

# Water Well Standards: State of California

Bulletin 74-81  
December 1981

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**Department of  
Water Resources  
Bulletin 74-81**

**Water Well  
Standards:  
State of California**

**December 1981**

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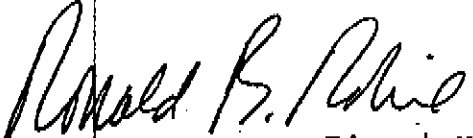
## FOREWORD

Our ground water resources are becoming increasingly important to all Californians. In an ordinary year, about 40 percent of the water used in the State is derived from underground sources. During the 1976-77 drought, however, that figure rose to 53 percent. To ensure the continued utility of our underground resources, they must be protected. Standards for both the construction of water wells and the destruction of abandoned wells can help protect ground water quality.

Furthermore, deficiencies in the design and construction of wells usually result in higher operating and maintenance costs. The establishment and implementation of well standards in an area provide more assurance that wells are likely to require less maintenance and will have longer useful lives.

Since the initial printing of these standards in February 1968, 30 counties and 132 cities have enacted ordinances, based on Bulletin 74, governing the construction, alteration, and destruction of all water wells within their boundaries. (At that time, three other counties already had ordinances in effect.) These ordinances specify that water wells be constructed, or destroyed when their useful lives are over, in accordance with the guidelines contained in the Department of Water Resources' standards.

Changes in the field of well construction (methods, equipment and materials), together with the experiences of applying the 1968 standards, warrant revising and updating them. As a result, this new edition is being issued. Counties and cities that have not yet done so are urged to consider enacting well construction standards to protect the quality of ground water supplies for the benefit of their citizens. Where standards are in effect, consideration should be given to revising them to reflect the modifications presented in this bulletin.

  
Ronald B. Robie, Director  
Department of Water Resources  
The Resources Agency

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## CHAPTER I. INTRODUCTION

About 40 percent of the water used in California comes from underground. During the 1976-77 drought the proportion rose to 53 percent. In some locations water from wells or springs is the only water available. The Department estimates that there are 500,000 to 750,000 water wells (irrespective of condition or whether used or idle) scattered throughout the State. Most are situated in the 400 significant ground water basins in California, although many thousands are located in the hilly and mountainous areas. They range from hand dug wells to carefully designed large production wells drilled to great depths.

If our ground water supplies are to remain useful to us, we are obligated to protect their quality. It is ironic that one way in which ground water quality can decline is through the well. This occurs when, because of inadequate construction, wells provide a physical connection between sources of pollution and usable water. The geologic environment has some natural defenses against pollutants, but each time we penetrate that environment, we may carelessly establish avenues for their uncontrolled introduction. Abandoned wells pose a particularly serious threat, not only to ground water quality but also to the safety of humans, especially children, and to animals. Such wells are frequently and conveniently forgotten and once out of mind, there is little chance of preventing them from eventually becoming a problem.

The potential for such problems is growing because the number of wells is increasing. Around 15,000 new wells are constructed each year. In 1977, at the height of the 1976-77 drought, an estimated 28,000 wells (about double an average year) were drilled in the State. The number of wells abandoned each year is not known.

A properly constructed or adequately destroyed well should maintain, as far as practicable, those subsurface conditions which, prior to construction of the well, prevented the entrance of unsanitary and inferior-quality water into usable ground water supplies. Standards for the construction of water wells and for the destruction of so-called "abandoned" wells can be a significant factor in the protection of ground water quality and should contribute to the betterment of the health and welfare of the people of the State.

Impairment of the quality of ground water of the State through improper construction or abandonment of wells has long been one of the concerns of the Legislature. In 1949 it enacted legislation which, among other matters, directed the Department of Public Works to investigate and survey conditions of damage to quality of underground water caused by improperly constructed, abandoned or defective wells and to report to the appropriate regional water pollution control board its recommendations for minimum

amended (or new) permit is issued a thorough review is made of (a) the location of the well with respect to potential contamination hazards, (b) design and construction of the well necessary to prevent contamination or the exclusion of undesirable water, and (c) the bacterial and chemical quality of the water produced. The Department may issue a permit if it finds that the water "under all circumstances is pure, wholesome; and potable and does not endanger the lives or health of human beings." Specific water quality and monitoring standards have been adopted by regulation. If at any time water produced from an existing well fails to comply with such standards, the Department may require changes or modifications of the well, provisions of appropriate water treatment, or cause the curtailed use, even destruction of the well, in order to assure a safe supply to the public.

In summary, the responsibility of the Department of Water Resources is to advise the Legislature and appropriate state agencies on the maintenance of ground water quality, including protection against adverse effects caused by improper well construction or the abandonment of wells. This responsibility applies to all wells, irrespective of purpose. The responsibility of the Department of Health Services is to investigate, evaluate, and approve public water supplies including the design and construction of water wells.

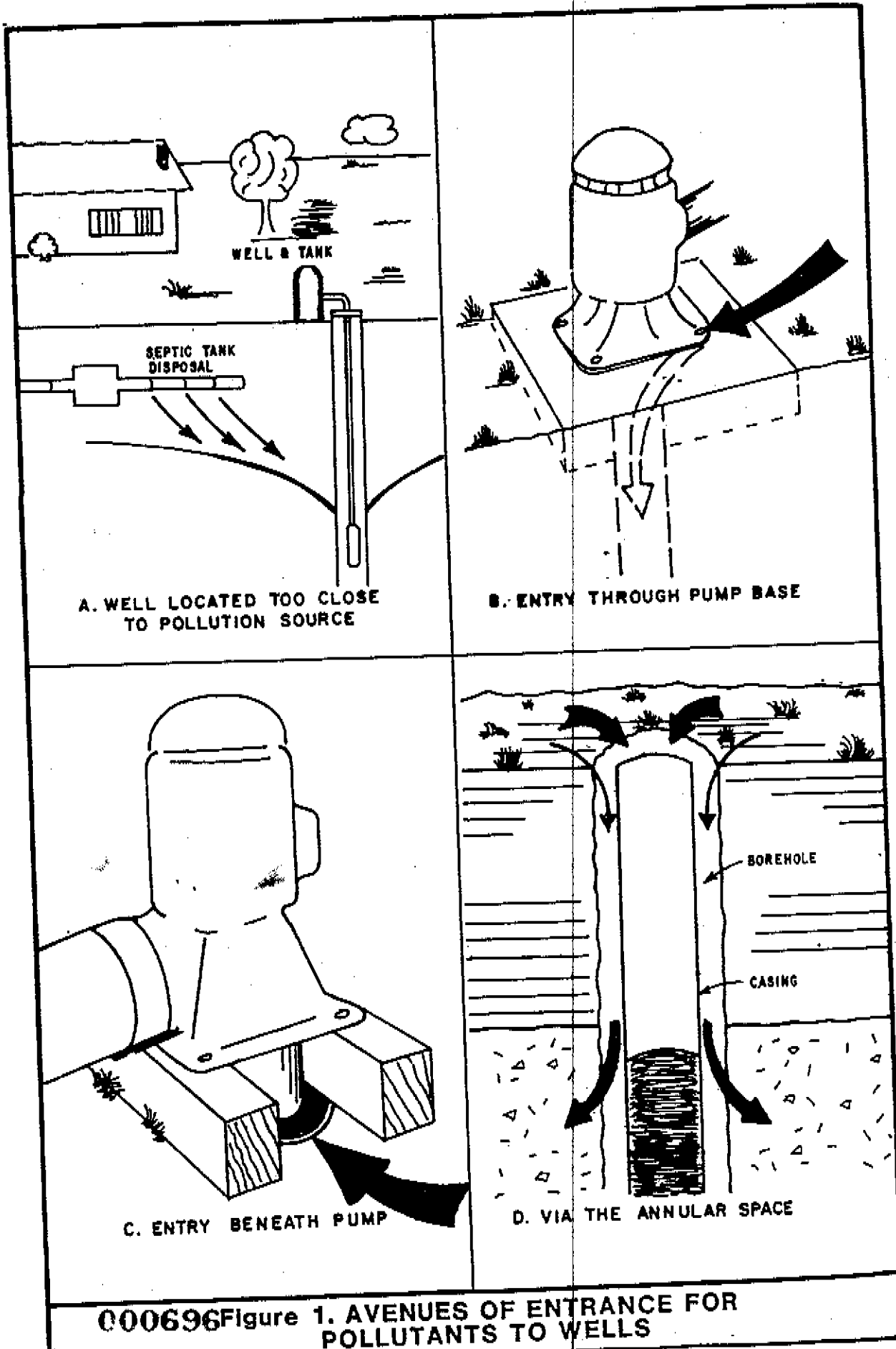
This report was prepared by the Department of Water Resources in fulfillment of its responsibilities under the provisions of Section 231 of the Water Code, and in cooperation with the State Department of Health Services.

#### Statement of the Problem

Wells themselves do not cause ground water quality to deteriorate. Rather, it is inadequate construction, or, in the case of wells that no longer serve a useful purpose, their improper destruction, that can result in the deterioration of ground water quality. Depending on the circumstances, such quality deterioration may affect the water supplying a single well, or if the pollution is substantial, a sizable segment of a ground water basin.

The impairment of water quality in an individual well, or group of wells, is the most common. Ground water supplies have been responsible for a sizable portion of the water-borne disease outbreaks reported in the United States. Most of these outbreaks occurred where wells were so poorly constructed that they allowed contaminants to enter the well. Contaminants entering improperly constructed wells are not limited to disease organisms. There is also a growing number of case histories concerning undesirable chemicals, both toxic and nontoxic, that have gained access to ground water and adversely affected wells a short distance away.

The mechanism of water quality impairment caused by faulty wells affecting large segments of a ground water basin is not well defined. In most instances, a number of factors have been involved; the wells have served primarily to facilitate the impairment. The most noteworthy examples in



A. WELL LOCATED TOO CLOSE TO POLLUTION SOURCE

B. ENTRY THROUGH PUMP BASE

C. ENTRY BENEATH PUMP

D. VIA THE ANNULAR SPACE

000696 Figure 1. AVENUES OF ENTRANCE FOR POLLUTANTS TO WELLS



Irrespective of the probability of occurrence and which form of deterioration takes place, wells should be constructed or destroyed such that they do not contribute to the impairment of the quality of California's ground water supplies. Moreover, while the well construction industry, advisory groups, and regulatory agencies want to protect the quality of the State's ground water supplies as well as assure that wells are adequately constructed, there is no broad, uniform approach for so doing in California. The resolution of this problem requires the development of standards for water well construction and destruction that will ensure the protection of the State's ground waters as they exist in the ground or as they pass through the well for use. Such standards should be capable of execution by the average competent well driller using commercially available equipment and materials, without imposing undue financial burden on the well owner.

Well standards do more than protect the quality of the ground water resource; they also provide a degree of consumer protection. When standards are established and implemented in an area, well owners have more assurance that their wells will be constructed properly. Proper construction could mean less maintenance with an extended well life. Most well owners do not realize that deficiencies in design and construction (including failure to close-off access to pollutants described above) are likely to result in higher operating and maintenance costs.

A subject touched upon earlier is the safety hazard posed by the unused or "abandoned" well. While safety is not a matter involving the maintenance of ground water quality, it should be a concern to all those involved with water wells. Any abandoned excavation is a threat to the safety of people, especially children and animals. Further, State law (Section 24400 of the California Health and Safety Code) requires that abandoned excavations be fenced, covered, or filled. Yet, children (and sometimes adults) and livestock do fall into abandoned wells and other excavations.

By properly destroying abandoned wells, we can easily eliminate this safety hazard.

#### Developing the Standards

The Department of Water Resources began formulating standards for the construction of water wells and the destruction of abandoned wells shortly after the enactment of Water Code Section 231 in 1949. The Department made a comprehensive survey of existing laws and regulations governing well construction and abandonment in the then 47 other states and in the counties and cities of California. This survey culminated in the publication of "Water Quality Investigations Report No. 9 - Abstracts of Laws and Recommendations Concerning Water Well Construction and Sealing in the United States", April 1955. Although the report is over 25 years old, it remains a useful source of background information. The Department has continued to keep informed of practices in other states, particularly those in which

helpful to describe the areal and vertical extent of geologic materials where sealing is needed to prevent the migration of poor quality water.

Thus, the Department maintained a concurrent and subsequent activity consisting of studies and reports describing the application of standards in designated areas of California. And, in addition to Bulletin 74, the Department issued a number of reports containing well standards for those areas (see Table 1).<sup>1/</sup>

#### The 1981 Edition

The foreword to the 1968 edition stated that:

"Whereas the standards in this report are as final as they can be at the present time, the Department will revise them from time to time. We recognize that, as with other published standards, to be effective and useful they must be revised and updated in light of both changes in practice and degree of success achieved in their application."

Sufficient changes in the field of water well construction and experience with applying the 1968 standards warrant revising them. Foremost among the changes in construction practices are:

1. The development and use of plastic materials for casing in water wells. A subject only alluded to in the 1968 edition, the use of plastic well casing and screen has had phenomenal growth in the United States. So much has the usage increased that a national materials standard has been developed and a manual of installation practices has just been published.
2. The use of the air rotary drilling method for constructing wells in the hard rock areas of the State. Although this method of drilling was in use in 1968, its use has mushroomed since then. The equipment is very effective and very fast. Coupled with the use of plastic well casing, the method has made the construction of a well several hundred feet deep in one day a common event in hard rock areas.
3. Rapid growth in the use of well screens in place of perforated casing in the intake sections of wells.
4. Increased use of the reverse-circulation method of well drilling for large diameter deep wells in unconsolidated formations. It too is an extremely fast method.

<sup>1/</sup> One other report, Bulletin 74-1, "Cathodic Protection Well Standards: State of California", March 1973 deals with another kind of well. Cathodic protection wells house devices used to alleviate electrolytic corrosion of pipelines, tanks, and similar installations. Such wells may also function as instruments for the deterioration of ground water quality. For that reason, standards for their construction and destruction have also been issued.

Other factors include:

1. Population growth in the hilly and mountainous rural areas of California, which has resulted in a heavy demand for individual and community water supplies in those areas.
2. The 1976-77 drought, the most severe in a half-century, which caused a heavy demand for new wells, replacement wells, and well deepenings. It also produced an increased awareness of the significance of the State's ground water resources.
3. The increasing cost of energy for pumping. In terms of well construction and operation, this has meant greater interest in the design of efficient wells and in well maintenance (previously, a much neglected activity).

These as well as other considerations led to the decision to revise the 1968 edition.

This edition is composed of this chapter, Chapter II, "Standards", and five appendixes.

While there have been a number of modifications and additions to them, the 23 sections of Chapter II, "Standards", are as listed in the 1968 edition. All references to existing laws, standards, and publications have been updated and, where appropriate, additional explanation is provided. Every effort has been made to clarify wording to ensure its understanding. A number of figures illustrating the standards have been included.

Many technical terms concerning ground water and water well construction are frequently misunderstood or misinterpreted. The term "seal" or "sealing", for example, has several meanings in the jargon of the well driller, geologist, and engineer, depending on what part of the well installation is under discussion. In this report, we have tried to ensure that the technical terms used are understandable.

A list of definitions appears in Appendix A. Certain definitions are made a part of the standards and are presented in Chapter II. Appendixes B, C, and D describe sealing methods, disinfection, and water quality sampling respectively.

Numerous publications relating to the construction of water wells and to the development, use, and protection of ground waters have been reviewed in preparation of this report. Included is a considerable body of literature on well construction that has been written since 1968. They are listed in Appendix E in alphabetical order by author.

#### Establishing and Enforcing Standards

Authority for establishing and enforcing standards for construction and destruction of water wells has always rested with the 58 counties and 429 cities in California.

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TABLE 2  
 COUNTY ORDINANCES IN CALIFORNIA  
 CONCERNING THE CONSTRUCTION AND DESTRUCTION OF WELLS  
 (As of December 1981)

County	Ordinance Number	Date Adopted	Remarks
Alameda	73-68	7/17/73	
Butte	1845	8/2/77	
Contra Costa	1189	1/14/58	
Del Norte	73-30	11/12/73	
Fresno	470-A-39	10/22/74	
Humboldt	897	12/21/72	
Inyo	309	10/4/76	
Kings	365	1/13/76	
Los Angeles	10075	9/1/70	
Madera	412	3/16/76	
Mariposa	373	9/18/73	
Mendocino	1135	8/28/73	
Merced	752	6/10/75	
Mono	75-459	8/26/75	
Monterey	1967	5/29/73	
Napa	335	12/1/70	
Orange	2607	7/18/72	
Placer	1498B	5/9/72	Amended 1977, 1981
Sacramento	508	10/26/55	
San Bernardino	1954	10/15/74	
San Diego	4286	4/3/74	
San Joaquin	1862	12/21/71	
San Luis Obispo	1271	5/7/73	
San Mateo 1/	2413	1/11/77	
Santa Barbara	2769	9/29/75	
Santa Clara 2/	75-6	10/14/75	Ordinance of the Santa Clara Valley Water Dist.
Santa Cruz	1577	2/16/71	
Shasta	479	6/30/69	
Sonoma	1594	12/18/72	
Stanislaus	NS443	6/5/73	
Tulare	1758	8/13/74	Amended 4/16/76
Ventura	2372	8/31/70	Amended 10/1/79
Yolo	765	9/7/76	

1/ Predecessor ordinance numbers 1100 (12/15/55) and 2324 (7/8/75).

2/ Separate ordinance for subdivision wells - NS1203.22 (4/21/64).

The amount of water needed is determined by the intended use of the water. For example, on the average, each person in a household uses 100 gallons (380 litres) of water a day. To the daily household use must be added seasonal uses such as lawn and garden irrigation, swimming pools, etc. Table 4 lists the volume of water supplied from a small capacity well, assuming continuous pumping for 24 hours. Thus, a well supplying one to three gallons (4 to 11 litres) per minute is a reasonable amount for a single family dwelling. Additional amounts, such as for watering livestock or irrigating small acreages of crops, must be added to these values. Table 4 also indicates that a family of four could subsist on the water supplied by a well pumping constantly at the rate of only one-quarter gallon (0.95 litre) per minute. Unfortunately, at this rate there is little margin for error.

Small Capacity Wells. Performance tests for small capacity wells are relatively simple. A widely used test for small capacity wells is a pump test which lasts for four hours or until an apparently stable pumping level has been achieved at a rate equal to that expected for the permanent pump. However, in the hilly and mountainous "hard rock" areas of the State there are no defined aquifers and supplies are related to fracture patterns, the nature and extent of the soil mantle, faults, changes in stratigraphy, etc. In such areas the production potential of a well cannot be accurately assessed. Further, wells in these areas often exhibit a satisfactory initial production, which then declines due to poor recharge characteristics of the surrounding material. In such situations a longer than usual test, upwards of 12 to 24 hours (and longer) duration, may be desirable.

Bailing or air-blow tests give an approximate indication of production. They do not provide information of the accuracy needed to determine well capacity or to design an efficient pump system. (Air lift testing differs from air-blow testing. It involves pumping with air, not blowing the water out of the well as is the case with the air-blow test.)

The ability of the water level in a small capacity well to recover should be observed. If the water level fails to return to nearly its original level after 24-hours, the reliability of the producing zone is open to question.

Large Capacity Wells. Where large capacity wells are concerned, capacity tests are more elaborate and extensive. Such wells are usually located in defined, productive ground water basins, where considerable information on existing conditions is normally available to aid in the evaluation of their performance. All should be pump tested; bailer tests are of little value. The test pump should be capable of pumping 125 percent of the desired yield of the well. Pumping should be continued at a uniform rate until the "cone of depression" reflects any boundary condition that could affect the performance of the well. This could be as short as six hours and as long as several days, depending on aquifer characteristics and knowledge

maintenance and operating costs over the long run, although it should be recognized that there is a limit to what can be achieved when compared to expenditure. Current design and construction technology is capable of producing wells with efficiencies of 80 to 90 percent. Pumping-plant or "wire-to-water" efficiency is currently at 65-70 percent.

### Sanding

Irrespective of size or composition, any loose material entering a well is usually called "sand", and wells that regularly produce significant quantities of loose material are termed "sanders". The continued influx of sand to a well results in damage to pumps and leads eventually to decreased capacity, and thus a reduction in well efficiency. Further, enough sand may pass through the well to create cavities in the aquifer around the intake section of the well. As a result, such cavities can collapse and damage the well casing or screen. While most wells pump a minor amount of sand, excessive sanding is usually caused by poor well design or inadequate development.

Uncased ("Open-bottom") Wells. Casing serves to hold up the walls of the borehole and provide a path for the movement of the water. In formations with material that will not loosen and be carried away by the inflowing water, such as crystalline rock and other "hard rock" formations, the practice is to leave the intake sections uncased. (Theoretically in such instances, well efficiency would be 100 percent.) Unfortunately, in certain areas some drillers, believing the underlying material to be fully consolidated or attempting to save on costs, have drilled open-bottom wells that later produced sand. Furthermore, as pumps lowered following declining water levels, such wells developed sanding problems. This occurred in several areas in the Central Valley during the 1976-77 drought. In such instances, the wells should have been completely cased to prevent caving and the intake section screened to prevent the entrance of sand.

Inadequately Designed Intake Sections. Sanding is often the result of poor selection of screen size or perforation dimensions and/or, where used, filter material (the "gravel pack"). The well screen aperture (slot) openings or the perforation size, together with the length of screen or perforated section, should be selected to provide sufficient open area to allow the desired quantity of water to enter with minimal friction losses while keeping out 90 to 95 percent of the natural aquifer material or filter material.

Artificial filter materials perform a similar function. In addition to allowing the water to enter the well openings and preventing the entrance of fine-grained material, artificial filters are also used to increase the effective diameter of the well and increase the yield of certain wells by allowing numerous thin aquifers to produce water. On the other hand they need not be used unless there are conditions that make their use desirable or necessary.

## Water Well Drillers' Reports

Detailed and comprehensive knowledge of the occurrence and quality of California's ground water resources is vital to protecting, conserving, and properly developing them. The data obtained during the construction of water wells are primary sources of geologic and hydrologic information. In 1949 the Legislature concluded that such information would be invaluable in the event of underground pollution, and would provide a fund of geologic information regarding the State's ground water resources. As a result, legislation was passed requiring the filing of a report with the Department. The report is called the Water Well Drillers' Report and its submittal is also a requirement of these standards (see Chapter II, Section 7 "Reports"). Additional information about the report is presented in "Guide to the Preparation of the Water Well Drillers' Report", Department of Water Resources, October 1977.

### Comments and Public Hearings on Draft Edition

Where a publication is of general interest or its subject is one on which there can be a diversity of opinion, it is the policy of the Department of Water Resources to issue it in preliminary form and solicit comments from interested organizations and individuals and the general public. Since the standards for the construction of wells and the destruction of abandoned wells recommended herein are for application throughout the State, and because they are specified by many counties and cities (in ordinances or regulations), a draft edition was prepared and distributed for comment (April 14, 1981). In addition, four public hearings or meetings (of an informal nature) were held to obtain the views of persons interested in, or concerned with, the construction and use of water wells. These hearings were conducted in cooperation with the Department of Health Services represented by its Sanitary Engineering Section since this report contains provisions which pertain to the public health aspects of water well construction. The hearings were held during June 1981 at Berkeley, Fresno, Redding and Los Angeles. In response to a number of requests, the comment period was extended to September 1981.

Fifty-five persons representing 33 individuals and organizations attended the four hearings. Five formal (written) statements were presented and 16 persons commented verbally. In addition, written comments were received from 33 other organizations and individuals. Those submitting written comments are listed in Table 5. Copies of the written comments are available for inspection in the Department's file in Sacramento.

All comments were carefully reviewed and considered. As might be expected, opinions differed on the applicability of certain standards, guidelines, and procedures. There is, of course, some validity in each point-of-view, which forms the basis for reconsideration. Many comments were incorporated in this final draft. Others were not used for various reasons. Most of the comments dealt mainly with (1) the

TABLE 5  
 ORGANIZATIONS SUBMITTING WRITTEN COMMENTS  
 ON DRAFT OF BULLETIN 74-81 (Continued)

<u>Organization</u>	<u>Representative</u>	<u>Date of Comments</u>
Southern California Water Co.	D. F. Kostas	8/20/81
Stanislaus Co. Department of Environmental Resources	J. Aud	6/25/81
State Water Resources Control Board	C. Whitney	6/16/81
Joseph B. Summers, Civil Engineer, Inc.	J. B. Summers	6/5/81
Joseph B. Summers, Civil Engineer, Inc.	R. L. Reynolds	8/28/81
Tulare Lake Basin Water Storage District <sup>1</sup>	B. L. Graham	6/5/81
Ventura Co. Environmental Health Department	D. W. Koepf	6/8/81
Ventura Co. Public Works Agency	G. J. Nowak	8/14/81
Water Well Surveys	W. C. Wigley	6/16/81
Well Products West, Inc.	C. Willis	6/12/81
Well Products West, Inc.	C. Willis	8/4/81
Woodward-Clyde Consultants	J. A. Gilman	6/24/81

standards in Chapter II (following) more specifically. sections 1, 8, 9, 10, 11, 12, 13, 21 and 23; (2) the Design and Performance Guidelines section of this chapter; and (3) Appendixes B, C and D, which deal with methods and procedures.



## CHAPTER II. STANDARDS

The standards presented in this chapter are intended to apply to the construction (including major reconstruction) or destruction of water wells throughout the State of California. However, under certain circumstances, adequate protection of ground water quality may require more stringent standards than those presented here; under other circumstances, it may be necessary to substitute other measures which will provide protection equal to that provided by these standards. Such situations arise from practicalities in applying any standards or, in this case, from anomalies in ground water geology or hydrology. Since it is impractical to prepare standards for every conceivable situation, provision has been made for deviation from the standards as well as for additional ones. However, the Department believes that for most conditions encountered in the State, the standards presented in this report are satisfactory for the protection of ground water quality.

In the past, the Department expended considerable effort in defining areas where standards should be applied to prevent the mixing of waters of differing qualities in specific ground water areas in California. For example, ground waters of varying quality in the San Joaquin Valley are naturally separated by a confining bed commonly called the "Corcoran Clay". The standards presented in this chapter continue to support the findings and recommendations made regarding the application of standards to the specific areas previously studied. (See Table 1, Chapter I.)

### Part I. General

#### Section 1. Definitions. 1/

A. Well or Water Well. As defined in Section 1371 of the Water Code, well or water well:

"...means any artificial excavation constructed by any method for the purpose of extracting water from, or injecting water into, the underground. This definition shall not include: (a) oil and gas wells, or geothermal wells constructed under the jurisdiction of the Department of Conservation, except those wells converted to use as water wells; or (b) wells used for the purpose of (1) dewatering excavations during construction, or (2) stabilizing hillsides or earth embankments."

B. Community Water Supply Well. A water well used to supply water for domestic purposes in systems subject to Chapter 7, Part 1, Division 5 of the California Health and Safety Code. Included are wells supplying public water systems classified by the Department of Health Services as

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1/ Technical terms are defined in Appendix A.

J. Test Wells. Wells constructed for the purpose of obtaining the information needed to design a well prior to its construction. Such wells are not to be confused with "test holes" or "exploration holes" which are temporary in nature (i.e., uncased excavations whose purpose is the immediate determination of existing geologic and hydrologic conditions). Test wells are cased and can be converted to observation or monitoring wells and under certain circumstances to production wells.

K. Inactive or Standby Well. A well not routinely operating but capable of being made operable with a minimum of effort.

L. Enforcing Agency. An agency designated by duly authorized local, regional or state government to administer laws or ordinances pertaining to well construction. For community water supply wells the enforcing agency is the State Department of Health Services or the local health department.

#### Section 2. Application to Type of Well.

Except as prescribed in Sections 3 and 4 (following) these standards shall apply to all types of wells described in Section 1. Before a change of use is made of a well, compliance shall be made with the requirements for the new use as specified herein.<sup>1/</sup>

#### Section 3. Exemption Due to Unusual Conditions.

If the enforcing agency finds that compliance with any of the requirements prescribed herein is impractical for a particular location because of unusual conditions or if compliance would result in construction of an unsatisfactory well, the enforcing agency may waive compliance and prescribe alternative requirements which are "equal to" these standards in terms of protection obtained.

#### Section 4. Exclusions.

The standards prescribed in Part II, "Construction", do not apply to exploration and test holes. However, the provisions of Section 7 "Reports" (following) and Part III, "Well Destruction", do apply to these holes.

Springs are excluded from these standards.<sup>2/</sup>

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- <sup>1/</sup> An example would be an agricultural well converted to use as a community water supply well.
- <sup>2/</sup> Methods which can be used to protect water supplies furnished by springs and infiltration galleries are described in "Manual of Individual Water Supply Systems", U. S. Environmental Protection Agency, Office of Drinking Water (EPA-430/9-74-007).

Most of the factors involved in determining safe distances in a particular area are usually not known. Based on past experience and general knowledge, the following horizontal distances are considered safe where dry upper unconsolidated formations, less permeable than sand, are encountered:<sup>1/2/</sup>

Sewer, watertight septic tank, or pit privy	50 feet (15 metres)
Subsurface sewage leaching field	100 feet (30 metres)
Cesspool or seepage pit	150 feet (45 metres)
Animal or fowl enclosure	100 feet (30 metres)

Where in the opinion of the enforcing agency adverse conditions exist, the above distances shall be increased or special means of protection, particularly in the construction of the well, shall be provided.

B. In addition, if possible, the well shall be located up the ground water gradient (upstream) from the specified sources of contamination. By doing so this provides assurance that potential contamination would be moving naturally away from the area of production. However, in an unconfined aquifer consideration shall also be given to the possibility of reversal of gradient near the well due to pumping (see Figure 3), the pumping of nearby wells, or general decline of the water table.<sup>3/</sup>

C. The top of the casing shall terminate above grade or above any known conditions of flooding by drainage or runoff from the surrounding land. For community water supply wells this level is defined as above the

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- <sup>1/</sup> Because of the many variables involved in the determination of the safe horizontal distance of a well from potential sources of contamination and pollution, no one set of distances will be adequate and reasonable for all conditions. In areas where adverse conditions exist, the distances listed should be increased. Conversely, where especially favorable conditions exist or where special means of protection, particularly in construction of the well are provided, lesser distances may be acceptable if approved by the enforcing agency.
- <sup>2/</sup> If the well is a radial collector well, these distances apply to the furthest extended points of the well.
- <sup>3/</sup> When water is pumped from a well a drawdown "cone of depression" is formed in the water surface surrounding the well and ground water in the area of the cone flows toward the well. Similar cones formed by nearby wells can influence the shape of the cone or enlarge the area being drawn upon resulting in a change in direction of flow.

"...floodplain of a 100 year flood..." or above "...any recorded high tide, ...", (Section 64417, "Siting Requirements", Title 22 of the California Administrative Code).<sup>1/</sup>

In addition, the area around the well shall slope away from the well and surface drainage shall be directed away from the well.

D. Where a well is to be near a building, the well shall be far enough from the building so that the well will be accessible for repair, maintenance, etc.

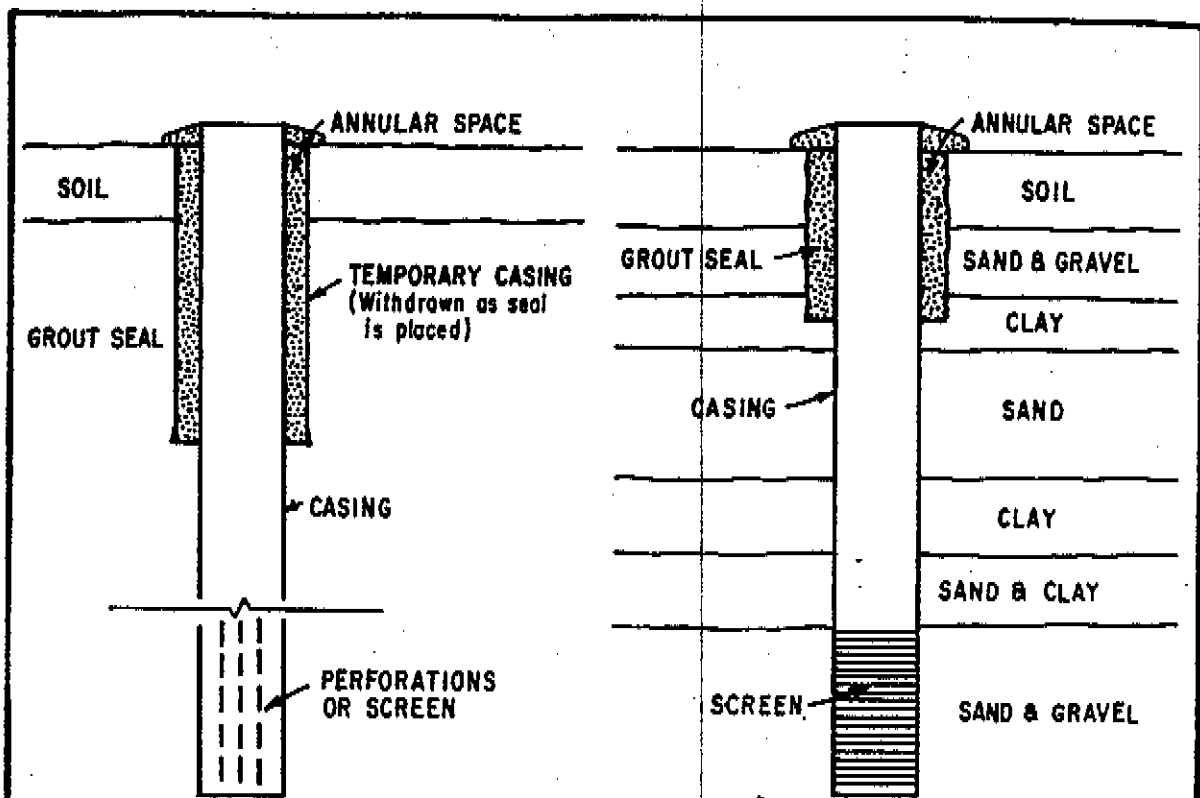
#### Section 9. Sealing the Upper Annular Space.

The space between the well casing and the wall of the drilled hole (the annular space) shall be effectively sealed to protect it against contamination or pollution by entrance of surface and/or shallow, subsurface waters.<sup>2/</sup>

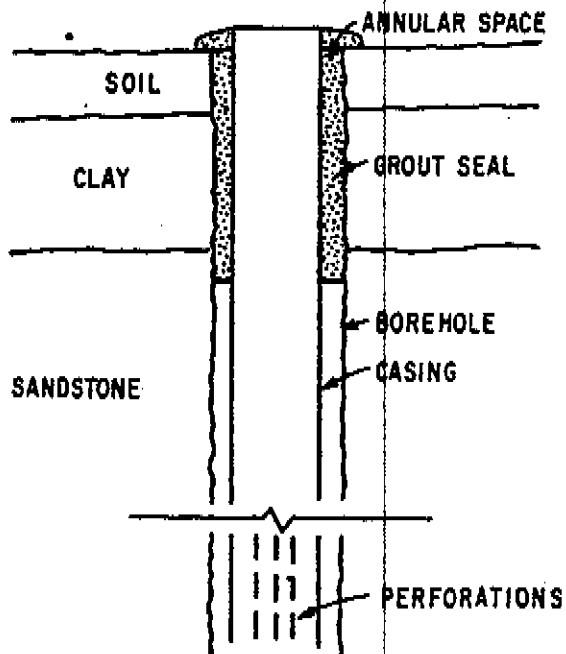
A. Minimum depth of seal below ground surface for various uses of wells:

<u>Types</u>	<u>Minimum Depth<sup>3/</sup> of Seal (below ground surface)</u>
Community Water Supply Wells	50 feet (15 metres)
Individual Domestic Wells	20 feet <sup>4/</sup> (6.1 metres)
Industrial Wells	50 feet <sup>4/</sup> (15 metres)
Agricultural Wells	20 feet <sup>4/5/</sup> (6.1 metres)
Air-Conditioning Wells	20 feet <sup>4/</sup> (6.1 metres)
Observation and Monitoring Wells	20 feet <sup>6/</sup> (6.1 metres)

- <sup>1/</sup> If compliance with this requirement for community water supply wells is not possible, the enforcing agency should be contacted regarding alternative means for protection.
- <sup>2/</sup> Annular seals are also installed to provide protection for the casing against corrosion, to assure structural integrity of the casing, and to stabilize the upper formation.
- <sup>3/</sup> In those cases where it is not possible to meet or, when necessary, increase, the lateral distances from pollution sources described in Section 8 of these standards; an alternative (or special) means of protection for the well is to increase the depth of the seal.
- <sup>4/</sup> Exceptions are shallow wells where the water to be developed is at a depth less than 20 feet (6 metres). In this instance, the depth of seal may be reduced but in no case less than 10 feet (3 metres) and special precautions taken in locating the well with respect to sources of pollution.
- <sup>5/</sup> The annular space shall be sealed to a depth of 50 feet (15 metres) from the surface when the well is close to sources of pollution listed in Section 8.
- <sup>6/</sup> Because they are constructed to measure specific conditions, the annular space in such wells is usually sealed to make the intake section "depth-discrete". Depending on the circumstances, this depth may be very shallow.

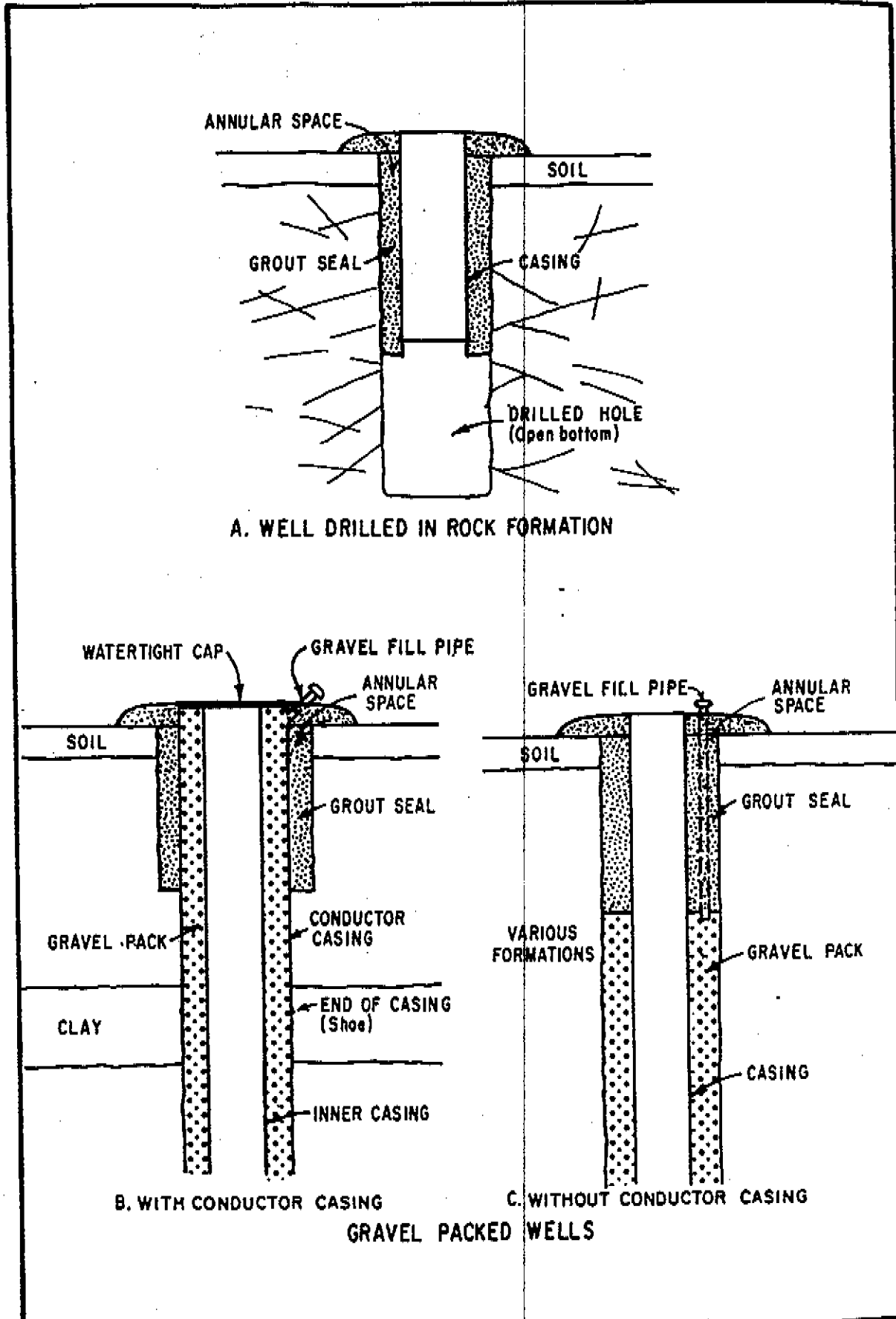


A. WELL DRILLED IN UNCONSOLIDATED CAVING MATERIAL B. WELL IN UNCONSOLIDATED STRATIFIED FORMATIONS



C. WELL IN SOFT CONSOLIDATED FORMATIONS

Figure 4. SEALING CONDITIONS FOR UPPER ANNULAR SPACE- UNCONSOLIDATED AND SOFT, CONSOLIDATED FORMATIONS



**Figure 5. SEALING CONDITIONS FOR UPPER ANNULAR SPACE-  
HARD ROCK FORMATIONS AND GRAVEL PACKED WELLS**

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5. Bentonite clay<sup>1/</sup> mixtures shall be composed of bentonite clay and clean water thoroughly mixed before placement so that there are no balls, clods, etc.

6. Used drillers' mud or cuttings or chips from drilling the borehole shall not be used as sealing material.

7. The minimum time that must be allowed for materials containing cement to "set" before construction operations on the well may be resumed shall be:

- a. Type I cement - 72 hours
- b. Type III cement - 48 hours
- c. Type V cement - 6 hours

When necessary these times may be reduced by the use of "accelerators", i.e., additives designed specifically to shorten setting time.

8. Where thermoplastic casing is used, caution should be exercised to control the heat generated during the curing of the cement (called "heat of hydration"). This is of special concern where casing of thinner wall thicknesses are to be installed. The addition of bentonite to the cement mixture (up to 8 percent) or circulating water inside the casing will lower the temperature of the cement. Additives which accelerate the curing process also tend to increase the heat generated and should not be used where thermoplastic casing is installed.

E. Thickness of Seal. The thickness of the seal shall be at least a nominal 2 inches,<sup>2/</sup> and not less than three times the size of the largest coarse aggregate used in the sealing material.

F. Placement of Seal.

1. Before placing the seal all loose cuttings, drilling mud, or other obstructions shall be removed from the annular space by flushing.

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<sup>1/</sup> Clay in the form of a mud-laden fluid is similar to and has the advantages of neat cement and sand-cement grout. There is a disadvantage in that clay may separate from the fluid. Clay should not be used where structural strength or stability of the seal is required, where flowing or moving water might break it down, or where it might dry out. Although there are other types of clay available, none have the sealing properties (particularly the ability to expand dramatically) comparable to bentonite. Therefore, only bentonite clays are recommended.

<sup>2/</sup> In other words, the borehole shall be nominally 4 inches (100 millimetres) larger in diameter than the nominal casing diameter (thus creating a 2-inch, or-50 millimetre annular space).

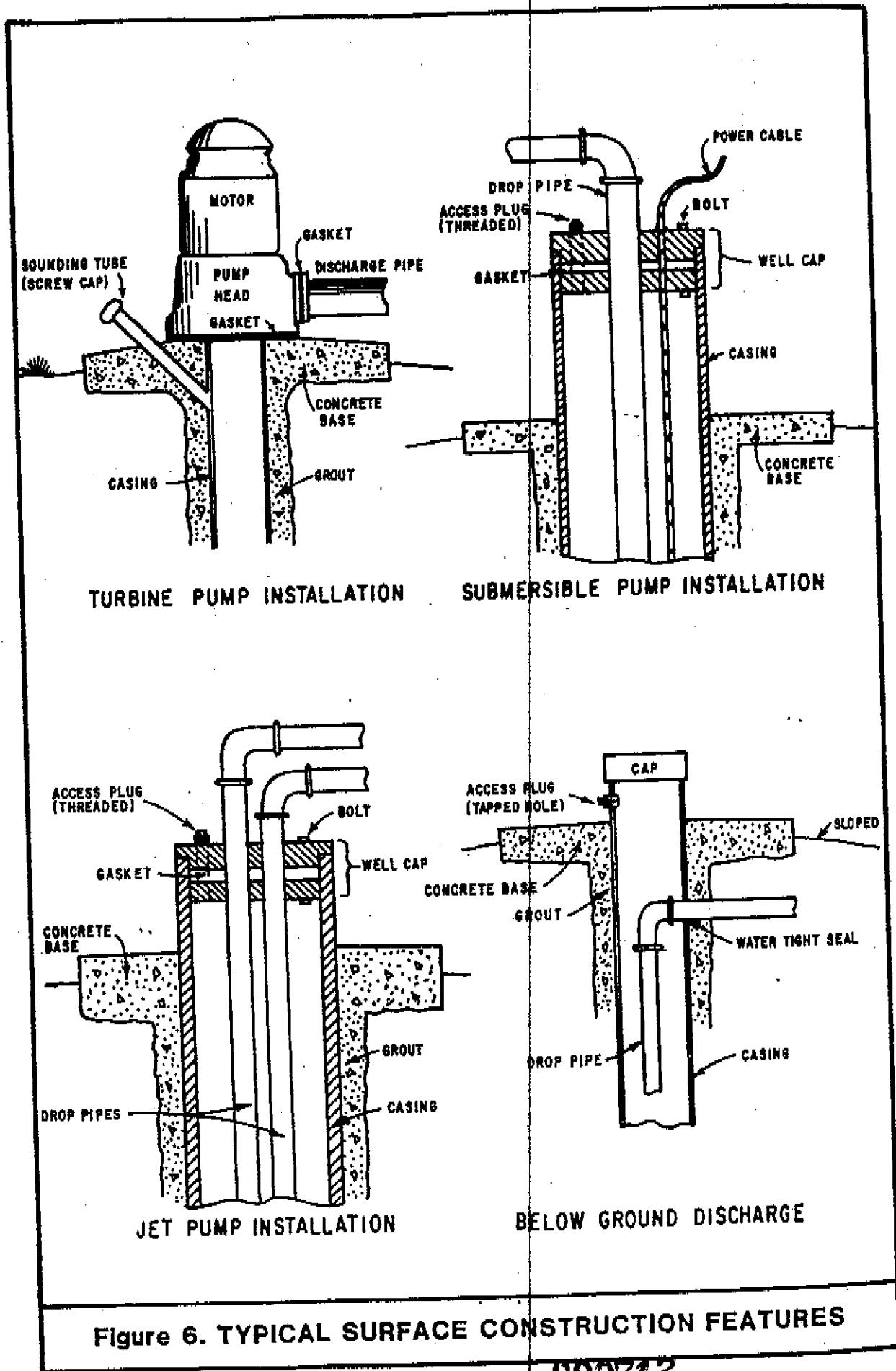


Figure 6. TYPICAL SURFACE CONSTRUCTION FEATURES

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2. Where the pump is offset from the well or where a submersible pump is used, the opening between the well casing and any pipes or cables which enter the well shall be closed by a watertight seal or "well cap".

3. If the pump is not installed immediately or if there is a prolonged interruption in construction of the well, a watertight cover shall be installed at the top of the casing.

4. A watertight seal or gasket shall be placed between the pump discharge head and the discharge line; or, in the event of a below-ground discharge, between the discharge pipe and discharge line (see Figures 6 and 7).

5. If a concrete base or slab (sometimes called a pump block or pump pedestal) is constructed around the top of the casing, it shall be free from cracks, honeycombs or other defects likely to detract from its watertightness. The joint between the base and the annular seal must also be watertight. The base shall slope away from the well casing. The minimum thickness of the concrete base shall be 4 inches (100 millimetres).<sup>1/</sup>

6. Where the well is to be gravel packed and the pack extends to the surface, a watertight cover shall be installed between the conductor casing and the inner casing (see also Section 9, Part B, Item 5 and Figure 5).

B. Well Pits. Because of their susceptibility to contamination and pollution, the use of well pits should be avoided whenever possible. A substitute device called a pitless adapter<sup>2/</sup> or pitless adapter unit (a variation) may be used in place of a well pit.

C. Enclosure of Well and Appurtenances. In community water supply wells, the well and pump shall be located in a locked enclosure to exclude access by unauthorized persons.

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<sup>1/</sup> This value is for small (under 10 inches or 250 millimetres in diameter) individual domestic well installations. The shape and dimensions of pump bases varies with the size, weight, and type of pumping equipment to be installed and the bearing capacity of the soil on which it is situated. A variety of designs have been used. For large diameter turbine pump installations the Vertical Turbine Pump Association has developed a standard design for a square, concrete pump base that is based on weight, including full pump column and soil bearing capacity. (See Bibliography, Appendix E.)

<sup>2/</sup> Pitless adaptors and units were developed for use in areas where prolonged freezing occurs and below ground (below frost line) discharges are common. Both the National Sanitation Foundation and Water Systems Council have developed standards for their manufacture and installation (See Bibliography, Appendix E.)

## Section 12. Casing.

A. Casing Material.<sup>1/</sup> Requirements pertaining to well casing are to insure that the casing will perform the functions for which it is designed, i.e., to maintain the hole by preventing its walls from collapsing, to provide a channel for the conveyance of the water, and to provide a measure of protection for the quality of the water pumped.

1. Well casing shall be strong and tough enough to resist the forces imposed on it during installation and those forces which can normally be expected after installation.

2. Steel is the material most frequently used for well casing, especially in drilled wells. The thickness of steel used for well casing shall be selected in accordance with good design practices applied with due consideration to conditions at the site of the well.<sup>2/</sup> There are three principal classifications of steel materials used for water well casing, and all are acceptable for use so long as they meet the following conditions.

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<sup>1/</sup> Abbreviations used are: API-American Petroleum Institute; ASTM-American Society for Testing and Materials; AWWA-American Water Works Association.

<sup>2/</sup> Selection of casing depends on its ability to resist external forces as well as factors affecting the casing serviceability. The maximum theoretical external pressure under which a particular well casing of a specific diameter and thickness will collapse can be calculated. However, other considerations such as the effect of driving the casing into place or other impact forces which may have an effect on the ability of a particular casing to resist external pressures, cannot be calculated with accuracy. Good design practices preclude the selection of a casing of a particular thickness for use where it will experience external pressures approaching the maximum or where unknown forces might magnify the effect of the external forces. Instead it is customary for designers to introduce factors of safety which tend to ensure that the casing selected will resist all probable forces imposed upon it. Consequently, experience and sound judgment, coupled with these factors of safety, have so far proved to be the best guide in selecting the proper casing. Suggested thicknesses for steel casing for various depths and diameters are to be found in material published by the various steel manufacturers and fabricators and in publications on the design of water wells. The suggested thicknesses contained in such publications are not to be considered a part of these standards.

- (4) ASTM A441, "Tentative Specification for High-Strength Low Alloy Structural Manganese Vanadium Steel".
- (5) ASTM A570, "Standard Specification for Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality".

c. High strength carbon steel sheets referred to by their manufacturers and fabricators as "well casing steel". At present, there are no standard specifications concerning this material. However, the major steel producers market products whose chemical and physical properties are quite similar. Each sheet of material shall contain mill markings which will identify the manufacturer and specify that the material is well casing steel which complies with the chemical and physical properties published by the manufacturer.

d. Stainless steel casing shall meet the provisions of ASTM A409, "Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High Temperature Service".

3. Plastic is also used as casing for water wells in many locations under a variety of circumstances.<sup>1/</sup> Because large-diameter (10 inches or 250 millimetres and larger) plastic casing has not been used extensively and especially at depths exceeding 300 feet (90 metres), special care must be exercised in the design and construction of wells that will employ these sizes. Particular attention should be given to the effect on thermoplastic casing of heat generated during cementing operations (see also Part B, "Installation of Casing" of this section, item 8, Part D, "Sealing Material" of Section 9, and discussion of plastic casing in Chapter I).

There are two groups of plastic materials available: thermoplastics and thermosets. Thermoplastics soften with the application of heat and reharden when cooled. Thus they can be repeatedly reformed. Thermosets cannot be reformed. During manufacture their molecules are permanently "set" by heat, chemical action or a combination of both. Thermoplastics used for plastic casing are ABS (acrylonitrile butadiene styrene), PVC (polyvinyl chloride) and SR (styrene rubber). The thermosetting plastic used for casing is fiberglass.

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<sup>1/</sup> Information about the selection and installation of thermoplastic casing will be found in "Manual on the Selection and Installation of Thermoplastic Water Well Casing", a joint publication of the National Water Well Association and the Plastic Pipe Institute.

- (b) ASTM C76, "Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe".
- (c) AWWA C300, "AWWA Standard for Reinforced Concrete Pressure Pipe Steel Cylinder Type, for Water and Other Liquids".
- (d) AWWA C301, "AWWA Standard for Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids".

5. Other materials,<sup>1/</sup> except as listed in No. 6 below, may be used as casing for water wells, subject to the approval of the enforcing agency.

6. Galvanized sheet metal pipe ("downspout"), or natural wood shall not be used as casing.

B. Installation of Casing. All casing shall be placed with sufficient care to avoid damage to casing sections and joints. All joints in the casing above the perforations or screens shall be watertight. The uppermost perforations shall be at least below the depth specified in Section 9, Part A, "Depth of Seal". Casing shall be equipped with centering guides to ensure even thickness of annular seal and/or gravel pack.

1. Metallic casing. Steel casing may be joined by either welding or by threading and coupling. Welding shall be accomplished in accordance with standards of American Welding Society or the most recent revision of the American Society of Mechanical Engineers Boiler Construction Code. Where casing is driven, (as is generally the case when the cable tool method of construction is used), the casing shall be equipped with a "drive shoe" at the lower end.

2. Plastic (non-metallic) casing.<sup>2/</sup> Depending on the type of material and its fabrication, plastic casing may be joined by solvent welding or mechanically joined (threaded or otherwise coupled). The solvent cement used for solvent welding shall meet the specifications for the type of plastic used and shall be applied in accordance with the manufacturer's instructions, particularly those pertaining to setting time required for the joint to develop handling strength. An adapter shall be used to join plastic casing to metallic casing or screen.

<sup>1/</sup> Such as wrought iron, asbestos cement pipe, and synthetic woods, all of which have been successfully employed as casing in California or elsewhere. Their present use is limited to special cases. Specifications for most of these materials are published by either ASTM or AWWA.

<sup>2/</sup> Information about the installation of thermoplastic casing will be found in "Manual on the Selection and Installation of Thermoplastic Water Well Casing", a joint publication of the National Water Well Association and the Plastic Pipe Institute.

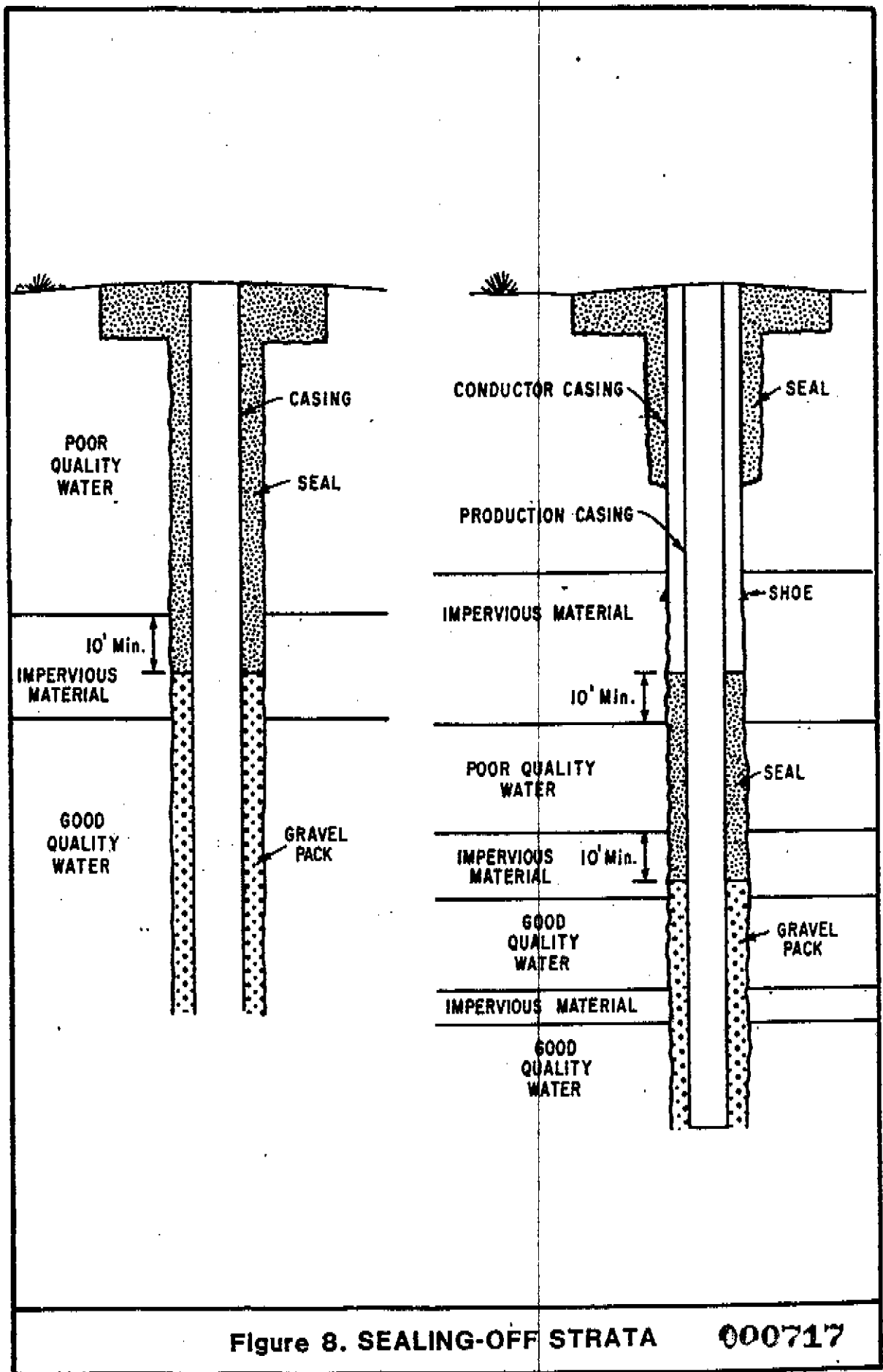


Figure 8. SEALING-OFF STRATA

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Section 16. Special Provisions for Large Diameter Shallow Wells.

A. Use as Community Water Supply Wells. Because shallow ground waters are often of poor quality and because they are easily contaminated, the use of bored or dug wells, or wells less than 50 feet (15 metres) deep, to provide community water supplies shall be avoided (unless there is no other feasible means for obtaining water). When used for this purpose, these wells shall be located at least 250 feet (76 metres) from any underground sewage disposal facility.

B. Bored Wells. All bored wells shall be cased with concrete pipe or steel casing whose joints are watertight from 6 inches (150 millimetres) above the ground surface to the depths specified in Section 9, Part A. Except where corrugated steel pipe is used as casing, the minimum thickness of the surrounding concrete seal shall be 3 inches (75 millimetres). Where corrugated steel pipe is employed, the joints are not watertight and a thicker annular seal (no less than 6 inches or 150 millimetres) shall be installed.

C. Dug Wells. All dug wells shall be "curbed" with a watertight curbing extending from above the ground surface to the depths specified in Section 9, Part A. The curbing shall be of concrete poured-in-place or of casing (either precast concrete pipe or steel) surrounded on the outside by concrete.

If the curbing is to be made of concrete, poured-in-place, it shall not be less than 6 inches (150 millimetres) thick. If precast concrete pipe or steel casing is used as part of the curbing, the space between the wall of the hole and the casing shall be filled with concrete to the depths specified in Section 9, Part A. The minimum thickness of the surrounding concrete shall be 3 inches (75 millimetres).

D. Casing Material. Either steel (including corrugated steel pipe) or concrete may be used for casing bored or dug wells. Corrugated aluminum pipe is not recommended for use as casing.<sup>1/</sup>

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<sup>1/</sup> Aluminum placed in an aggressive soil is subject to electrolytic corrosion. When the soil pH is very high (over 8.0) or very low (under 6.0) this could present problems and, therefore, the soil pH ought to be checked. In addition, galvanic corrosion is likely to take place unless the pump is also made of aluminum. Accordingly, the use of most of the aluminum alloys currently available is not recommended.

Section 17. Special Provisions for Driven Wells ("Well Points").

A. If the well is to be used as an individual domestic well, an oversize hole with a diameter at least 3 inches (75 millimetres) greater than the diameter of the pipe shall be constructed to a depth of 6 feet (1.8 meters) and the annular space around the pipe shall be filled with neat cement, cement grout, or bentonite mud.

B. The minimum wall thickness of steel drive pipe shall be not less than 0.140 inches (3.5 millimetres).

C. Well points made of thermoplastic materials should not be driven but jetted or washed into place.

Section 18. Rehabilitation, Repair and Deepening of Wells.

A. Rehabilitation is the treatment of a well by chemical or mechanical means (or both) to recover lost production caused by incrustation or clogging of screens or the formation immediately adjacent to the well. The following methods used for rehabilitating a well when done with care are acceptable: (1) introduction of chemicals designed for this purpose, (2) surging by use of compressed air, (3) backwashing or surging by alternately starting or stopping the pump, (4) jetting with water, (5) sonic cleaning, (6) vibratory explosives, and (7) combinations of these. Methods which produce an explosion (in addition to the use of vibratory explosives mentioned above) are also acceptable provided, however, they are used with great care, particularly where aquifers are separated by distinct barriers to the movement of ground water.

In those cases where chemicals or explosives have been used, the well shall be pumped until all traces of them have been removed.

B. In the repair of wells, material used for casing shall meet the requirements of Section 12 "Casing" of these provisions. In addition, the requirements of Section 11, Part A "Disinfection" and, when applicable, Section 14 "Sealing-off Strata" shall be followed.

C. Where wells are to be deepened, the requirements of Sections 11, 12, 13, 14, and 15 of these standards shall be followed.

Section 19. Temporary Cover.

Whenever there is an interruption in work on the well such as overnight shutdown, during inclement weather, or waiting periods required for the setting up of sealing materials, for tests, for installation of the pump, etc., the well opening shall be closed with a cover to prevent the introduction of undesirable material into the well and to insure the public safety. The cover shall be held in place or "weighted-down" in such a manner that it cannot be removed except with the aid of equipment or through the use of tools.

If the pump has been removed for repair or replacement, the well shall not be considered "abandoned". During the repair period, the well shall be adequately covered to prevent injury to people and to prevent the entrance of undesirable water or foreign matter.

Observation or test wells used in the investigation or management of ground water basins by governmental agencies or engineering or research organizations are not considered "abandoned" so long as they are maintained for this purpose. However, such wells shall be covered with an appropriate cap, bearing the label, "Observation Well", and the name of the agency or organization, and preferably shall be locked when measurements are not being made. When these wells are no longer used for this purpose or for supplying water, they shall be considered "abandoned".

#### Section 22. General Requirement.

All "abandoned" wells and exploration or test holes shall be destroyed. The objective of destruction is to restore as nearly as possible those subsurface conditions which existed before the well was constructed taking into account also changes, if any, which have occurred since the time of construction. (For example, an aquifer which may have produced good quality water at one time but which now produces water of inferior quality, such as a coastal aquifer that has been invaded by seawater.)

Destruction of a well shall consist of the complete filling of the well in accordance with the procedures described in Section 23 (following).

#### Section 23. Requirements for Destroying Wells.

A. Preliminary Work. Before the well is destroyed, it shall be investigated to determine its condition, details of construction, and whether there are obstructions that will interfere with the process of filling and sealing. This may include the use of downhole television and photography for visual inspection of the well.

1. If there are any obstructions, they shall be removed, if possible, by cleaning out the hole.

2. Where necessary, to ensure that sealing material fills not only the well casing but also any annular space or nearby voids within the zone(s) to be sealed, the casing should be perforated or otherwise punctured.

3. In some wells, it may be necessary or desirable to remove a part of the casing. However, in many instances this can be done only as the well is filled. For dug wells, as much of the lining as possible (or safe) should be removed prior to filling.

B. Filling and Sealing Conditions. Following are requirements to be observed when certain conditions are encountered:

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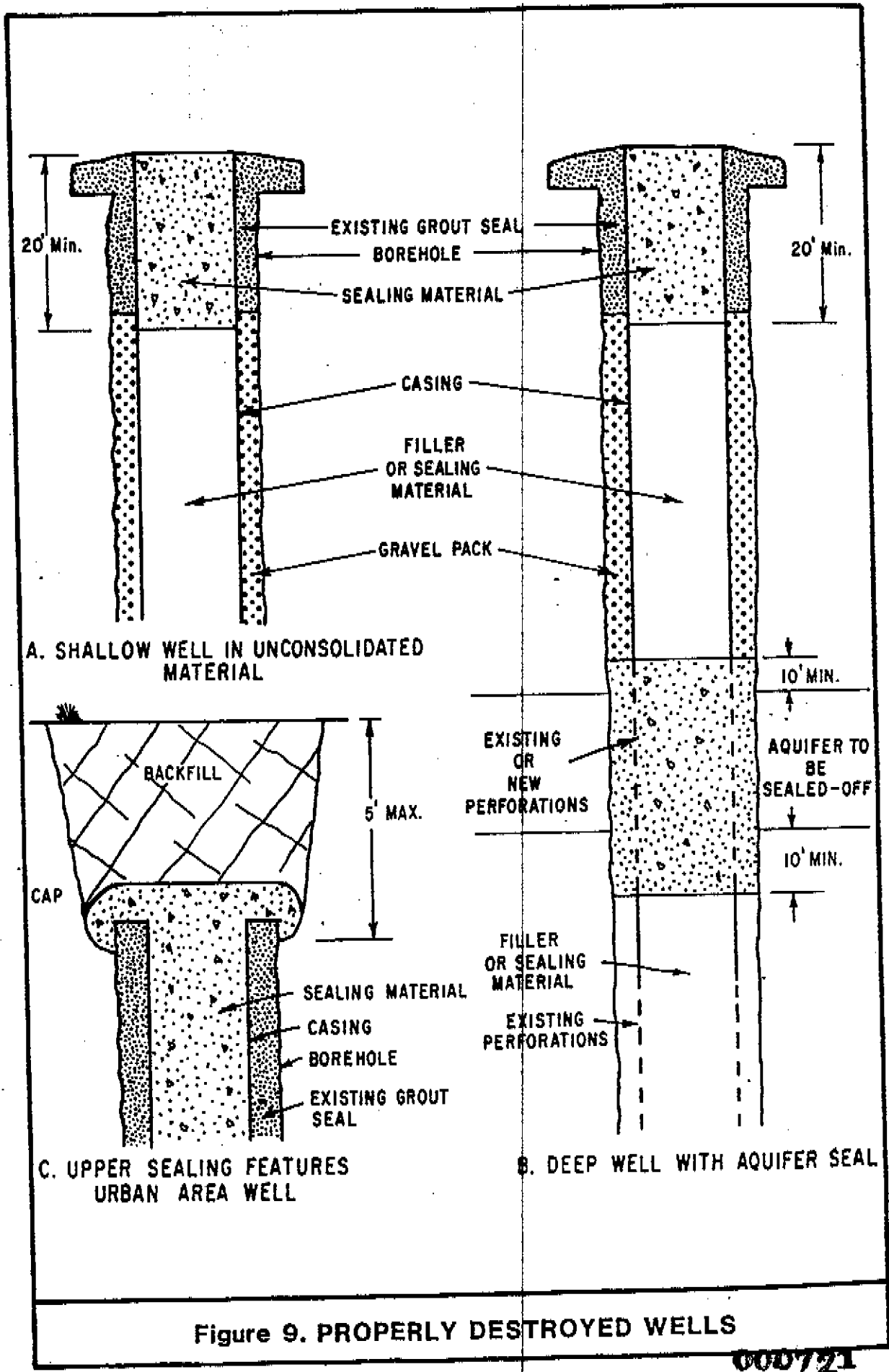


Figure 9. PROPERLY DESTROYED WELLS

7. To assure that the well is filled and there has been no jamming or "bridging" of the material, verification shall be made that the volume of material placed in the well installation at least equals the volume of the empty hole.

D. Materials. Requirements for sealing and fill materials are as follows:

1. Impervious Sealing Materials. No material is completely impervious. However, sealing materials shall have such a low permeability that the volume of water passing through them is of small consequence.

Suitable impervious materials include neat cement, sand-cement grout, concrete, and bentonite clay, all of which are described in Section 9, paragraph D, "Sealing Material" of these standards; and well-proportioned mixes of silts, sands, and clays (or cement), and native soils that have a coefficient of permeability of less than 10 feet (3 metres) per year.<sup>1/</sup> Used drilling muds are not acceptable.

2. Filler Material. Many materials are suitable for use as a filler in destroying wells. These include clay, silt, sand, gravel, crushed stone, native soils, mixtures of the aforementioned types, and those described in the preceding paragraph. Material containing organic matter shall not be used.

E. Additional Requirements for Wells in Urban Areas.

In incorporated areas or unincorporated areas developed for multiple habitation, to make further use of the well site, the following additional requirements must be met (see Figure 9C):

1. A hole shall be excavated around the well casing to a depth of 5 feet (1.5 metres) below the ground surface and the well casing removed to the bottom of the excavation.

2. The sealing material used for the upper portion of the well shall be allowed to spill over into the excavation to form a cap.

3. After the well has been properly filled, including sufficient time for sealing material in the excavation to set, the excavation shall be filled with native soil.

F. Temporary Cover. During periods when no work is being done on the well, such as overnight or while waiting for sealing material to set, the well and surrounding excavation, if any, shall be covered. The cover shall be sufficiently strong and well enough anchored to prevent the introduction of foreign material into the well and to protect the public from a potentially hazardous situation.

<sup>1/</sup> Examples of materials of this type are: very fine sand with a large percentage of silt or clay, inorganic silts, mixtures of silt and clay, and clay. Native materials should not be used when the sealing operation involves the use of pressure.

APPENDIX A  
DEFINITION OF TERMS

## APPENDIX A

### DEFINITION OF TERMS

The following terms are defined as used in this report:

Abandoned Well - A well whose use has been permanently discontinued or which is in such a state of disrepair that no water can be produced. Because abandonment is a state that also involves intent on the part of the well owner, a definition that prescribes a set of conditions and a time limit for use in applying standards appears in Section 21 of Chapter II, "Standards", of this report.

Active Well - An operating water well.

Annular Space - The space between two well casings or between the casing and the wall of the drilled hole.

Aquifer - A geologic formation, group of formations or part of a formation that is water bearing and which transmits water in sufficient quantity to supply springs and pumping wells.

Artesian Well - A well which obtains its water from a confined aquifer. The water level in an artesian well stands some distance above the top of the aquifer it taps. Where the pressure is sufficient to force the water level above the surface of the ground, the well is termed a flowing artesian well.

Bailer - A long narrow bucket with a valve in the bottom used to remove cuttings or fluids from a well.

Bentonite - A highly plastic colloidal clay composed largely of montmorillonite used as a drilling fluid additive or as a sealant.

Casing - A tubular retaining structure which is installed in the well bore to maintain the well opening.

Clay - A fine-grained geologic material (grain size less than 0.004 mm in diameter) which has very low permeability.

Conductor Casing - A tubular retaining structure installed in the upper portion of a well between the wall of the drilled hole and the inner well casing.

Cone of Depression - A depression in the water table or piezometric surface of a ground water body that is in the shape of an inverted cone and develops around a well which is being pumped. It defines the area of influence of the pumping well.

Ground Water Basin - A ground water basin consists of an area underlain by permeable materials which are capable of storing or furnishing a significant water supply; the basin includes both the surface area and the permeable materials beneath it.

Grout - A fluid mixture of cement and water of a consistency that can be forced through a pipe and placed as required. Various additives, such as sand, bentonite, and hydrated lime, are used to meet certain requirements. For example, sand is added when a considerable volume of grout is needed.

Impairment - A change in quality of water which makes it less suitable for beneficial use.

Impermeable - That property of a geologic material that renders it incapable of allowing water to move through it perceptibly under the pressure differences ordinarily found in subsurface water.

Impervious Strata - A geologic unit which will not transmit water in sufficient quantity to furnish an appreciable supply to wells or springs.

Inactive Well - A well not routinely operated but capable of being made an operating well with a minimum of effort.

Packer - A device used to plug or seal a well at a specific point; frequently used as retainers to keep grout in position until it "sets".

Perforations - Openings in a well casing to allow the entrance of ground water into the well. Perforations may be made either before or after installation of the casing.

Permeability - The capacity of a geologic material for transmitting a fluid. The degree of permeability depends upon the size and shape of the openings and the extent of the interconnections.

Pollution - Defined in Section 13050 of the California Water Code:

"(1) 'Pollution' means an alteration of the quality of the waters of the state by waste to a degree which unreasonably affects: (1) such waters for beneficial uses, or (2) facilities which serve such beneficial uses. 'Pollution' may include 'contamination'."

Pressure Grouting - A method of forcing grout into specific portions of a well, such as the annular space, for sealing purposes.

APPENDIX B

SUGGESTED METHODS FOR SEALING  
THE ANNULAR SPACE AND FOR SEALING-OFF STRATA

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## APPENDIX B

### SUGGESTED METHODS FOR SEALING THE ANNULAR SPACE AND FOR SEALING-OFF STRATA

#### Sealing the Annular Space

The annular space is the space between the well casing and wall of the drilled hole created during construction. This space must be adequately sealed to prevent the entrance of surface drainage or poor quality subsurface water, which may contaminate or pollute the well. This seal will also protect the casing against corrosion and possible structural failure.

A number of acceptable sealing methods are presented in this appendix. Other methods may be suggested by individual well drillers on the basis of their experience and availability of equipment. An acceptable method should provide for the complete filling of the sealing interval with the appropriate sealing material to the specified depth.

#### General

Prior to sealing, the annular space should be flushed to remove any loose formation material or drilling mud that might obstruct the operation. The use of centralizers -- devices which are affixed to the casing at regular intervals to prevent it from touching the walls of the hole, thereby keeping the casing centered in the borehole -- are recommended. This assures that the seal is not less than the desired minimum thickness. It is particularly significant for large diameter wells where the casing exceeds 10 inches (250 millimetres) in diameter.

The use of a tremie or grout pipe for the introduction of the sealing material into the annular space is preferred. Where a tremie or grout pipe is used, the minimum annular space should be 2 inches (50 millimetres) and the minimum tremie size should be a nominal 1-1/2 inches (38 millimetres) in diameter.

Gravity installation without a grout pipe or tremie should not be attempted when the sealing interval contains water or cannot be visually inspected (with the aid of a mirror or light). Where sealing material is to be introduced under water or the interval cannot be observed from the surface, methods involving "positive" placement (by a tremie or grout pipe, pumping or other application of pressure) must be used.

The sealing material must always be introduced at the bottom of the interval to be sealed. This prevents "bridging" (jamming) or segregation (separation of large aggregate from the mixture in sand-cement or concrete grouts) of the sealing material and eliminates gaps.

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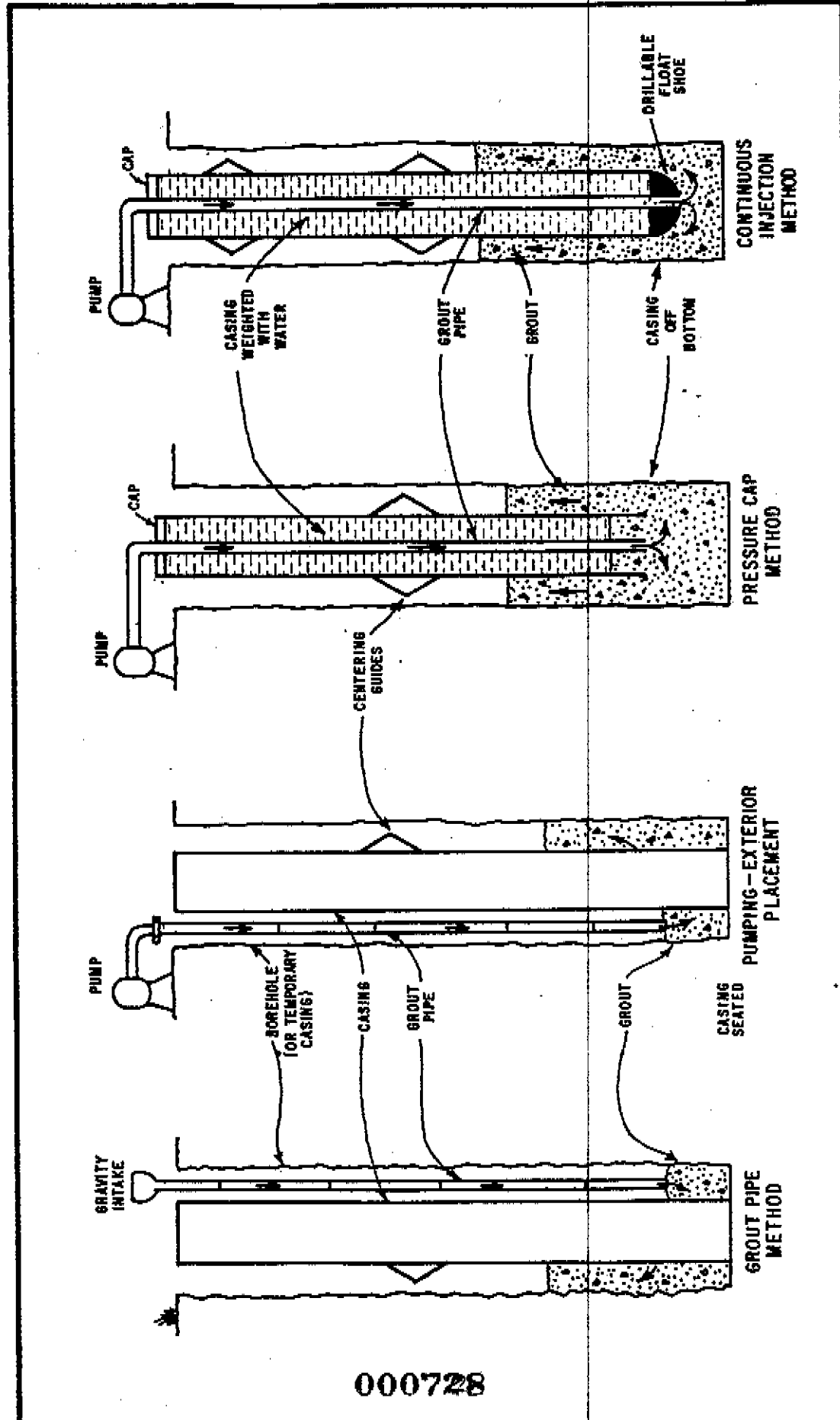


Figure 10. METHODS FOR SEALING THE ANNULAR SPACE

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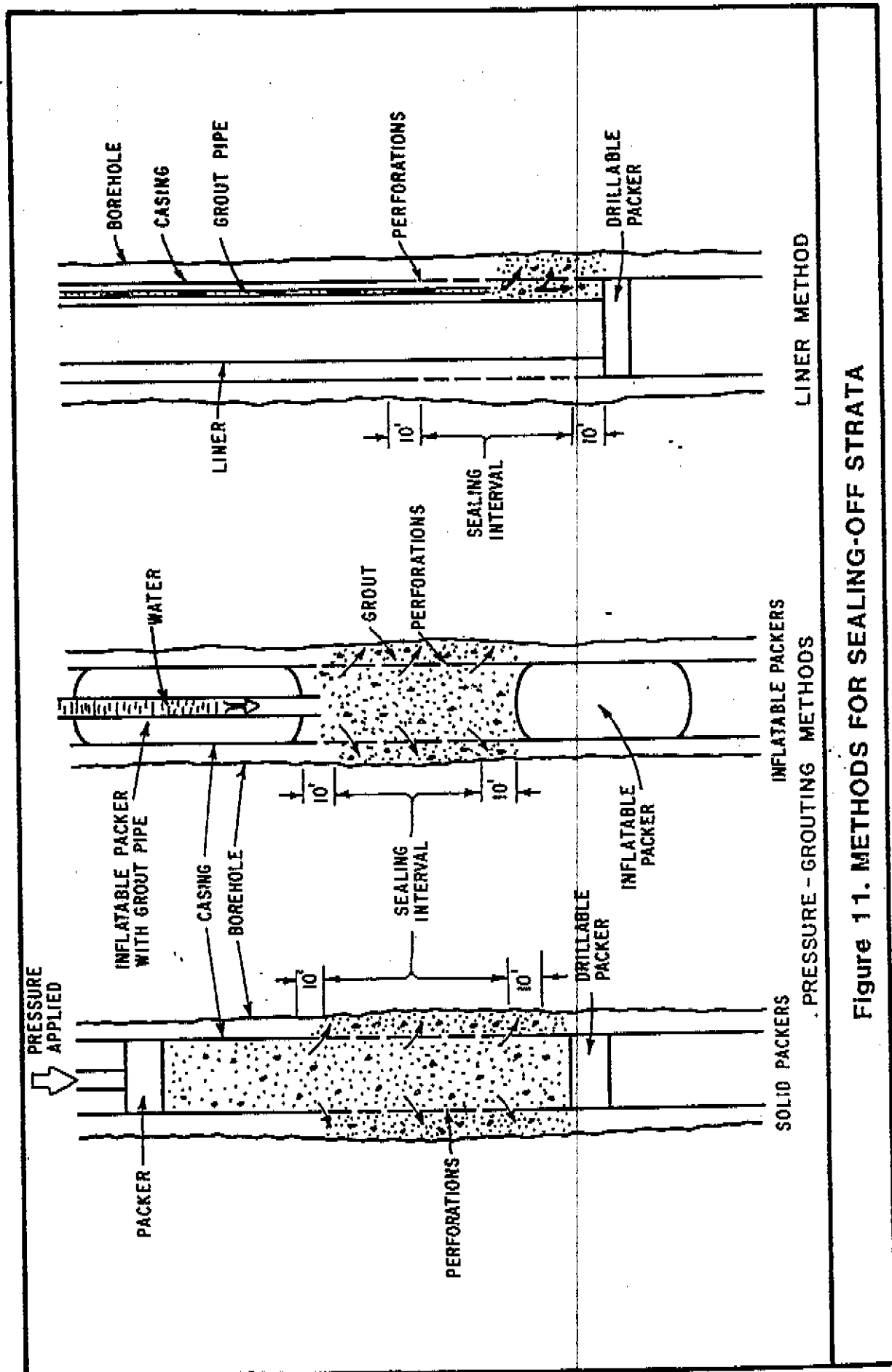


Figure 11. METHODS FOR SEALING-OFF STRATA

APPENDIX C  
SUGGESTED PROCEDURES FOR  
DISINFECTING WELLS

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## APPENDIX C

### SUGGESTED PROCEDURES FOR DISINFECTING WELLS

Disinfection of all wells is recommended to eliminate pathogenic organisms as well as organisms that can clog wells and thereby cause clogging and effect the quantity of water produced. Disinfection of the well is the first act of well construction or repair before it is placed in service. Wells should also be disinfected following the repair or replacement of the pump and/or well maintenance. Procedures described in this appendix are recommended for disinfected wells; however, other methods may be used provided it can be demonstrated that they will yield comparable results. For new wells, disinfection should take the following development (this will assure that the well is free of drilling mud, dirt and other debris that reduces the effectiveness of the disinfection), testing for yield, installation of the pump. When there is a delay in pump installation, interim or partial disinfection should be taken.

Disinfection involves seven steps:

1. A chlorine solution containing at least 100 mg/l (or parts per million) available chlorine, is added to the well. Table 6 lists quantities of various chlorine solutions required to dose 100 feet (30 metres) of water-filled casing at 50 mg/l for diameters ranging from 2 to 24 inches (50 to 600 millimetres). For wells that have been repaired or when the pump has been repaired or replaced and, when the well back into service quickly is desired, the disinfection solution should contain at least 100 mg/l available chlorine. To maintain this concentration, double the amounts shown in Table 6.
2. The pump column or drop pipe shall be treated with the chlorine solution as it is lowered into the well.
3. After it has been placed into position, the pump shall be turned on and off several times (i.e., "surged") to thoroughly mix the disinfectant with the water in the well. Pump until the water discharged has the odor of chlorine. Repeat this procedure several times at one-hour intervals.
4. The well shall be allowed to stand without pumping for 24 hours.

APPENDIX D  
COLLECTION OF WATER QUALITY SAMPLES

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APPENDIX E  
BIBLIOGRAPHY

APPENDIX E

BIBLIOGRAPHY

1. Ahrens, Thomas P. "Well Design Criteria. Part 2".  
Water Well Journal. November 1957.
2. Ahrens, Thomas P. "Corrosion in Water Wells". Water  
Well Journal. March and April 1966.
3. Ahrens, Thomas P. "Basic Considerations of Well Design".  
Water Well Journal. April, May, June and August  
1970. (Four parts)
4. American Association for Vocational Instructional  
Materials. "Planning for an Individual Water  
System". 1973.
5. American Society of Agricultural Engineers. "Designing  
and Constructing Water Wells for Irrigation".  
Tentative Recommendation: ASAE R 283 (T).  
December 1964.
6. American Water Works Association. "Standard Specifica-  
tions for Deep Wells". AWWA A-100-66. 1967.
7. American Water Works Association. "Ground Water". AWWA  
Manual No. M21. 1973.
8. American Water Works Association. "Standard for Vertical  
Turbine Pumps - Line Shaft and Submersible Types".  
AWWA E-101-77. June 1977.
9. American Water Works Association. "PVC Pipe - Design and  
Installation". AWWA Manual No. M23. 1980.
10. Anderson, K. "Water Well Handbook". Missouri Water Well  
Drillers Association. 1963.
11. Associated Drilling Contractors of the State of  
California. "Recommended Standards for Preparation  
of Water Well Construction Specifications".  
September 17, 1960.
12. Brantly, J. E. "Rotary Drilling Handbook". Palmer  
Publications. Fifth Edition. 1952.
13. California Department of Public Health, Bureau of  
Sanitary Engineering. "Occurrence of Nitrate in  
Ground Water Supplies in Southern California".  
February 1963.
14. California Department of Public Works, Division of Water  
Resources. "Ground Water Basins in California".  
Water Quality Investigations Report No. 3.  
November 1952.

9. California Legislature, Assembly Interim Committee on Water. "State and Local Responsibilities for Water Resources". Assembly Interim Committee Reports 1965-67. Volume 26, No. 17. December 1966.
10. California State Water Pollution Control Board. "Final Report on Field Investigation and Research on Waste-Water Reclamation and Utilization in Relation to Underground Water Pollution". Publication No. 6. 1953.
11. California State Water Pollution Control Board. "Report on the Investigation of Travel of Pollution". Publication No. 11. 1954.
12. California State Water Pollution Control Board. "Effect of Refuse Dumps on Ground Water Quality". Publication No. 24. 1961.
13. California State Water Quality Control Board. "Water Quality Criteria". By McKee, J. and Wolf, H. W. Second Edition. Publication No. 3-A. 1963.
14. Campbell, Michael D. and Lehr, Jay H. "Water Well Technology". McGraw-Hill Book Company, Inc. 1973.
15. Clark, N. L. and LuChang, S. "Enteric Viruses in Water". American Water Works Association Journal. Volume 51. October 1959.
16. Crocker, S. "Piping Handbook". Fourth Edition. McGraw-Hill Book Company, Inc. 1945.
17. Davis, Stanley N. and DeWiest, Roger J. M. "Hydrogeology". John Wiley and Sons, Inc. 1966.
18. Driscoll, Fletcher G., Hanson, David T. and Page, Lyn. "Well-Efficiency Project Yields Energy-Saving Data". The Johnson Drillers Journal, March-April, May-June, and September-October, 1980, and First Quarter, 1981. (Four parts)
19. Gordon, R. W. "Water Well Drilling with Cable Tools". Bucyrus-Erie Company. 1958.
20. Ham, Herbert H. "Water Wells and Ground-Water Contamination". Bulletin of the Association of Engineering Geologists. Volume VIII, No. 1. 1971.
21. Helweg, Otto J., Scalmanini, Joseph G. and Scott, Verne H. "Energy and Efficiency in Wells and Pumps". Presented to the Twelfth Biennial Conference on Ground Water sponsored by the University of California, Water Resources Center and the California Department of Water Resources, at Sacramento, California, September 20-21, 1979. California Water Resources Center, University of California, Davis. Report No. 45. November 1979.

- 1. National Water Well Association. "Water Well Drillers Beginning Training Manual". 1971.
- 2. National Water Well Association and The Plastic Pipe Institute "Manual on the Selection and Installation of Thermoplastic Water Well Casing". October 1, 1980.
- 3. Oregon Drilling Association, Incorporated. "Manual of Water Well Construction Practices for the State of Oregon". Second Edition. 1968.
- 4. Oregon Water Resources Department. "Rules and Regulations Prescribing General Standards for the Construction and Maintenance of Water Wells in Oregon". Effective January 1, 1979. Published jointly with Oregon Department of Human Resources, Health Division and Oregon Department of Commerce, Building Codes Division.
- 5. Rossum, John R. "Control of Sand in Water Systems". Journal American Water Works Association. Volume 46, No. 2. February 1954.
- 6. Schrock, B. J. "Thermosetting Resin Pipe". Presented at the American Society of Civil Engineers Fall Convention, San Francisco, California. October 17-21, 1977. Preprint No. 3088.
- 7. Schwalen, H. C. "The Stovepipe or California Method of Well Drilling as Practised in Arizona". University of Arizona, College of Agriculture. Bulletin No. 112. November 1, 1925.
- 8. Speedstar Division, Koehring Company. "Well Drilling Manual". (Undated)
- 9. Spiridonoff, S. V. "Design and Use of Radial Collector Wells". Journal American Water Works Association. Volume 56. June 1964.
- 10. State of Nevada, Department of Conservation and Natural Resources, Division of Water Resources. "Rules and Regulations for Drilling Wells and Other Related Material". Undated.
- 11. Stead, F. M. "A Discussion of Factors Limiting the Bacterial Pollution of Underground Waters by Sewage". Report of the California State Assembly Interim Fact-Finding Committee on Water Pollution. 1949.
- 12. Todd, D. K. "Ground Water Hydrology". John Wiley and Sons, Inc. 1959.
- 13. Tolman, C. F. "Ground Water". McGraw-Hill Book Company, Inc. 1939.
- 14. U. S. Bureau of Reclamation. "Groundwater Manual". First Edition. 1977.



- 1. U. S. Geological Survey. "Evaluation and Control of Corrosion and Encrustation in Tube Wells of the Indus Plains, West Pakistan". Water Supply Paper 1608-L. 1969.
- 2. U. S. Public Health Service. "Ground Water Contamination". Proceedings of the 1961 Symposium. Technical Report W61-5. 1961.
- 3. U. S. Public Health Service. "Recommended State Legislation and Regulations - Urban Water Supply and Sewerage Systems Act and Regulations - Water Well Construction and Pump Installation Act and Regulations - Individual Sewerage Disposal Systems Act and Regulations. July 1965.
- 4. United States Senate, Eighty-ninth Congress, Committee on Interior and Insular Affairs. "Mineral and Water Resources of California - Part II, Water Resources; Section I; Water Resources Appraisal". Report of the U. S. Department of the Interior, Geological Survey, in collaboration with the California Department of Water Resources. 1966.
- 5. University of California. "Irrigation Wells and Well Drilling". Agricultural Experiment Station, College of Agriculture. Circular 404. May 1951.
- 6. University of California. "Proceedings - Symposium on Agricultural Waste Waters, Davis, California, April 6-8, 1966". Water Resources Center Report No. 10.
- 7. University of California. "Water Wells and Pumps: Their Design, Construction, Operation and Maintenance". Division of Agricultural Sciences. Bulletin 1889. May 1978.
- 8. Vertical Turbine Pump Association. "Turbine Pump Facts". 1962.
- 9. Walker, T. R. "Ground Water Contamination in the Rocky Mountain Arsenal Area, Denver, Colorado". The Geological Society of America. Bulletin 72, Volume 3. March 1961.
- 10. Washington Department of Ecology. "Minimum Standards for Construction and Maintenance of Water Wells". Chapter 173-160 Washington Administrative Code. January 10, 1979.
- 11. Water Systems Council. "Water Systems Handbook". Sixth Edition. 1977.
- 12. Water Systems Council. "What you need to know about WELLS & WATER SYSTEMS". 1975.

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