (2) salt domes and growth faults of Gulf Coast, (3) salt dissolution structures of High Plains, (4) impermeable rocks of Llano Uplift. Very good list of major and minor aquifers in state report.

INVENTORY AND ASSESSMENT: 2356 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	108	High	Yes	N/A
5D2	52	Low	No	N/A
5A5	X	?	No	TX Railroad Comm.
5A6	1	?	No	TX Railroad Comm.
5A7	1014	Low	Yes	Authorized by rule
5W9	10	?	No	N/A
5W10	16	?	No	N/A
5W11	56	?	No	Differs locally
5X13	65	Low	No	TX Railroad Comm.
5X15	X	?	No	TX Railroad Comm.
5W20	2	N/A	No	Class I
5R21	44	Low	Yes	Local Authority
5X25	6	Low	No	N/A
5X26	37	N/A	No	N/A
5X29	945	N/A	No	P&A Rules

* "X" indicates well types known to exist; no numbers available.

Strategy	Rating
No inventory strategies discussed in state report.	

Recommendations (cont.):

1. New regulatory programs for heat pump system wells should be directed at large-scale systems rather than at systems for single-family dwellings. The Department should continue to inventory the wells, and maintain opportunity for review of project proposals for the purpose of issuing permits as necessary.

2.a. Regulatory orders for private sewage facilities should be adopted in areas which are not already protected. Orders should be based on current minimum standards for sewage disposal as published by the Department of Health and appropriate site-specific considerations.

2.b. Sewage disposal wells for private facilities are not acceptable under Texas Dept. of Health standards and should be phased out and replaced by alternate methods of sewage treatment and disposal.

2.c. Each proposed sewage disposal well, excluding single-family residence sewage facilities, should be authorized by site-specific permit rather than by rule, and existing wells should be individually reviewed for contamination potential with appropriate action taken in each case.

Region VII State Report Summaries

Iowa
Kansas
Missouri
Nebraska

Prepared: 1-30-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Iowa **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Class V Injection Well Assessment Report for Direct Implementation, State of Iowa

AUTHOR: U.S. EPA, UIC Section, Drinking Water Branch, Region VII

DATE: 11-86 **REPORT STATUS:** Final

RESPONSIBLE AGENCY: Iowa Conservation Commission, Dept. of Natural Resources

HYDROGEOLOGY: There are five major bedrock aquifers in Iowa which are separated by aquicludes. A sixth aquifer system consists of alluvial aquifers associated with stream systems and glacial drift. These aquifers provide 75 percent of the state's domestically used water.

INVENTORY & ASSESSMENT: 262 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Cotamination Potential	Case Studies	Regulatory System
5F1	230 (est 700)	High	Yes	Diversion Permit
5D2	6	?	No	N/A
5A7	17 (est 250)	Low	No	N/A
5W11	3	None*	No	N/A
5A19	5	N/A	No	4 permitted 1 monitored
5X28	1	High	No	N/A

* if "properly constructed and maintained"

Strategy	Response/ Rating
1. Sent letters to well drillers and heat pump installers	N/A
2. Ran public notices in thirteen Iowa newspapers	N/A
3. Compiled a list of AIW owners through well tax reporting cards	N/A
4. Used infrared and aerial photography to locate AIWs.	N/A

RECOMMENDATIONS:

(5F1)
Close highway surface inlets to ADWs. Provide alternate drainage or impoundments when necessary. Permits should be required to ensure compliance.

Raise inlets above maximum ponding levels. Abandoned wells are to be properly plugged. Nitrates should not be applied where subsurface tiles are present. Any other appropriate best management practices should be used. Perhaps water going down hole should be required to meet drinking water standards.

Elimination of ADWs could be accomplished gradually through attrition. A more rapid phase out could be accompanied by cost sharing plans like a onetime payment for plugging followed by annual tax incentives. The land could be bought by the government who would then plug ADWs on government lands.

(5A19)
Require permit stating type and volume of injected fluids, construction features, depth, date drilled, and driller. New wells would require grouted surface casing, and a concrete pad at top. EPA to be informed on any change of conditions, source and injected aquifer to be the same. Five year inspection.

(5A7)
Same as (5A19)

(5X28)
Require permit showing: Construction features and a plan to utilize separator and holding tank and a plan to sample and analyze injected fluid. Five year inspection.

(5D2)
Require permit showing locations, construction features; and plan to affix cover to tops of casings should a spill occur. Also show plan for emergency cleanup operations. Five year inspection.

(5W11)
Require permit giving construction features and stating that only sewage goes into tank. Five year inspection.

Prepared: 11-17-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Kansas **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Class V Well Assessment of Kansas

AUTHOR: Kansas Department of Health and Environment
Susan Hargadine

DATE: 11-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY: Kansas Department of Health and Environment

HYDROGEOLOGY: Class V well records were found in many areas with surface geology consisting of Tertiary and Pleistocene alluvail deposits (especially in the western and south-central parts of Kansas). In Butler, Cowley, and parts of Sedgwick Counties, the surface rocks are of Permian age and the wells penetrate rocks in the Chase and Sumner groups which are also used for supply purposes. A few wells are drilled into the Dakota formation in Barton, Cloud, Ellsworth, Hodgeman, and Pawnee counties.

INVENTORY AND ASSESSMENT: 419 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	3	Positive	N/A	N/A
5A7	394	Low	N/A	N/A
5A19	3	Possible	N/A	N/A
5R21	4	Possible	N/A	N/A
5X26	15	Low	N/A	N/A
5X27	758*	Low	N/A	N/A

* Hydrocarbon storage wells (should be Class II)

Strategy	Rating/Response
1. Used FURS printout for wells entered 1981-84.	N/A
2. Questionnaires were sent to well owners.	N/A
3. A printout was made of water wells with well types that would include most Class V wells.	N/A
4. Water well record files were checked manually to eliminate wells on the printout that were not Class V's.	N/A
5. Some data were aquired from discussion with field staff.	N/A
6. Phone contacts and letters were written to owners of poor serable wells.	N/A

RECOMMENDATIONS:

(Database)

1. It is possible that additional wells exist. The current inventory will have to be accepted until much time and manpower can be devoted to searching all possible avenues.

2. The computer inventory system is good and workable.

3. The inventory on the FURS system is not correct: the state system is correct and contains all information called for on the FURS system.

4. It would be desirable to get the state Class V inventory on a computer with capabilities to plot distribution, make graphs and maps, summarize, etc.

(Additional Information)

1. Public notices asking for voluntary information on Class V type wells could be printed in newspapers and trade journals.

2. Yellow pages could be checked for businesses advertising for construction or maintenance of Class V type wells; then businesses could be contacted for information.

3. Contact to personnel in county health departments, extension services, or public works could be helpful.

4. If field personnel of various agencies requiring field work (Board of Agriculture, Department of Health and Environment, etc.) are advised on the types of data needed, they may be able to supply information discovered during field investigations.

(5D2, 5W11, 5W20, 5X26)

1. These well types should be more closely monitored.

2. Inspections should be made to investigate construction of the wells.

3. The surrounding drainage areas should be studied and all possible pollution sources noted.

4. Samples should be taken of the waste stream to be analyzed.

(5A7)

1. Require all groundwater heat pump systems to have properly designed and maintained fresh water disposal wells (and reduce the number of systems discharging to surface).

2. Establish construction standards
   a. for specific site and hydrogeologic conditions
   b. for necessary volumes of water
   c. with back-check valves and disposal lines immersed below water level
   d. with spacing of 50-100 feet between disposal and supply wells
   e. with disposal well located down-gradient from supply well
   f. for proper grouting of vertical holes
   g. for line connectors

3. Establish formal requirements for reporting heat pump installations to the appropriate state agency.

4. Specify approved antifreeze solutions.

5. Monitor Class V well systems on a systematic basis particularly in areas of the state with high concentrations of wells.

Prepared: 1-16-87
Updated:

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Missouri **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Missouri Underground Injection Control Program Class V Assessment

AUTHOR: N/A

DATE: 12-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCIES: Department of Natural Resources, Division of Geology and Land Survey

HYDROGEOLOGY: Rocks ranging from PreCambrian to recent are exposed. They include volcanic and intrusive rocks, marine and continental sedimentary rocks, glacial deposits and wind blown soils. Table 4-1 in the state report contains a summary of geologic and hydrologic characteristics and locations of the surficial materials and bedrock in Missouri.

INVENTORY AND ASSESSMENT: 5324 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	x	High	No	None
5D3	250	Possible	Yes	None
5A7	741	Low	No	Registration
5W11	2	Low	No	Permit
5X13	4326 (abd)	Low	Yes	None
5X26	x	N/A	No	N/A
5X28	5 (abd)	Unknown	No	N/A

*"x" indicates well type is known to exist; no numbers available

Strategy	Response/ Rating
1. State and Federal agencies that may have information of Class V wells were contacted.	N/A
2. A telephone survey was made covering the manufacturing industry, disposal industry, heating and cooling contractors, installers, utilities, and the general public.	N/A
3. A field search was made to locate and determine type of injections and the rates of injection as required in 40 CFR 144.26.	N/A

RECOMMENDATIONS:

(5F1) 1. More careful N management could be used to reduce the amount of NO_3-N leaked and transported to an ADW.
2. Pesticide incorporation at application and the use of soil conservation practices, along with more strongly adsorbed pesticides could decrease pesticide losses.
3. For bacteria, moderately or strongly adsorbed pesticides, and sediment itself, closing the surface inlets and forcing surface water to infiltrate through soil would decrease their transport into the aquifer.
4. Transport of the slightly adsorbed anioxic herbicides with subsurface flow, or the even lesser movement of other pesticides would have to be solved by banning the pesticides of concern or closing the ADW's if this transport was deemed a problem.

(5D3) 1. Further dye tracing will be necessary to better define the boundaries of the spring recharge areas.
2. It is suggested that a careful dye trace study be run on any existing or planned improved sink hole drainage systems and that occasional monitoring of both entering and exiting fluids be run after the system is in operation.

(5A7) Areas that need addressing include:
1. Regional meetings with drillers and installers so that information can be distributed and exchanged.
2. More energy directed toward public awareness of the rules and regulations regarding heat pumps.
3. More detailed research about the theoretical environmental effects of heat pumps.
4. Standards set for the construction of supply and return wells so that the problems associated with them can be reduced.

(5W11) Proper construction and installation guidelines should be considered before and during construction of a sewage disposal system.

(5X13) Water supplies having a known or suspected close connection to mining activities should be tested prior to use to insure against contamination from such sources.

Prepared: 11-13-86
Updated:

STATE REPORT SUMMARY

(All information is recorded as described in state report, additional correspondence, and verbal communication)

STATE: Nebraska **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Inventory and Assessment of Class V Injection Wells and Related Sources

AUTHOR: N/A

DATE: 8-86 **REPORT STATUS:** Final

RESPONSIBLE AGENCIES: Nebraska Department of Environmental Control

HYDROGEOLOGY: Much of Nebraska is underlain at shallow depth by a thick, moderately to highly permeable unconsolidated rock of Cenozoic and/or Tertiary age. This is the principal aquifer, Ogallala, and it supplies large quantities of good quality water. In northwest Nebraska there is a group of secondary aquifers which are generally deeper and provide low to moderate quantities of acceptable quality water. These aquifers include the Arikaree Group, Brule Formation, and Chadron Formation. Another secondary aquifer in eastern Nebraska is the Dakota aquifer, which is currently utilized.

INVENTORY AND ASSESSMENT: 672 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	5	High	No	Rule
5D2	1	Low	No	Rule
5A7	650	Low	No	Rule
5W10	X	N/A	No	Rule
5W11	X	High	No	Rule
5A19	8	Variable	No	Rule
5R21	4	Variable	No	Rule
5X25	2	N/A	No	Rule
5X27	2	Low	No	Rule
5X29	X	N/A	No	Rule

* "X" indicates well type is known to exist; no numbers available.

Strategy	Response/Rating
Review of DEC files and records	?
Mailing to each member of the Nebraska Well Drillers Association	33%
Mailing to Natural Resource District Mangers and follow-up phone call	100%
Remote sensing techniques	-
Mailing to Residential Groundwater Heat Pump Contractors and Installers	25%

RECOMMENDATIONS:

Based upon information gained from the Class V injection well technical review, inventory, and assessment, the following recommendations will aid in prevention of groundwater contamination from Class V injection wells in Nebraska.

All Class V Injection Wells

1. The injection well should not be located in any depressions where it would be subject to influence from surface runoff or flooding (not including ADWs).

2. The injection well should be located at least 50 feet from any septic tank, cesspool, or other surface or subsurface waste disposal area.

3. A continuous inventory program for Class V injection wells should be established. This program should include:

   i) the filling out of Class V injection well application forms. These forms would be distributed to well drillers and heat pump contractors and installers to in turn be distributed to owners of Class V injection wells. These forms would then be sent back to the Department as each well is installed;

   ii) data on all existing and future Class V injection wells should be stored in a computer data base for easy access.

4. On all Class V injection well applications (if applicable), details should be included on well depth, well casing type, screen locations, gravel pack depths, static and injection water levels, and a well log.

5. The definition of Class V Injection Wells under Title 122 Rules and Regulations for Underground Injection and Mineral Production Wells should be modified to include closed loop heat pump systems and single family septic systems.

Agricultural Drainage Wells

1. All ADWs would require a permit from DEC. The permit requirements would include the following:

   i) a Gas Chromatography/Mass Spectrophotometry (GC/MS) analysis be done on injection water on at least a quarterly basis to determine the presence of any pesticides. Parameters to be monitored for pesticide concentrations would be later determined by DEC;

   ii) water should be monitored and meet standards for nitrate-nitrogen (10 mg/l).

Recommendations (cont.)

2. A Class V injection well application form specifically for ADWs which would require:

   i) a detailed map of the location of the injection well including the locations of all municipal, domestic, and stock wells within one mile of the injection well;

   ii) a diagram of the drain tile (if applicable) and the injection well.

3. The drainage well should be located at least 2,000 feet from any stock, municipal, or domestic well.

Any ADW not meeting the above requirements would have a potential to adversely impact ground water quality and would not be allowed.

Cooling Water Return Flow Wells

1. Minimum design requirements for cooling water return flow wells including:

   i) wells be grouted from a point at least 20 feet below land surface to the land surface or to the water table;

   ii) wells be designed only for noncontact systems where injection water is not chemically altered.

2. A Class V injection well application form specifically for cooling water return flow wells which would require:

   i) a detailed map of the location of the injection well including the locations of all municipal, domestic, and stock wells within one mile of the injection well;

   ii) a diagram of the injection well including screen depths, gravel pack, and grout;

   iii) a diagram of the injection well system.

3. Minimum locating requirements for the injection well relative to any nearby municipal supply wells.

Any cooling water return flow well not meeting requirements 1, 2, and 3 from above would require a permit.

Recommendations (cont.)

Residential Ground Water Heat Pump Systems

1. Minimum design criteria for the injection well in open loop systems which would include:

   i) the well be grouted from a point at least 20 feet below land surface to the land surface or to the water table;

   ii) wells be designed only for noncontact systems where injection water is not chemically altered.

2. Minimum design criteria for the underground loop in closed loop systems which would include:

   i) the loop be built of flexible, stress resistant, high density, noncorroding pipe such as polyethylene, polybutylene, or other pipes approved by DEC;

   ii) joints and links in the underground loop should be properly sealed as outlined in the National Standard Plumbing Code.

3. The underground loop or the injection well should be located at least 100 feet from any domestic and 500 feet from any municipal supply wells.

4. A Class V injection well application form specifically for residential ground water heat pump systems which would require:

   i) a detailed map of the location of the injection well including the locations of all municipal, domestic, and stock wells within one half mile of the injection well or underground loop;

   ii) if the system is closed loop, details on the design including the type of pipe and the type of antifreeze used.

Any residential groundwater heat pump system not meeting the above criteria would require a permit.

Commercial Ground Water Heat Pump Wells

1. Minimum design criteria for commercial ground water heat pump wells including:

   i) wells be grouted from a point at least 20 feet below land surface to the land surface or to the water table;

   ii) wells be designed only for noncontact systems where injection water is not chemically altered.

Recommendations (cont.)

2. A Class V injection well application form specifically for commercial ground water heat pump wells which would require:

   i) a detailed map of the location of the injection well including the locations of all municipal, domestic, and stock wells within one mile of the injection well.

3. The injection well should be located at least 500 feet from any stock, municipal, or domestic supply well.

Any commercial ground water heat pump well not meeting the above requirements would require a permit.

Ground Water Recharge Wells

1. Water from streams, rivers, canals, lakes, or ground water which is to be used to recharge ground water should be monitored for and meet standards for the following limits:

   i) nitrate-nitrogen (10 mg/l);

   ii) fecal coliform (200 per 100 ml) as outlined in the 1976 EPA Quality Criteria for Water.

2. A GC/MS analysis should be done on any water source which will be used to recharge ground water to determine the presence of any pesticides. Parameters to be monitored for pesticide concentrations would be later determined by DEC.

3. Treated sewage water to be used to recharge ground water should be tested for and should meet standards for:

   i) all parameters listed under Chapter 4, Title_118 Nebraska Ground Water Protection Standards (excluding radionuclides);

   ii) biological oxygen demand (30 mg/l);

   iii) fecal coliform (200 per 100 ml);

   iv) chlorides (200 mg/l);

   v) ammonia-nitrogen (5 mg/l);

   vi) any other parameters determined by DEC.

4. The ground water recharge well should be located at least 2000 feet from any stock, domestic, or municipal supply well.

5. A Class V injection well application form specifically designed for ground water recharge wells which would include:

   i) the exact location of the injection well including the location of any municipal, domestic, and stock wells within one mile of the recharge well;

   ii) the type of water being used for recharge and its source;

   iii) time of year which recharge will be done and expected injection rates to be used.

6. The injection well should be grouted from a point at least 20 feet below land surface to the land surface or to the water table.

Any ground water recharge well not meeting the above criteria would require a permit.

Septic Tank Systems

1. Local planning groups should be encouraged to examine establishing septic tank density limits. These limits would be based upon, among other things:

   i) depth to ground water;

   ii) soil permeabilities;

   iii) potential for further septic tank installations; and

   iv) quantities of wastes being discharged to individual systems.

2. Many industries discharge process wastes, in addition to sanitary wastes, to septic tank systems. Discharge of industrial process wastes should be restricted due to the fact that septic tank systems are not designed to adequately treat this waste type.

Region VIII State Report Summaries

Colorado
Montana
Indian Lands
North Dakota
South Dakota
Utah
Wyoming

Prepared: 12-15-86
Updated:

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Colorado **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Inventory of Class V Injection Wells in the State of Colorado

AUTHOR: SMC Martin, Inc.

DATE: 3-85 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES):
N/A

HYDROGEOLOGY:
Colorado can be broadly divided into 5 major groundwater regions: High Plains, Unglaciated Central Region, Central Mountains, San Luis (alluvial) Valley, and Colorado Plateau. The geologic and hydrologic frameworks are not generally conducive to the utilization of injection wells.

INVENTORY AND ASSESSMENT: 115 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5F1	X	High	N/A	N/A
5D2	2	Low	N/A	N/A
5A6	2	Low	N/A	N/A
5A7	2	Low	N/A	N/A
5X13	2	?	N/A	Rule
5X15	23	?	N/A	Rule
5A19	1	Low	N/A	N/A
5X25	2	Low	N/A	N/A
5X26	81	Low	N/A	N/A
5X29	X	High	N/A	P&A Rules

* "X" indicates this well type is known to exist; no number available

Strategy (Date)	Rating/Response
1. (1984) Contacts were made with governmental and private sector sources of general information on Class V injection wells.	?
2. (1984) Mass mailings were made to individuals and organizations presumed to be knowledgeable about specific types of Class V wells.	Low

Strategy (Date) - cont.	Rating/Response
3. (1984) Telephone contacts were made with specific individuals and organizations determined to have information on individual well, well types, or well facilities in Colorado	High
4. (1985) Lists of names and phone numbers compiled from phone books, directory assistance and preliminary inventory report (over 200 calls made).	High
a. State agencies within the Board of Health, Department of Natural Resources and other public sector groups	
b. Private sector individuals	
c. Legal contacts for all inventoried wells in order to verify inventory information	

RECOMMENDATIONS:

1. State of Colorado Division of Water Resources should alter its drilling permit form (WRJ-5-Rev.76) to categorize wells as "injection" or "extraction" wells.

2. State officials involved in developing new ground water regulations should provide a means in the legislation of maintaining the inventory.

3. Identify and inventory agricultural drainage wells and make further recommendations based on combined efforts of the State Department of Health and the EPA.

Prepared: 12-15-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Montana **STATUS:** DI **BIBLIOGRAPHY:** No

TITLE: Inventory of Class V Wells in the State of Montana

AUTHOR: SMC Martin, Inc.

DATE: 3-85 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES):
N/A

HYDROGEOLOGY:
N/A

INVENTORY AND ASSESSMENT: 4587 wells **FURS COMPATIBLE:** YES (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	4500	High	N/A	(private) permit: Building Dept. (municipal) Engineer's Dept.
5A7/19	20	Low	N/A	None
5W11	2	High	N/A	permit: County Sanitation Authority
5X13	10	?	N/A	permit: Bureau of Abd. Mines
5G30	55	Low	Yes	permit: Dept. of Highways

Strategy (Date)			Rating/Response
(1983)	o	Inventory compiled by telephone interviews and correspondence with various federal, state, county, and municipal agencies as well as industrial firms, drillers, pump sales and service companies, and private individuals.	N/A
	o	All county sanitation officers were initially contacted through letters stating the purpose of the survey and describing the types of Class V wells. The sanitarians were requested to list all Class V facilities in their counties. Telephone calls were subsequently made to verify information and obtain other sources of information.	N/A

Strategy (Date) - cont.		Rating/Response
	o All drillers listed in the Montana telephone directories were contacted. Information given by a driller concerning an injection well, if incomplete, was followed up with a telephone call to the owner of the well.	N/A
	o Pump sales and service companies were contacted. They were occasionally able to give the names of unlisted local well drillers, who were then contacted.	N/A
(Post-1983)	SMC Martin conducted an extensive series of telephone interviews to assess and evaluate the previously completed inventory. See the state report for the scope of this effort.	N/A

RECOMMENDATIONS:

1. Site specific study is needed to determine the nature and extent of degradation from 5X13 wells.

2. EPA should contact county sanitation authorities concerning sanitary waste disposal wells: A more reasonable assessment of the number of these wells could be obtained by a review of permits in county sanitation files. Site specific study is needed to evaluate the impact and extent of this degradation.

3. An assessment of the effects of 5D2 wells should be conducted prior to completing a complete inventory because the inventory would be time consuming and costly. If found to be an actual source of significant contamination, this inventory should be completed immediately.

Prepared: 4-15-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Region VIII - Indian Land **STATUS:** DI **BIBLIOGRAPHY:** No

TITLE: Inventory of Class V Injection Wells in the Indian Lands of EPA Region VIII

AUTHOR: SMC Martic

DATE: 3-85 **REPORT STATUS:** Final

RESPONSIBLE AGENCIES: U.S. EPA Region VIII, Bureau of Indian Affairs, Bureau of Land Management

HYDROGEOLOGY: N/A

INVENTORY AND ASSESSMENT: 2 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5A7	1	Minor, localized	No	N/A
5W11	1	N/A	No	N/A

Strategy (Date) **Response/Rating**

(Date N/A) Contacted government agencies on several levels: federal, regional, state, and reservation. BIA agencies were the most valuable source of information. Very little specific information was gathered from state agency contacts.

RECOMMENDATIONS:

This inventory can best be updated if individuals in local agencies who are familiar with the operations of individual reservations are periodically contacted to determine if any activity involving Class V injection wells has recently taken place on the reservation. Local BIA officials and/or tribal council members should be contacted. A knowledgeable person on each reservation could be empowered by the EPA to monitor Class V (and perhaps all) injection wells on that reservation. Periodic reporting by these people to EPA would ensure that the inventory remains current.

Prepared: 12-15-86
Updated:

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: North Dakota **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: Evaluation of the Inventory and Assessment of Class V Injection Wells in North Dakota

AUTHOR: SMC Martin, Inc.

DATE: 3-85 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES):
N/A

HYDROGEOLOGY:
N/A

INVENTORY AND ASSESSMENT: 448 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory* System
5F1	1	N/A	No	N/A
5A7	135	Low	N/A	All water well drillers must submit a log of wells that have been completed Installation must be approved by the State Water Department
5X13	300	Positive	N/A	Rule
5X16	1	?	N/A	N/A
5A19	1	?	N/A	N/A
5X27	10	?	N/A	N/A

*Every individual well owner is required to register his injection well with the State Department of Health.

Strategy (Date)	Rating/Response
Telephone survey conducted of:	N/A

- o Private residences
- o Industrial and commercial sites
- o Municipal and other governmental operations
- o Various public facilities including schools, churches, etc.
- o Industrial installers and dealers of heat pumps

RECOMMENDATIONS:

N/A

Prepared: 12-15-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: South Dakota **STATUS:** DI **BIBLIOGRAPHY:** No

TITLE: Evaluation of the Inventory and Assessment of Class V Injection Wells in the State of South Dakota

AUTHOR: SMC Martin, Inc.

DATE: 3-85 **REPORT STATUS:** Final

RESPONSIBLE AGENCY(IES):
N/A

HYDROGEOLOGY:
N/A

INVENTORY AND ASSESSMENT: 49 Wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5A7	48	N/A	N/A	N/A
5A19	1	N/A	N/A	N/A

Strategy		Rating/Response
(1983)	Telephone surveys soliciting information from:	Thorough and accurate for heat pumps
o	Electric cooperative member service directories	
o	Plumbing and heating contractors	
o	Water well drillers	
o	State agencies-limited effort	
(Post 1983)	SMC Martin conducted a more extensive survey: See state report for details	N/A

RECOMMENDATIONS:
Water wells should be designated as "supply" or "injection" wells on drilling permits.

Prepared: 3-16-87
Updated: 4-27-87

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Utah **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Draft Class V Well Inventory for the UIC Program

AUTHOR: Morton, Loren B. and James H. Martin

DATE: 2-87 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES): Utah Bureau of Water Pollution Control (BWPC)

HYDROGEOLOGY: The state of Utah is composed of three physiographic provinces which each contain distinct aquifer characteristics and vulnerabilities. In the Basin and Range Province, injection wells penetrating the confining layer or located in the recharge area pose the greatest threat to current public water supplies. In the Middle Rocky Mtn. Province the bedrock aquifer systems are at high risk for groundwater pollution while the alluvial and glacial aquifer systems are less vulnerable. No information is currently available on the Colorado Plateau Province.

INVENTORY AND ASSESSMENT: 3,088 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential+	Case Studies	Regulatory System°
5D2	2743	2-5		Rule
5D4	321	3-7		Rule
5A6	1	5	No	Permit
5A7	7	4		Permit
5A19	3	4		Permit
5W20	4	5-7		(Prohibited)
5X28	2	6		(Prohibited)
5X29	7	2-7		(Illegal)
5W11	X*	N/A	-	N/A

* "drainfields are believed to exist and should be included
\+ contamination potential is rated on a scale of 2 to 7, (2=lowest, 7=highest)
o information concerning responsible agencies rather than system (e.g. permit, rule, etc.)

Strategy	Rating/Response
City, State, and Federal Cooperation.....	Good
Public Education.....	To Be Implemented
Industry Response.....	Mixed
(5D2,4) Contacted city and county engineers, planning and zoning staff, building inspectors, public works directors, and local environmental health staff. Also conducted site inspection.	

Strategy (cont.)		Rating/Response
(5A5-7)	Reviewed records of Utah Division of Water Rights (DWR). Some site inspections.	N/A
(5A19)	Contacted DWR and potential well owners.	N/A
(5W20)	Contacted BWPC personnel and local health department staff.	N/A
(5X28)	Located during drainage well inventory.	N/A
(5X29)	Contacted DWR and BWPC.	N/A

RECOMMENDATIONS:

(5D2,4)

A. The most obvious alternative to these wells is the conventional storm sewer. In most Utah communities this would require extensive public works construction. A ban on drainage wells would force communities to construct and extend storm sewers for all public streets and some private property. This creation or augmentation would result in increased costs to the local taxpayer.

B. Another alternative would be to provide environmental management.
   1. Studies should first be undertaken to assess:
      (a) organic parameters of urban runoff entering drainage wells from public streets (5D2 wells),
      (b) total water chemistry, including organics, of runoff enter commercial/industrial drainage wells (5D4 wells).

      Priority attention in the study should be given to wells located in the recharge area of the public water supply aquifers. In these areas ground water pollution problems should be addressed immediately upon discovery.

   2. Once armed with facts, efforts should be focused on prevention of pollution from drainage wells. This could best be accomplished by:

      (a) Establishment of state and federal standards for drainage well water quality, and associated design, siting, and spill prevention requirements.
      (b) Propagation of authority and implemention of state and federal standards to local government. Multiple point source nature of drainage wells will require highly labor intensive management which could best be accomplished at the local level.

   3. After prevention, cleanup of drainage well polluted sites should be emphasized. This would be accomplished through accepted aquifer cleanup practices.

C. Additional regulation is needed in storage and loading areas which are vulnerable to hazardous product and spills.

1. Increased attention could be provided in changes to local zoning and building code ordinances or environmental regulations.

2. Plan review in the permit approval process could give opportunity for local government to assist the private sector in proper design and siting, including spill prevention.

D. Little federal attention has been given to regulation of urban runoff to date. Even less attention has been given to urban runoff disposed in drainage wells. We recommend that drainage well studies be conducted, regulations as necessary be implemented, and coordination be accomplished between local government, and the UIC and NPDES programs. Today, the UIC program is ineffective at regulating these systems due to 1) lack of understanding of regulatory needs of drainage wells, and 2) the sheer numbers of wells to be managed by a limited staff. It must be noted that any increase in regulatory requirements for these wells, without an increase in program resources, will only result in even more diminished program effectiveness.

(5A6,7,19)

A. The most practical corrective alternative is one that should already exist in these systems: non-contact use of the groundwater. System design should emphasize prevention of groundwater contact with any other fluids or soluble solids.

B. If operation and maintenance inspections of these wells is required in the future, more resources will be necessary to match the increased workload.

C. The federal government can be effective by providing information on necessary environmental regulations and encouraging states to adopt them. Currently the UIC program is ineffective in regular inspection and day-to-day management of these wells due to lack of resources. Increased requirements will have to be accompanied by increased resources to achieve better program effectiveness.

(5W20)

A. The best corrective alternative for these wells is to connect the waste streams to the sanitary sewer, following any necessary pretreatment requirements. Direct discharge to a well or dry well does not provide the treatment necessary to render the waste water harmless to groundwater supplies. This treatment can be provided by local water reclamation plants.

B. These wells can be detected and managed by local building code, environmental, or sewer pretreatment programs. However, the fact that some of these wells exist may be indicative of a lack of Class V well experience, and the high workloads and low funding levels that local government programs endure. Occurrence of these wells in rural areas may also be caused by a lack of community water reclamation systems.

C. The low number of these wells found indicates local government is doing a good job of regulating industrial process water. However, the NPDES program can be more effective in helping the UIC program by requiring sewer improvement districts to inventory all industrial users of their system and to review details of each user's waste stream(s). This assistance will help locate these wells in urban areas of the state. The UIC program should then closely examine rural industry, in conjunction with state ground water protection staff and with the help of local government, to identify industrial dischargers to ground water. Such a study would locate discharges not only to wells but also to drainfields, sumps, dry wells, etc. Once again without increased resources this effort may never be accomplished.

(5X28)

A. These wells can be corrected by providing underground holding tanks (total containment) for the waste oils/fluids. These tanks would require regular off-loading to waste oil reclaimers. In Utah, there is economic incentive for a service station to sell waste oil to a reclaimer. The management of these wells would best be accomplished at the local government level because they already enforce their building and sewer ordinances. Any inspections by state or federal staff would be a duplication of effort.

B. Communities with a water reclamation system commonly prohibit oil and grease discharges to their sewer. Consequently, some operators opt to discharge to dry wells as a "loophole" to the environmental regulations. Local building code and sewer pretreatment inspection should be able to locate and manage these wells.

C. The UIC program has not been effective in controlling this problem, but local government has. Considering the thousands of service stations in the state, to find only two of these wells thus far is encouraging. The UIC program can be more effective by educating those local government staff who conduct building and environmental inspections. This training will help locate these violators and hopefully solve the problem.

(5X29)

A. The only corrective alternative for these wells is closure. This practice must be halted to prevent aquifer contamination. In the case of domestic waste, sanitary sewer hook-up should be required. Industrial wastes should receive any necessary pretreatment and should also be discharged to the sanitary sewer. Hazardous waste should be handled in accordance with RCRA regulations.

B. Disposal practices are difficult to detect without inspecting each and every water well; a Herculean task. Perhaps a more practical way to find these problems is through inspections carried out by other existing state, local, and federal regulatory programs. Educating those who conduct building code, water appropriation, and environmental inspections on what to look for should be the most cost effective way to find these types of violations. Prevention of this problem would best be accomplished through public education, particularly of water well owners.

C. It appears that the most practical way these wells can be located and closed is to educate the public and personnel in other government programs (i.e., RCRA, NPDES, local environmental and planning/building programs) in how to locate these wells, what they consist of, and the damage they can do to the ground water supply. Short of this, these wells could only be detected by an exhausting review of all existing water wells in the state; an impossible task considering current funding levels.

Prepared: 1-16-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Wyoming **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Assessment of Class V Injection Wells in the State of Wyoming

AUTHOR: Western Water Companies

DATE: 9-86 **REPORT STATUS:** Final

RESPONSIBLE AGENCY: Department of Environmental Quality (DEQ)

HYDROGEOLOGY: The formations most sensitive to Class V injection operations include those areas underlain by: 1. Quaternary-age alluvium; 2. Mountain glacial deposits; 3. Shallow bedrock aquifers; 4. Paleozoic-age aquifers; 5. Dune sand and loess. Less Vulnerable units include igneous, metamorphic, and volcanic rocks; Mesozoic sandstone aquifers; playa lake and other lacustrine deposits; landslides; and Mesozoic shales (aquitards).

INVENTORY AND ASSESSMENT: 738 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential*	Case Studies	Regulatory System
5D2	5	3	No	Any party who in-
5A7	7	8	No	tends to construct
5W10	3	5	No	or operate any fac-
5W11	420	5	No	ility which may
5X13	74	3,10	No	cause or contribute
5X14	14	1	No	to pollution of any
5X15	41	4,7	2 facilities	water of the
5W20	32	3	No	state is required
5R21	7	6	1 facility	to obtain a permit
5X25	135	1,9	3 facilities	from the WQD.

* Well types are ranked according to contamination potential (1 = highest, 10 = lowest). Some well types had different rankings for different facilities.

Strategy (Date): see state report for individual strategies.		Rating/ Response
(1984)	1. Interviewed state and federal government agencies and reviewed available records.	N/A
	2. Local government offices were asked to provide information about Class V wells within their jurisdictions.	N/A
	3. Potential owners of and businesses likely to install or service Class V wells were identified and contacted.	N/A
	4. When potential well owners or information sources could not be reached, an extensive letter and telephone follow-up system was employed.	N/A

RECOMMENDATIONS:

1. Continue current regulatory efforts.

2. Investigate the environmental effects of dry wells within the state.

3. Obtain a computerized standard ground-water quality model to verify model results submitted by permit applicants and independently evaluate proposed projects.

4. Develop and use a standard data management system for routine monitoring data submitted by permittees.

Region IX State Report Summaries

Arizona
California
Hawaii
Nevada
American Samoa
Trust Territories and Pacific Islands
Guam
CNMI

Prepared: 7-22-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in April 10, 1987 memorandum from Richard A. Coddington to Michael B. Cook)

STATE: DI States - USEPA Region IX (AZ, CA, Guam, HI, NV, TTPI)

RESPONSIBLE AGENCY: U.S. Environmental Protection Agency

INVENTORY AND ASSESSMENT: 64,105 wells

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5D2,4	59,323	See individual State Report Summaries		
5G30	1		"	
5A5	81		"	
5A6	7		"	
5A7	53		"	
5A8	25		"	
5W9	3		"	
5W10	120		"	
5W11	1,311		"	
5W31	73		"	
5W32	1,279		"	
5W12	358		"	
5X13	1		"	
5X14	875		"	
5X17	35		"	
5X18	22		"	
5A19	26		"	
5W20	209		"	
5R21	103		"	
5B22	155		"	
5X25	45		"	

Strategy (Date)	Rating/Response
See individual State Report Summaries	

RECOMMENDATIONS:

1. Develop a system to consistently update and maintain the Class V inventory. This system should:

   * focus on obtaining inventory information and well specific data about high priority or high contamination potential wells prior to construction;

* focus on obtaining data about wells in areas which have a high level of groundwater usage and a high density of wells which could endanger the USDW;

* coordinate with and utilize information from existing state programs;

* utilize authority under UIC or RCRA program to request information from operators of high contamination potential wells;

* contact and obtain information from well drillers, cities and other groups that maintain records on recent and new well construction and operation; and

* utilize information gathered by other Federal programs (e.g. through RCRA at hazardous waste generation facilities with stormwater drainage wells).

2. Develop and implement an effective inspection, compliance, and enforcement program. This should include:

   * review state specific Class V assessments, Class V inventory, state program reports, and local program reports, and identify specific facilities with high contamination potential wells which must be inspected;

   * inspect high contamination potential well types in high risk areas (e.g., areas overlying sole source aquifers with a high density of high contamination potential wells);

   * coordinate inspection and work in conjunction with existing state programs;

   * sample waste streams when necessary to assess possible violations;

   * bring enforcement actions against all Class IV wells which may be uncovered; and

   * take appropriate enforcement actions against operators of Class V wells which are "endangering" an USDW.

3. Develop and implement an interim UIC Class V permit program. This interim permit program should contain proper siting, construction, monitoring, reporting, and closure requirements which will assure that a permitted Class V well will not endanger an USDW.

Prepared: 2-3-87
Updated: 6-1-87

STATE REPORT SUMMARY

(All information recorded as described in state reports, additional correspondence, and verbal communication)

STATE: Arizona **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Report on Class V Injection Well Inventory and Assessment in Arizona

AUTHOR: Engineering Enterprises, Inc.

DATE: 5-87 **REPORT STATUS:** Final Draft

RESPONSIBLE AGENCY(IES): USEPA, Region IX, UIC Section

HYDROGEOLOGY: The Upper Alluvian Unit of the basin-fill aquifer in the Salt River Valley groundwater area receives the majority of water injected through Class V wells in Arizona. This basin-fill aquifer is utilized for domestic, industrial, irrigation and public water supply. Groundwater withdrawals from this aquifer account for 25 percent of groundwater withdrawals in the state.

INVENTORY AND ASSESSMENT: 51,207 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	40,000 - 60,000	Moderate	Yes	Registration
5D4	Combined w/5D2	Moderate	Yes	Registration
5W20	72	High	Yes	Permit
5W10	17	High	No	Permit
5W11	143	High	No	Permit
5W12	1	High	No	Permit
5W31	18	High	No	Permit
5W32	3	High	No	Permit
5X14	870	Low to Mod.	Yes	Permit
5R21	51	Low	Yes	Permit
5X25	32	Low to Mod.	Yes	Permit
5A7	X	Low	No	None

Strategy		Rating/Response
Jan.-Feb., 1985	Inventory questionnaires mailed to various federal, state and local agencies.	N/A
April-May, 1985	A second inventory questionnaire was mailed to businesses and industries and potentially owning/operating Class V wells.	N/A

May-June, 1985	Inventory questionnaires were mailed to irrigation, drainage, and other water districts in Arizona.	N/A
August, 1986	A fourth questionnaire was mailed to county health departments and the Arizona Department of Health Services to increase the inventory of Class V sewage treatment/disposal systems.	N/A
July, August, Sept., 1986	A file investigation/site inspection study was conducted by EEI to obtain further data on solution mining wells and industrial disposal wells.	N/A

RECOMMENDATIONS:

Solution Mining Wells (5X14) and Experimental Technology Wells (5X25) Associated with Solution Mining:

1. Require operators currently grandfathered from having to obtain a permit to seek one through the appropriate state agency.
2. Additional study is needed to determine if post-closure requirements are sufficient to protect USDW.
3. Performance bonds may be necessary to insure compliance with permit conditions.

Aquifer Recharge Wells (5R21):

1. USEPA and Arizona regulators should agree on guidelines to address how water quality versus water quantity conflicts are resolved for projects using injection wells.

Heat Pump/Air Conditioning Return Flow Wells (5A7):

1. Well construction and choice of injection zone should be regulated.

2. Additional study on the impact of additives such as biocides, corrosion or scale inhibitors, and clay dispersal agents used to increase injection well performance is needed.

Sewage Waste Water Disposal Wells (5W10, 5W11, 5W31, 5W32):

1. Inventory may be improved by working with state and local agencies. Inventory efforts should focus upon systems receiving industrial/commercial wastes or process waters.

2. Groundwater Quality Protection Permit conditions should be tested to ensure protection of USDW by conducting site investigations, including groundwater monitoring.

3. Class V on-site systems should be reclassified in order that waste stream quality and quantity may be determined from the type of system indicated on the returned questionnaire.

4. The public should be educated on the appropriate use of on-site treatment systems.

Domestic Waste Water Treatment Plant Effluent Disposal (5W12):

1. Conduct additional inventory efforts.

2. Groundwater Quality Protection Permit conditions should be tested to ensure protection of USDW by conducting site investigations including groundwater monitoring.

Storm Water Drainage and Industrial Drainage (5D2 and 5D4):

1. Additional study of the water quality impacts to USDW are needed. These should involve sampling of sediments in settling basins of drainage wells, storm water run off, and groundwater within the saturated and unsaturated zone at selected sites. Also, use studies as a basis for establishing a minimum vertical separation distance between the water table and the bottom of the well.

2. Provide depth to water maps for drillers and planners especially in commercial areas.

3. Continue public information efforts on the newly instituted registration program.

Industrial Process Water and Waste Water Disposal Wells (5W20):

1. Conduct targeted questionnaire mailings, telephone follow-ups, and facility inspections. Also, review ADHS files for additional inventory.

2. Any operating permits which are granted should require water level data and a geologic description of sediments down to the regional water table.

3. Develop case studies at selected sites, including groundwater monitoring, to determine if permit conditions protect USDW.

4. Continue to require a complete waste stream analysis as part of the permit application.

5. In conjunction with (3) above, conduct studies on the attenuation of contaminants within the vadose zone in order to specify a minimum separation distance between completion depth and the water table.

Agricultural Drainage Wells (5F1):

If such wells are installed or discovered in the future, they should be regulated. Guidelines should include well construction standards, injectate quality standards, choice of injection zones and injection volume.

Prepared: 1-28-87
Updated: 5-7-87

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: California **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Reporting on Class V Injection Well Inventory & Assessment in California

AUTHOR: Engineering Enterprises, Inc.

DATE: 5-87 **REPORT STATUS:** Final Draft

RESPONSIBLE AGENCY(IES):

California Division of Oil & Gas (CDOG); Division of Water Resources (DWR); Regional Water Quality Control Boards (RWQCB); Bureau of Land Management (BLM)

HYDROGEOLOGY:

Groundwater withdrawals account for 40% of California's water use. Total storage capacity of all groundwater basins is 1.3 billion acre-feet. Principal aquifers are alluvium and older sediments in coastal regions. Basin-fill aquifers typify desert regions. Volcanic aquifers are found primarily in northern California, flanking the Cascade & Siskiyou Ranges, and along the eastern Sacramento Valley. Consolidated crystalline rocks and bedded sandstones are principal aquifers locally.

INVENTORY AND ASSESSMENT: 12,236 wells (Est) **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2 - 5D4	9175 (est)	MOD	1	NO PERMIT REQUIRED
5A5	65	LOW	4	PERMIT
5A6	1	LOW	1	PERMIT
5A7	53	LOW	NO	PERMIT
5W10	46	HIGH	NO	BANNED
5W11	1165	HIGH	NO	N/A
5W12	22	HIGH	NO	PERMIT
5X14	5	UNKNOWN	1	PERMIT
5X17	35	MOD-HIGH	5	PERMIT
5X18	22	MOD-HIGH	9	PERMIT
5A19	20	UNKNOWN	NO	PERMIT
5W20	93	HIGH	6	PERMIT
5R21	52	UNKNOWN	YES	PERMIT
5R22	155	LOW	YES	PERMIT
5X25	2	UNKNOWN	NO	PERMIT
5W31	42	HIGH	NO	PERMIT
5W32	1276	HIGH	NO	PERMIT

Strategy		Rating/Response
(1,2-1985)	Questionnaires I & II mailed by EEI & EPA to: county health departments, public works departments, departments of transportation, department of agriculture, U.S. Soil Conservation Service, known geothermal operators, selected RCRA applicants	Moderate
(4-1985)	Questionnaires mailed by EEI to: petroleum refiners and chemical plants, chemical manufacturers, industrial manufacturers, drilling service companies, campgrounds/RV discharge areas, mortuaries, refuse haulers, industrial disposal services, waste oil refiners, smelters, pumping contractors	Low
(6-1985)	Similar questionnaires mailed by EEI to new operator	Low
(7-9-1986)	Agency file reviews and site investigations for hi-tech facilities	Moderate
(9-12,1986)	Contact regional boards and county health departments to increase the inventory of Class V sewage disposal systems.	Moderate

RECOMMENDATIONS:

A. STORMWATER AND INDUSTRIAL DRAINAGE WELLS (5D2 & 5D4)

Increased inventory efforts are needed to locate and identify wells of this type. In addition, the severity of contamination potential posed by these wells needs to be better defined by further field investigations. Factors to consider in establishing interim regulations for these wells include:

1) Prohibition of wells in areas served by storm water sewers.
2) Prohibition of well development into public supply aquifers.
3) Definition of minimum vertical separation requirements.
4) Definition of minimum horizontal setback requirements.

B. GEOTHERMAL ELECTRIC POWER GENERATION INJECTION WELLS (5A5)

It is recommended that all permit applications are accompanied by baseline hydrogeological studies, complete with maps showing all water supply wells in the area, detailed drilling and completion plans, and comprehensive injectate and injection formation fluid chemical analyses. Mechanical integrity tests and analysis of injection fluids should be required annually. In addition, continual monitoring of injection volumes and pressures should be required.

C. GEOTHERMAL DIRECT HEAT INJECTION WELLS (5A6)

Recommendations are generally the same as for electric power generation. In addition, further inventory efforts are needed to locate other low-temperature geothermal injection facilities in northern California.

D. HEAT PUMP/AIR CONDITIONING RETURN FLOW WELLS (5A7)

Potential for USDW contamination is lowest when the source and injection zones are the same aquifer. It is recommended that all injection of heat pump/air conditioning return flow water is into the source aquifer. In addition, increased inventory efforts are needed to identify new and existing wells, and to evaluate their potential for USDW contamination.

E. SEWAGE WASTEWATER DISPOSAL SYSTEMS (5W10, 5W11, 5W12, 5W31, 5W32)

Increased inventory efforts are needed. Inventory efforts should be concentrated on cesspools, septic systems with wells, and septic systems with drainfields receiving industrial/commercial wastes or process waters. Septic systems and cesspools should be classified according to the types of waste water disposed. Operators of cesspools should be required to develop alternate disposal systems. Sewage disposal systems should not be designed for areas with existing sewers. Owners of these disposal systems should submit waste discharge reports. Operators should be required to characterize their waste streams before discharging and at any time composition changes. Permitting for small facilities should be conducted at the local agency level.

F. SOLUTION MINING INJECTION WELLS (5X14)

A more thorough database for existing facilities should be developed. Monitoring well networks should be established down gradient to the mine and semi-annual sample analysis should be conducted for each well. Monthly volumetric analysis of injection and recovery fluids should be conducted to ensure balance. Mechanical integrity for all wells should be demonstrated periodically.

G. AIR SCRUBBER WASTE DISPOSAL WELLS (5X17)

It is recommended that a sampling program is developed to characterize waste streams at all facilities. Samples should be taken at the injection pumps or wellhead. Semi-annual waste stream analyses should be required, and standard sample parameters should be Total Organic Carbon (TOC), oil and grease, and total recoverable hydrocarbons. Injection into USDW that are not oil bearing should be prohibited. Finally, consistency in permit requirements for each facility should be established.

H. WATER SOFTENER REGENERATION BRINE DISPOSAL WELLS (5X18)

For recommendations, see Air Scrubber Waste Disposal Well Summary.

I. COOLING WATER RETURN FLOW WELLS (5A19)

Increased inventory efforts are necessary to locate and identify all wells of this kind. Injection of contact cooling water into Class IIB aquifers should not be allowed, and all new systems should be of the closed loop variety. Spent cooling water should be injected back into the source aquifer to prevent aquifer degradation due to fluid incompatibility. Finally, permit applications should address the hydrogeology for a 1/4-mile radius around the facility.

J. INDUSTRIAL PROCESS WATER & WASTE DISPOSAL WELLS (5W20)

Monitoring well systems should be implemented at large facilities to trace the migration of contaminants. Injection of industrial waste and process water into USDW should be prohibited. Increased inventory efforts are needed to identify new and existing facilities. More in-depth hydrogeological background should be acquired prior to permit approval. Finally, all permits should require regular chemical analysis of injected fluids.

K. AQUIFER RECHARGE WELLS (5R21)

Agricultural chemicals and nutrients should be removed from return flows in agricultural areas where recharge is being conducted. Sewage wastewater should always be treated prior to use as recharge fluid. Water not meeting National Primary and Secondary Drinking Water Standards should not be injected into currently used USDW.

L. SALTWATER INTRUSION BARRIER WELLS (5B22)

Case studies should be conducted to assess the influence of this injection upon potential or present public drinking water supplies. Studies should also be conducted to further define the lithologic and hydrogeologic controls over salt water intrusion. Characterization of injectate and injection zone fluids should be conducted at all salt water intrusion barrier projects. Finally, increased inventory efforts are needed to ensure that all such projects have been identified.

M. EXPERIMENTAL TECHNOLOGY INJECTION WELLS (5X25)

Increased inventory efforts are necessary to locate other experimental facilities. Site-specific studies should be conducted for each facility located through continued inventory efforts.

Prepared: 2-3-87
Updated: 5-7-87

STATE REPORT SUMMARY

(All information recorded as described in state reports, additional correspondence, and verbal communication)

STATE: Hawaii **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE:
(1) Draft Report, Inventory and Assessment of Class V Injection Wells in Hawaii for US EPA Region IX

(2) Draft Report of Investigation Class V Injection Well Inspections, Oahu and Hawaii Islands, Hawaii

(3) Letter with inventory updates from Hawaii Department of Health and various correspondence

AUTHOR: (1), (2) Engineering Enterprises, Inc.

DATE:
(1) April 1987
(2) November 1985
(3) August 1986

REPORT STATUS: Draft

RESPONSIBLE AGENCY(IES):

U.S. EPA Region IX, UIC Section
Hawaii Department of Health, Environmental Permits Branch

HYDROGEOLOGY: Primary water source is groundwater on major islands. Surface water is locally important. Groundwater occurs primarily as (1) basal lens, underlying all islands, comprising major groundwater source, (2) water held in dike complexes, above basal lens and/or sea level, and (3) perched water at high elevations above basal lens and/or sea level. Specific information is contained in draft reports.

INVENTORY AND ASSESSMENT: 617 wells **FURS COMPATIBLE:** No

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	129*	Moderate	No	All Class V
5D4	4	Moderate	No	injection wells
5A8	25	Moderate	Yes	are regulated
5W9	3	High	Yes	under a permit
5W10	57	High	No	system by the
5W31	7	High	Yes	Hawaii Dept.
5W12	335	High	Yes	of Health,
5A19	5	Low	Yes	Environmental
5W20	44	High	Yes	Permits Branch.
5X25	6	Low	No	
5G30	1	Unknown	No	

* Many more wells thought to exist.

Strategy (Date)	Response/Rating
(1) Hawaii Dept. of Health obtained a list of injection well owners which USGS compiled and mailed request-for-permit application forms to people on list. The USGS list was based on: permit applications for privately owned treatment works; personal memories of regulatory officials; and well drilling permits. (pre-1985)	Good
(2) Hawaii Dept. of Health also mailed request-for-permit application forms to: businesses in the telephone book; potential sewage disposal well owners in non-sewered areas; and known industrial plants or operations. (pre-1985)	Good
(3) Follow-up letters were mailed to non-respondents of surveys listed in (1) and (2).	?
(4) EEI inspection program added three facilities (sewage related wells) during site inspection program. One facility was in a non-sewered area and was found to use well disposal. Two other facilities were state/county hospitals disposing of sewage waste for which the Health Dept. had not had manpower before inspections to obtain data needed to complete permit application. (August 1985)	Good

RECOMMENDATIONS

From EEI Draft Report "Inventory and Assessment of Class V Injection Wells in Hawaii" (April, 1987):

- Inventory efforts should continue.
- The public should be educated with regard to proper operation of Class V injection well systems and potential groundwater contamination which may result from unregulated Class V injection. The public should be made aware of regulations regarding Class V wells.
- In-depth hydrogeologic studies should be conducted by a qualified individual for active and proposed areas of Class V injection.
- Wells should be properly designed, constructed, and operated. Regulatory personnel should review proposed construction specifics and the submitted hydrogeologic report before granting permission to construct wells.

- Periodic sampling and analysis of injected fluids should be conducted. Receiving waters should also be sampled periodically for signs of degradation from injection practices.

- Mechanical integrity of selected well types should be maintained and verified through testing periodically. Appropriate mechanical integrity tests may need to be developed.

- Wells should be properly plugged and sealed when injection is terminated.

- The UIC Line may need to be relocated in some areas, as it is only a rough approximation of groundwater containing at least 5,000 mg/l TDS.

- Research should be conducted with regard to attenuation capabilities of basalts at various stages of weathering.

- An organized sample and core library could be formed to facilitate areal mapping and hydrogeologic evaluation. This proposal should be considered.

From EEI Draft Report of Investigations (November 1985):

SITE INVESTIGATIONS AND HAWAII UIC PROGRAM

- Site inspections should be conducted at facilities which submit permit applications to verify and augment submitted information.

- Appropriate chemical analyses should be done to characterize injected fluids at permitted facilities.

- Site hydrogeology at permitted facilities should be better documented, at least in the form of injection well boring logs.

- Water usage in the area of the permitted facilities should be considered during the permitting process.

- Abandoned wells should be properly plugged and abandoned.

- Efforts should be continued to locate facilities not currently under the regulatory process. This activity could entail substantial field work. This task could be aided by requiring and strictly enforcing a rule on well installation. This rule would require submittal of well logs, completion details, and other pertinent data to all appropriate state agencies.

From Hawaii Department of Health Correspondence (May 1986)

ELEMENTS NEEDED FOR THE FUTURE

- Review and revision of existing state regulations to provide more prudent control of injection and monitoring requirements.

- Promote cooperation between regulatory agencies and the regulated community. Cooperation must be coupled with education of the regulated community and the public.

- Seek out and regulate injection facilities which have not yet been reported.

Prepared: 1-28-87
Updated: 5-4-87

STATE REPORT SUMMARY

(All information recorded as described in state reports, additional correspondence and verbal communication)

STATE: Nevada **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Report on Class V Injection Well Inventory and Assessment in Nevada

AUTHOR: Engineering Enterprises, Inc.

DATE: 5-87 **REPORT STATUS:** Final Draft

RESPONSIBLE AGENCY(IES):

Division of Environmental Protection (DEP); Division of Water Resources (DWR); Department of Minerals (DOM); Division of Health (DOH)

HYDROGEOLOGY:

Groundwater withdrawals account for about 20% of all water used in Nevada. Basin-fill (valley-fill) aquifers are currently supplying the majority of groundwater withdrawals. Carbonates (limestone and dolomite) and volcanic rocks also function as principle aquifers in certain parts of the state.

INVENTORY AND ASSESSMENT: 46 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number*	Contamination Potential	Case Studies	Regulatory System
5D2	15	Moderate	No	N/A
5D4	X	Moderate	No	N/A
5A5	16	High - Low	3 facilities	Permit
5A6	6	Low	5 facilities	Permit
5A7	X	Low	No	N/A
5W11	3+	Moderate	No	Permit
5W32	X			Permit
5X25	5+	Unknown	No	Permit
5X28	X	High	No	N/A
5X13	1	Unknown	No	N/A

* "X" indicates well type is believed to exist; no numbers available

Strategy		Rating/Response
(1981)	"Feasibility Report of the Underground Injection Control Program for the State of Nevada"	N/A
(1983)	Inventory of injection wells, compiled by SMC Martin	N/A
(1984)	Assessment of injection wells, compiled by SMC Martin	N/A
(1,2-85)	Questionnaires I & II mailed by EEI & EPA to: county health depts., public works depts., depts. of transportation, dept. of agriculture, Nev. Pollution Control Federation, U.S. Soil Conservation Service, various other state and federal agencies, known geothermal operators, selected RCRA Part A permit applicants, and others from previously constructed lists.	Moderate
(4,5-85)	Questionnaires mailed by EPA to: petroleum refiners, petroleum chemical plants, chemical manufacturers, other industrial manufacturers, drilling service companies, campgrounds/ R.V. discharge areas, mortuaries, major refuse hauling and disposal services, industrial waste disposal services, waste oil re-refineries, smelters, and pumping contractors (sewage).	Low
(5,6-85)	Questionnaires mailed by EPA to irrigation, drainage, and various water districts in Nevada.	Low
(9-86)	Survey conducted by EEI/EPA to increase the inventory of sewage disposal well facilities.	Low

RECOMMENDATIONS:

Sewage Disposal Wells (5W11, 5W32):

1. Effluent limitations, periodic inspections and public education may alleviate problems of misuse through improper disposal.
2. Site investigations or case studies may provide information in order to ascertain whether siting guidance for individual systems is suitable for Class V systems.
3. State, county, and local agency files may be examined in order to improve inventory.
4. Site investigations may be desirable when the inventory is improved.

Experimental Technology Wells (5X25):

1. Additional inventory data should be obtained.
2. Additional study should be conducted on current regulatory jurisdiction.

2. Injection fluids should be sampled and analyzed for parameters of the National Primary Drinking Water Standards (NPDWS).
3. State should expand the scope and detail of baseline hydrologic investigations required in permit applications.

Geothermal Direct Heat Injection Wells (5A6):

1. A discussion should be held with state agencies in order to inventory domestic size systems.
2. Additional study is needed to determine appropriate MIT's and frequency of testing.
3. Injection fluids should be sampled and analyzed for parameters of the NPDWS.
4. State should expand the scope and detail of baseline hydrologic investigations required in commercial permit applications.

Storm Water and Industrial Drainage Wells (5D2, 5D4):

1. Likely present and future uses of drainage wells should be determined by asking state and local officials if ordinances requiring or banning drainage wells exist.
2. Consider public education as a means to control future use of this well type and on-site sewage waste water disposal systems. Periodic conferences and literature distributions for public officials or interested parties regarding the uses and abuses of such systems would provide education and promote awareness of the Federal UIC program. Regulatory approaches could also be discussed through such means.

Prepared: 2-3-87
Updated:

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: American Samoa **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Assessment Report - American Samoa

AUTHOR: UIC, Region IX

DATE: 1-87 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES): EPA Region IX, UIC

HYDROGEOLOGY: All of the groundwater occurs in either high-level aquifers or basal aquifers. Ground water in high level aquifers is either (1) prevented from migrating downward by flat-lying aquitards, or (2) impounded behind near vertical dikes that have intruded highly permeable basalt flows. Discharges range from 2 liters/sec. to 24 liters/sec. Basal aquifers drain directly to the sea without significant retention times. They are generally located near the coast. Discharge rates range from 2 liters/day to 21 liters/day. Inhabitants generally depend on surface water.

INVENTORY AND ASSESSMENT: 0 Wells **FURS COMPATIBLE:** N/A

Type	Number	Contamination Potential	Case Studies	Regulatory System
0	0	0	0	0

Strategy	Rating/Response
Not Applicable	

RECOMMENDATIONS:

Prior to the early 1970's, the inhabitants of American Samoa relied almost entirely on surface water sources to support their drinking water needs. With the installation of numerous water wells in the last decade, however, groundwater now represents the bulk of the drinking water consumed on the islands of American Samoa. Despite this element of progress, new groundwater sources must be developed to meet the needs of the growing population.

The islands of American Samoa will probably soon face the problem of large scale waste disposal as new industries are introduced. Due to the delicate water balance that exists on each island, the disposal of waste must be approached cautiously. At present, little recorded data exists on the distribution of high-level and basal aquifers on the islands. Because of this, it is difficult to assess hydrogeologic vulnerability. There are, however, numerous examples of locations that clearly should not be used as waste disposal sites such as the Taruna-Leone Plaine and the upper Pagaala Valley. These two areas are

vulnerable because the local aquifers, which occur at or near the surface, are essentially unprotected from contamination due to the high level of hydraulic interconnection between the geologic units. Other areas characterized by highly permeable formations or deposits are likewise unsuitable as waste disposal sites for the reason given above.

In order to objectively identify areas of hydrogeologic vulnerability, a set of standard criteria must be developed that define in precise terms what consitutes vulnerability and what does not. Once these criteria have been established, it will be possible to isolate areas that are vulnerable to contamination, and to evaluate the potential for Class V well installation in a site-specific manner.

Prepared: 2-3-87
Updated:

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Trust Territories of the Pacific Island (TTPI) **STATUS** DI **BIBLIOGRAPHY:** NO

TITLE: Trust Territory of the Pacific Islands Underground Injection Control Program

AUTHOR: John Mink

DATE: 1-87 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES): EPA Region IX, UIC; Trust Territory Environmental Protection Board

HYDROGEOLOGY: Two island types are prevalent: volcanic and raised limestone. The people rely on a variety of sources for water supply including rain catchment, stream flow, and shallow hand dug wells.

INVENTORY AND ASSESSMENT: 0 Wells **FURS COMPATIBLE:** N/A

Type	Number	Contamination Potential	Case Studies	Regulatory System
0	0	0	0	0

Strategy	Rating/Response
Not Applicable	

RECOMMENDATIONS:

As mentioned previously, the completion of the 1985 EPA study reaffirmed the original assumption that there were no UIC wells in Micronesia. However, it should be noted that limestone aquifers are highly susceptible to dissolution by acidic solutions, i.e., disintegration by acidic injectates. Therefore, the pH of the injectate should be carefully monitored and assessed should consideration be given to allow future injection near these limestone formations. Unconsolidated and semi-consolidated rock types are highly permeable, and therefore if used as receiving formations, can pose a potential endangerment to nearby underground sources of drinking water (USDW's). Unweathered volcanic rocks, on the other hand, are considered highly consolidated units and should make very stable, impermeable confining zones. Efforts should be made to locate any future Class V wells in areas where aquifers or USDWs can be adequately protected from injection zones by such consolidated confining zones. Where injection must occur into a USDW, a detailed chemical analysis of the injectate should be first conducted to protect against any direct contamination of the USDW. At a minimum, total dissolved solids (TDS) and any constituents for which drinking water standards have been developed should be measured and evaluated. Also, because of the fragile nature of ground water resources, alternatives such as surface treatment facilities, should be considered prior to making the final decision.

Prepared: 12-1-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Guam **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Underground Injection Control Class V Assessment Report

AUTHOR: Guam Environmental Protection Agency

DATE: 9-86 **REPORT STATUS:** Final

RESPONSIBLE AGENCY (IES): Guam Environmental Protection Agency (GEPA), Water Program Division, Safe Drinking Water Programs

HYDROGEOLOGY: Northern half: limestone plateau covered by Guam clay, contains three groups of ground water resources: (1) basal, (2) parabasal, and (3) perched limestone caps on hills of volcanic rock. The "Northern Lens" serves as a source of potable water for 95% of the population. Southern half: Volcanic uplands. Ground water occurs in limestone lenses, volcanic rocks, and noncalcareous sediments. Not adequate for large scale development (i.e., beyond local needs).

INVENTORY AND ASSESSMENT: 164 Wells **FURS COMPATIBLE:** YES(10-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5D2	164	Low	N/A	Permit Required

Strategy	Response/Rating
GEPA contacted all federal, state, and local agencies in Guam	+

RECOMMENDATIONS: (These practices are presently in effect in Guam)

1. GEPA has issued permits to all Class V wells and prohibits the construction and operation of new injection wells without a permit.

2. GEPA requires the operator to sample and monitor the injection fluids for MBAS, Oil and Grease, and NO_3-N.

3. GEPA staff conduct inspections of injection wells to ensure that only surface water runoff and storm water are disposed of into the wells and to ensure that no toxic or hazardous chemicals or other pollutants are injected.

4. Periodically, GEPA staff conduct surveillance, islandwide, for possible illegal activities concerning underground injection control.

Prepared: 12-1-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: CNMI **STATUS:** Primacy **BIBLIOGRAPHY:** No

TITLE: Underground Injection Control Class V Assessment Report

AUTHOR: Division of Environmental Quality

DATE: 9-86 **REPORT STATUS:** Final

RESPONSIBLE AGENCY (IES): Division of Environmental Quality (DEQ);

HYDROGEOLOGY: Primary water sources are basal, characteristic of coastal regimes. More specific information about Saipan, Rota, and Tinian is included in the state report.

INVENTORY AND ASSESSMENT: 2 Wells **FURS COMPATIBLE:** YES(8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
	2	Low	N/A	None required

egy	Response/Rating
.c was notified of requirement to notify DEQ ·in one year) of ownership of Class V wells through	
(1) publication of regulations in the Commonwealth Register	0
(2) conduction of a public hearing	0
ıtine safe drinking water inspection	found 2 wells

COMMENDATIONS:

- DEQ should be on the look out for other Class V wells
- Interviews should be conducted with staff members of the Department of Public Works, who were aware of the above described wells, for information on other possible wells.

Region X State Report Summaries

Alaska
Idaho
Oregon
Washington

Prepared: 1-18-87
Updated:

STATE REPORT SUMMARY

(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Alaska **STATUS:** DI **BIBLIOGRAPHY:** Yes

TITLE: Preliminary Class V Injection Well Inventory and Assessment Report-Alaska

AUTHOR: Engineering Enterprises, Inc., Zonge Engineering and Research Organization

DATE: 11/86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):
Alaska Department of Environmental Conservation (ADEC)

HYDROGEOLOGY:
Alaska's principal aquifers consist of unconsolidated alluvium and glacial deposits, and consolidated clastic and carbonate sedimentary rocks. They produce shallow, high-yield and deep, low-yield wells, respectively. Permafrost, a major factor in groundwater availability, and groundwater storage and recharge are also discussed in the state report.

INVENTORY AND ASSESSMENT: 2542 wells **FURS COMPATIBLE:** NO (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5X29	3	High		
5D2	66	High		
5A5	4	Moderate	N/A	Require a permit to discharge
5A7	7	Moderate		
5A19	2	Moderate		
5W20	230	High		
5W9	3			Require plan review...in some cases permits to discharge
5W10	>79			
5W11	8	High	N/A	
5W12	4			
5W31	3			
5W32	2133			

Strategy (Date)	Response/Rating
Agency contact - seven days contacting state, federal and local (Anchorage) agencies reviewing files	95%
Written inquiry - four mailing programs conducted including - municipalities industry (I) service stations industry (II)	12%

RECOMMENDATIONS:

Ongoing inventory - tailoring specific and concise questionnaire targeted for specific potential well owners rather than general mailing programs.
- Public awareness improvement of UIC regulations in Alaska
- Agency file search in Alaska

Hydrogeologic and jurisdictional - WATSTORE incorporation with UIC programs (to achieve hydrogeologic Database to accompany UIC Database)
- Identify jurisdictions best regulated by state and local agencies and incorporate into cooperative UIC program

Well site investigations -
(1) Review Alaskan inventory to identify high densities of industrial process water and waste disposal systems.
(2) Gather hydrogeologic information for these areas.
(3) Gather regulatory information from state, local, and/or federal agencies.

Carry out site inspections for 5W20 focusing and examining facility records, facility layout, industrial process, sampling of injected fluids.

Prepared: 3-11-87
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Idaho **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Idaho Assessment of Class V Injection Wells

AUTHOR: W.G. Graham, Linford J. Campbell, Ingrid Sather

DATE: 1-87 **REPORT STATUS:** Final Draft

RESPONSIBLE AGENCY(IES): Idaho Dept. of Water Resources

HYDROGEOLOGY: Ninety percent of all inventoried Class V injection wells, excluding mine tailings backfills, are located in areas overlying the Snake Plain, Boise Valley, and Rathdrum Prairie ground water systems. These three groundwater systems provide drinking water for 41 percent of the state population and supply large quantities of water for irrigation and industrial users. Mine backfills occur in formations that are effectively isolated from underground sources of drinking water.

INVENTORY AND ASSESSMENT: 2,533 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential°	Case Studies	Regulatory System
5F1	572	2	Yes	*
5D2	1,165	1	Yes	*, +
5A5	4	12	Yes	Permit
5A6	2	5	Yes	Permit
5A7	20	12	No	Permit
5W11	52	6	No	*, +
5W12	9	7	No	+
5X13	575	3	No	Rule
5A19	49	11	No	Permit
5W20	46	10	No	*, +
5R21	7	7	Yes	*
5N24	4	7	Yes	*
5X28	21	4	No	+
5C30	7	14	Yes	*, +

° Well types are ranked according to contamination potential (1=highest, 2=lowest)
* Deep wells (>18 feet) authorized by permit requiring compliance with discharge quality standards and locational criteria.
+ Shallow wells (<18 feet) authorized by rule provide that required inventory information is furnished and use of the well does not contaminate a drinking water source.

Strategy (Date)	Rating/Response
(1974) Permit application reviews and regional office surveys....	N/A
(?) 1. Remote sensing/high-altitude aerial photographs (5F1).	
2. Mail-out surveys to city and county engineers, highway district supervisors, airport managers, pesticide applicators, owners/operators of various automotive and implement service facilities (5D2)	initial: 50-60% final: 2002/2248
3. Mail survey for mine backfill wells	100%
4. Follow-up mailings	85%
5. Follow-up phone calls	100%

RECOMMENDATIONS:

1. Shallow injection wells (less than or equal to 18 feet in depth) generally discharge small quantities of nonhazardous wastes into horizons well above the underlying drinking-water sources. Continued authorization of shallow injection wells by rule is recommended for Idaho where the quality of underground drinking-water sources are not endangered. This option should continue to be available to the States under the federal UIC program.

2. Deep injection wells (greater than 18 feet in depth), excluding mine backfills, may discharge large volumes of fluids into drinking-water sources, or into injection horizons that are generally close to drinking-water sources. Authorization of these practices should require submittal of data concerning well construction, quality of injected fluids and pertinent geologic and hydrologic features in addition to the required inventory information.

3. Continued authorization of mine backfill wells (Class 5X-13) without permit is recommended where the tailings are injected into formations that are effectively isolated from underground sources of drinking water.

4. With regard to the possible endangerment to underground drinking-water sources from fluids injected through service station waste disposal wells (Class 5X-28), a concerted effort should be undertaken to determine the nature of the injected fluids and to ensure that all such wells are inventoried. Subsequent permitting and abandonement may be required.

Prepared: 12-22-86
Updated:

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Oregon **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Underground Injection Control Class V Inventory and Assessment in the State of Oregon

AUTHOR: Oregon Department of Environmental Quality

DATE: 12-86 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES):

Department of Environmental Quality (DEQ), Water Quality Division
Department of Water Resources (DWR) - well construction standards; geothermal fluids < 250°F
Department of Geology and Mineral Industries (DOGAMI) - oil & gas related; geothermal fluids > 250°F

HYDROGEOLOGY: Highly permeable alluvial deposits (central Multnomah County) are generally used for disposal of storm water drainage and sewage. Fractured basalt and layers of volcanic pumice and scoria were used for sewage disposal before the installation of sewers and treatment plants. Geothermal resources are used for space heating, agriculture, and industrial process heating. In arid areas groundwater is used for irrigation.

INVENTORY AND ASSESSMENT: 7,120 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number+	Contamination Potential	Case Studies	Regulatory System*
5F1	16	2nd highest	No	N/A
5D2	4,162	3rd highest	Yes	Limited to depth
5D4			No	of 100'.
5A6	20	low	No	Permit required if
5A7		low	Yes	water produced ex-
5A8		N/A	No	ceeds 5,000 gpd.
5A19		N/A	No	
5W9			No	Rules resulting
5W10		1st highest	Yes	from the Mid-
5W11	6320	(5W9-12)	Yes	Multnomah Co.
5W12			No	Plan & EWPCA Study.
5W20		N/A	No	Individually per-
				mitted.

*Numbers were not reported according to the most recent breakdown of subclassifications.

*Permits are required for disposal of all wastes. Subsurface discharge requires a Water Pollution Control Facilities (WPSF) permit.

STRATEGY (DATE)	RESPONSE/ RATING
1. (1982) EPA contracted with the Dept. of Geology and Oregon State University to conduct an inventory and assessment.....	Incomplete
2. (?) Personal inquiries of employees of the DEQ and DWR were conducted.....	+
3. (?) Public notices were published in major newspapers throughout the state which informed the public of the necessity of reporting any underground injection activity.....	-
4. (?) Cities and counties involved with storm water disposal and sewage disposal were called upon to provide information.....	?
5. (?) Agricultural disposal well information was solicited from water masters located throughout the state.....	?

RECOMMENDATIONS:

(5W9-10-11) 1. The Department should continue to monitor the implementation of the order adopted by the Environmental Protection Quality Commission for the Mid-Multnomah County Area (see state report).

2. The Department should continue to implement its present control strategy for the communities of Central Oregon (see state report).

(5F1) 1. Inventory of disposal wells should be coordinated with the Dept. of Water Resources and Central Oregon Irrigation District.

2. Irrigation runoff quality data should be collected by the Department.

3. Guidelines for the construction and operation of irrigation disposal wells should be developed by DEQ and DWR.

4. The Central Oregon Irrigation district should encourage the use of pump back ponds and develop informational programs on proper irrigation practices.

(5D2-4) 1. Water quality data for storm runoff should be collected in the Bend area by either the Dept. or the city in lieu of a formal storm runoff study.

2. There should be guidelines and policies that will delineate the responsibilities of the Dept. and local governments for evaluating proposed storm drainage wells.

3. The City of Portland and Multnomah County should review their storm drainage well control program including usage, design, and siting of wells.

4. Guidelines should be developed for proposed drainage wells in newly developing industrial areas.

5. A monitoring program for both surface runoff and drainage wells should be implemented by the local authorities and coordinated with the Department.

Prepared: 2-17-87
Updated: 4-27-87

STATE REPORT SUMMARY
(All information recorded as described in state report, additional correspondence, and verbal communication)

STATE: Washington **STATUS:** Primacy **BIBLIOGRAPHY:** Yes

TITLE: Class Five Injection Well Inventory

AUTHOR: Lawrence Goldstein, Washington Department of Ecology

DATE: 2-87 **REPORT STATUS:** Draft

RESPONSIBLE AGENCY(IES): Washington Department of Ecology

HYDROGEOLOGY: The occurrence, quantity, and quality of groundwater in Washington is closely tied to regional differences in climate, topography, surficial geology, and land uses. Descriptions of the geology and hydrology of Washington, which are provided in the state report, are based on approximately twenty principal aquifer regions.

INVENTORY AND ASSESSMENT: 14,242 wells **FURS COMPATIBLE:** No (8-20-86)

Type	Number	Contamination Potential	Case Studies	Regulatory System
5F1	66	Unknown (wells) High (chemigation)	No	Undecided
5D2	14,903	Mod to High	No	None
5D4	2,141	Mod to High	No	None
5A7/19	110	Low	No	Permit (county planning codes)o
5W20	69	Unknown	No	N/A
5R21	7	Low	No	Permit
5N24	116	High	Yes	Permit
5X25	3	N/A	No	N/A
5G30	108	N/A	Yes	- N/A
5W32	108**	Site-Specific	No	Permit o

o Construction standards available ** Estimated total is 1,000
+ Natural Gas Storage & Municipal dewatering

Strategy (Date) **Rating/Response**

(1981) Spokane Valley

1. In-house records search of county records N/A
2. City of Spokane records search.
3. Personal interviews with city and county utility design and maintenance personnel.
4. Field work using block by block, section by section, search method.

(1981) Pierce County

1. Record search of county records.
2. Personal interviews with county engineers, technicians, public works employees, and field sanitarians.

(1981) Field Investigations

(N/A) Public Notification of need to file construction and operation data, published in major daily newspapers and letter to Washington Well Drillers Assocation.

(1985) State Inventory

1. Public Notification - letter to county and city public works directors; follow up on phone calls.
2. Records searches of county and city records.
3. Personal interviews with public works directors and maintenance personnel, public utilities personnel, engineers, technicians, and private well owners.
4. Field Investigations.

RECOMMENDATIONS:

(5A7)

1. A concerted effort should be made to ensure proper construction of these wells and heat pump installations.
2. Permits for development of a commercial system should include requirements for water quality characterizations of both source and receiving water.
3. Records should be maintained by counties and periodically uploaded to the state water rights data management center in order to monitor well density.
4. Monitoring wells should be installed to track changes in water chemistry and temperature.
5. A policy of prohibiting new well installation in known or suspected contaminated aquifers should be developed and implemented by the state...This policy would be administered by local government, with the assistance of the department.

(5D2/4)

1. Further study is recommended in areas of (a) attenuation processes, (b) well design, (c) inventory of private wells, (d) specific industrial and commerical activities, and (e) land-use site characteristics.
2. Dry wells or other facilities discharging to the ground should not be allowed where they may be exposed to potentially contaminating industrial materials or discharges. Loading docks and material storage areas should be designed so that spilled materials cannot be washed, either deliberately or accidentally, into a drainage device discharging to the ground.
3. Commerical or industrial wastewaters containing chemicals should not be discharged to the ground without treatment. Current state waste discharge permits allowing this practice should be reevaluated.

4. Monitoring and regulatory activities should be increased, focusing on wells in areas of high contamination potential.

(5N24)

1. The department proposes to use the provisions of [the state waste discharge permit program (Chapter 173-216 WAC)] to authorize and take enforcement actions for discharges which do not satisfy the standard of all known available reasonable methods of treatment and control.
2. The disposal standard for cribs and french drains will be to treat the waste before discharge and not to rely solely on evaporation, the soils, and dilution to treat the wastes.
3. The number of permits issued and permit compliance and enforcement actions will be negotiated annually with Environmental Protection Agency through the State/EPA Agreement program planning process.

(5W32)

There is a critical need to establish a statewide monitoring system, inventory methodology, and database in order to evaluate design for existing systems, establish ambient water quality in vulnerable aquifer regions, and be able to quantify changes in critical parameters.

(5W20)

1. Until additional data is at hand to define the fate of industrial wastes in the saturated zone, it is prudent to taken extraordinary precautions to minimize the potential for aquifer degradation via injection of highly toxic substances.
2. Alternatives to land disposal such as recycling or resource recovery, reduction of wastes generated through process modification, and improved methods of hazardous waste neutralization should be actively pursued.

APPENDIX 3

Glossary

GLOSSARY

Absorption. The process of sucking up or taking up to make part of an existent whole.

Adsorption. To gather on a surface in a condensed layer.

Aeolian. See eolian.

Alluvial. Material deposited by a stream or running water.

Alpha particle. A positively charged particle consisting of two protons and two neutrons, emitted in radioactive decay or nuclear fission.

Annulus. The space between the casing in a well and the wall of the hole, or between two concentric strings of casing, or between casing and tubing.

Aquifer. A body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs.

Asphaltenes. Any of the solid, amorphous, black to dark brown dissolved or dispersed constituents of crude oils and other bitumens that are soluble in carbon disulfice but insoluble in paraffin naphthas.

Bulkhead. A stone, steel, wood, or concrete wall-like structure primarily designed to resist earth or water pressure.

Cambrian. The earliest period of the Paleozoic era, thought to have covered the span of time between 570 and 500 million years ago; also, the corresponding system of rocks.

Confined aquifer. An aquifer bounded by impermeable beds, or beds of distinctly lower permeability than that of the aquifer itself, confined groundwater is generally subject to pressure greater than atmospheric pressure.

Connate water. Water entrapped in the interstices of a sedimentary rock at the time of its deposition.

Crystalline. Pertaining to or having the nature of a crystal, or formed by crystallization; specifically having a crystal structure or a regular arrangement of atoms in a space lattice.

Dewatering. To lower the groundwater level to a determined depth through the use of water extraction wells.

Dolomite. A common rock-forming rhombohedral mineral: $CaMg(CO_3)_2$.

Downdip. A direction that is downwards and parallel to the dip of a structure or surface.

Effective stress. The average normal force per unit area transmitted directly from particle to particle of a soil or rock mass. It is the stress that is effective in mobilizing internal friction.

Eolian. Pertaining to the wind; especially said of such deposits as loess and dune sand, of sedimentary structures such as wind-formed ripple marks, or of erosion and deposition accomplished by the wind.

Eutrophication. The process by which waters become more eutrophic; esp. the artificial or natural enrichment of a lake by an influx of nutrients required for the growth of aquatic plants such as algae that are vital for fish and animal life.

Evapotranspiration. Loss of water from a land area through transpiration of plants and evaporation from the soil.

Coliform. Relating to, resembling, or being the colon bacillus (bacteria).

Feldspathic. Said of a rock or other mineral aggragate containing feldspar.

Halogens. One of the electronegative elements of Group VII A of the Periodic Table (fluorine, chlorine, bromine, iodine, and astatine).

Hydraulic conductivity. Rate of flow of water in gallons/day through a cross section of 1 $ft.^2$ under a unit hydraulic gradient at the prevailing temperature.

Hydraulic gradient. The rate of change in total head per unit of distance of flow in a given direction.

Hydrogeology. The science that deals with subsurface waters and with related geologic aspects of surface waters.

Hydrostatic head. The height of a vertical column of water whose weight, if of unit cross section, is equal to the hydrostatic pressure at a given point.

Hydrothermal. Of or pertaining to hot water, to the action of hot water, or to the products of this action, such as a mineral deposit precipitated from a hot aqueous solution.

Igneous. Said of a rock or mineral that solidified from molten or partly molten material.

Injectivity. The ability of a formation to accept fluids; can be measured as the change in injection rate divided by the corresponding change in injection pressure.

In situ. In the natural or original position.

Karstic. A type of topography that is formed on limestone, gypsum, etc. by dissolution, characterized by sinkholes and caves.

Lacustrine. Pertaining to, produced by, or formed in a lake, or lakes.

Leachate. A solution obtained by the separation, selective removal, or dissolving-out of soluble constituents from a rock or orebody by the natural action of percolating water.

Lithology. The physical character of a rock.

Lixiviant. See leachate.

Louver. A transverse wall plate in archaeocyathids, commonly developed between the edges of adjacent septa or longitudinal ribs and usually tilted with reference to the wall surface.

Magma. Naturally occurring mobile rock material, generated within the Earth and capable of intrusion and extrusion.

Magmatic water. Water contained in or expelled from magma.

Metamorphic. Pertaining to the process of metamorphism or to its results.

Metamorphism. The mineralogical, chemical, and structural adjustment of solid rocks to physical and chemical conditions which have generally been imposed at depth below the surface zones of weathering and cementation, and which differ from the conditions under which the rocks in question originated.

Meteoric water. Pertaining to water of recent atmospheric origin. Also: pertaining to, dependent on, derived from, or belonging to the Earth's atmosphere.

Nitrate. A salt or ester of nitric acid, or any compound containing the univalent group; ONO_2 or NO_3.

Nitrogen. A colorless, odorless, gaseous element that constitutes about four fifths of the volume of the atmosphere and is present in combined form in animal and vegetable tissues, especially in proteins; used chiefly in the manufacture of ammonia, nitric acid, fertilizers, cyanide, explosives, etc.

Packer. A short expansible-retractible device deliberately set in a cased or uncased well bore to prevent upward or downward fluid movement; generally for temporary use.

Perched water table. The water table of perched ground water.

Permeability. The property or capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure.

Phosphate. A salt or ester of phosphoric acid, containing phosphorus.

Phosphorous. A solid, nonmetallic element existing in two allotropic forms, one that is yellow, poisonous, flammable and luminous in the dark, and another that is red, less poisonous, and less flammable.

Piezometric surface. An imaginary surface representing the total head of groundwater, and defined by the level to which water will rise in a well.

Pneumatic. Of, relating to, or using gas.

Porosity. The percentage of the bulk volume of a rock or soil that is occupied by interstices.

Potentiometric surface. An imaginary surface representing the total head of groundwater and defined by the level to which water will rise in a well.

Radioactivity. The phenomenon exhibited by certain elements spontaneously emitting radiation as a result of changes in nuclei of atoms of the element.

Radium. A highly radioactive metallic element that upon disintegration produces the element radon and alpha particles.

Regolith. A general term for the layer or mantle of fragmental and unconsolidated rock material, whether residual or transported and of highly varied character, that nearly everywhere forms the surface of the land and overlies or covers the bedrock.

Resin. Any of various hard, brittle, transparent of translucent substances formed esp. in plant secretions and obtained as exudates of recent or fossil origin by the condensation of fluids on the loss of volatile oils.

Sedimentary. Formed by the deposition of sediment, or pertaining to the process of sedimentation.

Seepage stress. The force that is transferred from water flowing through a permeable granular medium to the medium itself by means of viscous friction.

Shear. A deformation resulting from stresses that cause or tend to cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact.

Siltstone. An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility.

Sluicing. Concentrating heavy minerals by washing unconsolidated material through boxes (sluices) equipped with riffles that trap the heavier minerals on the floor of the box.

Slurry. A highly fluid mixture of water and finely divided material.

Stratified. Formed,arranged, or laid down in layers or strata; especially said of any layered sedimentary rock or deposit.

Stratigraphy. The science of rock strata. It is concerned not only with the original succession and age relations of rock strata but also with their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties.

Stratum. A layer of sedimentary rock,visually separable from other layers above and below.

Sump. An excavation in which the drainage water of an area is collected for subsequent use in irrigation or wild-fowl conservation.

Tectonic. Said of, or pertaining to the forces involved in, structural or deformational features of the outer (crustal) part of the Earth.

Topography. The general configuration of a land surface or any part of the Earth's surface, including its relief and the position of its natural and man-made features.

Transmissivity. The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient.

Unconfined aquifer. An aquifer which is not confined under pressure by relatively impermeable strata.

Vadose zone. A subsurface zone containing water under pressure less than that of the atmosphere, including water held by capillarity; and containing air or gases generally under atmospheric pressure. This zone is limited above by the land surface and below by the surface of the water table.

Viscosity. The property of a substance to offer internal resistance to flow.

Water Balance. An accounting of the inflow to, outflow from, and, storage in a hydrologic unit.

APPENDIX C

Acronyms and Abbreviations

ACRONYMS AND ABBREVIATIONS

ADHS.	Arizona Department of Health Services.
AMD.	Acid mine drainage.
AOR.	Area of review.
BIA.	Bureau of Indian Affairs, U.S. Department of the Interior.
BLM.	Bureau of Land Management, U.S. Department of the Interior.
BOD.	Biological oxygen demand.
CDOG.	California Department of Conservation, Division of Oil and Gas.
CERCLA.	Comprehensive Environmental Response, Compensation and Liability Act.
CFR.	Code of Federal Regulations.
COD.	Chemical oxygen demand.
DI.	Direct implementation (state).
EA.	Environmental assessment.
FLGMS.	Florida Groundwater Management System.
FURS.	Federal Underground Injection Control Reporting System.
LQD.	Land Quality Division (Wyoming).
MIT.	Mechanical integrity test.
NURP.	Nationwide Urban Runoff Program.
NPDES.	National Pollution Discharge Elimination System.
pH.	The negative log of the concentration of hydrogen ions in a solution.
RCRA.	Resource Conservation and Recovery Act.
SBW.	Service Bay Water.
SCS.	Soil Conservation Service, United States Department of Agriculture.
SDWA.	Safe Drinking Water Act.

SQG. Small quantity generator.

TDS. Total dissolved solids.

TOC. Total organic carbon.

TRH. Total recoverable hydrocarbons.

TTPI. Trust, Territories of the Pacific Islands.

UIC. Underground Injection Control.

USDW. Underground Source of Drinking Water.

USEPA. United States Environmental Protection Agency.

USGS. United States Geological Survey.

APPENDIX J

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APPENDIX E

List of Supporting Data

NATIONAL CLASS V INVENTORY AND ASSESSMENT

REPORT TO CONGRESS

SUPPORTING DATA INDEX

Drainage Wells

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1. Synopsis of Agricultural Drainage Reports Prepared by EPA Region VII UIC Section - November 1986.
2. Iowa Agricultural Drainage Well Assessment Report.
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6. A Case Study of Dry Well Recharge (Southwest U.S.) - September 1983.
7. Evaluation of Sump Impacts on Ground Water in East Mutnomah County, Washington - April 1986.
8. The Impact of Stormwater Runoff on Groundwater Quality and Potential Mitigation (Washington State) - October 1984. (Cover page only)

9. Potential of Ground Water Impacts Resulting From Storm Water Runoff Disposal in Spokane County, Washington - December 1983. (Cover page only)

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13. Case Study: Moana - Steamboat Hot Springs, Nevada.

Heat Pump/Air Conditioning Return Flow Wells:

14. Case Studies: Massachusetts, Minnesota, Oregon

Aquaculture Disposal Wells:

15. UIC Inspection Report - Marine Culture Enterprises, Laie, Oahu, Hawaii.

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Raw Sewage Waste Disposal Wells and Cesspools:

16. UIC Inspection Report (Inspection 4) - Laie Cesspool Sump, Oahu, Hawaii.

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23. Case Study: Recharge Wells - Teton Village, Wyoming.

Mineral and Fossil Fuel Recovery Related Wells

Mining, Sand or Other Backfill Wells:

(Supporting Data Pending State Report Submittals)

Solution Mining Wells:

24. UIC Program Inspection Report - Noranda Lakeshore Mines, Inc., Casa Grande, Arizona.

In Situ Fossil Fuel Recovery Wells:

25. Case Study: Underground Coal Gasification - USDOE Hanna Area, Wyoming.

26. Case Study: Oil Shale In Situ Retorting - USDOE Rock Springs Site, Wyoming.

Spent Brine Return Flow Wells:

27. Types of Class V Injection Wells with Potential for Use in Arkansas - Brine Disposal Injection Wells.

28. Results from Analysis of Brine Disposal Injection Well Injection Fluid (Arkansas).

29. Class V Brine Disposal Injection Well Plugging Details (Arkansas).

Oil Field Production Waste Disposal Wells

Air Scrubber and Water Softener Regeneration Brine Disposal Wells

30. UIC Program Inspection Reports - Texaco Producing, Inc., San Ardo Field, San Ardo, California.

31. UIC Program Inspection Report - Tosco Enhanced Oil Recovery Corporation, Newhall, California.

Industrial, Commercial, Utility Disposal Wells

Cooling Water Return Flow Wells:

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36. Case Study IV: Eastern Air Devices, Dover, New Hampshire.
37. Case Study V: Viscase Puerto Rico Corp., Barceloneta, Puerto Rico.
38. Case Study VI: RCA del Caribe, Inc., Barceloneta, Puerto Rico.
39. Case Study VII: Glamourette Fashion Mills, Quebradillos, Puerto Rico.
40. Case Study VIII: Lotus, Barceloneta, Puerto Rico.
41. Case Study IX: Kendall McGraw Laboratories, Sabana Grande, Puerto Rico.
42. Case Study X: Various Automobile Dealers, Long Island, New York.
43. Case Study XI: Permit Compliance System, New York.
44. Case Study XII: Lehigh Portland Cement Co., Woodsboro, Maryland.

45. Case Study XIII: Applied Electro-Mechanics, Inc., Point of Rocks, Maryland.

46. Case Study XIV: Hammermill Paper Co., Erie, Pennsylvania.

47. Case Study XV: Rodale (Square D), Emmaus Borough, Pennsylvania.

48. Case Study XVI: National Wood Preservers, Haverford Township, Pennsylvania.

49. Case Study XVII: Highway Auto Service Station, Pittstown Township, Pennsylvania.

50. Case Study XVIII: Franklin A. Holland & Son, New Church, Virginia.

51. Case Study XIX: Reverse Osmosis Brine Facility, Florida.

52. Case Study XX: American Cyanamid, Michigan City, Indiana.

53. Case Study XXI: Puregro Co., Bakersfield, California.

54. Case Study XXII: Mefford Field, Tulare, California.

55. Case Study XXIII: Kearney-KPF, Stockton, California.

56. Case Study XXIV: T.H. Agricultural and Nutrition Co., Fresno, California.

57. Case Study XXV: Various Petroleum Refineries, California.

58. Case Study XXVI: Unidynamics, Goodyear, Arizona.

59. Case Study XXVII: Honeywell, Phoenix, Arizona.

60. a. Table 1: Class V Deep Industrial Waste Disposal Wells.

b. Table 2: Class V Shallow Industrial Waste Disposal Wells.

c. Table 3: Class V Industrial Waste Disposal Wells of Unknown Depth.

Gasoline Service Station Disposal Wells:

61. Table: Contaminant Levels in Samples Collected at Catch Basins and Disposal Wells at Gasoline Service Station and other Industrial Facilities in Long Island, New York.

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62. Class V Connector Wells (Class V Type 5R21 Wells) (Florida).

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