STATEMENT OF BASIS AND PURPOSE

UNDERGROUND INJECTION CONTROL REGULATIONS

OFFICE OF DRINKING WATER
ENVIRONMENTAL PROTECTION AGENCY

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STATEMENT OF BASIS AND PURPOSE

INTRODUCTION

This document is intended to summarize the basis and purpose underlying the underground injection control regulations promulgated in 40 CFR Part 146. It sets forth generally the reasoning behind the Agency's regulatory choices and references data upon which EPA relied.

This statement first discusses the categorization of wells. It then surveys the major pathways which contaminants can take to enter underground sources of drinking water and the requirements which these regulations impose to assure that movement of fluids resulting from well injection does not contaminate underground sources of drinking water. Programmatic requirements of Part 146, such as monitoring and reporting, are covered in the concluding section.

In general, the requirements of the regulation differ from those of the initial proposal of this regulation (**41 FR 36730**, August 31, 1976) and the reproposal of this regulation (**44 FR 36730**) in that they furnish a greater degree of flexibility to State Directors in regulating well injection. EPA has modified its earlier proposal in this way as it became more fully aware of various well injection practices, the characteristics of substrata into which fluids are injected, and the range of methods by which well injection is accomplished.

CATEGORIZATION OF WELLS

The regulations separate wells into distinct categories. This categorization is necessary to assure that wells with common design and operating techniques will be required to meet appropriate performance criteria.

In categorizing wells, EPA first looked to available literature regarding the injection practices. It considered information on existing and abandoned injection well practices, well construction technology, and on the variety of fluids injected into wells. It discussed with regulatory agency personnel from many States their experience with then-existing well injection regulatory practices and reviewed existing regulations in a number of States.[1] After such review and discussions, it commissioned a reputable consulting organization to provide assessments and a report on types of wells and their typical operation.[2] EPA then studied this information to arrive at a consistent and comprehensive well classification scheme. As a result, EPA decided to classify wells into the following five groups:

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[1] Interviews with State officials from Texas, Florida, Kansas, California and Michigan.

[2] Preliminary Injection Well Practices, Geraghty and Miller, Inc., Tampa, Florida; 1977.

Class I: Wells used by generators of hazardous wastes or owners or operators of hazardous waste management facilities to inject hazardous waste, other than Class IV wells. other industrial and municipal disposal wells which inject fluids beneath the lowermost formation containing, within one quarter mile of the well bore, an underground source of drinking water.

Class II: Wells which inject fluids (1) which are brought to the surface in connection with conventional oil or natural gas production (2) which are used for enhanced recovery of oil or natural gas and (3) which are used for storage of hydrocarbons which are liquid at standard temperature and pressure.

Class III: Wells which inject for e.xtraction of minerals or energy, including: mining of sulfur by the Frasch process; solution mining of minerals; in-situ combustion of fossil fuel, and recovery of geothermal energy.

Class IV: Wells used by generators of hazardous wastes or of radioactive wastes, by owners or operators of hazardous wasce management facilities or by owners or operators of radioactive wastes disposal sites to dispose of hazardous wastes into or above a formation which within one quarter mile of the well contains an underground source of drinking water.

Class V: Injection wells not included in Classes I, II, III, or IV.

In formulating these classifications, EPA gave substantial weight to a number of considerations. First the Agency concluded that wells which inject into strata nearest thd land surface should, as a general matter, be classified separately from those which inject into strata at greater depth. The method of injection which wells use is frequently dependent upon the injection horizon into which they deposit fluids. Wells which inject into strata near the land surface often inject by use of simple gravity. often crudely constructed, they can simply be holes dug or bored into the ground, the sides of which may be stabilized by brick, stone, timber, or other materials in the well. They can function as convenient dumping sites for wastes, or, in other instances, can serve beneficial purposes, such as recharging groundwater supplies or creating a subsurface barrier to saltwater intrusion.[3]

[3] See Generally The Report to Congress, Waste Disposal Practices and Their Effects on Ground Water, U.S. Environmental Protection Agency (January, 1977), Sections V, VIII, XIII ("Report to Congress"); A Manual of Laws, Regulations, and Institutions-for Control of Groundwater Pollution, U.S. Environmental Protection Agency, (June, 1976), Chapter I ("Manual"). Underground Injection Control Regulations, Subpart F, Injection Well Practices, Draft Final Report, Geraghty and Miller, Inc. and Temple, Barker and Sloane, Inc. March, 1978 ("Subpart F"). Preliminary Evaluation of- Well Injection Practices, Geraghty and Miller, ("Preliminary Evaluation").

Wells which inject into lower strata are usually constructed and operated differently from wells which inject into strata near the land surface. Such wells are drilled rather than dug or bored, and emplace fluids into the subsurface by use of more sophisticated technology, materials, and equipment. Wells of this sort require the use of casing and cementing.[4] Escape of injected fluids into sources of drinking water is prevented by such casing, and by tubing and packer or other methods. Injection is accomplished by either the force.of gravity or the application of additional mechanical pressure to overcome the natural friction and hydrostatic,resistance of the receiving formation.[5]

In addition, aquifers nearest the land surface most often supply water for domestic use.[6] Consequently, wells which inject into or above these aquifers increase the risk of human exposure to the injected contaminants.

These considerations influenced the categorization of wells in Classes I and II separately from those in Classes IV and V. Classes I and II encompass wells which normally inject into strata below underground sources of drinking water. Class I wells are further limited to those which inject beneath formations which contain an USDW within 1/4 mile of the well site; other wells are included in Class V. The agency chose this approach since individual formations may be identifiable for hundreds of miles and a formation which is suitable in one area as a source of drinking water may not be in other sections. This limitation prevents a well from being subjected to Class I requirements simply because it injects under an aquifer which, miles away, contains drinking water. Class IV wells (which by definition inject into or above strata containing underground sources of drinking water) will generally inject into or above the aquifers nearest the land surface. Class V for the most part comprises wells which inject non-hazardous materials into those same aquifers.[7]

Also influencing this proposed well class-ification was the nature of injected fluids. Wells which handle hazardous materials war-rant close regulatory scrutiny. This consideration influenced EPA to create a separate category (Class I) for wells which dispose of industrial and municipal wastes. Such wastes commonly contain chemicals or other substances which can be fairly characterized as noxious and, as appropriate, require separate performance criteria. Nuclear waste practices are currently being reviewed by the Administration and therefore EPA is

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[4] §§ 146.12(b); 146.22(b); 146.32(a)

[5] See Generally Report to Congress, Section XI, XIII; Manual, Chapter IC: Preliminary Evaluation; Ground Water Pollution From Subsurface Excavations, U.S. Environmental Protection Agency, 1973, Part 2, Section II, Ground Water Pollution."

[6] Report to Congress, Sections III, IV; Manual, Chapter I, pp. I-10 -- 1-50.

[7] Report to Congress, Section VIII, IX, XIII: Manual, Chapter I; Subpart F; Preliminary Evaluation..

not including wells which inject nuclear waste a USDW into a Class I at this time.[8] Until a final policy is developed, such wells are included in Class V.

Similarly, among those wells which inject into aquifers nearest the land surface,.Class IV wells were separated from Class V because of the heightened risk which Class IV wells create. Class IV wells may be the most harmful class of wells because of the hazardous nature of fluids injected into them and the proximity of their injection zone to underground sources of drinking water. Within wells categorized as Class IV, two general subcategories may be defined: those which inject hazardous waste directly into underground sources of drinking water, and those which inject hazardous waste above underground sources of drinking water. It was felt that this difference was sufficient to warrant-distinct treatment. Accordingly, Class IV wells which inject into an underground source of drinking water are being banned under an "interim final" rule within 6 months after a State UIC program becomes effective. A decision regarding Class IV wells which inject above an underground source of drinking water is being reserved-at this time pending further Agency consideration and public comment. The rational for this approach is presented in more detail in a later discussion. Management of radioactive waste which is injected into or above USDWs will follow this same regulatory scheme, i.e., such waste injected into a underground source of drinking water will be banned within 6 months after a State UIC program becomes effective, and decisions regarding such waste injected above USDWs are being reserved. This applies to radioactive waste as defined by both RCRA and the Atomic Energy Act of 1954.

An additional factor which influenced this reproposed classification of wells was the Safe Drinking Water Act ("SDWA") itself. Sections 1421(b),(2) and 1422(c) of the SDWA state that regulations for State underground-injection control programs may not prescribe requirements which interfere with or impede underground injection in connection with oil and natural gas production or the secondary or tertiary recovery of oil and gas production unless such requirements are essential to assure that underground sources of drinking water will not be endangered by such injection. House Report No. 93-1185 accompanying the Act takes care to clarify this directive. At page 31, the Report characterizes the term "interferes with or impedes" as referring to only those requirements which could "stop or substantially delay" oil or natural gas production. Thus, the "test" of essentiality would only be relevant upon a demonstration that a requirement would stop or substantially delay such production.

EPA has observed this statutory admonition by including all injection wells relating to oil and natural gas production and hydrocarbon storage into a single category (Class II) with the exception of gas storage wells. Gas storage wells have been included in Class V wells. Such a grouping makes it possible to modify specific requirements and allow additional flexibility where possible without endangering human health. It was felt that the economic incentive for preventing leakage, and the relatively innocuous character (natural gas is not highly soluble)

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[8] Comprehensive Radioactive Waste Management Program Message from the President Received during Recess, Congressional Record - Senate, February 18, 1980

associated with gas storage wells warranted that these wells be studied further before subjecting them to regulation equivalent to other Class II wells.

Class III, which includes special process wells (including those used for solution mining) are classified separately from other wells because of their atypical injection practices. Special process wells serve a variety of purposes, including the extraction of minerals or other materials from the earth. Individual domestic injection wells used to generate heat and/or electricity, although special process wells, have been included in Class V. The Agency chose to consider these systems under Class V due to the limited impact on underground sources of drinking water anticipated from these wells. It should be noted that domestic syst ems utilizing a closed loop in conjunction with heat exchangers are not injection wells and consequently, are not covered under these regulations.

In the course of public review, a number of commenters urged that Class III wells be subcategorized. In response, the Agency commissioned a study to provide information on this issue.[9] Based on this study it does not appear that either current operating and construction practice for existing State regulations governing such wells differentiate sufficiently to warrant subcategorizing Class III wells. Consequently, the final regulations do not establish subcategories for Class III wells.

As stated earlier, Class IV wells injecting into a USDW are banned; decisions concerning Class IV wells injecting above an USDW are being reserved. In order to afford some level of protection before the final promulgation of regultions for Class IV wells and implementation of State UIC programs, all injectors of hazardous waste must obtain "interim Status" under the RCRA hazardous waste management program. The Agency decided to reserve final decisions concerning Class IV wells which inject above USDW's for several reasons. Commenters pointed out that injection wells which overlie deep or remote drinking water supplies would have little or no potential for contaminating the aquifer and thereby endangering health. Moreover, portions of some aquifers may be so deep or so remote that they may never serve as drinking water sources, or may not be subject to contamination from injection practices.

A further reason for the proposed approach is that regulations under RCRA and SDWA overlap at several points. Facilities under Class I and Class IV overlap the class of facilities designated under RCRA as hazardous waste management facilities. It is, therefore, appropriate that technical standards under RCRA and UIC be consistent, to the extent allowable under the governing statutes, for facilities capable of causing a similar degree of risk.

EPA anticipates issuance of permitting standards for HWM facilities until fall 1980. Adoption of UIC standards now for class IV wells could prove misleading to the States and the public, because EPA might decide this fall to revise the standards to reflect policy decisions

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[9] Development of Procedures for Subclassification of Class III Injection Wells, Geraghty and Miller, April 30, 1980.

made in connection with RCRA standards. Accordingly, EPA has determined that the best course is to defer the "technical standards for Class IV wells which inject above USDWs until fall 1980.

Finally, Class V wells include all wells not covered by the preceding categories, and those wells for which EPA currently lacks comprehensive information. With the exception of wells injecting radioactive waste, which are covered under Class IV and V, the Agency has reason to believe that Class V wells pose a significantly lesser environmental danger than do other categories of wells. Some Class V wells can cause risks to public health, of course, but many of them can be actually beneficial to groundwater. Due to incomplete data, EPA has classified these remaining wells together and is proposing no immediate performance criteria for them at this time. Instead, these wells are to be assessed and, based on that assessment, EPA will formulate a regulatory program suitable.for them at a later time. In the meantime, if remedial action appears necessary, an individual permit may be required (§122.37) or the Director may require remedial action or closure by order (§122.37(c)).

PERFORMANCE CRITERIA

The regulations propose the use of a variety of measures to assure that injection wells will not jeopardize underground sources of drinking water. This section addresses, the major technical requirements by discussing each in conjunction with the particular problem it is designed to prevent or remedy. The "problems" are basically six in number, and are described here as "pathways of
contamination" - ways in which fluids can escape the well or injection horizon and enter underground sources of drinking water. These "pathways" are the following:

1. movement of fluids through a faulty injection well casing;

2. movement of fluids through the annulus located between the casing and well bore;

3. movement of fluids from'an injection zone through the confining strata;

4. vertical movement of fluids through improperly abandoned and improperly completed wells;

5. lateral movement of fluids from within an injection zone into a protected portion of that stratum; and

6. direct injection of fluids into or above an underground source of drinking water.

PATHWAY 1 - MIGRATION OF FLUIDS THROUGH A FAULTY INJECTION WELL CASING

The casing of a well can serve a variety of purposes. It supports the well bore to prevent collapse of the hole and consequent loss of the well, serves as the conductor of injected fluids from the land surface to the intended injection zone, and supports other components of the well. If a well casing is defective, injected fluids may leak through it. Such migration can contaminate an underground source of drinking water.[10]

To prevent migration of fluids in this manner, the promulgated regulations require that wells in Class I use casing sufficient to prevent the movement of fluids into any underground source of drinking water. Casing requirements for Class II and III wells are different and are discussed in more detail below.[11] The impact of this standard should va.ry on a well-by-well basis. In some instances, injection wells would only need a minimal surface casing to prevent migration of fluids into underground sources of drinking water. In other cases, multiple strings of casing might be necessary. EPA is proposing this flexible, goal-related standard, rather than a fixed requirement, in order to allow State Directors the discretion to vary the requirement, as appropriate, in each instance. Allowing this discretion should lessen the cost of the requirement while still accomplishing its preventive objective.[12]

The regulations also require wells to comply with certain operational requirements which can serve to minimize migration of fluids through casing. Foremost among these are the requirements to demonstrate mechanical integrity.[13] A mechanical integrity test is used to verify, as its name indicates, the "integrity" of a well, i.e., whether there is an absence of significant leaks.[14]

The determination of what constitutes a significant leak is left to the Director. This acknowledges the site-specific nature of the question and allows a case-by-case review of important local phenomena that must be considered in establishing-"significance". The regulations require operators of all new Class I-III wells (wells coming into operation after an

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[10] Report to Congress, Section XI, XIII; An Introduction to the Technology of Subsurface Wastewater Injection, U.S. Environmental Protection Agency (December, 1977), Chapter 7 ("Subsurface Wastewater Injection").

[11] §146.12(b). For a full discussion of the requirements for Class II, and III wells, see pages 11-12 below.

[12] Subsurface Wastewater Injection, Chapter 7.

[13] §146.08.

[14] See generally, Mechanical Integrity Testing of Injection Wells, Geraghty and Miller, Inc., April 30, 1980.

applicable UIC program becomes effective in the State) to conduct mechanical inte§rity tests and provide the results to the Director. If a test indicated that a well did not have mechanical integrity, i.e., it leaked injected fluids, the well would not be authorized for injection. For existing-wells, the regulations require that mechanical integrity be demonstrated before continued operation.of the well can be authorized.

The selection of a mechanical integrity test as a requirement of these regulations is uniquely appropriate because normally wells cannot be inspected directly. Well integrity can be demonstrated by the absence of a significant leak in the casing, tubing or packer and the absence of significant fluid movement into an underground source of drinking water. The regulations specify a choice of two tests to detect leaks, and two others to detect fluid movement.[15] The regulations specify monitoring of annulus pressure or pressure tests'with a liquid or gas for detecting leaks, and use of noise or temperature logs for detecting fluid movement. Existing Class II wells may use well records as proof of adequate cement to prevent fluid movement. These tests are commonplace in the well injection, industry, and are considered reliable indicators of mechanical integrity.[16]

The regulations also would allow the-use of mechanical text.[17] To integrity tests not specifically listed in the t use any of these tests, a Director would have to demonstrate its suitability for the intended. purpose and secure EPA approval prior to its use. Once approved by EPA, the test would be eligible for use by all persons unless specifically restricted. EPA allows this flexibility because it recognizes that there may be mechanical integrity tests which, although unspecified in the regulations, are fully adequate to detect well defects. Moreover, tests which might be acceptable may be developed in the future.

The regulations further require that operators of wells which have been authorized for injection under this program perform, additional,mechanical integrity testing at least once every five years of operation for most wells.[18] However, additional mechanical integrity tests for Class III wells will only be required for those wells which are used for relatively long periods, such-as salt solution and geothermal wells. Other Class III wells, which have a shorter life span, will not be required to perform periodic mechanical integrity tests. In addition, Class II wells may use well records to demonstrate the presence of adequate cement to prevent significant fluid movement. As part of an evaluation, a statistically valid random sample of wells will be tested with either noise or temperature logs to assess the adequacy of well records as a measurement of mechanical integrity.

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[15] §146.08(b),(c).

[16] see generally, Mechanical Integrity Testing of Injection Wells.

[17] §146.08(d).

[18] §§146.13(b),(3), 146.23(b),(3), 146.33(b),(3).

The Agency decided on the five year frequency period after long consideration and consultation with state officials. EPA staff determined that the requirement for a mechanical integrity test at least every five years during operation of the well would provide satisfactory assurance of continued well soundness and in addition would be reasonable from a cost perspective. Moreover, the five-year review schedule facilitates Agency efforts to combine the several permit programs under its charge.

A second protective feature of these regulations is the requirement for a tubing and packer, fluid seal, or an alternative approved by the director for Class I wells. The Agency applied this requirement to Class I wells due to the potentially corrosive nature associated with Class I wastes. This requirement does not apply to municipal. wells injecting non-corrosive fluids. The reproposal specified only tubing and packer or alternative. As a result of public comment, the Agency included the use of a fluid seal in the final regulations. Fluid seals are used extensively and have proved effective. Tubing and packer can best be described as a removable liner device within a well which isolates the casing of the well from injected fluids. By preventing this contact between casing and injected fluids, the possibility of movement of contaminants through leaks in the casing is greatly diminished. For the same reason, tubing and packer or equivalent also lessens the chances of corrosion of the casing. Tubing and packer offers two further advantages. It isolates the annulus (between the tubing and casing) from the injection zone, facilitating detection of any leaks in the tubing. It also allows for visual inspection for deterioration of the tubing during routine maintenance.[19]

The regulations make the use of tubing and packer or an acceptable substitute mandatory for Class I well S,[20] except for municipal wells injecting only non-corrosive wastes. EPA expects that Class I wells will be injecting highly corrosive material more frequently than Class II or III wells,[21] hence, routine use of tubing and packer or an acceptable substitute becomes appropriate (For Class II and III wells, the requirement to use tubing and packer is discretionary with the Director because the inflexible use of the requirement for Class II and III wells would likely interfere with production from many of these wells without any significant benefit to protecting USDW).[22] Even though a tubing and packer requirement is not mandatory for wells in Classes II and III, Directors should require its use when appropriate to prevent fluid migration into underground sources of drinking water.)

When the use of a packer in Class I wells is inappropriate, the regulations allow for use of alternative means to accomplish the'saime objective provided that the Director approves such

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19 Subsurface Wastewater Injection, Chapter 7.

20 §146.12(c).

21 Report to Congress, Section XIII; Ground-Water Pollution, Part 2, Section II.

22 Subsurface Wastewater Injection, Chapter 7.

methods.[23] In fact, based upon the type of well involved, it is possible that an alternative to tubing and packer or fluid seal might actually provide a greater degree of protection.[24] When other effective methods are proposed, EPA.does not oppose their use. Prior to use, however, EPA reserves the right of review and approval.

The final provision by which the regulations propose to eliminate contamination through this first pathway is to require that Class I and Class III wells-which in ect corrosive fluids be constructed of corrosion'-resistant materials. [25] This standard is intended to prolong the operating life and continued viability of wells.

PATHWAY 2 - MIGRATION OF FLUIDS THROUGH THE ANNULUS LOCATED BETWEEN THE CASING AND THE WELL BORE

A second way by which contaminants can reach underground sources of drinking water is by migrating upward through the annulus located between the drilled hole and the casing. Under usual injection conditions, injected fluids, upon leaving the well in the injection zone, enter a stratum which to some degree resists the entry of the fluids. Resistance results from friction created by extremely small openings in the materials which comprise the injection zone. Because fluids tend to take the path of least resistance unless properly contained, they may travel upward through this annulus. If sufficient injection pressure exists, the fluids could migrate into an overlying source of drinking water.

The measures taken in the regulations to prevent contamination by this pathway are parallel to those already mentioned concerning Pathway 1. In this case, well injectors must demonstrate to the satisfaction of the Director that there is no significant fluid movement into underground sources of drinking water through this annulus. Mechanical integrity tests can be conducted to provide information on contamination by this route.[26] As with Pathway 1, and for the same reasons, mechanical integrity must be demonstrated at least every five years.

For Class I and III wells, the annulus between the hole and casing must also be filled with cement adequate to prevent the flow of fluids into an overlying drinking water source.[27] Depending upon the complexity of the well, this cementing can be accomplished in different

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[23] §146.12(c)(1).

[24] Subsurface Wastewater Injection, Chapter 7; See also Cook, T.D. Underground Waste Management and Environmental Implications. American Association of Petroleum Geologists (Tulsa, Okla., 1972).

[25] §146.12(c).

[26] §146.08

[27] §§146.12(b); 146.32(a).

ways. A well with a single casing, for example, may need cementing at only one interval (e.g., through the confining stratum which separates the injection zone from the source of drinking water). Other wells, which penetrate to greater depths or which involve more than one casing, may need a more elaborate cementing procedure. Because of this range, EPA is proposing the cementing requirement in general terms and intends to leave decision making to Directors' discretion. Directors are instructed in the regulations to take a variety-of factors into account when determining specific cementing requirements for individual wells.[28]

All new Class II wells will be subject to requirements outlined above. Existing and converted Class II wells need nut meet these requirements if they were subject to regulatory controls at the time they were drilled and they are in compliance with those controls, and injection will not result in the migration of fluids into an underground source of drinking water so as to create a significant risk to the health of persons using the source as drinking water. Similarly, new (newly drilled) wells in existing fields must meet casing and cementing requirements applicable to the field, and cannot allow movement of fluids into an underground source of drinking water if such movement will create a significant risk to health of persons.[29]

For Class III wells, all new wells must comply with the requirements discussed above. Existing wells which have long lives, such as salt solution and geothermal wells, must demonstrate mechanical integrity; however, they are not required to meet other casing and cementing requirements. Various considerations underlie this modified approach.

As mentioned in the preamble to these regulations, costs played a role: EPA data indicates that compliance for Class II wells equivalent to casing and cementing requirements for Class I wells could generate costs to the oil industry of more than $20 billion over 5 years.[30],[31] Imposing regulatory requirements of this financial magnitude in EPA's view, would interfere with injection of brines or other fluids which are brought to the surface in connection with Oil and natural gas production and with injection for secondary or tertiary recovery of oil or natural gas without being essential to assure that underground sources of drinking water will not be endangered by such injection. Moreover, the imposition of this casing and cementing requirement could be an unnecessary disruption of state UIC programs currently in effect and being enforced in a substantial number of states.

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28 §§ 146.12(b),(l)-(7); 146.22(b),(l)-(7); 146.32(a),(l)-(7).

29 §146.22(b).

30 Estimated after discussions with consultants. See generally Cost of Compliance Proposed Underground Injection Control Programs, Oil and Gas Wells, Arthur D. Little, Inc. (June, 1979) ("Oil and Gas Wells").

31 See generally Underground Injection Control Program Class II Well Incremental Compliance Cost Refinements. Booz, Allen and Hamilton Inc., and Geraghty and Miller, Inc., April 30, 1980.

In addition, the imposition of the "full" casing and cementing requirement on Class II wells in existing injection fields would not yield significant environmental benefit. If past injection was performed in an unsafe way, nearby water resources will likely be too contaminated for consumption as drinking water. Imposing casing and cementing in this instance would not be helpful to the environment. On the other hand, if the injection has been performed historically in a way which is protective of underground drinking water, it is reasonable to believe that the injection method will continue to protect underground sources of drinking water. These facts are particularly applicable to Class II wells because they are relatively older than wells in other categories[32] and are normally found in groups the members of which are similarly constructed.[33] Older wells, with longer histories of operation; are more likely to have contaminated drinking water, if at all, by this time, than are newer wells. Moreover, the similar construction of wells in specific fields increases the chances that, if contamination has occurred, it is already extensive.

Lastly, the need for the "full" casing and cementing of Class II wells is generally less because-brine and other fluids associated with oil and natural gas production pose less threat to human health than fluids which Class I and some Class III wells often inject.

PATHWAY 3 - MIGRATION OF FLUIDS FROM AN INJECTION ZONE THROUGH THE CONFINING STRATA

The third way by which fluids can enter an underground source of drinking water is from an injection zone through the confining strata. Upon entry into an injection zone, fluids injected under pressure will normally travel away from the well laterally and through the receiving formation. In most cases, this expected occurrence gives rise to no concern, but, if the confining stratum which separates the injection zone from an overlying or underlying underground source of drinking water is either fractured or permeable, the fluids can migrate out of the receiving formation and into the protected region.

For obvious reasons, there are no well construction standards which can address this problem of migration of fluids through this pathway. Consequently, the regulations propose two provisions to assure that fluids do not travel this pathway into underground drinking water. First, the regulations require that, prior to the issuance of a permit, the geologic characteristics of the injection zone and confining strata be reviewed.[34] Data already available to states can assist Directors in making these reviews. A permit should only be issued upon the Director's finding that the underground formations are sufficiently sound to contain fluids in the injection zone.

Second, the regulations require that well injection pressure be controlled to prevent opening fractures in the confining strata or otherwise causing the rise of fluids into an overlying

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[32] Report to Congress, Section XI.

[33] Id.

[34] §§146.14(a)(l); 146.24(a)(l); 146.34(a)(l).

protected zone.[35] Using this mechanism, injection pressures can be restricted to provide conservative protection even in the face of less than ideal geologic characteristics. For example, if a confining stratus is known to be fractured or permeable, injection might be permissible if done at predetermined pressure levels which under no circumstances could cause a rise of fluid to the height at which it would enter a drinking water source.

PATHWAY 4 VERTICAL MIGRATION OF FLUIDS THROUGH IMPROPERLY ABANDONED AND IMPROPERLAY COMPLETED WELLS

One of the common ways by which fluids can enter an underground source of drinking water is by migration through improperly abandoned and improperly completed wells. This would occur if fluids moving laterally within an injection zone encountered an improperly abandoned or completed well, and, following the path of least resistance, flowed upward within the well until entering an overlying underground source of drinking water or overflowing onto the land surface. Because of the large number of wells drilled in the past, and because well operation and abandonment have not always benefitted from close regulatory scrutiny, contamination by this route can present a significant risk to public health. It is estimated that there are about 17,000 improperly abandoned or improperly completed wells which could cause this problem.[36]

To prevent this contamination, the regulations require Directors to determine an "area of review" for injection wells. This is the area around the injection well through which the incremental pressure of injection can cause vertical migration. Operators of Class I, III, and new Class II wells (operators of existing and converted Class II wells are treated differently; see below) must locate other wells within the "area of review" and correct any problems related to improperly abandoned or improperly completed wells before beginning injection.[37] Under this approach, well injectors would have the affirmative responsibility to demonstrate that the proposed injection operation would not cause contamination by this route.

Directors could choose either of two methods to determine the area of review. the first method would be to require use of mathematical formulae to determine, on a case by case basis, the lateral impact which an injection operation could cause. The formula would indicate the distance outward from the well which this particular injection would or could affect. The Regulations provide one formula which can be used for this purpose. It takes into account a range of factors, including hydraulic conductivity, thickness of the injection zone, time of injection, storage coefficient, injection rate, hydrostatic head and specific gravity. EPA is proposing this particular formula because it is based on an equation which has been in common use for years and, in that time has demonstrated satisfactory results; however, other suitable

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[35] § 146.06

[36] Oil and Gas Wells; Chapter VIII-D.

[37] §122.44(a).

formulae are acceptable.[38]

If a suitable formula indicates that no problem exists, injection could commence without any obligation to repair faulty wells found within the area of review. If it did indicate a problem, however, the well operator would be expected to correct it. Correcting the problem could mean that the well operator would have to plug a faulty well at his/her expense. In other cases, the operator might simply have to modify injection pressure to assure that the rise of fluids caused would not cause fluids to enter an underground source of drinking water.

The use of a formula to determine the area of review may not always be feasible. In some instances, necessary information may be lacking. Such formulae also do not have universal applicability: Mathematical formulae, because they are based on ideal conditions (that aquifers are homogeneous, isotropic, and infinite in extent, for example), may not always reflect actual subsurface conditions. Moreover, they assume radial flow in all directions and, in some cases, will not yield a finite distance measurement for well review purposes.

Because of these possibilities, the regulations offer a second method for determining the area of review. Directors may use (in lieu of a case by case formula) a fixed radius of one-quarter mile or greater. The Agency selected this minimum radius after consideration of current state practices and after applying it to a randomly selected population of well fields representing various geologic conditions. EPA had considered use of more extensive review requirements, particularly the use of one-half mile radius for area of review computation, but decided-against them because the less rigorous requirement is more cost-effective, and the one-fourth mile radius proved satisfactory in actual applications.[39] In many cases, use of a larger fixed radius would result in duplicative review of the same wells.

Moreover, the quarter-mile radius is compatible with coverage practiced in most states. Generally, states impose review requirements on we'll operators in a range of 1000 feet from the injection site up to two miles. EPA's selection of the quarter-mile distance represents its assessment of the effectiveness of these varying requirements in the state programs.[40]

EPA has modified the area of review requirement for Class II wells.[41] Unlike the proposal for wells in Classes I and III, the regulations require that only new Class II wells observe area of review requirements. Class II is characterized by large numbers of wells clustered in oil fields. Because new injection wells are interspersed with existing Class II wells, imposing the area of review requirements on new Class II wells should still result in discovery

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[38] §146.06(a).

[39] See generally Oil and Gas wells, Chapter VIII.

[40] Preliminary Evaluation of Well Injection Practices.

[41] §146.24(a),(2).

and correction of all faulty wells within the existing well fields, although over a more extended time frame.[42] The Agency opted for this approach because it deemed it to be effective, both.from an environmental and cost perspective, and because it considers placing expenses on new, rather than existing, well operators to be a preferable regulatory approach.[43]

With respect to corrective action itself, the regulations impose a flexible standard. Corrective action required for each well will be fashioned by the Director on a case by case basis after considering a variety of site specific criteria.[44] EPA prefers this approach because of the variety of problems or conditions which can trigger the need for corrective action. In one instance, the only corrective action which may be needed to prevent the migration of fluids into an underground source of drinking water through a faulty well might be a reduction of the pressure at which fluids are injected. In other instances, monitoring of nearby wells coupled with a contingency plan to remedy any problems which result from the injection operation might be feasible. In still other cases, it might be necessary to correct the wells. This range of possibilities, as well as the significant costs which corrective action can generate; have encouraged the Agency to adopt the more flexible approach.

PATHWAY 5 - LATERAL MIGRATION OF FLUIDS FROM WITHIN AN INJECTION ZONE INTO A PROTECTED PORTION OF THAT STRATUM

In the most cases, the injection zone of a particular well will be physically segregated from underground sources of drinking water by impermeable materials. In some instances, however, well injectors,may inject into an unprotected portion of an aquifer which in another area will be designated for drinking water purposes. In this event, there may be no impermeable layer or other-barrier to prevent migration of fluids into underground drinking water.

Injection into unprotected portions of aquifers which contain drinking water in other areas must be done with great care. The regulations control this potentially dangerous activity by according the Director a range of construction and operating controls which can be imposed at his/her discretion.[45] Notwithstanding the discretionary controls afforded the Director, specific information must be considered by him prior to allowing injection into such an aquifer. The Director must consider such factors as the injection pressure, the nature of the fluid injected, specific geologic and hydrogeologic conditions, ground water use patterns and other factors. Usually, Directors can allow injections of this type if the predominant flow of the aquifer is such that injected fluids will tend to move away from, rather than toward, the protected part of the aquifer. Even if that is not the case, however, Directors could still allow the injection if any of a

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[42] See generally Oil and Gas Wells, Chapter VIII.

[43] Id.

[44] §§146.07, 146.14.

[45] §146.12; 146.22; 146.32.

variety of operational conditions were satisfied. For example, the Director might allow an injection upon a determination that the rate of flow or the volume or pressure of injection was sufficiently small to assure that fluids would not enter.the prote-cted region.

PATHWAY 6 - DIRECT INJECTION OF FLUIDS INTO OR ABOVE AN UNDERGROUND SOURCE OF DRINKING WATER

The last pathway of contamination of groundwater is potentially the most worrisome. The injection of fluids into or above underground sources of drinking water can present the most immediate risk to public health because it can directly degrade groundwater especially if the injected fluids do not benefit from any natural attenuation from contact with soil, as they might during movement through an aquifer or separating stratum.

The regulations prohibit injection of contaminants directly into an underground source of drinking water for wells in Classes I to III;[46] Class IV wells, which inject directly into underground drinking water are to be banned as soon as possible but in no event later than six months after a State underground injection control program becomes effective. Class IV wells which inject above an underground drinking water source are to be studied further. Accordingly, EPA has decided to defer issuance of permitting and technical standards for Class IV wells until this fall. Class V wells, of which little is known, will be assessed before regulations for their operation are proposed[47] (for a fuller discussion of the regulatory approach proposed for Class IV and V wells, see the preamble to the regulations).

OTHER REQUIREMENTS

ABANDONMENT - the regulations also require that well injectors abandon their injection wells in a way which will prevent the contamination of underground sources of drinking water.[48],[49] As indicated earlier, abandoned wells can act as conduits for contaminants to enter protected aquifers. To assure that currently used and future wells do not create problems of this type, the regulations require plugging of wells after termination of operation. Again, the exact means of accomplishing an effective abandonment are left to the judgment of the Director to be exercised on a case by case basis. In addition, §146.10(d) requires the operator of a Class III well to subinit a plan of abandonment which must demonstrate that no movement from the mining zone into underground sources of drinking water will occur after abandonment.

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46 §122.34(a)(1).

47 §146.52(b)(l).

48 §146.10.

49 See Generally, Development of Procedures and Costs for Proper Abandonment and Plugging of Injection Wells, Booz Allen and Hamilton Inc., and Geraghty and Miller, April 30, 1980.

§146.10(b) specifies that the dump bailer method, the balance method, or.the two plug method be used to plug a well. These practices represent existing methods employed that have proved effective in a wide range of application.[50]

With respect to Class IV wells, traditional methods of abandonment, such as plugging, may be inappropriate due to the crude construction of the well. In such a case, the only abandonment requirements might simply be closure of the well.

MONITORING FREQUENCIES

The regulations also require various kinds of monitoring.[51] Monitoring can provide an early warning of potential serious degradation of underground sources of drinking water.

Wells in Classes I, II, and III share common monitoring requirements. Injection fluids must be tested with sufficient frequency to field data representative of fluid characteristics. Information of this sort is essential for the Director to understand the operation of a particular well. Such information serves the important function of providing basic knowledge of enabling Directors to analyze reasons for well failures, to establish appropriate remedies to correct them and to assess any endangerment the failures might cause.

The regulations also require monitoring of operating characteristics of wells in Classes I, II, and III. Class I and III wells must have continuous recording devices to monitor injection pressure, flow rate, and volume of injection fluids.[52] Continuous monitoring is appropriate because fluids injected by Class I and III wells are usually more corrosive and hazardous than are fluids injected by others. These fluid properties increase the risk of serious well leaks or failures. Continuous monitoring, furthermore, is a common practice for these wells, in part because they often inject fluids in uninterrupted streams.

Class I wells must comply with the additional requirement of continuously monitoring the pressure in the annulus of the well between the tubing and the long string. The "long string" is the casing which extends from the ground surface to the injection zone. Wells in Class III which may require the use of the annulus for injection, need not meet this requirement since, when the annulus is employed for injection, pressure measurements reflect injection pressure.

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[50] Development of Procedures and Costs for Proper Abandonment and Plugging of Injection Wells.

[51] §§146.13; 146.23; and 146.33.

[52] §§146.13(b)(2); and 146.33(b)(2).

Class II injection well monitoring provisions aze less stringent than those for Classes I and III.[53] Continuous monitoring is not required for Class II; rather, depending on the actual injection operation, monitoring frequency varies from daily to monthly. A stricter approach is not essential for Class II wells because of the lesser toxicity and corrosivity of fluids which Class II wells handle and because the total cost of imposing continuous monitoring on Class II wells would have been inordinately burdensome in EPA's view.[54]

Class III wells are also required to monitor, on a quarterly basis, water supply wells adjacent to the injection site to detect any excursions from the injection site.[55] This monitoring is commonly practiced by operators of Class III wells.[56] EPA is promulgating this requirement for Class III wells (and not for Class I wells) because Class III wells are often designed to inject into shallower strata, thereby increasing the possibility of contamination of aquifers nearest the land surface.

This added risk has prompted the Agency to require monitoring wells at each project site, located to maximize the probability of detecting any horizontal or vertical fluid excursion from the injection zone. Weekly monitoring of the fluid levels in these monitoring wells and of parameters appropriate to determine if any excursions of injected fluids are entering underground sources of drinking water, is also required. This requirement, although involving additional expense, was considered necessary to assure that any migration of these potentially harmful injected fluids into underground sources of drinking water, which are often located quite close to the injection zones, would be discovered and rectified promptly. Class III wells may be monitored on a field or project basis rather than an individual well basis by manifold monitoring e.g. using a common header with individual well points. This approach may be used with facilities that consist of more than one injection well if the owner or operator can demonstrate that manifold monitoring is comparable to individual well monitoring.[57]

No monitoring requirements are proposed for Class V wells. These wells will be assessed under the proposed regulatory scheme. The assessment should produce a substantial amount of data upon which an entire regulatory approach, including monitoring, can be used.

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[53] §146.23(b).

[54] <u>Oil and Gas Wells</u>, Chapter V-B, C.

[55] §146.33(b)(5).

[56] Comments of Freeport Sulfur Co., Jan. 14, 1977; Statement by Texas Gulf Co., Oct. 13, 1976.

[57] §146.33(b)(6).

REPORTING

The regulations also impose reporting requirement on well injectors.[58] Owners and operators of wells regulated under Classes I and III must report the results of monitoring and any other significant operational information at least quarterly, while Class II well owners and operators need only report to the director annually. The reasons underlying these proposals parallel those for the monitoring requirements. Owners and operators of wells which inject fluids of greater potential hazard must report more often than those which do not. Class V wells need not submit monitoring or reporting data because the assessment planned for this category will supply EPA with a substantial amount of data in its own right.

[58] §§ 146.13; 146.23; and 146.33.