VERSION 4

CALIFORNIA WELL STANDARDS

A WORKING DRAFT REVISION OF CALIFORNIA DEPARTMENT OF WATER RESOURCES

Bulletins 74-81, 74-90 and 1999 Draft of Geothermal Heat Exchange Well Standards

Prepared by the Bulletin 74 Revision Subcommittee of the Water Well Technical Advisory Committee, California Conference of Directors of Environmental Health (CCDEH) in cooperation with the California Groundwater Association (CGA)

September 2013

1450 Koll Circle, Suite 114
San Jose, CA 95112
September 17, 2013

Cheryl Hawkins REHS, Chair
Water Well Technical Advisory Committee
of the California Conference of Directors of
Environmental Health
c/o Sacramento County Environmental
Management Department
10590 Armstrong Avenue
Mather, CA 95655

RE: TRANSMITTAL OF WORKING DRAFT VERSION 4 REVISION, BULLETIN 74 CALIFORNIA WELL STANDARDS OF THE CALIFORNIA DEPARTMENT OF WATER RESOURCES

Dear Cheryl:

Transmitted herewith is Version 4 of the revision of Bulletin 74, California Well Standards of the California Department of Water Resources that combines Bulletins 74-81, 74-90, and the 1999 draft of the Geothermal Heat Exchange Standards. This working draft was prepared by the Bulletin 74 Revision Subcommittee of the Water Well Technology Advisory Committee (WWTAC) of the California Conference of Directors of Environmental Health (CCDEH). The working draft was completed by the Subcommittee under the auspices of the WWTAC and was initiated at the request of CCDEH. The work began in July 2010, and represents a cooperative 3-year effort of a dedicated volunteer group of members from both WWTAC and the California Groundwater Association (CGA). A previous draft (Version 3) was circulated to the Subcommittee members for review in early August 2013. Version 4 incorporates a number of comments received since that date, along with some editorial changes needed to improve the text.

This draft is being transmitted to you, so that it may be distributed to the greater WWTAC membership for their review and comment, on whatever schedule you consider appropriate.

Sincerely,

Jeremy C. Wire, CHG
Subcommittee Chair
CGA Representative to WWTAC

INTRODUCTION AND ACKNOWLEDGMENTS
WORKING DRAFT REVISION 4 DWR Bulletin 74

Background

Revision of DWR Bulletins 74-81, 74-90, and the draft 1999 Geothermal Heat Exchange Well (GHEW) standards was not seriously considered until 2005-06 when Carl Hauge then of the DWR started work on this task. However, due to lack of funding and Carl's subsequent retirement this attempt and a similar effort started by a committee of the CGA in 2007 never came to fruition. However, because of increasing interest from the regulatory community, in April 2010 the CCDEH requested that the WWTAC convene a Subcommittee to work on the revision. The Subcommittee was to include not only members of WWTAC but also members of CGA, who, through efforts of Mike Mortensson, Executive Director had promoted the need for several years to the DWR for a revision of Bulletin 74.

Accordingly, the Subcommittee began its work in July 2010, with the goal that revisions would be made and a draft document prepared, that while "unofficial" could be useful having up-to-date information, and eventually that the draft would be incorporated by DWR in an "official" updated Bulletin. This goal has been partially realized, as the Subcommittee's draft revision of GHEW (Chapter IV) was submitted to the DWR in August 2012, to be incorporated in their current program of revising the GHEW Standard.

Version 4 Draft Format

The basic document that the Subcommittee started with was prepared by the Southern District of the DWR and included a combined text of Bulletin 74-1, 74-90, and the 1999 draft GHEW Standard. Portions of this original document that have been deleted are shown in red strikeout. New text revisions are shown in bold red italics. Comments contained in "Editorial Notes" include discussion of issues that could not be resolved by consensus of the Subcommittee members, or may include citations of useful references containing more detailed information on specific topics. The original Illustrations in Bulletin 74-81 and 74-90 were digitized and redrafted with revisions made where appropriate, and several new illustrations were prepared.

Committee Members and Acknowledgments

The Subcommittee has met generally on a quarterly basis since July 2010, and notes are available for each meeting documenting the topics discussed. Members of the Subcommittee that have participated are as follows:

Troy Boone, REHS, County of Santa Cruz Environmental Health Services

Mike Duffy, PG, Santa Clara Valley Water District

Norman Fujimoto, REHS, Santa Barbara County Public Health Dept.

Amy Gagne´, PG, Monterey County Water Resources Agency

Augie Guardino, Guardino Well Drilling, Inc.

Cheryl Hawkins, REHS, Sacramento County Environmental Management Dept.

David A. Landino, Sr., Landino Drilling Company

Mike Mortensson, Executive Director, California Groundwater Association

Cheryl Sandoval, REHS, Monterey County Environmental Health Bureau

Susan Williams, MS, Sacramento County Environmental Management Dept.

Peggy Zarriello, REHS, Nevada County Environmental Health Dept.

We have benefitted from input from outside well drilling contractors and consultants. Dave Fulton of Diamond Well Drilling gave input on topics such as the liner method in well rehabilitation and also provided the original digitized figures from his previous effort of combining the Bulletins. Lisa Meline, PE of Meline Engineering provided data and review of the GHEW chapter, and Steve McKim, Consultant, gave us input for Cathodic Protection Well chapter. Paul Funston of Funston Industrial Sands provided data on sealing materials, with particular reference to “uses and abuses” of fly ash.

The Subcommittee is particularly indebted to members Susan Williams who undertook the task of formatting a significant part of the entire revised draft text in addition to seeing the final draft format of the GHEW text through to its submission to DWR, and to Norman Fujimoto who as chair of WWTAC during the first years of review provided general encouragement, input and editing of the Cathodic Protection Well chapter, and recently, editorial review of Version 3.Mike Duffy provided organization to a somewhat difficult revision of the Monitoring Well chapter. Cheryl Hawkins also provided encouragement in her current term as WWTAC Chair.

It has been a privilege to chair this Subcommittee, composed of representatives from the water well industry and regulatory community, who have diligently discussed the topics and issues of common concern over an extended time frame in preparing this draft revision of Bulletin 74. The result is a work in progress, that when subjected to further "peer" review, should result in improvement of this first complete draft revision.

Finally, this draft is dedicated to Carl Hauge, now retired from DWR, who for many years advised the California regulatory community as well as the California well drilling industry on issues concerning well standards, and as noted previously, started the process resulting in this present draft.

Jeremy C. Wire, CHG, Chair
WWTAC Bulletin 74 Revision
Subcommittee
Geoconsultants, Inc.
CGA Representative to WWTAC

San Jose, California
September 2013

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Chapter II. WATER WELL 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 groundwater 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, 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 groundwater quality.

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

Part I. General

Section 1. Definitions.

A. Well or Water Well. As defined in Section 13710 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."

EDITORIAL NOTE: Since dewatering wells are presently specifically excluded by the Water Code, their regulation is probably best considered to be an option of the local enforcing agency. However, their inclusion in Bulletin 74 Standards revision might be open for more discussion by the subcommittee.

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~~ ***Department of Public Health or its successor*** as "Noncommunity water systems" and "State small water systems" (California Water Works Standards, Title 22, California Administrative Code). Such wells are variously referred to as "Municipal Wells", "City Wells: or "Public Water Supply Wells". ***Also included are "Transient Non-Community" wells.***

C. Individual Domestic Wells. A water well used to supply water for domestic needs of an individual residence or systems of four or less service connections (or "hook-ups" as they are often called).

D. Industrial Wells. Water wells used to supply industry on an individual basis (in contrast to supplies provided through community systems).

E. Agricultural Wells. Water wells used to supply water only for irrigation or other agricultural purposes, including so-called "stock wells".

F. Recharge or Injection Wells. Wells constructed to introduce water into the ground as a means of replenishing groundwater basins, repelling the intrusion of seawater, or disposing of waste water.

G. Air-conditioning Wells. Wells constructed to return to the ground water which has been used as a coolant in air conditioning processes. Because the water introduced into these wells is degraded (from the standpoint of temperature). Such wells have been construed as waste discharge and are, therefore, subject to water quality control laws (Division 7 of the Water Code and Division 5 of the Health and Safety Code).

H. Horizontal Wells. Water wells drilled horizontally or at an angle with the horizon (as contracted with the common vertical well). This definition does not apply to horizontal drains or "wells" constructed to remove subsurface water from hillsides, cuts, or fills (such installations are used to prevent or correct conditions that produce landslides.

I. Exploration Hole (or Boring). An uncased, temporary excavation whose purpose is the determination of hydrologic conditions at a site.

J. Test Wells. Wells constructed to obtain information needed for design or other wells. Test wells should not be confused with "exploration holes" which are temporary. Test wells are cased and can be converted to other uses such as groundwater monitoring and under certain circumstances, to production wells.

K. Inactive or Standby Wells. 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 and enforce laws or ordinances pertaining to the construction, alteration, maintenance, and destruction of water wells. The California Department of ***Public Health or its successor*** ~~Services~~ or the local health agency is the enforcing agency for community supply wells.

M. Cathodic Protection Wells. A cathodic protection well contains devices to minimize electrolytic corrosion of metallic pipelines, tanks, and other facilities in contact with the earth.

~~N.~~ ***Geothermal Heat Exchange Wells (GHEW). A geothermal heat exchange well or loop well is part of a geothermal heat pump system consisting of a vertical borehole within which is emplaced a heat exchange (loop) tube grouted in place from the bottom of the borehole to the surface.***

O. Monitoring Wells. Wells constructed for the purpose of observing or monitoring groundwater conditions such as water levels or water quality.

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.

Section 3. Exemption Due to Unusual Conditions.

If the enforcing agency finds that the compliance with any of the requirements prescribed herein is impractical for a particular location because of unusual conditions or if any 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 Section 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.

Section 5. Special Standards.

A. In locations where existing geologic or groundwater conditions require standards more restrictive than those described herein, such special additional standards may be prescribed by the enforcing agency.

B. Special Standards are necessary for the construction of recharge or injection wells, horizontal wells and other unusual types of wells. Design of these wells is subject to the approval of the enforcing agency.

Section 6. Well Drillers.

The construction, alteration, or destruction of wells shall be performed by contractors licensed in accordance with the provisions if the Contractors License Law (Chapter 9, Division 3, of the Business and Professions Code) unless exempted by that act.

Section 7. Reports.

Reports concerning the construction, alteration, or destruction of water wells shall be filed with the California Department of Water Resources in accordance with the provisions of Section 13750 through 13755 (Division 7, Chapter 10, Article 3) of the California Water Code.

Part II. Well Construction

As a guiding principle it should be remembered that all wells should be designed and constructed to also facilitate their eventual destruction at the end of their useful service life.

Section 8. Well Location With Respect to Pollutants and Contaminants and Structures.

A. Separation. All water wells shall be located an adequate horizontal distance from known or potential sources of pollution and contamination. Such sources include, but are not limited to:

(1) sanitary, industrial, and storm sewers;
(2) septic tanks and leachfields;
(3) sewage and industrial waste ponds;
(4) barnyards and stable areas;
(5) feedlots;
(6) solid waste disposal sites;
(7) above and below ground tanks and pipelines for storage and conveyance of petroleum products or other chemicals; and

(8) storage and preparation areas for pesticides, fertilizers, and other chemicals.

Consideration should also be given to adequate separation from sites or areas with known or suspected soil or water pollution or contamination.

The following horizontal separation distances are generally considered adequate where a significant layer of unsaturated, unconsolidated sediment less permeable than sand is encountered between ground surface and groundwater. These distances are based on present knowledge and past experience. Local conditions may require greater separation distances to ensure groundwater protection.

Potential Pollution or Contamination Source	**Minimum Horizontal Separation Distance Between Well and Known or Potential Source**
Any sewer line (sanitary, industrial, or storm; main or lateral)	50 feet
Watertight septic tank or subsurface sewage leaching field	100 feet
Cesspool or seepage pit	150 feet
Animal or fowl enclosure	100 feet
Petroleum products pipeline	***150 feet***

EDITORIAL NOTE: The setback distance of 150 feet from petroleum product pipelines is specified by some local jurisdictions in practice, but is subject to further discussion.

If the well is a radial collector well, minimum separation distances shall apply to the furthest extended point of the well.

Many variables are involved in determining the “safe” separation distance between a well and a potential source of pollution or contamination. No set separation distance is adequate and reasonable for all conditions. Determination of the safe separation distance for individual wells requires detailed evaluation of existing and future site conditions.

Where, in the opinion of the enforcing agency adverse conditions exist, the above separation distances shall be increased, or special means of protection, particularly in the construction of the well, shall be provided, such as increasing the length of the annular seal.

Lesser distances than those listed above may be acceptable where physical conditions preclude compliance with the specified minimum separation distances and where special means of protection are provided.

Lesser separation distances must be approved by the enforcing agency on a case-by-case basis.

B. Gradients. Where possible, a well shall be located up the groundwater gradient from potential sources of pollution or contamination. Locating wells up gradient from pollutant and contaminant sources can provide an extra measure of protection for a well. However, consideration should be given to the fact that a gradient near a well can be reversed by pumping, as ~~should~~ ***shown*** in Figure *1* ~~(page 28 Bulletin 74-81)~~, or by other influences.

C. Flooding and Drainage. If possible, a well should be located outside areas of flooding. The top of the well casing shall terminate above grade and above known levels of flooding caused by drainage or runoff from surrounding land. For community water supply wells, this level is defined as the: "...floodplain of a 100 year flood...or above...any recorded high tide..." (Section 64417, Siting Requirements, Title 22 of the California Code of Regulations.)

If compliance with the casing height requirement for a community water supply wells and other wells is not practical, the enforcing agency shall require alternate means of protection.

Surface drainage from areas near the well shall be directed away from the well. If necessary, the area around the well shall be built up so that drainage moves away from the well.

D. Accessibility. All wells shall be located an adequate distance from buildings and other structures to allow access for well modification, maintenance, repair, and destruction, unless otherwise approved by the enforcing agency.

Section 9. Sealing the Upper Annular Space

"The space between the well casing and the wall of the drilled hole, often referred to as the annular space, shall be effectively sealed to prevent it from being a preferential pathway for movement of poor-quality water, pollutants, or contaminants. In some cases, secondary purposes of an annular seal are to protect casing against corrosion or degradation, ensure structural integrity of the casing, and stabilize the borehole wall."

A. Minimum Depth of Annular Surface Seal. The annular surface seal for various types of water wells shall extend from the ground surface to the following minimum depths:

Well Type	Minimum Depth Seal Must Extend below Ground Surface
Community Water Supply	50 feet
Industrial	50 feet
Individual Domestic	20 feet
Agricultural	20 feet
Air-Conditioning	20 feet
All Other Types	20 feet

1. Shallow Groundwater. Exceptions to minimum seal depths can be made for shallow wells at the approval of the enforcing agency.~~,~~ ~~where the water to be produced is a depth less than 20 feet.~~ In no case shall an annular seal extend to a total depth less than ~~10~~ ***20*** feet below land surface. The annular seal shall be no less than ~~10~~ ***20*** feet in length.

   EDITORIAL NOTE: The language and numbers in this paragraph merit further discussion. Producing groundwater occurring between 10 and 20 feet in depth may be a holdover from the days of "hand dug" wells.

   Caution shall be given to locating a well with a "reduced" annular seal with respect to sources of pollution or contamination. Such precautions include horizontal separation distances greater than those listed in Section 8, ~~Page 12,~~ above

2. Encroachment on Known or Potential Sources of Pollution or Contamination. When, at the approval of the enforcing agency, a water well is to be located closer to a source of pollution or contamination than allowed by Section 8, ~~Page 12,~~ above, the annular space shall be sealed from ground surface to the first impervious stratum, if possible. The annular seal for all such wells shall extend to a minimum depth of 50 feet.

3. Areas of Freezing. The top of an annular seal may be below ground surface in areas where freezing is likely, but in no case more than 4 feet below ground surface. "Freezing" areas are those where the mean length of the freeze-free period described by the National Weather Service is less than 100 days. In other words, "freezing" areas are where temperatures at or below 32 degrees Fahrenheit are likely to occur on any day during a period of 265 or more days each year. In general these areas include:

EFFECT OF REVERSAL OF GROUND WATER GRADIENT

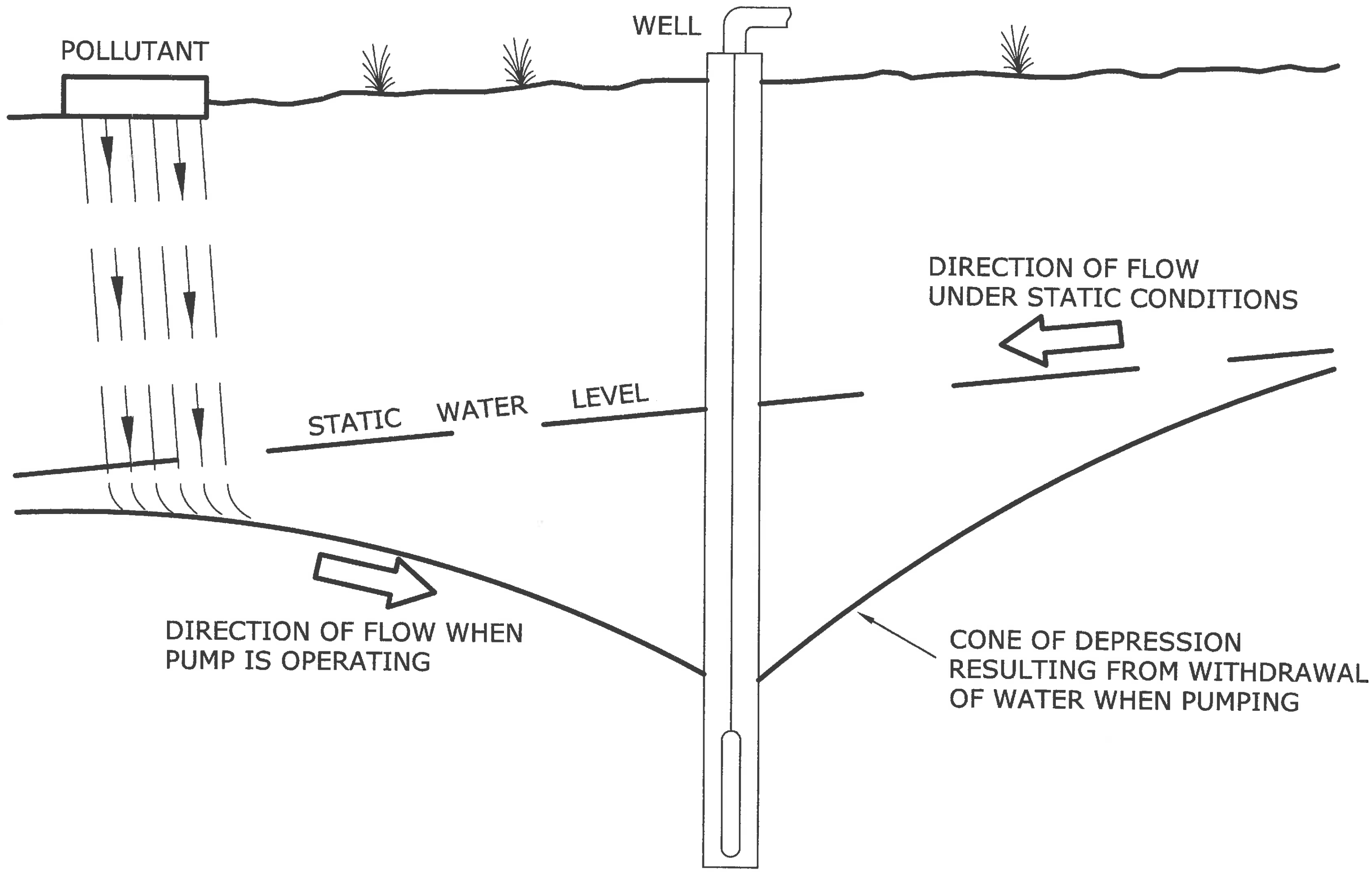


FIGURE 1

Follows page 10

Portions of Modoc, Lassen and Siskiyou Counties; Portions of the North Lahontan area including the eastern slope of the Sierra Nevada and related valleys north of Mount Whitney and Mono Lake; and, the area of Lake Arrowhead in the San Bernardino Mountains.

4. Vaults. At the approval of the enforcing agency, the top of an annular surface seal and well casing can be below ground surface where traffic or other conditions require, if the seal and casing extend to a watertight and structurally sound subsurface vault, or equivalent feature. ***To eliminate the requirement for shoring the vault excavation,*** ~~In no case shall~~ ***it is recommended that*** the top of the annular surface seal be ***no*** more than ~~4~~ ***5*** feet below ground surface. The vault shall extend from the top of the annular seal to at least ground surface.

EDITORIAL NOTE: Five (5) feet is the maximum depth of excavation without shoring, pursuant to the California Health & Safety Code.

~~The use of subsurface vaults to house the top of water wells below ground surface is rare and is discouraged due to susceptibility to the entrance of surface water, pollutants, and contaminants. Where appropriate, pitless adapters should be used in place of vaults.~~

Vaults and the alternative of pitless adapters should be avoided wherever possible in favor of above ground discharge. However, where project considerations dictate, either may provide a solution for subsurface discharge. The employment of one or the other depends on specific job and site conditions.

EDITORIAL NOTE: Refer to CGA Standard Practice 290: *"Below Grade Well Head Discharge,"* for further details on this issue, if needed.

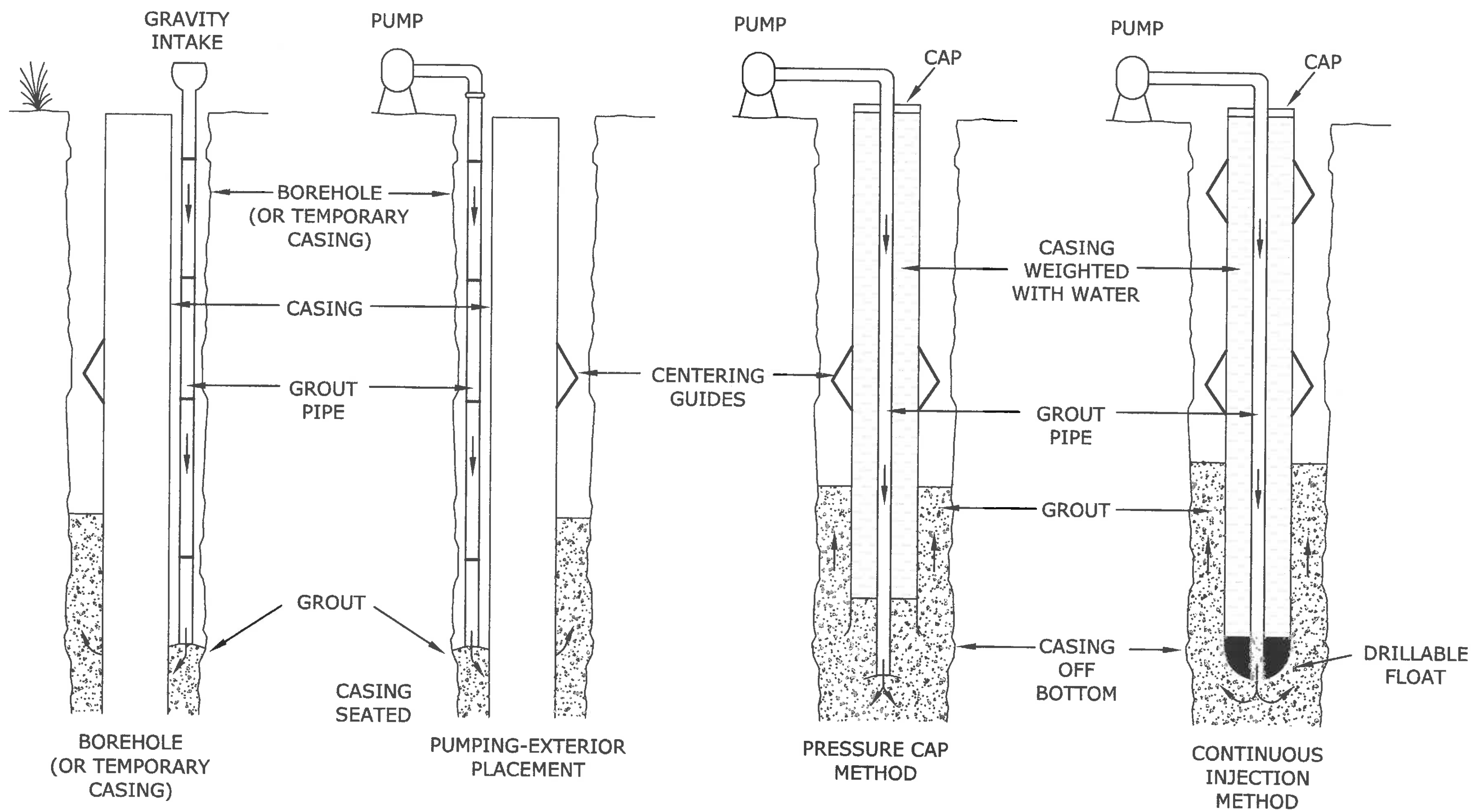
B. Sealing ***Methods*** and Conditions.

Sealing Methods.

EDITORIAL NOTE: This section is taken from Appendix B in Bulletin 74-81"Sealing the Annular Space", and because of its importance, is inserted here.

The following methods can be used to seal the upper portion of the annular space. Except for the first, these methods are illustrated on Figure

METHODS FOR SEALING THE ANNULAR SPACE



NOT TO SCALE

FIGURE 2

Follows page 11

2. The first method is frequently used where short seals, under 20 feet deep are placed in dry material.

Gravity Installation (Without Tremie). In this method of sealing, material is poured into the annular space without the use of a tremie or grout pipe. It cannot be used where the annular space contains water and is limited to intervals less than 30 feet deep. When used, visual observation (with the aid of a mirror or light) should be made during placement of the seal.

Grout Pipe Method. In this method, the seal is placed in the annular space by gravity through a grout pipe (or tremie) suspended in the annular space (*see Figure 2*).

1. Drill the hole large enough to accommodate the grout pipe (at least 4 inches greater in diameter than the diameter of the casing. **(Note: For public supply wells, the California Department of Public Health has adopted a minimum annular space of 3-inches, unless the "Halliburton" cementing method is used, A borehole 6-inches in diameter greater than the diameter of the casing would then be needed.)**

2. In caving formations, install a conductor casing.

3. Provide a packer or grout retainer in the annular space below the interval to be sealed.

4. Extend the grout pipe down the annular space between the casing and the wall or conductor to near the bottom of the interval to be sealed just above the retainer.

5. Add grout in one continuous operation, beginning at the bottom of the interval to be sealed. The bottom end of the grout pipe should remain submerged in the sealing material during the entire time it is being placed. The grout pipe is gradually withdrawn as the sealing material is placed. Where a conductor casing is used to hold back caving material, it may be withdrawn as the sealing material is placed.

Pumping-Exterior Placement. For this method the same procedure as described for the Grout Pipe Method (above) is followed except that the material is placed by pumping instead of gravity flow. The grout pipe must always be full of sealing material and its bottom end must remain submerged in the sealing material until the interval has been filled.

Pressure Cap Method. In the pressure cap method, the grouting is done with hole drilled about 2 feet below the bottom of the conductor casing and the remainder of the well drilled after the grout is in place and set. The grout is placed through a grout pipe set inside the conductor casing.

1. The casing is suspended about 2 feet above the bottom of the drilled hole and filled with water.

2. A pressure cap is placed over the conductor casing and grout pipe extended through the cap and casing to the bottom of the hole.

3. The grout is forced through the pipe, up into the annular space around the outside of the conductor casing, to the ground surface.

4. When the grout is set, the pressure cap and the plug formed during grouting are removed and drilling of the rest of the well is continued.

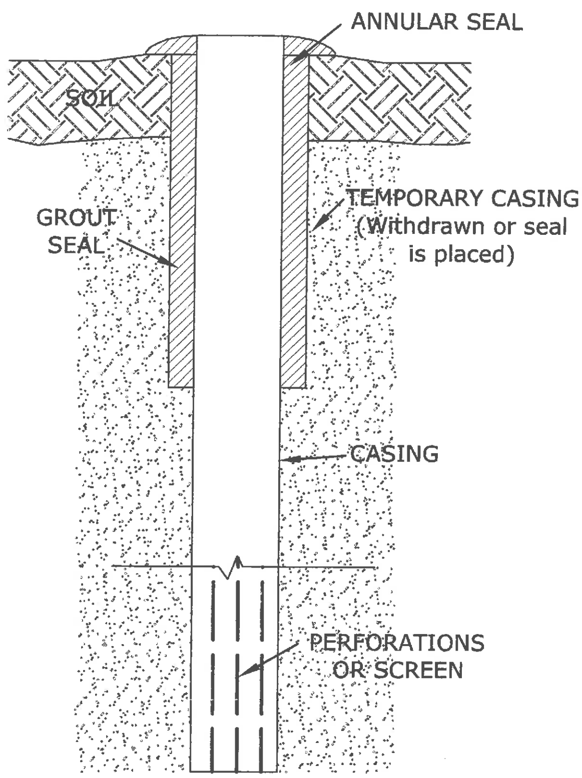
Because there is the possibility that coarse aggregate will "jam" the grout pipe, concrete cannot be used as a sealant when this method is used.

EDITORIAL NOTE: Cement with coarse aggregate ("concrete") is not recommended as sealing material in this revision, in any event, and only "fine" aggregate should be used. For definition of "fine" aggregate refer to ASTM Standard C-33-03, Standard Specification for Concrete Aggregates, and CGA Standard Practice Series Article 210 "Definition of Sand as Used in Sand-Cement Mixtures for Annular Seals"

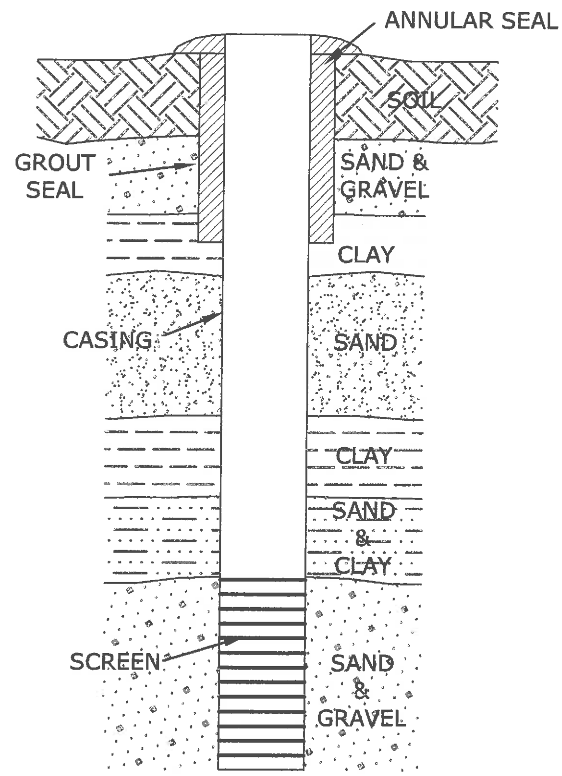
Continuous Injection. This method, called the Normal Displacement Method in the oil industry (which developed it involves pumping grout through a tube or pipe centered in the casing via a "float shoe" fitted at the bottom of the casing. The grout is forced up in the annular space to the gro7und surface as is the case with pressure cap method (above). The tube is detached and flushed. The float shoe, which has a back pressure valve, is drilled out. Because there is the possibility that coarse aggregate will "jam" the grout pipe, concrete cannot be used with this method.

EDITORIAL NOTE: See above regarding use of "concrete".

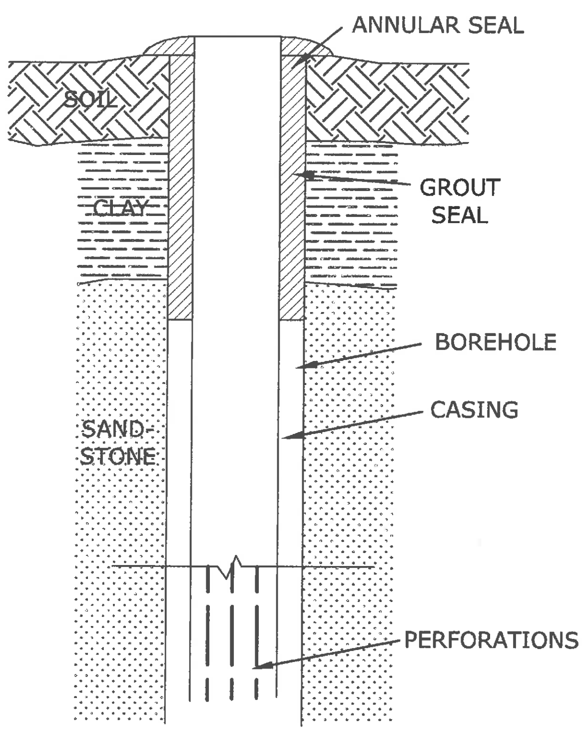
SEALING CONDITIONS FOR UPPER ANNULAR SPACE
UNCONSOLIDATED & SOFT, CONSOLIDATED FORMATIONS



WELL DRILLED IN UNCONSOLIDATED CAVING MATERIAL



WELL DRILLED IN UNCONSOLIDATED STRATIFIED FORMATIONS



NOT TO SCALE

WELL DRILLED IN SOFT CONSOLIDATED FORMATIONS

NOT TO SCALE

Follows page 13

FIGURE 3

Sealing Conditions

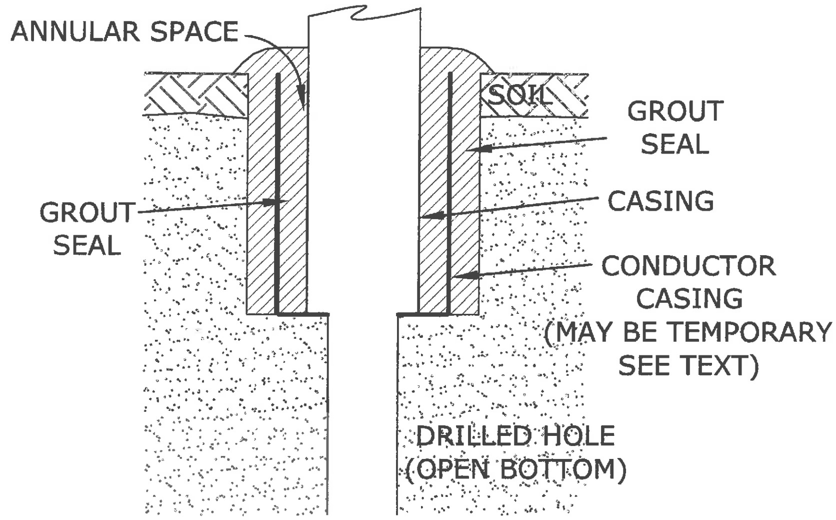
1. Wells drilled in unconsolidated, caving material. An 'oversized' hole, at least 4 inches greater in diameter than the outside diameter of the well casing, shall be drilled and a conductor casing temporarily installed to at least the minimum depth of annular seal specified in Subsection A, ~~Page 14,~~ above. Permanent conductor casing may be used if it is installed in accordance with Item 3, ~~Page 16,~~ below, and ~~Item 5 (Page 32 of Bulletin 74-81)~~ ***provision may be made for the gravel pack between the conductor casing and the production casing to extend to the top of the well. In this case an annular or "ring" seal plate shall be placed (welded in the case of steel casing) at the top to prevent contamination by surface drainage (Figure 3A). The conductor casing should*** ~~and if it extends~~ ***extend to*** at least ~~to~~ the depth specified in Subsection A, above. One purpose of conductor casing is to hold the annular space open during well drilling and during the placement of the well casing and annular seal.

   Temporary conductor casing shall be withdrawn as sealing material is placed between the well casing and the borehole wall, as shown in Figure 4A ~~(Page 31 of Bulletin 74-81)~~. Sealing material shall be placed at least within the interval specified in Subsection A, above. The sealing material shall be kept at a sufficient height above the bottom of the temporary casing as it is withdrawn to prevent caving of the borehole wall.

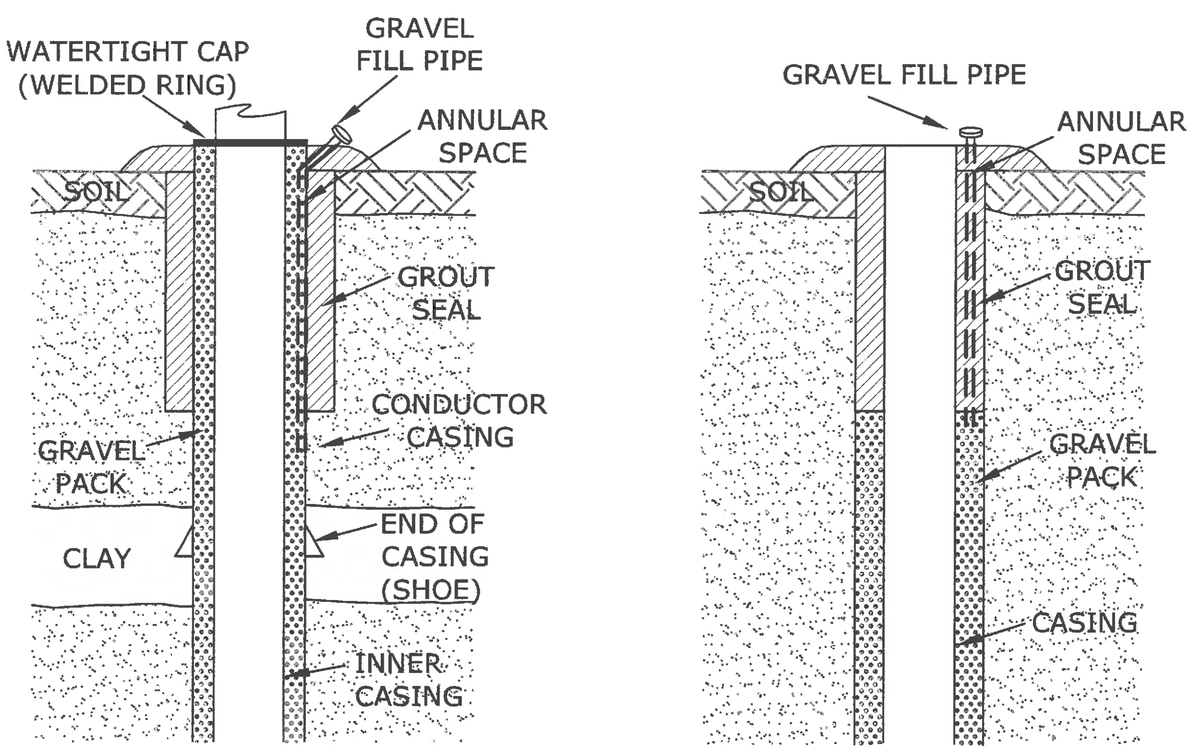
   Temporary conductor casing may be left in place in the borehole after the placement of the annular seal only if it is impossible to remove because of unforeseen conditions and not because of inadequate drilling equipment, or if its removal will seriously jeopardize the integrity of the well and the integrity of subsurface barriers to pollutant or contaminant movement. Temporary conductor casing may be left in place only at the approval of the enforcing agency on a case-by-case basis.

   Every effort shall be made to place sealing material between the outside of the temporary conductor casing that cannot be removed and the borehole wall to fill any possible gaps or voids between the conductor casing and the borehole wall ***as shown on Figure 4A***. At least two inches of sealing material shall be maintained between the conductor casing and the well casing. At a minimum, sealing material shall extend through intervals specified in Subsection A, above.

SEALING CONDITIONS FOR UPPER ANNULAR SPACE HARD ROCK FORMATIONS AND GRAVEL PACK



WELL DRILLED IN ROCK FORMATION



WITH CONDUCTOR CASING

WITHOUT CONDUCTOR CASING

GRAVEL PACKED WELLS

NOT TO SCALE

Follows page 14

FIGURE 4

Sealing material can often be placed between temporary conductor casing that cannot be removed and the borehole by means of pressure grouting techniques, as described below.~~(Page 67 of Bulletin 74-81)~~. Other means of placing sealing material between the conductor casing and the borehole wall can be used, at the approval of the enforcing agency.

Pressure grouting shall be accomplished by perforating temporary conductor casing that cannot be removed, in place. The perforations are to provide passages for sealing material to pass through the conductor casing to fill any spaces and voids between the casing and the borehole wall. Casing perforations shall be suitable size and density to allow passage of sealing materials through the casing and the proper distribution of sealing material in spaces between the casing and the borehole wall. At a minimum, the perforations shall extend through the intervals specified in Subsection A, above, unless otherwise approved by the enforcing agency.

~~Temporary conductor casing that must be left in place shall be perforated immediately before sealing operations begin to prevent drilling or well construction operation from clogging casing perforations. Once the casing has been adequately perforated, sealing material shall be placed inside the conductor casing and subjected to sufficient pressure to cause the sealing material to pass through the conductor casing perforations and completely fill any space or voids between the casing and the borehole wall, at least within the intervals specified in Subsection A, above. Sealing material shall consist of neat cement, or bentonite prepared from powdered bentonite and water, unless otherwise approved by the enforcing agency.~~

~~Sealing material must also fill the annular space between the conductor casing and the well casing within the required sealing intervals.~~

EDITORIAL NOTE: The procedures outlined in the above two paragraphs are impractical and should be stricken as shown. Once the production casing is installed, and it is found that the "temporary" conductor casing can't be removed, there is no way to perforate it. The conductor casing would have to be pre-perforated before installation.

2. Wells drilled in unconsolidated material with significant clay layers. An 'oversized' hole, at least 4 inches greater in diameter than the outside diameter of the well casing, shall be drilled to at least the

depth specified in Subsection A, ~~Page 14,~~ above, and the annular space between the borehole wall and the well casing filled with sealing material in accordance with Subsection A, above (see ***Figure 3B***~~, Page 31 of Bulletin 74-81~~). If a significant layer of clay or clay-rich deposits of low permeability is encountered within 5 feet of the minimum sealing depth prescribed in Subsection A, above, the annular seal shall be extended at least 5 feet into the clay layer. Thus, the depth of seal could be required to be extended as much as another 10 feet. If the clay layer is less than 5 feet in total thickness, the seal shall extend through the entire thickness.

If caving material is present within the interval specified in Subsection A, a temporary conductor casing shall be installed to hold the borehole open during the well drilling and placement of the casing and annular seal, in accordance with the requirements of Item 1, ~~Page 15,~~ above. Permanent conductor casing may be used if it is installed in accordance with Item 3, below and Item 5 ~~(Page 32 of Bulletin 74-81)~~ ***below*** and it extends to at least the depth specified in Subsection A, above.

3. Wells drilled in soft consolidated formations (extensive clays, sandstones, etc.) An 'oversized' hole, at least 4 inches greater in diameter than the outside diameter of the well casing, shall be drilled to at least the depth specified in Subsection A, ~~Page 14,~~ above. The space between the well casing and the borehole shall be filled with sealing material to at least the depth specified in Subsection A, above, as shown by Figure ***3C*** ~~(Page 31 of Bulletin 74-81)~~. **(Note: Refer to previous Section 9.B.1 regarding minimum 3-inch annular space required by California Public Health Department for public supply wells, resulting in the "oversized" hole being 6-inches in diamteter).**

If a permanent conductor casing is to be installed to facilitate the construction of the well, an oversized hole, at least 4 inches greater in diameter than the outside surface of the permanent conductor casing shall be drilled to the bottom of the conductor casing or to at least the depth specified in Subsection A, above, and the annular space between the conductor casing and the borehole wall filled with sealing material. In some cases, such as cable tool drilling, it may be necessary to extend permanent casing beyond the depth of the required depth of the annular surface seal in order to maintain the borehole. Sealing material is not required between conductor casing and the borehole other than the depths specified in Subsection A, above, and Section 13, Sealing-Off Strata below. ~~(Page 46 of Bulletin 74-81).~~

4. <u>Wells situated in "hard" consolidated formations (crystalline or metamorphic rock).</u> An oversized hole shall be drilled to the depth specified in Subsection A of this section and the annular space filled with sealing material. If there is significant overburden, a conductor casing may be installed to retain it. If the material is heavily fractured, the seal should extend into solid material. If the well is to be open-bottomed (lower section uncased), the casing shall be sealed ***in the oversized hole, prior to drilling inside the casing and extending the smaller diameter open hole to total depth (Figure 4A)*** ~~in the sealing material (see Figure 5A)~~.

5. <u>Gravel Packed Wells</u>.

    a. <u>With Conductor Casing</u>. An oversized hole, at least 4 inches greater than the diameter of the conductor casing, shall be drilled to the depth specified in Subsection A of this section and the annular space between the conductor casing and the drilled hole filled with sealing material. (In this case the gravel pack may extend to the top of the well but to prevent contamination by surface drainage, a welded cover shall be installed over the production casing, see ***Figure 4B***.)

    b. <u>Without Conductor Casing</u>. An oversized hole at least 4 inches greater in diameter than the production casing, shall be drilled to the depth specified in Subsection A of this section and the annular space between the casing and the drilled hole filled with sealing material. If the gravel fill pipes are installed through the seal, the annular seal shall be of sufficient thickness to assure that there is a minimum of 2 inches between the gravel fill pipe and the wall of the drilled hole. The gravel pack shall terminate at the base of the seal (see ***Figure 4C***). If a temporary conductor casing is used, it shall be removed as the sealing material is placed. **(Note: refer to previous Section 9.B.1 for discussion of minimum annular seal required for public supply wells).**

6. For wells situated in circumstances differing from those described above, the sealing conditions shall be as prescribed by the enforcing agency.

7. <u>Converted Wells</u>. Wells converted from one use to another, particularly those constructed in prior years without annular seals, shall have annular seals installed to the depth required in Subsection A of this section and at the thickness described in Part E. Where it is anticipated that a well will be converted to another

use, the enforcing agency may require the installation of a seal to the depth specified for community water supply wells.

8. Wells that penetrate zones containing poor-quality water, pollutants, or contaminants. If geologic units or fill known or suspected to contain poor-quality water, pollutants, or contaminants are penetrated during drilling, and the possibility exists that poor-quality water, pollutants, or contaminants could move through the borehole during drilling and well construction operations and significantly degrade groundwater quality in other units before sealing material can be installed, then precautions shall be taken to seal off or 'isolate' zones containing poor-quality water, pollutants, and contaminants during drilling and well construction operations. Special precautions could include the use of temporary or permanent conductor casing, ~~borehole liners,~~ ***use of "Strata Seal-Off Procedures" described in Section 13***, and specialized drilling equipment. The conductor casing is described in Item 1, ~~Page 15~~ above.

C. Conductor Casing. For community water supply wells, the minimum thickness of steel conductor casing shall be ¼ inch for single casing or a minimum of No. 10 U.S. Standard Gage for double casing. Steel used for steel casing described in Section 12.

D. Sealing Material. Sealing material shall consist of neat cement, sand cement, ~~concrete~~, or bentonite. Cuttings from drilling, or drilling mud, shall not be used for any part of the sealing material.

1. Water. Water used to prepare sealing mixtures should generally be of drinking water quality, shall be compatible with the type of sealing material used, be free of petroleum and petroleum products, and be free if suspended matter. In some cases water considered non-potable, with a maximum of 2,000 milligrams per liter (mg/l) chloride and 1,500 mg/l sulfate, can be used for cement-based sealing mixtures. The quality of water to be used for sealing mixtures shall be determined where unknown.

2. Cement. Cement used in sealing mixtures shall meet the requirements of American Society for Testing and Materials C150, Standard Specifications for Portland Cement, including the latest versions thereof.

Types of Portland cement available under ASTM C150 for general construction are:

Type I - General Purpose. Similar to American Petroleum Institute Class A.

Type II - Moderate resistance to sulfate. Lower heat of hydration than Type I. Similar to API Class B.

Type III - High early strength. Reduced curing time but higher heat of hydration than Type I. Similar to API Class C.

Type IV – Extended setting time. Lower heat of hydration than Types I and III.

Type V - High sulfate resistance.

Special cement setting accelerators and retardants and other additives may be used in some cases. Special field additives for Portland cement mixtures shall meet the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete, and the latest revision thereof.

Pozzolan (also commonly known as "fly ash") combined with Portland cement, contributes "cementitious" properties. Some principal benefits of the use of Type F coal fly ash as a component of cement sealing material include enhanced workability, less water demand, reduced permeability and chloride penetration, greater resistance to sulfate attack, and reduced shrinkage during curing. When a deep annular seal is to emplaced, pozzolan may be mixed up to a 50/50 ratio with cement. This mixture, having lighter unit weight reduces the potential for borehole formation breakdown and the resulting lost circulation of sealing material.

EDITORIAL NOTE: Further research may be needed to determine whether generally available "fly ash" can meet existing DWR Standards ASTM C494 or ASTM C618 or the latest revisions thereof.

Hydrated lime may be added up to 10 percent of the volume of cement used to make the seal mix more fluid, Bentonite may be added to cement-based mixes, up to 6 percent by weight of cement used, to improve fluid characteristics of the sealing mix and reduce the rate of heat generation during setting.

~~Dry additives should be mixed with dry cement before adding water to the mixture to~~ ***The normal process of cement "batching" will*** ensure proper mixing ***of the additives***, uniformity of hydration, and an effective and homogeneous seal. The water demand of additives shall be taken into account when water is added to the mix.

Minimum times required for sealing materials containing Portland cement to set and begin curing before construction operations on a well can be resumed are:

Type I and Type II cement – 24 hours

Type III cement - 12 hours

Type V cement - 6 hours

Type IV cement is seldom used for annular seals because of its extended setting time.

Allowable setting times may be reduced or lengthened by use of accelerators or retardants specifically designed to modify setting time, at the approval of the enforcing agency.

More time shall be required for cement-based seals to cure to allow greater strength when construction or development operations following the placement of the seal may subject casing and sealing materials to significant stress. Subjecting a well to significant stress before a cement-based sealing material has adequately cured can damage the seal and prevent proper bonding of cement-based sealants to casing(s).

If plastic well casing is used, care shall be exercised to control the heat of hydration generated during the setting and curing of cement in an annular seal. Heat can cause plastic casing to weaken and collapse. Heat generation is a special concern if thin wall plastic well casing is used, if the well casing will be subject to significant net external pressure before the setting of the seal, and/or if the radial thickness of the annular seal is large. Additives that accelerate cement setting also tend to increase the rate of heat generation during setting and, thus, should be used with caution where plastic casing is employed.

The temperature of a setting cement seal can be lowered by circulating water inside the well casing and/or by adding bentonite to the cement mixture, up to 6 percent by weight of cement used.

Cement-based sealing material shall be constituted as follows:

a. Neat Cement. For Types I or II Portland cement, neat cement shall be mixed at a ratio of one-94 pound sack of Portland cement to 5 to 6 gallons of 'clean' water. Additional water may be required where special additives, such as bentonite, or 'accelerators' or 'retardants' are used.

b. Sand Cement. Sand-cement shall be mixed at a ratio of not more than 188 pounds of sand to one-94 pound sack of Portland cement (2 parts sand to 1 part cement, by weight) and about 7 gallons of clean water, where Type I or Type II Portland cement is used. This is equivalent to a 10.3 sack mix.' Less water shall be used if less sand than 2 parts sand per 1 part cement by weight is used. Additional water may be required when special additives, such as bentonite, 'accelerators' or 'retardants' are used.

EDITORIAL NOTE: The general proportion is usually 6.3 gallons of water per pound of bentonite.

c. ~~Concrete. Concrete us often used for larger volume annular seals, such as in large-diameter wells. The proper use of aggregate can decrease the permeability of the annular seal, reduce shrinkage, and reduce the heat of hydration generated by the seal.~~

~~Concrete shall consist of Portland cement and aggregate mixed at a ratio of at least six-94 pound sacks of Portland cement per cubic yard of aggregate. A popular concrete mix consists of eight-94 pounds of Type I or Type II Portland cement per cubic yard of uniform 3/8 inch aggregate.~~

~~In no case shall the size of the aggregate be more than 1/5 the radial thickness of the annular seal. Water shall be added to concrete mixes to attain proper consistency for placement, setting, and curing.~~

~~d.~~ Mixing. Cement-based sealing materials shall be mixed thoroughly to provide uniformity and ensure that no 'lumps' exist.

Ratios of the components of cement-based sealing materials can be varied depending on the type of cement and additives used. Variations must be approved by the enforcing agency.

3. Bentonite. Bentonite clay in 'gel' ***or chip*** form has ~~some~~ ***many*** of the advantages of cement-based sealing material, ***along with additional useful characteristics as a sealing material.*** ~~a disadvantage is that the clay can sometimes separate from the clay-water mixture.~~

Although many types of clay mixtures are available, none has sealing properties comparable to bentonite clay. Bentonite expands significantly in volume when hydrated. Only bentonite clay is an acceptable clay for ~~annual~~ ***annular*** seals~~.~~, ***and it is in two forms:***

High solids sodium bentonite: This type of "sealing grade" grout consists of 20 to 30 percent solids content by weight of sodium bentonite when mixed with water. Pumping in place is necessary for this bentonite to lower the viscosity, and generally higher pumping pressures are needed than normally used with cement grout.

Bentonite chips: These grout products, commonly known as "Hole Plug"or medium or coarse "Enviroplug" are intended to be poured into the well annulus to form a seal. The materials readily absorb water and form a very low permeability and permanent seal. Being denser than water they can be poured through standing water.

~~Unamended~~ ***B***entonite clay seals should not be used where structural strength of the seal is required, or where it will be dry. Bentonite seals may have a tendency to dry, shrink and crack in arid and semi-arid area of California where subsurface moisture levels can be low. Bentonite clay seals can be adversely affected by subsurface chemical conditions, ***such as in wells that penetrate formations containing water of high salinity (generally 2,000 parts per million TDS or more) such as in coastal areas subjected to seawater intrusion.*** ~~as can cement-based materials.~~

Bentonite clay shall not be used as a sealing material if roots from trees and other deep rooted plants might invade and disrupt the seal, and/or damage the well casing. Roots may grow in an interval containing a bentonite seal depending on surrounding soil conditions and vegetation.

Bentonite-based sealing material shall not be used for sealing intervals of fractured rock or sealing intervals of highly unstable, unconsolidated material that could collapse and displace the sealing material, unless otherwise approved by the enforcing agency. Bentonite clay shall not be used as a sealing material where flowing water might erode it.

Bentonite clay products used for sealing material must be specifically prepared for such use. Used drilling mud and/or cuttings from drilling shall not be used in sealing material.

Bentonite used for annular seals shall be commercially prepared, powdered, granulated, pelletized, or chipped/crushed sodium montmorillonite clay. The largest dimension of pellets or chips shall be less than 1/5 the radial thickness of the annular space into which that is placed.

Bentonite clay mixtures shall be thoroughly mixed with clean water prior to placement. A sufficient amount of water shall be added to the bentonite to allow proper hydration. Depending on the bentonite sealing mixture used, ***6.3 gallons*** of water should be added to about every ***one*** pound of bentonite. Water added to bentonite for hydration shall be of suitable quality and free of pollutants and contaminants.

Bentonite preparations normally require ½ to 1 hour to adequately hydrate. Actual hydration time is a function of site conditions and the form of bentonite used. Finely divided forms of bentonite generally require less time for hydration, if properly mixed.

Dry bentonite pellets or chips may be placed directly into the annular space below water, where a short section of annular space, up to 10 feet in length, is to be sealed. Care shall be taken to prevent bridging during placement of bentonite seal material.

EDITORIAL NOTE: This restriction needs further discussion, as contractors report placing coated (time-release) chips in favorable situations (large annular space) below water to depths of 100 feet or more.

USEFUL REFERENCE: Additional information on bentonite vs. cement sealing material is contained in the "Nebraska Grout Task Force Study," Nebraska Conservation and Survey Division Education Circular EC-20, dated October 2009.

E. Radial Thickness of Seal. A minimum of two inches of sealing material shall be maintained between all casings and the borehole wall, within the interval to be sealed, except where temporary conductor casing cannot be removed, as noted in Subsection B, ~~Page 15,~~ above***, or the "strata seal off" method is employed in***

an existing well as described in Section 13.C. A minimum of two inches of sealing material shall be maintained between each casing, such as permanent conductor casing, well casing, gravel fill pipes, etc., in a borehole within the interval to be sealed, unless otherwise approved by the enforcing agency. Additional space shall be provided, where needed, for casings to be properly centralized and spaced and allow the use of a tremie pipe during well construction (if required), especially for deeper wells.

EDITORIAL NOTE: AWWA Standard for Water Wells, AWWA A100-06 (Section 4.7.8.3) allows 1.5 inch annular space if the "Halliburton" or similar method of grouting is used. Refer also to previous Section 9.B.1 for discussion of minimum 3-inch annular space required by the California Department of Public Health for public supply wells.

F. Placement of Seal.

1. Obstructions. All loose cuttings, or other obstructions to sealing shall be removed from the annular space before placement of the annular seal.

2. Centralizers. Well casing shall be equipped with centering guides or 'centralizers' to ensure the 2-inch minimum radial thickness of the annular seal is at least maintained. Centralizers need not be used in cases where the well casing is centered in the borehole during well construction by the use of removable tools, such as hollow-stem augers.

   The spacing of the centralizers is normally dictated by the casing materials used, the orientation and straightness of the borehole, and method used to install the casing.

   Centralizers shall be metal, plastic, or other non-degradable material. Wood shall not be used as a centralizer material. Centralizers must be positioned to allow the proper placement of sealing material around the casing within the interval to be sealed.

   Any metallic component of a centralizer used with metallic casing shall consist of the same material as the casing. Metallic centralizer components shall meet the same metallurgic specifications and standards as the metallic casing to reduce the potential for galvanic corrosion of the casing.

3. <u>Foundation and Transition Seals</u>. A packer or similar retaining device, or a small quality of sealant that is allowed to set, can be placed in the bottom of the interval to be sealed before final sealing operations begin to form a foundation for the seal.

A transition seal, up to 5 feet in length, consisting of bentonite, is sometimes placed in the annular space to separate filter pack and cement-based sealing materials. The transition seal can prevent cement-based sealing materials from infiltrating the filter pack. A short interval of fine-grained sand, usually less than 2 feet in length, is sometimes placed between the filter pack and the bentonite transition seal to prevent bentonite from entering the filter pack. Also, fine sand is sometimes used in place of bentonite as the transition seal material.

Fine-sized forms of bentonite, such as granules and powder, are usually employed for transition seals if a transition seal is to be placed above the water level in a well boring. ~~Course~~ ***Coarse*** forms of bentonite, such as pellets and chips, are often used where a bentonite transition seal is to be placed below water level.

Transition seals should be installed by use of a tremie pipe, or equivalent. However, some forms of bentonite may tend to bridge or clog the tremie pipe.

Bentonite can be placed in dry form or as a slurry for use in transition seals. Water should be added to the bentonite transition seal prior to the placement of cement-based sealing materials where bentonite is dry in the borehole. Care should be exercised during the addition of water to the borehole to prevent displacing the bentonite.

Water should be added to bentonite at a ratio~~n~~ **of about 6.3 gallons of water for each pound** of bentonite to allow for proper hydration. Water added to bentonite for hydration shall be of suitable quality and free of pollutants and contaminants.

Sufficient time should be allowed for bentonite transition seals to properly hydrate before cement-based sealing materials are placed. Normally, ½ to 1 hour is required for proper hydration to occur. Actual time of hydration is a function of the site conditions.

The top of the transition seal shall be sounded to ensure that no bridging has occurred during placement.

4. Timing and Method of Placement. The annular space shall be sealed as soon as practical after completion of drilling or a stage of drilling. In no case shall the annular space be left unsealed longer than 14 days following the installation of casing.

   Sealing material shall be placed in one continuous operation from the bottom of the interval to be sealed, to the top of the interval. Where the seal is more than 100 feet in length, the deepest portion of the seal may be installed first and allowed to set or partially set. The deep initial seal shall be no longer than 10 feet in length. The remainder of the seal shall be placed above the initial segment in one continuous operation.

   Sealing material shall be placed by methods (such as the use of a tremie pipe or equivalent) that prevent freefall, bridging, or dilution of the sealing material, or separation of sand or aggregate from the sealing material.

   Annular sealing materials shall not be installed by freefall unless the interval to be sealed is dry and no deeper than 30 feet below ground surface.

   EDITORIAL NOTE: Refer to Section 9.D.3 on bentonite "time release" materials relative to this "freefall" issue.

5. Groundwater Flow. Special care shall be used to restrict the flow of groundwater into a well boring while placing material, where subsurface pressure causing the flow of water is significant.

   EDITORIAL NOTE: Refer to CGA Standard Practice Article 550 – "Management of Surface Artesian Flows During Well Construction," for further detail.

6. Verification. It shall be verified that the volume of sealing material placed at least equals or exceeds the volume to be sealed.

7. <u>Pressure</u>. Pressure required for placement of sealing materials shall be maintained long enough for cement-based sealing materials to properly set.

<u>Section 10. Surface Construction Features.</u>

A. <u>Openings.</u> Openings into the top of the well which are designed to provide access to the well, i.e., for measuring, chlorinating, adding gravel, etc., shall be protected against entrance of surface waters or foreign matter by installation of watertight caps or plugs. Access openings designed to permit the entrance or egress of air or gas (air or casing vents) shall terminate above the ground and above known flood levels and shall be protected against the entrance of foreign material by installation of down-turned and screened "U" bends (see ***Figures 5 and 6***).

All other openings (holes, crevices, cracks, etc.) shall be sealed.

A "sounding tube", taphole with plug, or similar access (see ***Figure 6***) for the introduction of water level measuring devices shall be affixed to the casing of all wells. For wells fitted with a "well cap" the cap shall have a removable plug for this purpose.

1. Where the pump is installed directly over the casing, a watertight seal (gasket) shall be placed between the pump head and the pump base (slab), or a water tight seal (gasket) shall be placed between the pump base and the rim of the casing, or a "well cap" shall be installed to close the annular opening between the casing and the pump column pipe (see ***Figures 5 and 6***).

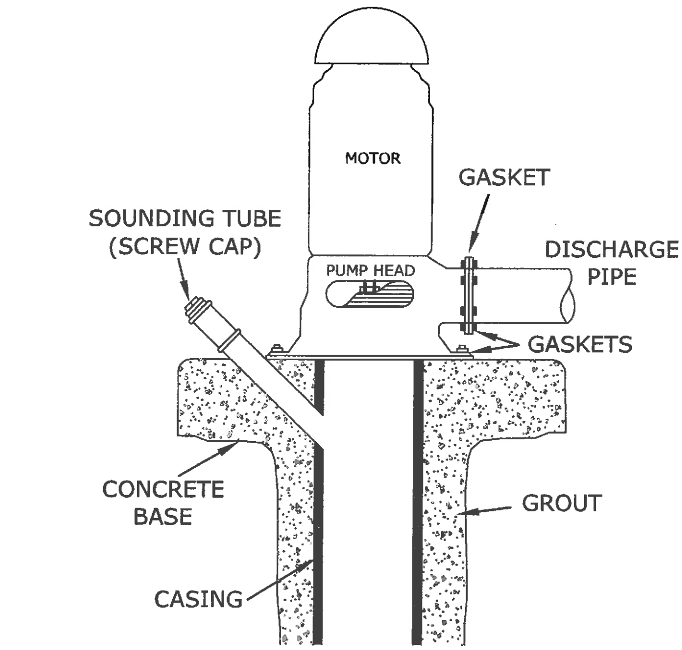
2. Where the pump is offset from the well or where a submersible pump is used, the opening between the well casing and any pipes or cables which enter the well shall be closed by a watertight seal or "well cap".

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.

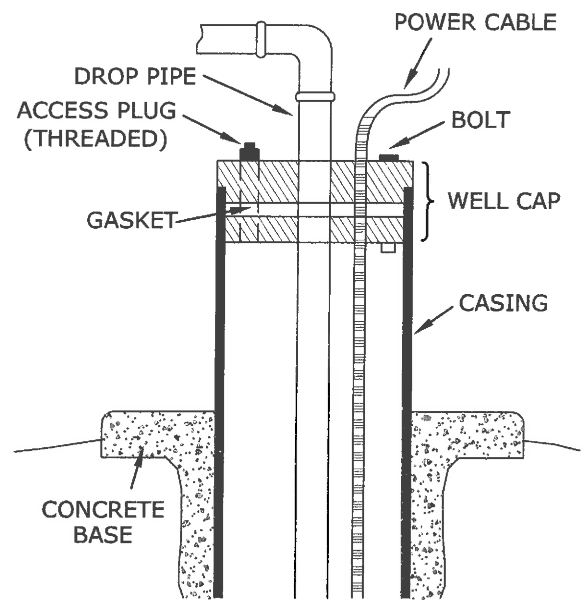
4. A watertight seal or gasket shall be placed between the pump discharge head and the discharge line; or, in the event of a below-ground discharge, between the discharge pipe and discharge line (see ***Figures 5 and 6***).

5. <u>Bases</u>. A concrete base or pad, sometime called a pump block or pump pedestal, shall be constructed at ground surface around the top of the well casing and the contact the annular seal, unless the

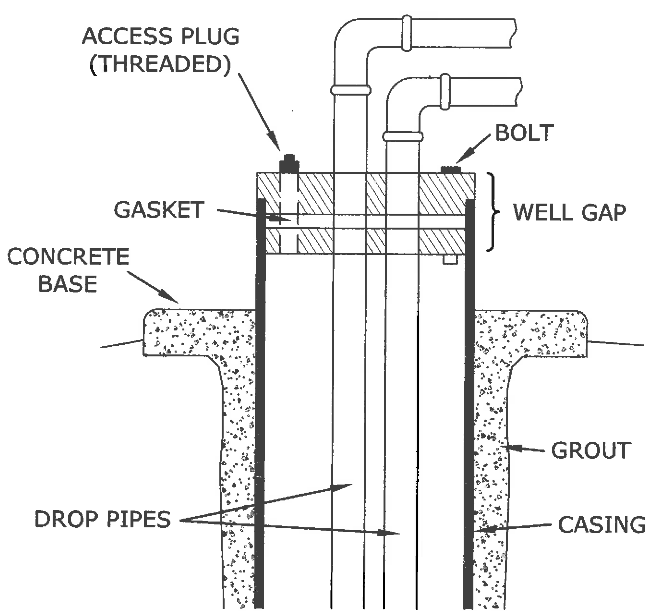
TYPICAL SURFACE CONSTRUCTION FEATURES



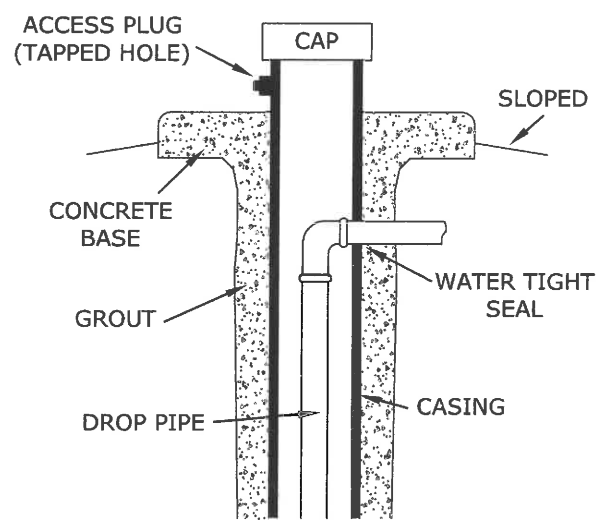
TURBINE PUMP INSTALLATION



SUBMERSIBLE PUMP INSTALLATION



JET PUMP INSTALLATION



BELOW GROUND DISCHARGE

NOT TO SCALE

Follows page 27

FIGURE 5

top of the casing is below ground surface, as provided by Subsection B, ~~Page 23,~~ below.

The base shall be free of cracks, voids, or other significant defects likely to prevent water tightness. Contacts between the base and the annular seal and the base and the well casing, must be watertight and must not cause the failure of the annular seal or well casing. ~~Where cement-based annular sealing material is used, the concrete base shall be poured before the annular seal has set, unless otherwise approved by the enforcing agency.~~

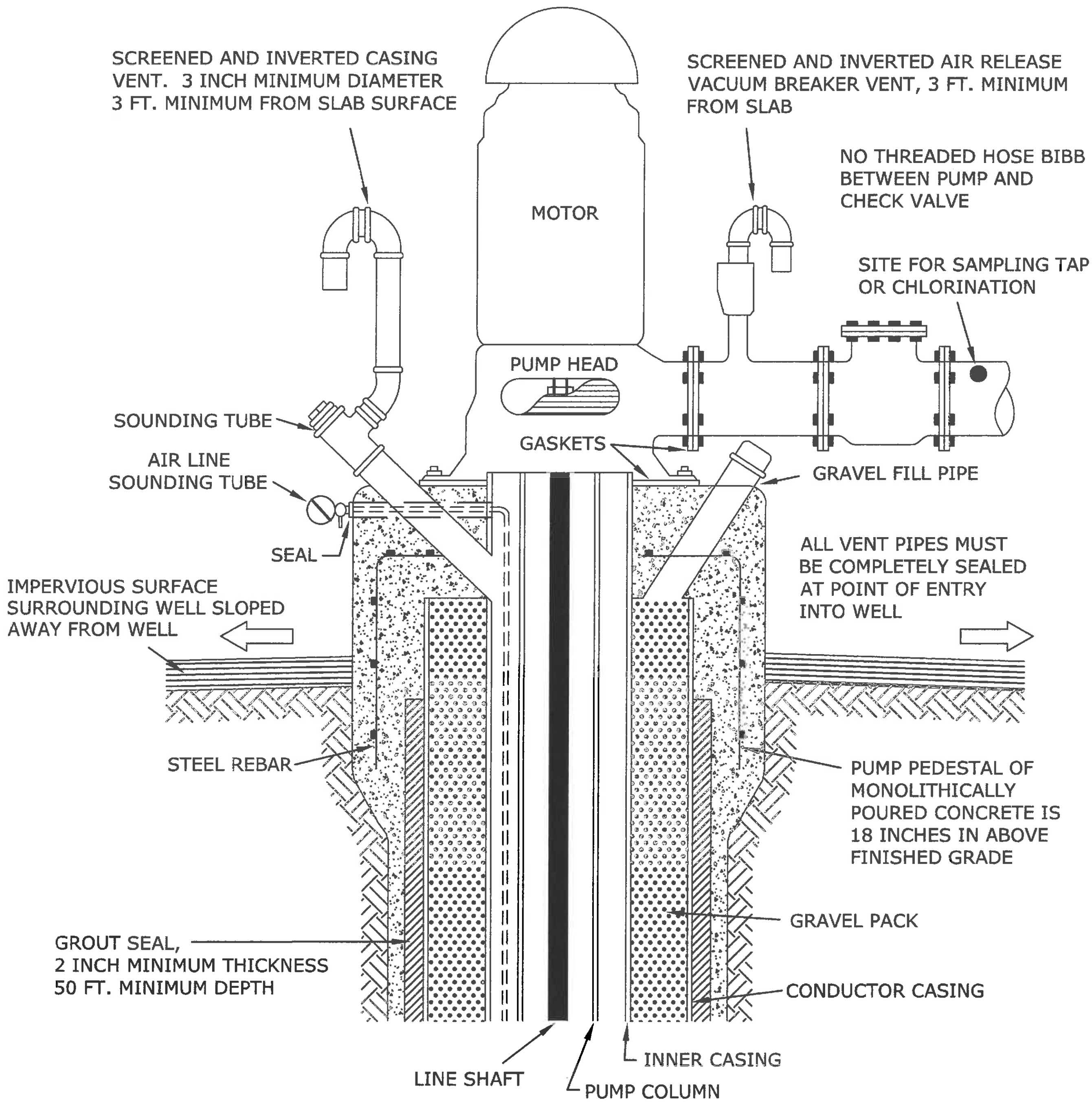
EDITORIAL NOTE: Although ideal, in the "real world" this operation is impractical. Annular seals are usually placed by the driller at a stage in the drilling operation where the drilling machine is still in place, preventing pouring of the base. Additionally, cement seals are placed by the drillers, and the base is usually constructed later by pump installers along with the other surface components of the wellhead. The annular seal itself is the primary prevention against contamination.

The upper surface of the base shall slope away from the well casing. The base shall extend at least two feet laterally in all directions from the outside of the well boring, unless otherwise approved by the enforcing agency. The base shall be a minimum of 4 inches thick.

A minimum base thickness of 4 inches is normally acceptable for small diameter, single-user domestic wells. The base thickness should be increased for larger wells. Shape and design requirements for well pump bases vary with the size, weight, and type of pumping equipment to be installed, engineering properties of the soil on which the base is to be placed, and the local environmental conditions. A large variety of base designs have been used. The Vertical Turbine Pump Association has developed a standard base design for large lineshaft turbine pumps. This design consists of a square, concrete pump base whose design is dependent on bearing weight and site soil characteristics.

EDITORIAL NOTE: The Vertical Turbine Pump Association is cited in Bulletin 74-81. There does not appear to be a "standard" from the California Department of Public Health for well-head design with respect to base and pedestal for municipal wells with large vertical turbine motors; the best example guideline available is shown on Figure 6.

SURFACE CONSTRUCTION FEATURES
COMMUNITY WATER SUPPLY WELL



NOT TO SCALE

FIGURE 6

Follows page 28

Where freezing conditions require the use of pitless adapter, and the well casing and annular seal do not extend above ground surface or into a pit or vault, a concrete base or pad shall be constructed as a permanent location monument for the covered well. The base shall be 3 feet in length on each side and 4 inches in thickness, unless otherwise approved by the enforcing agency. The base shall have a lift-out section, or equivalent, to allow access to the well. The lift-out shall facilitate inspection and repair of the well.

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

EDITORIAL NOTE: Refer to CGA Standard Practice Series Article 290 "Below Grade Well Discharge" for further details.

B. Well Pits and Vaults. The use of well pits, vaults, or equivalent features to house the top of a well casing below ground surface shall be avoided, if possible, because of their susceptibility to the entrance of poor-quality water, contaminants and pollutants. Well pits or vaults can only be used if approval is obtained from the enforcing agency. ~~A substitute device, such as a pitless adapter or pitless adapter unit (a variation), should almost always be used in place of a vault or pit.~~

EDITORIAL NOTE: See discussion of this issue, Section 9.A.4.

Pitless adapters and units were developed for use in areas where prolonged freezing occurs, and below ground (frost line) discharges are common. Both the National Sanitation Foundation and Water Systems Council have developed standards for the manufacture and installation of pitless adapters and units. (See Appendix E, bibliography~~, Page 85 of Bulletin 74-81~~)

If a pit or vault is used it shall be watertight and structurally sound. The vault shall extend from the top of the annular seal to at least ground surface.

The vault shall contact the annular seal in a manner to form a watertight and structurally sound connection. Contacts between the vault and the annular seal and the vault and the well casing, if any, shall not fail or cause the failure of the well casing or annular seal.

~~Where cement-based annular seal materials are used, the vault shall be set into or contact the annular seal material before it sets, unless otherwise approved by the enforcing agency. If bentonite-based sealing~~

~~material is used for the annular seal, the vault should be set into the bentonite before it is fully hydrated.~~

EDITORIAL NOTE: As noted for bases (Section 10.A.5) this operation as specified is impractical. A vault cannot be constructed immediately during the annular sealing operation due to logistical considerations as noted for bases, and the seal will likely have "set up" in any event before vault construction. Vaults now are usually pre-cast, and not poured in place, which further negates the procedure in the language above, which should be eliminated.

Cement-based sealing material shall be placed between the outer walls of the vault and the excavation into which it is placed to form a proper, structurally sound foundation for the vault, and to seal the space between the vault and the excavation.

~~The sealing material surrounding the vault shall extend from the top of the annular seal to ground surface unless precluded in areas of freezing. If cement-based sealing material is used for both the annular seal and the space between the excavation and vault, the sealing material shall be emplaced in a 'continuous pour". In other words, cement-based sealing material shall be placed between the vault and excavation and contact the cement-based annular seal before the annular seal has set.~~

The vault cover or lid shall be watertight but shall allow the venting of gases. ***However, this consideration should not prevent those wells that are "double cased" and are non-vented because they are designed to draw a vacuum to enhance the pumping of water from the aquifer, from being installed in a vault.*** The lid shall be fitted with a security device to prevent unauthorized access. The outside of the lid shall be clearly and permanently labeled 'WATER WELL'. The vault and its lid shall be strong enough to support vehicular traffic where such traffic might occur.

The top of the vault shall be set at, or above, grade so that drainage is away from the vault. The top of the well casing contained within the vault shall be covered in accordance with requirements under Subsection A, above, ~~(Page 36, Bulletin 74-81)~~ so that water, contaminants and pollutants that may enter the vault will not enter the well casing. The cover shall be provided with a pressure relief or venting device for gases.

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.

D. Pump Blowoff. When there is a blowoff or drain line from the pump discharge, it shall be located above any known flood levels and protected against the possibility of back siphonage or back pressure. The blowoff or drain line shall not be connected to any sewer or storm drain except when connected through an airgap.

E. Air Vents. In community water supply wells to minimize the possibility of contamination caused by the creation of a partial vacuum during pumping, a casing vent shall be installed (***Figure 6***). In addition, to release air trapped in the pump column when the pump is not running, air release vents shall be installed (***Figure 6***). Air vents are also recommended for other types of wells except those having jet pump installations requiring positive pressure (which cannot have a vent).

F. Backflow Prevention. All pump discharge pipes not discharging or open to the atmosphere shall be equipped with an automatic device to prevent backflow and/or back siphonage into a well. Specific backflow prevention measures are required for drinking water supply wells, as prescribed in Title 17, Public Health, California Code of Regulations (Sections 7583-7585 and 7601-7605, effective June 25, 1987).

Irrigation well systems, including those used for landscape, and other well systems that employ, or that have been modified to employ, chemical feeders or injectors shall be equipped with a backflow prevention device(s) approved by the enforcing agency.

EDITORIAL NOTE: Refer to CGA Standard Practice Series Article 320 "Backflow Prevention for Agricultural Wells" for further details if needed.

Section 11. Disinfection and Other Sanitary Requirements.

A. Disinfection. All wells producing water for domestic use (i.e., drinking or food processing) shall be disinfected following construction, repair, or when work is done on the pump, before the well is placed in service.

a. Gravel. Gravel used in gravel-packed wells shall come from clean sources and should be thoroughly washed before being placed in the well. Gravel purchased from a supplier should be washed at the pit or plant prior to delivery to the well site.

During the placement of the gravel in the annular space disinfectants (usually sodium hypochlorite in tablet or granular form) shall be added to the gravel at a uniform rate (two tablets per cubic foot or one pound of the granular form per cubic yard).

EDITORIAL NOTE: Refer to CGA Standard Practice Series Article 225 "Gravel Pack Materials and Handling" for further information.

C. Lubricants. Mud and water used as a drilling lubricant shall be free of sewage contamination. Oil and water used for lubrication of the pump and pump bearing shall also be free of contamination.

Section 12. Casing Material *and Installation*.

A. Casing Material. 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 water, and to provide a measure of protection for the quality of the water pump*ed*.

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. There are three principal classifications of steel materials used for water well casing, and all are acceptable for the use so long as they meet the following conditions.

a. Standard and Line Pipe. This material shall meet one of the following specifications, **including the latest revisions thereof**:

1. API Std. 5L, "Specification for Line Pipe"

2. API Std. 5LX, "Specification for High-Test Line Pipe"

3. ASTM A53. "Standard Specification for Pipe, Steel, Black and Hot-Dipped Zinc-Coated Welded and Seamless"

4. ASTM A120, "Standard Specification for Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Ordinary Uses"

5. ASTM A134, "Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (Sizes NPS 16 and over)."

6. ASTM A135, "Standard Specification for Electrical-Resistance-Welded Steel Pipe."

7. ASTM A139, "Standard Specification for Electric-Fusion (Arc)- Welded Steel Pipe (Sizes 4 inches and over)."

~~8. ASTM A211, "Standard Specifications for Spiral-Welded Steel or Iron Pipe."~~ **(Note: apparently withdrawn in 1993 and not replaced)**

9. AWWA C200, "AWWA Standard for Steel Water Pipe 6 inches and larger."

b. Structural Steel. This material shall meet one of the following specifications of the American Society for Testing Materials, including the latest revision thereof:

1. ASTM A36, "Standard Specification for Structural Steel."

2. ASTM A242, "Standard Specification for High Strength Low Alloy Structural Steel."

3. ASTM A283, "Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality."

4. ASTM A441, "Tentative Specification for High-Strength Low Alloy Structural Manganese Vanadium Steel."

5. ASTM A570, **(now A1011/A1011M)** "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 Specifications for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High Temperature Service."

3. Plastic. Two basic types of plastic are commonly used for plastic well casing: thermoplastics and thermosets. Thermoplastics soften with the application of heat and reharden when cooled. Thermoplastics can be reformed repeatedly using heat and sometimes can unexpectedly deform. Attention should be given to the effect of heat on thermoplastic casing from the setting and curing of cement. Additional discussion on sealing material and heat generation is in Section 9, Subsection D, "Sealing Material."

Thermoplastics used for well casing include ABS (acrylonitrile butadiene styrene), PVC (polyvinyl chloride), and SR (styrene rubber). PVC is the most frequently used thermoplastic well casing in California. SR is seldom used.

Unlike thermoplastics, thermoset plastics cannot be reformed after heating. The molecules of thermoset plastic are "set" during manufacturing by heat, chemical action, or a combination of both. The thermoset plastic most commonly used for well casing is fiberglass.

a. Thermoplastics. Thermoplastic well casing shall meet the requirements of ASTM F480, "Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimensions Ratios (SDR), Sch 40 and Sch 80, including the latest revisions thereof. (Note: A "dimensional ratio" is the ratio of the pipe diameter to pipe wall thickness)

Pipe made in Schedule 40 and 80 wall thickness and pipe designated according to certain pressure classifications are listed in ASTM F480, as well as casing specials referencing the following ASTM specifications:

1. ABS Pipe. ASTM D1527, "Standard Specification for Acrylonitrile-butadiene-styrene (ABS) Plastic Pipe, Schedules 40 and 80."

2. PVC Pipe. ASTM D1785-**12**, “Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.

3. Pressure-Rated PVC Pipe. ASTM D2241. “Standard Specification for Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series).”

Thermoplastic well casing that may be subject to significant impact stress during or after installation shall meet or exceed the requirements for impact resistance classification set forth in Section 6.5 of ASTM F480. Casing that may be subject to significant impact forces includes, but is not limited to, casing that is installed in large diameter, deep boreholes; and casing through which drilling tools pass following installation of the casing in a borehole.

2. Thermoset Plastics. Thermoset casing material shall meet the following specifications, as applicable, including the latest revisions thereof:

1. Filament Wound Resin Pipe. ASTM D2996, “Standard Specification for Filament Wound Reinforced Thermosetting Resin Pipe.”

2. Centrifugally Cast Resin Pipe. ASTM D2997. “Standard Specification for Centrifugally Cast Reinforced Thermosetting Resin Pipe.”

3. ~~Reinforced Plastic Mortar Pressure Pipe~~. ***ASTM D3517-11***, “Standard Specification for ***“Fiberglass”*** **(Glass-Fiber Reinforced Thermo-setting-Resin) Pressure Pipe.”**

4. Glass Fiber Reinforced Resin Pressure Pipe. AWWA C950, “Standard Specification for Glass-Fiber Reinforced Thermosetting Resin Pressure Pipe.”

3. Drinking Water Supply. All plastic casing used for drinking water supply wells, including community supply well and individual domestic wells, shall meet the provisions of National Sanitation Foundation Standard No. 14, Plastic Piping Components and Related Materials and any revision thereof. The casing shall be marked or labeled following

requirements in NSF Standard No. 14. Standard No. 14 includes the requirements of ASTM F480.

4. Storage, Handling, and Transportation. Plastic casing shall not be stored in direct sunlight or subjected to freezing temperatures for extended periods of time. Plastic casing shall be stored, handled, and transported in a manner that prevents excessive mechanical stress. Casing shall be protected from sagging and bending, severe impacts and loads, and potentially harmful chemicals.

5. Large Diameter Wells. ~~Because~~ ***Although*** large diameter plastic casing has ~~not~~ been used ~~extensively~~ at depths exceeding ~~500~~ ***1000*** feet, special care shall be exercised with its use in deep wells.

4. Concrete Pipe used for casing should conform to the following specifications, including the latest revisions thereof:

   a. ASTM C14, "Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe."

   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. Unacceptable Casing Material. Galvanized sheet metal pipe such as "downspout", tile pipe, or natural wood shall not be used as well casing.

6. Other Materials. Materials in addition to those described above may be used as well casing, subject to enforcing agency approval.

B. Casing Installation. All well casing shall be assembled and installed with sufficient care to prevent damage to casing sections and joints. All casing joints above intervals of perforations or screen shall be watertight. Any perforations shall be below the depths specified in Section 9, Subsection A, ~~Page 14~~ above.

Casing shall be equipped with centering guides or "centralizers" to ensure the even radial thickness of the annular seal and filter pack.

1. Metallic Casing. Metallic casing may be joined by welds, threads, or threaded couplings. Welding shall be accomplished in accordance with the standards of the American Welding Society or the most recent revision of the American Society of Mechanical Engineers Boiler Construction Code. Metallic casing shall be equipped with a "drive shoe" at the lower end if it is driven into place.

~~2.~~ Plastic Casing. Plastic casing ***may be*** ~~may be joined by solvent welding or~~ mechanically joined by threads or other means, ***such as "Certa-Lok" couplings*** depending on the type of material and it***s*** fabrication. ~~Solvent cement shall be applied in accordance with solvent and casing manufacturer instructions. Particular attention shall be given to instructions pertaining to required setting time for joints to develop strength.~~

2\.

~~The following specifications for solvent cements and joints for PVC casing shall be met, including the latest revisions thereof:~~

~~a. ASTM D2564, "Standard Specification for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings."~~

~~b. ASTM D2855, "Standard Practice for Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings."~~

Plastic casing or screen shall not be subjected to excessive stress during installation and shall not be driven into place. Care shall be taken to ensure that plastic casing and joints are not subjected to excessive heat from cement-based sealing material.

A specifically designed adapter shall be used to join plastic casing to metallic casing or screen.

Section 13. Sealing-Off Strata.

In areas where a well penetrates more than one aquifer, and one or more of the aquifers contains water that, if allowed to mix in sufficient quantity, will result in a significant deterioration of the quality of water in the other aquifer(s) or the quality of water produced, the strata producing such poor-quality water shall be sealed off to prevent entrance of the water into the well or its migration to other aquifer(s).

METHODS FOR SEALING - OFF STRATA

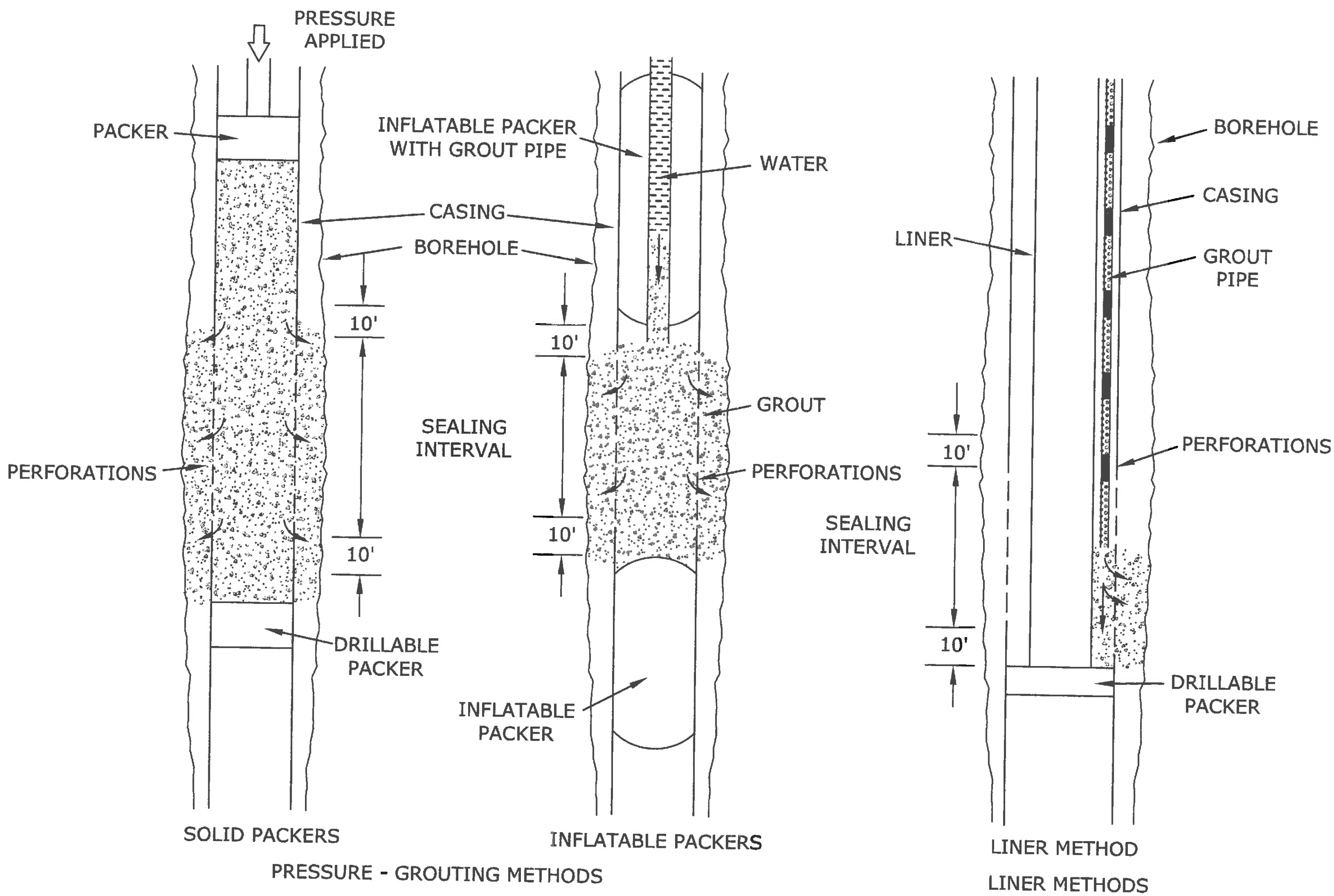


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FIGURE 7

Sealing Methods and Conditions

<u>EDITORIAL NOTE</u>: This section is taken from Appendix B in Bulletin 74-81, "Sealing the Annular Space" and because of its importance is inserted here. However, that portion of Appendix B dealing with "strata seal-off" is expanded and included herein as Section 13.C.

Sealing Methods

When the hole for a well is drilled, a strata may be found that produces water of undesirable quality. To prevent the movement of this water into other strata and to maintain the quality of the water to be produced by the well, such strata must be sealed-off. Also, where a highly porous non-water producing strata is encountered, it too must be sealed-off to prevent the loss of water or hydraulic pressure from the well.

The following methods can be used in sealing-off strata or zones (*Figure 7*). In addition, several of the methods described for sealing the upper annular space can also be used.

.**Pressure Grouting Method.** This method can be employed where a substantial annular space exists between the well casing and the wall of the drilled hole.

1. Perforate the casing opposite the interval to be sealed.
2. Place a packer or other sealing device in the casing below the bottom of the perforated interval.
3. Use a dump bailer or grout pipe to place grout in the casing opposite the interval to be sealed. Sufficient grout shall be placed to fill the annular space and extend out into the strata to be sealed-off.
4. Place a packer or other sealing device in the casing above the perforations.
5. Apply pressure to the top packer to force the grout through the perforations into the interval to be sealed.
6. Maintain pressure until the material has set.
7. Drill out the packers and other material remaining in the well.

SEALING-OFF STRATA

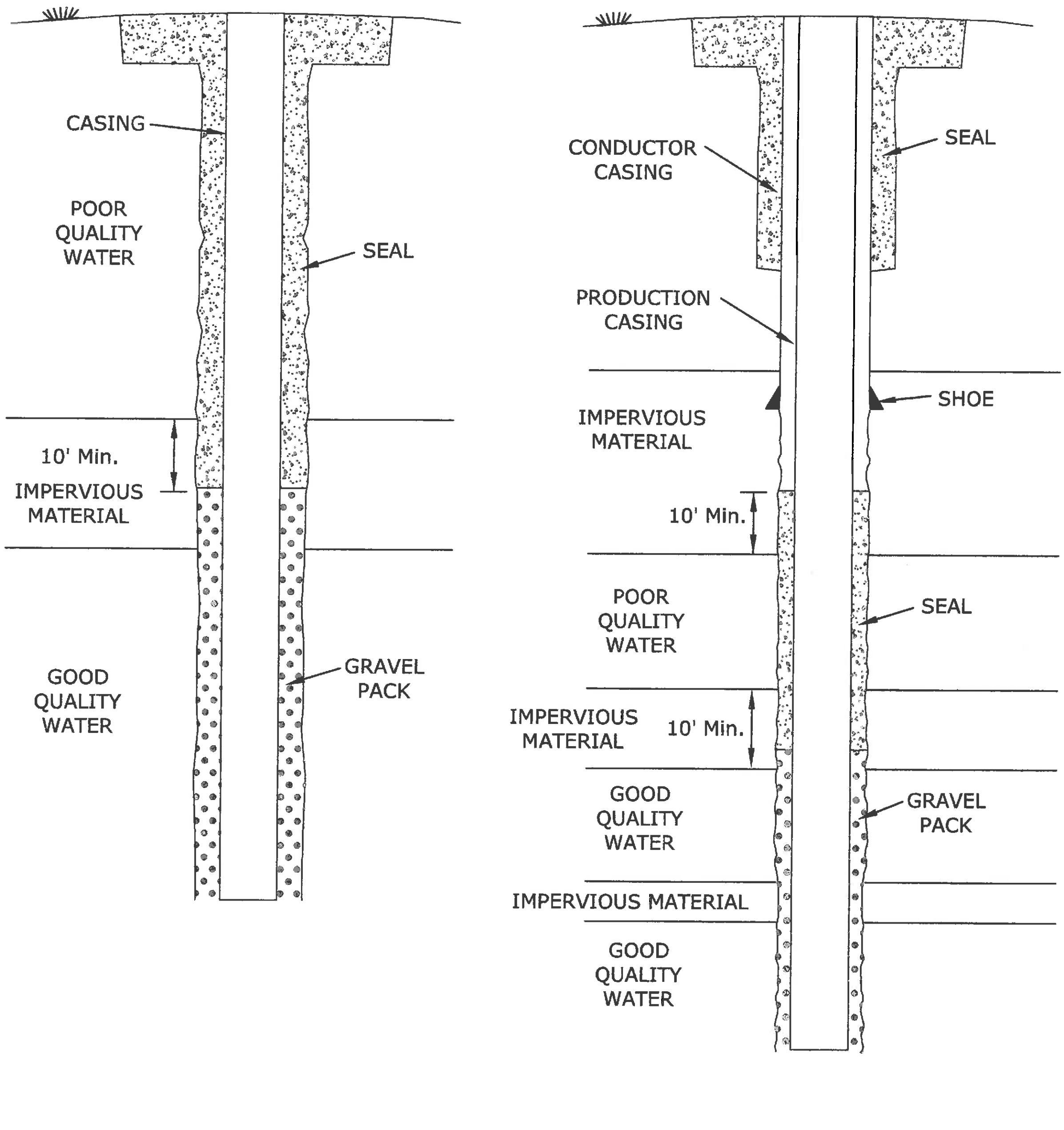

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FIGURE 8

Frequently, an assembly consisting of inflatable (balloon) packers and grout pipe is used. The packers are placed to enclose the interval to be sealed, they are inflated and the grout pumped down the hose (which passes through the upper packer) into the interval to be sealed. Water is then pumped into the interval, squeezing the grout through the perforations. When the grout is sufficiently hardened, the packers are deflated and removed.

Liner Method. When the annular space between the casing and the wall of the drilled hole is minimal, the liner method can be employed.

1. Perforate the casing opposite the interval to be sealed.

2. Place a small diameter metal liner, about 2 inches less in diameter, inside the casing opposite the perforated interval to be sealed, and extend it at least 10 feet above and below the perforated interval.

3. Provide a grout retaining seal at the bottom of the annular space between the liner and the well casing.

4. Extend the grout pipe into the opening between the liner and casing, and fill the annular space with grout in one continuous operation.

5. The bottom end of the grout pipe should remain submerged in the sealing material during the entire time it is being re[placed. The grout pipe is gradually withdrawn as the sealing material is placed.

Conditions

A. Strata producing the undesirable quality water shall be sealed off by placing impervious material opposite the strata and opposite the confining formation(s). (See *Figure 8*) The seal shall extend above and below the strata no less than 10 feet even should the confining formation be less than 10 feet in thickness. In the case of "bottom" waters, the seal shall extend 10 feet in the upward direction. The sealing material shall fill the annular space between the casing and the wall of the drilled hole in the interval to be sealed, and the surrounding void spaces which might absorb the sealing material. The sealing material shall be placed from the bottom to the top of the interval to be sealed.

In areas where deep subsidence may occur (as, for example, portions of the San Joaquin Valley) provisions shall be made for maintaining the integrity of the annular seal in the event of subsidence. Such preventative measures may include the installation of a "sleeve" or "slip joint" in the casing, which will allow vertical movement in the casing without collapse.

B. Sealing material shall consist of neat cement, cement grout, or bentonite clay (see Section 9, Part D for description of the various materials).

C. *The "strata seal off" (liner) method may be employed to seal off fractured intervals containing poor quality water in previously constructed "hard rock" wells that were appropriately sealed and approved in accordance with local regulations. Such wells are not usually cased to their total depth, having a relatively short section of casing installed and sealed through weathered materials into solid rock. At some time after well completion, poor quality water may originate from below the depth of the existing annular seal, and the "strata seal off" (liner) method may be employed to remedy this occurrence (Figure 9).*

In this method, blank and perforated casing 2-inches less in diameter than the production casing should be installed from the surface to the total depth of the well. A packer or "shale-trap" to confine the bottom of the interval to be sealed should be placed at least 10 feet below the contaminated zone (and at least 20 feet from the bottom of the existing production casing), and the top of the sealing material should be at least 10 feet above the contaminated zone. The sealing material can be emplaced in the 1-inch annulus by a small diameter tremie pipe, which is entirely feasible with current grouting materials and equipment.

D. Sealing shall be accomplished by a method approved by the enforcing agency.

Section 14. Well Development.

Development, redevelopment, or reconditioning of a well shall be performed with care, by methods that will not damage the well structure or destroy natural barriers to the movement of poor quality water, pollutants, and contaminants.

Acceptable well development, redevelopment, or reconditioning methods include:

Over pumping;
Surging or swabbing by use of "plungers";
Surging with compressed air;
Backwashing or surging by alternately starting and stopping a pump;
Jetting with water;
Introduced specifically-formulated chemicals into a well; and,
Combinations of the above.

EXISTING WELL STRATA SEAL-OFF

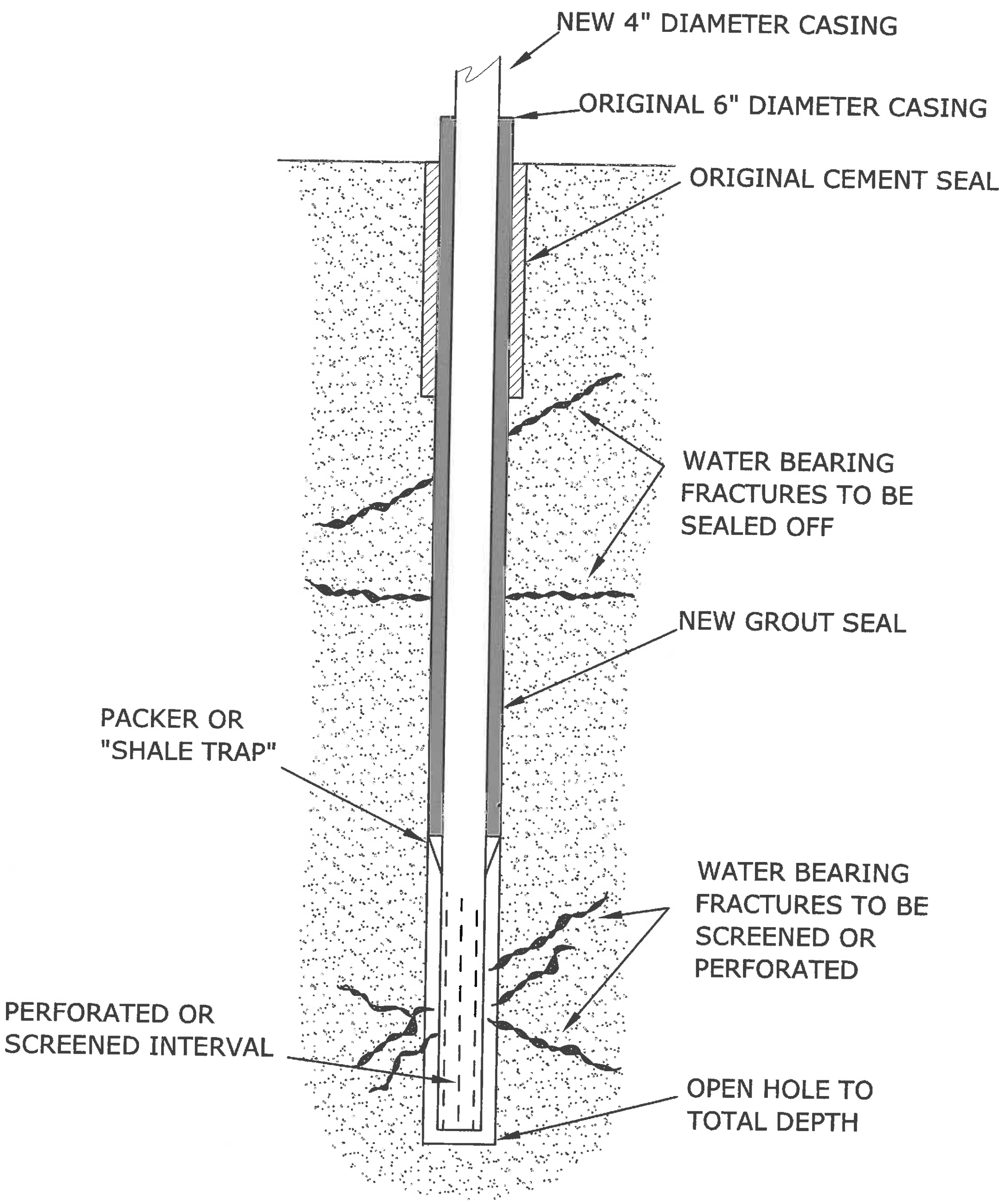

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FIGURE 9

Hydraulic Fracturing (hydrofracturing) is sometimes an acceptable well development and redevelopment method when properly performed. Good quality water shall be used in hydrofracturing. The water shall be disinfected prior to introduction into a well. Material used as "propping" agents shall be free of pollutants and contaminants, shall be compatible with the use of a well, and shall be thoroughly washed and disinfected prior to placement in a well.

Development, redevelopment, or reconditioning by use of specially designed explosive charges is in some cases, another acceptable development method. Explosives shall be used with special care to prevent damage to the well structure and to any natural barriers to the movement of poor-quality water, pollutants, and contaminants. Explosives shall only be used by properly-trained personnel.

Wells subjected to chemicals or explosives during development, redevelopment, or reconditioning operation shall be thoroughly pumped to remove such agents and residues immediately after completion of operations. Chemicals, water, and other wastes removed from the well shall be disposed of in accordance with applicable local, State, and federal requirements. The enforcing agency should be contacted regarding the proper disposal of waste.

EDITORIAL NOTE: Refer to CGA Standard Practice Series Article 227 "Well Development" for further reference if needed.

Section 15. Water Quality Sampling.

The requirements to be followed with respect to water quality sampling are:

A. Community Water Supply Wells and Certain Industrial Wells. The water from all community water supply wells and industrial wells which provide water for use in food processing shall be sampled immediately following development and disinfection, and appropriate analysis made.

Rules and regulations governing the constituents to be tested, type of testing, etc., for community water supply systems are contained in Chapter 15, "Domestic Water Quality Monitoring", of Title 22, California Administrative Code. Water analysis shall be performed by a laboratory certified by the California Department of Public Health. A copy of the laboratory analysis shall be forwarded to the CDPH or the local health department. Approval of the enforcing agency must be obtained before the well is put into use.

Except where there is free discharge from the pump (that is, there is no direct connection to the water delivery system such as to a sump), a sample tap (see Figure 7) shall be provided on the discharge line so that water representative of the water in the well may be drawn for laboratory analysis. The tap shall be located so as to prevent back siphonage to the pump discharge when the pump is shut off (e.g., in the system side of the check valve.

B. Other Types of Wells. To determine the quality of water produced by a new well it should be sampled immediately following construction and development. Appropriate analysis hall be made based upon the intended uses of the water.

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 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 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 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. Where corrugated steel pipe is employed, the joints are not watertight and a thicker annular seal (no less than 6 inches) shall be installed.

C. Dug Wells. All dug wells shall be "curbed" with a watertight curbing extending from above the ground surface to 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) surround on the outside by concrete.

If the curbing is to be made of concrete, poured-in-place, it shall be not less than 6 inches 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.

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

8. Steel used in the manufacture of casing for bored or dug wells should conform to the specifications for casing material described in Section 12. Minimum thickness of steel casing for bored or dug wells shall be:

Diameter Inches	Diameter Millimeters	US Standard Gage or Plate Thickness	
18	450	8 gage	4.18 mm
24	600	¼ inch	6.35 mm
30	750	¼ inch	6.35 mm
36	900	¼ inch	6.35 mm
42	1050	¼ inch	6.35 mm
48	1150	¼ inch	6.35 mm

Corrugated steel pipe used as casing shall meet the specifications (including the latest revision) of ASTM A444, "Standard Specification for Steel Sheet, Zinc Coated (Galvanized) by the HOT-DIP Process for Culverts and Underdrains." The minimum thickness of sheet used shall be 0.109 inches (2.8 mm)

9. Concrete casing can consist of either poured-in-place concrete or precast concrete pipe. Poured-in-place concrete should be sufficiently strong to withstand the earth and water pressure imposed on it during, as well as after, construction. It should be properly reinforced with steel to furnish tensile strength and to resist cracking, and it should be free of honeycombing or other defects likely to impair the ability of the concrete structure to remain watertight. Aggregate small enough to place without "bridging" should be used. Poured-in-place concrete shall be "Class A' (6 sack if Portland cement per cubic yard) or "Class B" (5 sacks of Portland cement per cubic yard.)

Precast concrete pipe is usually composed of concrete rings from 1 to 6 feet in diameter and approximately 3 to 8 feet long. To serve satisfactorily as casing, these rings should be free of blemishes that would impair their strength or serviceability. Concrete pipe shall conform to the specifications listed in Section 12, Part A, item 4.

E. Covers. All bored and dug wells shall be provided with a structurally sound, watertight, cover made of steel or concrete.

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 greater than the diameter of the pipe shall be constructed to a depth of 6 feet and the annular space around the pipe shall be filled with neat cement, cement grout, or bentonite ~~mud~~ ***sealing material***.

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

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;
7. ***brushing and swabbing; or***
8. combination 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 groundwater.

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 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 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.

During prolonged interruptions (i.e., one week or more), a semi-permanent cover shall be installed. For wells cased with steel, a steel cover, tack-welded to the top of the casing, is adequate.

Part III. Destruction of Wells.

Section 20. Purpose of Destruction.

A well that is no longer useful (including exploration and test holes) must be destroyed in order to:

1. Assure that the groundwater supply is protected and preserved for further use.

2. Eliminate the potential physical hazard.

Section 21. Definition of "Abandoned" Well.

Pursuant to Section 115700 of the California Health and Safety Code, ~~A~~ a well is considered "abandoned" or permanently inactive if it has not been used for ***a period of*** one year, unless the owner demonstrates intention to use the well again. In accordance with Section ~~24400~~ ***115700*** of the California Health and Safety Code, the well owner shall properly maintain an inactive well as evidence of intention for future use in such a way that the following requirements are met:

1. The well shall not allow impairment of the quality of water within the well and groundwater encountered by the well.

2. The top of the well or well casing shall be provided with a cover that is secured by a lock or by other means to prevent its removal without the use of equipment or tools, to prevent unauthorized access, to prevent a safety hazard to humans and animals, and to prevent illegal disposal of wastes in the well. The cover shall be watertight where the top of the well casing or other surface openings to the well are below ground level, such as in a vault or below known levels of flooding. The cover shall be watertight if the well is inactive for more than five consecutive years. A pump motor, angle drive, or other surface feature of a well, when in compliance with the above provisions, shall suffice as a cover.

3. The well shall be marked so as to be easily visible and located, and labeled so as to be easily identified as a well.

4. The area surrounding the well shall be kept clear of brush, debris, and waste materials.

If a pump has been temporarily removed for repair or replacement, the well shall not be considered "abandoned" if the above conditions are met. The well shall be adequately covered to prevent injury to people and animals and to prevent the entrance of foreign material, surface water, pollutants, or contaminants into the well during the pump repair period.

Section 22. General Requirements.

All "abandoned" wells and exploration or test holes shall be destroyed. The objective of destruction is to restore as nearly as possible ~~w~~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 procedure 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. Obstructions. The well shall be cleaned, as needed, ***to its total depth if known,*** so that all undesirable materials. Including

obstructions to filling and sealing, debris, oil from oil-lubricated pumps, or pollutants and contaminants that could interfere with well destruction are removed for disposal. ***It should be recognized that despite diligent efforts, such as in trying to extract old pump bowls that have fallen to the bottom of the well, or in attempting to remove collapsed casing, that such efforts may not be successful. The clearing of obstructions should be carried out only to an extent that is reasonably feasible. Demonstrating "proof" of the bottom of the hole may depend on local hydrogeologic conditions and/or requirements of the enforcing agency.***

The enforcing agency shall be notified as soon as possible if pollutants and contaminants are known or suspected to be in a well to be destroyed. Well destruction operations may then proceed only at the approval of the enforcing agency.

The enforcing agency should be contacted to determine requirements for proper disposal of materials removed from a well to be destroyed.

2. ***Casing Destruction:*** Where necessary, to ensure that sealing materials 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.

   Openings in the casing may be made with a gun-perforator per oilfield practice, with an air-percussion perforator, by ripping with a mechanical knife or similar device if casing condition allows, or by explosive devices. PVC casing can be difficult to perforate; in some cases it may be perforated successfully with a "wheel cutter", but more commonly PVC casing must either be "drilled out" or destroyed by use of a detonator cord or shaped charges inserted into the well at selected intervals. After filling the well with neat cement sealing materials, the explosives are detonated, simultaneously opening the casing and driving the sealing material into the annulus and borehole wall. The purpose of any of these operations is to facilitate entry of the sealing material into the annulus and achieve penetration into the native formation or any existing gravel pack to the maximum extent possible.

3. In some wells, it may be necessary or desirable to remove 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:

1. ~~Wells situated in unconsolidated material in an unconfined groundwater zone. In all cases the upper 20 feet of the well shall be sealed with suitable sealing material and the remainder of the well shall be filled with suitable fill, or sealing material. (See Figure 9A, Page 55 of Bulletin 74-81)~~

~~2~~. Well penetrating several aquifers or formations. In all cases the upper 20 feet of the well shall be sealed with impervious material.

In areas where the interchange of water between aquifers will result in a significant deterioration of the quality of water in one or more aquifers, or will result in a loss of artesian pressure, the well shall be filled and sealed ***from the bottom to the top with sealing materials as specified in Section 23.D*** so as to prevent such interchange. ~~Sand or other suitable inorganic material may be placed opposite the producing aquifers and other formations where impervious sealing material is not required. To prevent the vertical movement of water from the producing formation, impervious material must be placed opposite confining formations above and below the producing formations for a distance of 10 feet or more. The formation producing the deleterious water shall be sealed by placing impervious material opposite the formation, and opposite the confining formations for a sufficient vertical distance (but no less than 10 feet) in both directions, or in the case of "bottom: waters, in the upward direction. (See Figure 9B)~~

~~In locations where interchange is in no way detrimental, suitable inorganic material may be placed opposite the formations penetrated. When the boundaries of the various formations are unknown, alternate layers of impervious and pervious material shall be placed in the well.~~

~~3.~~ ***2.*** Well Penetrating Creviced or Fractured Rock. If creviced or fractured rock formations are encountered ~~just below the surface~~, ~~the portions of~~ the well ~~opposite this formation~~ shall be sealed with neat cement, sand-cement grout, or ***bentonite chips*** ~~concrete~~ ***from the bottom of the well to the top***. ~~If these formations extend to considerable depth, alternate layers of coarse stone and cement grout or concrete may be used to fill the well.~~ Fine grained material shall not be used as fill material for creviced or fractured rock formations.

~~4.~~ ***3.*** Well in Noncreviced, Consolidated Formation. The upper 20 ***to 50*** feet of a well ***(depending on original annular seal depth)*** in a noncreviced consolidated formation shall be filled with impervious ***sealing*** material ***as defined in Section 23.D***. The remainder of the well may be filled with ***clean fill materials such as sand or gravel as defined in Section 23.D.*** ~~clay or other suitable inorganic material.~~

~~5.~~ ***4.*** Well Penetrating Specific Aquifers, Local Conditions. Under certain local conditions, the enforcing agency may require that specific aquifers or formations be sealed off during destruction of the well.

C. Placement of Material. The following requirements shall be observed in placing ~~fill or~~ sealing material in wells to be destroyed:

1. The well shall be filled with appropriate material (as described in item D of this section) from the bottom of the well up ***using a tremie pipe which is kept submerged in the mixture and is periodically raised as the well bore is filled***.

2. Where neat cement grout, ***or*** sand-cement grout~~, or concrete~~ is used, it shall be poured in one continuous operation.

3. Sealing material shall be placed in the interval or intervals to be sealed by methods that prevent free fall, dilution, and/or separation of aggregates from cementing materials. ***If bentonite chips are used, they should be screened to eliminate "fines" and installed slowly to prevent bridging, and the fill depth should be measured frequently to assure proper placement.***

4. Where the head (pressure) producing flow is great, special care and methods must be used to restrict the flow while placing the sealing material. In such cases, the casing must be perforated opposite the area to be sealed and the sealing material forced out under pressure into the surrounding formation.

5. In destroying gravel-packed wells, the casing shall be perforated or otherwise punctured opposite the area to be sealed. The ~~sealing material~~ ***neat cement*** shall then be placed within the casing, completely filling the portion adjacent to the area to be sealed and then forced out ~~under pressure~~ into the gravel envelope ***by whatever method is being used***.

6. When pressure is applied to force sealing material into the annular space, the pressure shall be maintained for a length of time sufficient for the cementing mixture to set.

7. To ensure 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. ***Used drilling muds or cuttings are not acceptable sealing materials.***

~~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 per year. Used drilling muds are not acceptable.~~

Recommended sealing materials include: neat cement, sand-cement, bentonite, or combinations of these materials. In some cases, additives are used to affect viscosity, setting time, and strength. It should be noted that make-up water chemistry may be important in determining the ultimate behavior of the sealing materials during placement and curing. The water quality of the make-up water should be checked before operations begin to ensure that the water is compatible with the sealing materials.

- ***Neat cement grout: Neat cement grout generally involves use of a ratio of one 94-pound bag of Portland cement to no more than 6-1/2 gallons of water (which is equal to a 17-sack cement/water mix as available from a "ready mix" source). A small amount of bentonite (up to 6% by weight) may be added to make the mixture more "fluid" and reduce shrinkage. Special additives may be needed to prevent deterioration of the cement column in areas subjected to seawater intrusion, for example.***

- ***Sand-cement mixtures: Sand-cement mixtures increase the "bulk" and might be used in such situations as filling a large diameter hand-dug well. The recommended mixture is generally 2 parts sand to 1 part Portland cement by weight and about 7 gallons of water.***

- ***High solids sodium bentonite: This type of "sealing grade" grout consists of 20 to 30% solids content by weight of sodium bentonite when mixed with water. Pumping in place is necessary for this bentonite to lower the viscosity, and generally higher pumping pressures are needed than normally used with cement grout. Bentonite sealing material will not "gel" properly and should not be used in wells that penetrate formations containing water of higher salinity (generally 2,000 parts per million TDS or greater) such as in coastal areas subjected to seawater intrusion. Also, in such subsurface environments, increasing formation water salinity with time may compromise the sealing properties of bentonite.***

- ***Bentonite chips: These grouts products, commonly known as "Hole Plug" or medium and coarse "Enviroplug" are intended to be poured into the well to form a seal. The materials readily absorb water and form a very low permeability and permanent seal. Being denser than water they can be poured through standing water.***

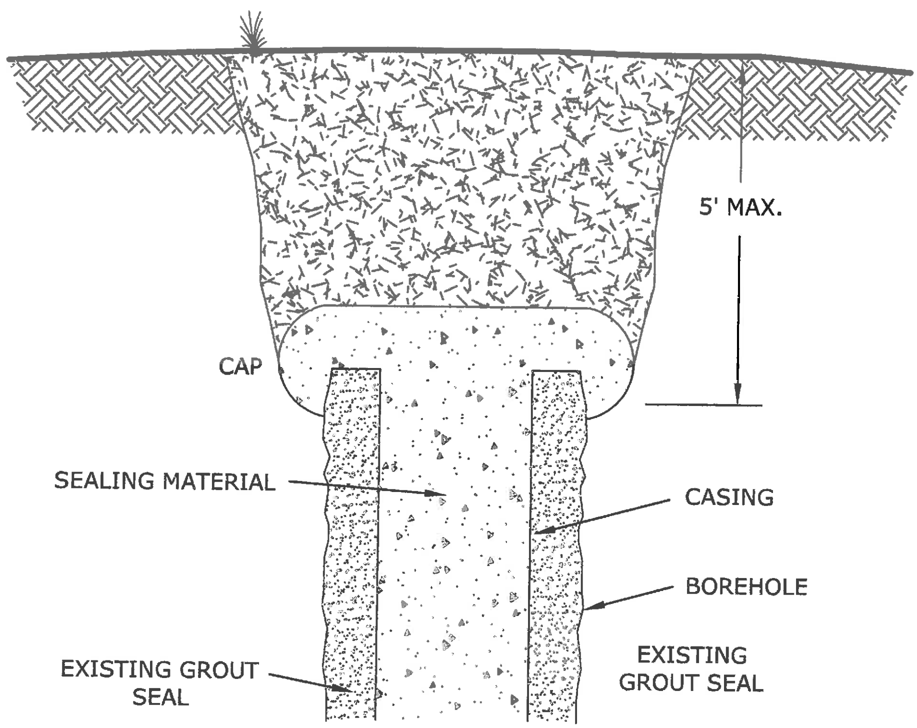
- ***Materials for filling: In cases where no sealant is needed to prevent water flow and materials are only needed to fill the well, such as completed in a non-creviced, consolidated formation, coarse sand or gravel may be employed. These materials should be clean and not contaminated, and of a particle size that minimizes the potential for "bridging" during placement.***

~~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 9A***):

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

PROPER WELL DESTRUCTION
UPPER SEALING FEATURES
URBAN AREA WELL



NOT TO SCALE

FIGURE 9A

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. ***However, it should be noted that old wells that have been "sand pumpers" may have a cavity surrounding the top of the well, and excavation for the "mushroom" cap may be hazardous to the safety of personnel and equipment, as the soil in the annulus around the excavation of the casing may be unstable. Cutting off the casing at a lesser depth than 5 feet may be warranted in such a situation, along with emplacement of sealing material to a minimum depth of 20 feet. With this treatment, the "mushroom" cap is not recommended.***

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

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.

G. Disposal of Fluids and Solids: Disposal of fluids and solids resulting from well destruction operations should be accomplished in accordance with applicable local and State regulations relative to "Best Management Practices (BMP)".

H. Records: Records of the materials and well destruction procedures are normally required by enforcing agencies and their requirements should be adhered to. It is always useful to survey the well location using a GPS system so the location of a destroyed well may be recovered if a problem or contamination, for example, should arise in the future. In addition, a method of visual identification such as a marker or ID tag could be placed at the well location (or above it, if top of casing is below ground) and would be useful in recovering the location at a later date.

EDITORIAL NOTE: For further information, refer to CGA Standard Practice Series Article 299 – "Destruction of Water Wells," and/or references (some of which have been updated) cited therein. Another reference is Section 11 "Permanent Well and Test-Hole Decommissioning" in the April 2011 draft of the National Groundwater Association (NGWA) ANSI/NGWA-01-07 Water Well Construction Standard.

(End of Chapter II)

Chapter III. MONITORING WELL STANDARDS

Introduction

Groundwater monitoring wells are principally used for observing groundwater levels and flow conditions, obtaining samples for determining groundwater quality, and for evaluating hydraulic properties of water-bearing strata. ~~Monitoring wells are sometimes referred to as observation wells.~~

The quality of water intercepted by a monitoring well can range from drinking water to highly polluted water. In contrast, production or water wells are usually designed to obtain water from productive zones containing good-quality water.

In contrast to water supply wells which are typically designed to obtain water from multiple water-bearing strata**, **the screen***ed*** or perforated section of a monitoring well usually extends only a short length to obtain water from, or to monitor conditions within, an individual water-bearing unit or zone. ~~Water wells are often designed to obtain water from multiple water-bearing strata.~~ Although there are usually differences between the design and function of monitoring wells and water wells, water wells sometimes are used as monitoring wells, and vice versa.

Monitoring wells, along with other types of wells, can provide a pathway for the movement of poor-quality water, pollutants, and contaminants. Because monitoring wells are often purposely located in areas affected by pollutants and contaminants, they pose an especially significant threat to groundwater quality if they are not properly constructed, altered, maintained, and destroyed.

The California Legislature amended the California Water Code in 1986 specifically to include requirements for monitoring well standards. Monitoring wells we***re*** previously assumed by the Department to be covered by the collective term 'well" in the law.

History of Monitoring Wells

Monitoring wells were first used mainly for water level measurements. The wells were often referred to as piezometers in reference to the "piezometric surface" of groundwater. ~~In recent years the term "piezometric surface" is often replaced by "potentiometric surface.~~ ~~-~~"However the term "piezometer" is still sometimes used for monitoring wells installed only for water level measurements.

Many water level monitoring wells ~~are~~ constructed in the past were relatively large in diameter in comparison to today's monitoring wells. Wells up to 10-inches in diameter were often constructed to accommodate various means of water level measurement, including floats for mechanically-operated, continuous water level recorders. Many inactive water wells that could accommodate mechanical water level recording equipment were used as monitoring wells.

Modern electronic water level measuring and recording devices now allow for small-diameter water-level monitoring wells. Some continuous water-level measurement devices can be used in wells less than 2-inches in inside diameter **or narrower**

Most monitoring wells constructed today are used to assess:

- The nature and distribution of pollutants and constituents in ~~groundwater~~ ***in the saturated and vadose zones.*** The nature and distribution of naturally occurring chemical constituents **in the saturated and vadose zones;**
- Subsurface hydrologic conditions; The hydraulic properties of strata as they relate to pollutant and contaminant movement; ***and,***
- ***The effectiveness of implemented soil and groundwater mitigation operations***

Some monitoring wells are designed to be multipurpose. Monitoring wells can sometimes be used as "extraction" or "injection" wells for mitigation of pollutants or contamination ***while they are also being monitored. Others can be used to monitor conditions in both the saturated and vadose zones.***

Although a significant number of monitoring wells constructed today are for detection and assessment of groundwater quality impairment, many monitoring wells are constructed for evaluating groundwater supply conditions by allowing groundwater level measurement and/or aquifer testing. Still others are constructed for observing water levels associated with excavations and irrigated agriculture.

Monitoring wells have been constructed in nearly all California counties. ***In some urbanized counties as many as 90 percent of annual well construction and destruction activities are related to monitoring wells.*** ~~The largest concentrations of water quality monitoring wells occur in metropolitan areas of the State. Large numbers of monitoring wells are installed for detetion and assessment of leaks from underground storage tanks.~~

Types of Monitoring Wells

For the purpose of these standards, the term "monitoring well" is limited to wells designated to monitor subsurface ***conditions*** in the saturated and vadose zones. ~~existing at or above atmospheric pressure (groundwater) rather than water, water vapor, and/or gasses contained in the unsaturated or vadose zone. Monitoring devices used for the unsaturated zone differ significantly from those used for the saturated (groundwater) zone.~~
As shown in Figure ***10***, three types of monitoring wells ***commonly installed are:***

- ***Single cased*** monitoring wells;
- Nested monitoring wells; and,
- Clustered monitoring wells

EDITORIAL NOTE: At some sites, polyethelyene Continuous Multi-Channel Tube (CMT) monitoring wells have been installed, where several (3 to 7) smaller channels are extruded to form the CMT well casings. This allows for multi-level monitoring within one borehole. When their useful life has ended, these installations are extremely difficult to destroy. The small diameter of the multi-casings makes effective pressure grouting difficult, and the materials they are made of do not cut, as they are pliable and "stretch", and are very hard if not impossible to drill out. Accordingly, the Subcommittee recommends that the installation of this type of monitoring well should be discouraged, owing to the difficulty in destroying them once they are no longer needed.

Single cased monitoring wells consist of a single casing ~~string~~ within a ***unique*** borehole, as illustrated in Figures ***10*** and ***11***. ***Single cased monitoring wells*** are the most common type of monitoring well constructed in California. ***While single cased monitoring wells typically have only one screened interval to monitor conditions in a single, discrete depth interval, some single cased monitoring wells can contain multiple screened intervals.***

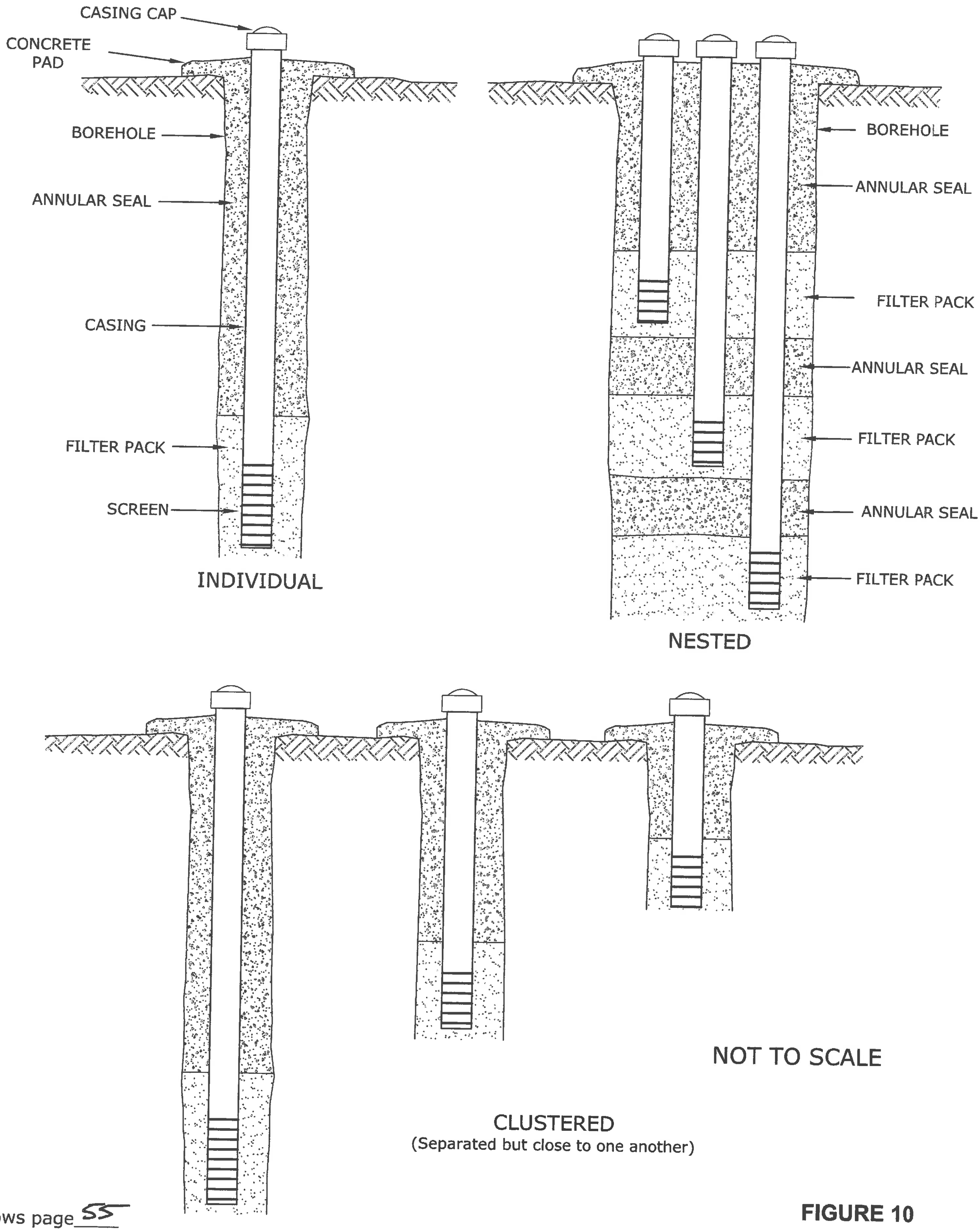
Nested monitoring wells consist of two or more casing***s*** within the same borehole. Normally the screened interval of each casing is designed to obtain groundwater or soil vapor data from ***discrete*** zones.

Clustered monitoring wells consist of individual monitoring wells situated close together but not in the same borehole. The wells within a cluster are normally constructed to obtain water from different aquifers or water-bearing zones. Clustered wells are most often used for monitoring groundwater conditions at various depths in roughly the same area.

~~A nested monitoring well cn be ifficult to construct because of multiple casings within the same borehole. Care is required during construction to ensure water-bearing zones for each casing string are hydraulically isolated from oneanother and the annular seals are effective. Some regulatory agencies may prohibit the use of nested monitoring wells for certain contamination or pollution investigations. Normally this can be due to uncertainties about whether water-bearing strata can be isolated and whether the annular seals in a nested well are always effective.~~

~~Individual casing strings for the various types of monitoring wells discussed above, as sometimes designated to obtain water from more than one aquifer or water-bearing unit. These casing strings usually have multiple intervals of openings or screen. Such well casing strings, often referred to as multi-level monitoing wells" can sometimes serve as a potential pathway for the movement of poor quality water, pollutants, and contaminants from one unit to another. Some regulatory agencies prohibit the use of multi-level monitoring wells for certain pollution or contamination investigations out of concerns for water quality protection and data quality requirements.~~

MONITORING WELL TYPES



Follows page 55

FIGURE 10

Authority and Responsibilities of Other Agencies

These standards are intended to protect groundwater resources by providing direction on monitoring well construction, modification, and destruction. They are intended to provide the minimum requirements at a statewide level. Other Federal, State, and local regulatory agencies also have developed well construction, modification, and destruction guidance documents that pertain to monitoring wells. These guidance documents may be more conservative than this standard, so as to provide added groundwater protection in their jurisdictions. Jurisdictional entities who have adopted a well ordinance should be consulted prior to initiation of any well construction, modification, or destruction activity. Ultimate responsibility for compliance to local, State, and Federal requirements associated with monitoring wells rests with the well owner.

Scope, Organization, and Limitations of Standards

Certain standards that apply to water wells also apply to monitoring wells. Therefore, the Monitoring Wells Standards refer frequently to the Water Well Standards. Standards that apply only to monitoring wells, or that require emphasis are discussed in detail in the Monitoring Well Standards. The Monitoring Well Standards are arranged in a format similar to the Water Well Standards.

The standards are not intended as a complete manual for monitoring well construction, alteration, and destruction. These standards serve only as minimum statewide guidelines towards ensuring that monitoring wells do not ***create a pathway*** for the movement of poor quality water, pollutants, or contaminants. These standards provide no assurance that a monitoring well will performs a desired function. In most cases groundwater monitoring practices and monitoring well performance, or functional requirements, fall under the purview of the various agencies mentioned earlier. Ultimate responsibility for the design and performance of a monitoring well rests with the well owner.

MONITORING WELL STANDARDS

Part I. General

Once a monitoring well is constructed it permanently alters the subsurface environment. Because this alteration can negatively affect our groundwater resources, special care must be taken in the design and construction of monitoring wells so that their impact is minimized, both while they are being used and after their use has ended. Monitoring wells should be designed and constructed to minimize or eliminate the negative effects of the inter-aquifer transfer of fluids and surface water introduction, and be designed in a manner that facilitates their later destruction. At no time should a monitoring well be

designed and constructed such that it cannot be properly destroyed using existing well destruction techniques.

Section 1. Definitions

A. Monitoring Well: The term "monitoring well" is defined in Section 13712 of the California Water Code as:

"...any artificial excavation by any method for the purpose of monitoring fluctuations in groundwater levels, quality of underground waters, or the concentration of contaminants in underground waters."

B. Exploration hole (Boring): An uncased temporary excavation whose purpose is the immediate determination of hydrologic conditions at a site.

C. Enforcement Agency: An agency designated by duly authorized local, regional, or State government to administer and enforce laws or ordinances pertaining to the construction, alteration and destruction of monitoring wells..

Section 2. Application to Well Type.

These standards apply to all types of monitoring wells, except as prescribed in Sections 3, 4, and 5 below. Before a change in use of a well is made any standards for the new use must be complied with.

Section 3. Exemptions for Unusual Conditions.

Under certain circumstances the enforcing agency may waive compliance with these standards and prescribe alternate requirements. These standards may be waived where they are impractical or ineffective because of unusual conditions or would result in an unsatisfactory condition or well function. In waiving any of these standards the enforcing agency shall, if at all possible, require measures be implemented to provide the same or greater level of water-quality protection that would otherwise be provided by these standards.

Section 4. Exclusions.

Most standards in Part II, "Monitoring Well Construction," do not apply to "exploration holes." However, provisions in, Part III, "Destruction of Monitoring Wells," do apply directly to exploration holes.

Exploration holes for determining suitability of on-site sewage disposal that are less than 10 feet in depth are exempt from the reporting and destruction requirements of these standards, ***though these holes should be destroyed such that they do not allow poor quality water to more easily enter the subsurface or act as public nuisances.***

Large volume excavations for determining suitability of on-site sewage disposal, such as backhoe trenches, that exceed 10 feet in depth are exempt from the requirements of Part III of these standards. However, such excavations shall be backfilled with the excavated material or other suitable fill material and the backfill compacted in lifts to attain at least 90 percent relative compaction in order to restore physical conditions in the excavation as much as possible. If a layer or layers of material that serve to impede the movement of poor-quality water, pollutants, and contaminants are penetrated by the excavation, they shall be reestablished to the degree possible to provide protection for underground waters, unless otherwise approved by the enforcing agency. In some cases it may be necessary to backfill all or a portion of the excavation with sealing material meeting these standards to reestablish natural barriers to the movement of poor-quality water, pollutants, and contaminants.

Section 5. Special Standards.

The enforcing agency may prescribe measures more stringent than standards presented here, where needed to protect public safety or protect water quality.

Section 6. Responsible Parties.

Pursuant to Section 13750.5 (Division 7, Chapter 10, Article 3) of the California Water Code; construction, alteration, and destruction of monitoring wells shall be performed by contractors licensed in accordance with the California Contractor's License Law (Division 3, Chapter 9, California Business and Professions Code), except where exempted by law. Construction, alteration, and destruction of monitoring wells to monitor hazardous waste facilities, or underground storage tanks, shall be performed under the supervision of a California Professional ***Civil*** Engineer, California ***Professional*** Geologist, California Certified Engineering Geologist, ***or Certified Hydrogeologist***.

Section 7. Reports.

Monitoring well construction, alteration, and destruction reports shall be completed on forms provided the California Department of Water Resources. Other types of forms may be used for submission to the Department with the prior approval of the Department. The completed forms shall be submitted to the Department in accordance with relevant provisions of Sections 13750 through 13754 (Division 7, Chapter 10, Article 3) of the California Water Code. Information concerning completion and submission of well construction, alteration, and destruction reports is contained in ***the document "How to Fill***

Out a Well Completion Report" issued by the California Department of Water Resources, *dated November 1999 or its* latest revision.

Part II. Monitoring Well Construction

As a guiding principle it should be remembered that all monitoring wells should be designed and constructed to also facilitate their eventual destruction at the end of their useful service life.

Section 8. Well Location With Respect to Pollutants and Contaminants, and Structures.

Monitoring wells are usually constructed to observe conditions at defined or required locations. Monitoring well locations are usually selected on the basis of known or suspected hydrologic, geologic, and water quality conditions and the location of pollutant or contaminant sources. Monitoring wells frequently need to be located close to or within areas of pollution or contamination.

A. Separation: Monitoring wells shall be located an adequate distance from known or potential sources of pollution and contamination ***as shown in the table below:***

Potential Pollution Sources and / or Monitoring Well Destruction Obstructions	*Minimum Horizontal Separation Distances * Between Well and Potential Pollution Sources / Well Destruction Obstructions*
Any sewer line (sanitary, industrial, or storm); main or lateral	*10 feet*
Watertight septic tank or subsurface sewage leaching field < 8 feet deep	*10 feet*
Cesspool, seepage pit, seepage sump > 8 feet deep	*20 feet*
Animal or fowl enclosure	*10 feet*
Stream, ditch, drainage course, pond, or lake	*10 feet*
Subsurface utility lines (gas, electrical, water, fiber optics, etc.)	*10 feet*
Underground Storage Tank (UST) pit, subsurface Hazardous Material tank pit, subsurface fuel/product lines, fuel dispensers, etc.	*10 feet*
Building foundation, canopy, overhangs, other structures.	*10 feet*
Water well	*50 feet*

* Separation distances may be encroached if it can be demonstrated to the Department that the monitoring well can be properly destroyed using the enforcement agency's required destruction method and the encroachment will not cause further degradation of the penetrated groundwater.

EDITORIAL NOTE: Although this table is new, and not in Bulletin 74-90, it is not shown red for purposes of this draft.

~~A~~*B.* Flooding and Drainage: Monitoring wells should be located in areas protected from flooding, if possible. Provisions for locating monitoring wells in areas of flooding and drainage are contained in Section 8 of the Water Well Standards.

~~B~~*C.* Accessibility: All monitoring wells shall be located an adequate distance from buildings and other structures to allow access for well maintenance, modification, repair, and destruction, unless otherwise approved by the enforcing agency. ***Care shall be taken to maintain this accessibility throughout the life of the well.***

~~C~~*D.* Disposal of Wastes When Drilling in Contaminated or Polluted Areas: ***All materials generated during permitted activities must be safely***

handled, properly managed, and disposed of according to all applicable Federal, State, and local statutes regulating such. Unless approved by the enforcing agency in no case shall materials/waters generated during permitted construction, destruction, or alteration activities be allowed to enter, or potentially enter, on- or off-site storm drains, dry wells, or waterways, or move off the property where the work is taking place. ~~Drill cuttings and wastewater from monitoring wells or exploration holes in areas of known or suspected contamination or pollution shall be disposed of in accordance with all applicable federal, State, and local requirements. The enforcing agency should be contacted to determine requirements for proper disposal of cuttings and wastewater.~~

Section 9. Sealing the Annular Space *and Excess Borehole.*

The space between the monitoring well casing and the wall of the well boring, usually referred to as the "annular space," shall be effectively sealed to prevent it from being a preferential pathway for the movement of poor quality water, pollutants, and contaminants. Since monitoring wells are often constructed to obtain water from discrete intervals, a secondary purpose of the annular seal can be to isolate the well intake section or screen to one water-bearing unit. The annular seal can also serve to protect the structural integrity of the well casing and to protect the casing from chemical attack and corrosion. Because monitoring wells are often located close to, or within areas affected by pollutants and contaminants, an effective annular seal is often critical for the protection of groundwater quality.

General discussion of sealing methods and requirements ***also applicable to*** monitoring wells is contained in Section 9, and Section 13, of the Water Well Standards. Special requirements for monitoring wells include the following:

A. Minimum Depth of Annular Seal.

1. Water quality monitoring wells and monitoring wells constructed in areas of known or suspected pollution or contamination. The annular space shall be sealed from the top of the filter pack or monitoring zone to ground surface, unless otherwise approved by the enforcing agency. The top of the filter pack or monitoring zone shall not extend into another water-bearing unit above the single water-bearing unit being monitored unless otherwise approved by the enforcing agency. The filter pack or monitoring zone shall not extend into any confining layer that overlies or underlies the unit to be monitored, unless approved by the enforcing agency. The annular surface seal shall be no less than 20 feet in length.

Seal lengths less than 20 feet are permissible only if shallow zones will be monitored and approval has been obtained from the enforcing agency. If possible, special protection shall be provided where a reduced-length seal is used, as described in Section 8 of the Water Well Standards.

2. Other Monitoring Wells: The upper annular seal shall extend from the ground surface to a minimum depth of 20 feet. An annular seal less than 20 feet in length is permissible if provisions in Item 1, above, are followed.

~~3. Sealing Off Strata: Additional annular sealing material shall be placed below the depth of the upper annular seal, as is needed, to prevent the movement of poor quality water, pollutants, and contaminants through the well to zones of good quality water. Requirements for sealing off zones are in Section 13 of the Water Well Standards.~~

EDITORIAL NOTE: This sealing procedure would not be easily accomplished in practice particularly in a small diameter bore hole, so the Subommittee recommends this procedure be stricken.

B. Shallow Water Level Observation Wells: Water level ***monitoring*** wells less than 15 feet in total depth that are used to assess root zone drainage in agricultural areas are exempt from an annular surface seal requirements, unless otherwise required by the enforcing agency. ***When shallow water level monitoring wells are no longer being used for their intended purpose, they shall be properly destroyed.***

C. Areas of Freezing: The top of the annular seal may be below ground surface in areas where freezing is likely. Such areas include those listed in Section 9 of the Water Well Standards. The top of the annular seal shall not be more than 4 feet below ground surface. The remainder of the space above the seal may be made an integral part of a vault, in accordance with Section 10, Subsection E.

D. Vaults: At the approval of the enforcing agency, the top of the annular seal and well casing can be below ground surface where traffic or other conditions require. In no case shall the top of the annular seal be more than 4 feet below ground surface. ***All vaults must be secured so that they do not allow unauthorized access to the monitoring well head, and are completely water-tight.***

E. ***Sealing Excess Borehole: any portion of the borehole that extends more than three (3) feet below the bottom of the casing or penetrates a***

confining layer must be backfilled with 10-sack sand/cement slurry or commercially produced bentonite pellets or chips.

B. Sealing Conditions:

1. Temporary Conductor Casing. If "temporary" conductor casing is used during drilling, it shall be removed during the placement of the casing and annular sealing materials, as described in Section 9 of the Water Well Standards. If the temporary conductor casing "cannot" be removed, as defined in Section 9 of the Water Well Standards, sealing material shall be placed between the conductor casing and the borehole wall, and between the well casing and conductor casing, in accordance with methods described in Section 9 of the Water Well Standards. Sealing material shall extend to at least the depths specified in Subsection A of this section.

2. Permanent Conductor Casing. If a permanent conductor casing is to be installed, the borehole diameter shall ~~be at least 4 inches greater~~ ***large enough to allow for the effective placement of approved sealing material by means of a tremie pipe, while maintaining a uniform annular seal radial thickness of at least one (1) inch between the conductor casing and the borehole wall during and after the sealing*** operation.. ***Similarly, the*** inner diameter of the permanent conductor casing shall be ***large enough to allow for the effective placement of approved sealing materials by means of a tremie pipe, while maintaining a uniform annular seal radial thickness of at least one (1) inch between the conductor casing and the interior (monitoring casing during and after the sealing operation.***

C. Radial Thickness of Seal. ~~A minimum~~ of ~~two inches of sealing material shall be maintained between all casings and the borehole wall, within the interval to be sealed, except as noted in Section 9 of the Water Well Standards.~~ ***The borehole diameter shall be large enough to allow for the effective placement of approved sealing materials by means of a tremie pipe, while maintaining a uniform annular seal thickness of at least one (1) inch between the conductor casing and the borehole wall during and after the sealing operation***. At least ~~two inches~~ **one** inch of sealing material shall also be maintained ***between*** all "casings" in a borehole, within the interval to be sealed unless otherwise approved by the enforcing agency. Additional space shall be provided, where needed, to allow casings to be properly centralized and spaced ad allow the use of a tremie pipe during well construction (if required), especially for deeper wells.

~~C.~~ **EDITORIAL NOTE:** There is much discussion "pro and con" relative to retaining the 2-inch traditional annular space versus the 1-inch annular space, but on balance the Subommittee views the 1-inch annular space as being compatible with current pumping equipment and sealing materials.

D. Sealing Materials: Sealing materials *allowed for sealing the annular space of monitoring wells are Sand/Cement Slurry-Mixed at a ratio of one (1) 94# bag of ASTM Type I or Type II Portland Cement to 188 pounds of clean sand and seven (7) gallons of clean water; commonly known as a "10-Sack Mix:. Up to 6 percent by dry weight of bentonite may be added to the cement. The cement/sand slurry must be fully mixed so that no "lumps" are present and must be free of gravel or foreign material. Special considerations for the use of cement-based sealing materials in monitoring wells are:*

E *Additives: Caution should be exercised in the use of special additives for cement-based materials, such as those used for modifying cement setting time, as increased heat of hydration could affect the integrity of PVC casing. Some additives could also interfere with sensitive water quality determinations.*

F. *Cooling Water: Any cooling water introduced into the well to protect PVC casing from heat build-up during setting of cement-based sealing materials shall be of potable quality.*

Bentonite Chips or Pellets-Bentonite used for annular seals shall be commercially prepared , granulated, pelletized, or shipped/crushed sodium montmorillonite clay. The largest dimension of pellets or chips shall be less than 1/5 the radial thickness of the annular space into which they are placed.

Bentonite mixtures shall be thoroughly mixed with clean water prior to placement. A sufficient amount of water shall be added to bentonite to allow proper hydration. Depending on the bentonite sealing mixture used, 1 gallon of water should be added to about every 2 pounds of bentonite. Water added to bentonite for hydration shall be of suitable quality and free of pollutants and contaminants. Bentonite preparations normally require ½ to 1 hour to adequately hydrate. Actual hydration time is a function of site conditions and the form of bentonite used. Finely divided forms of bentonite generally require less time for hydration, if properly mixed.

Dry bentonite pellets or chips may be placed directly into the annular space below water where a short section of annular space below

water, up to 30 feet in length is to be sealed. Precaution shall be taken to prevent bridging during the blacement of the bentonite seal material. Before placement, chips or pellets should be screened to eliminate "fines".

Unamended bentonite seals should not be used where structural strength of the seal is required or where the seal will dry. Bentonite seals have a tendency to dry, shrink, and crack in arid and semi-arid area of California where subsurface moisture levels can be low. Bentonite clay seals can be adversely affected by subsurface chemical conditions, as can cement-based materials.

Bentonite clay shall not be used as a sealing material if roots from trees and other deep-rooted plants might invade and disrupt the seal, and/or damage the well casing. Roots may grow in an interval containing a bentonite seal depending on surrounding soil conditions and vegetation.

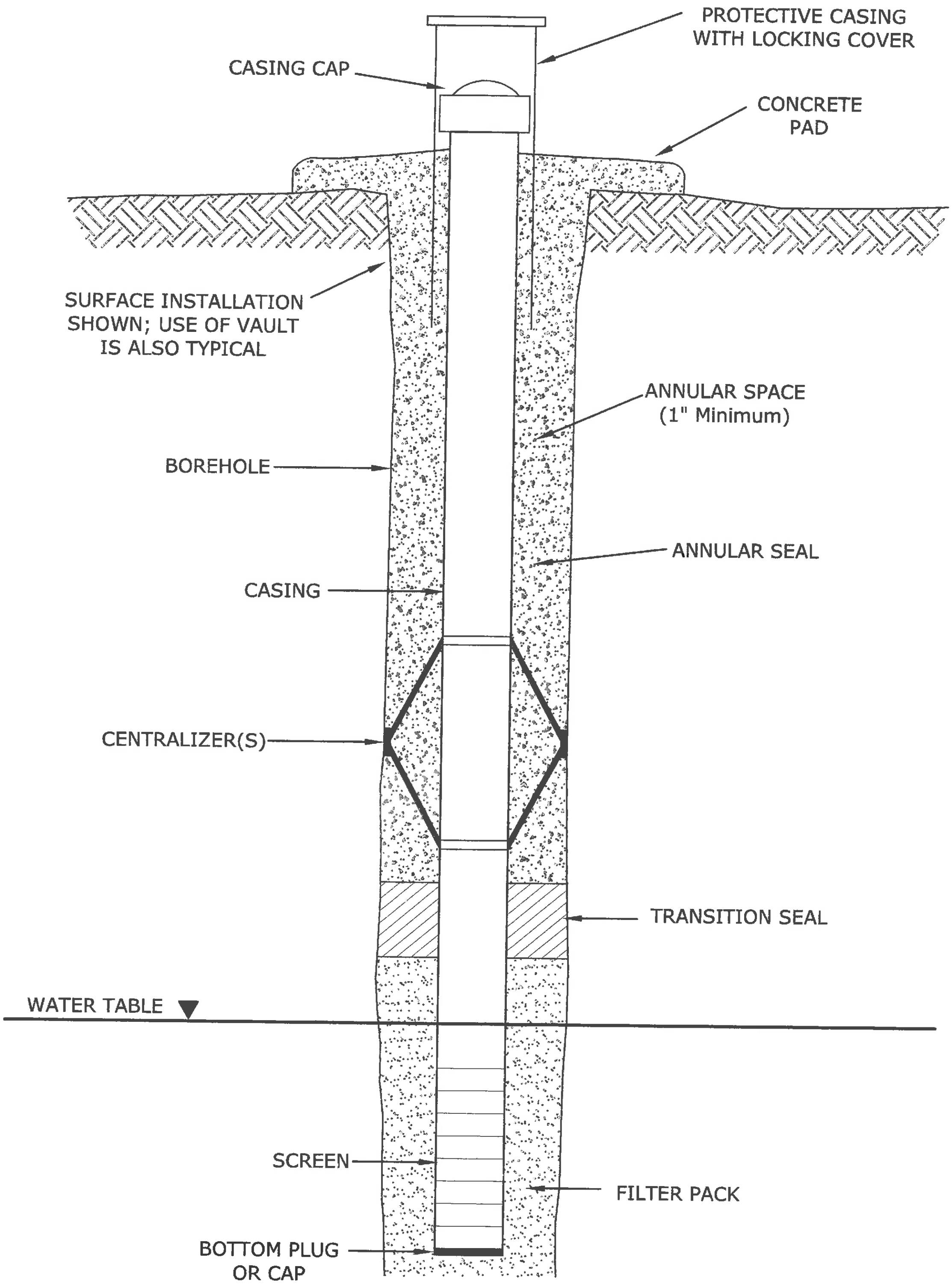
Bentonite-based sealing material shall not be used for sealing intervals of fractured rock or sealing intervals of highly unstable, unconsolidated material that could collapse and displace the sealing material, unless otherwise approved by the enforcing agency. Bentonite based sealing materials should not be used where low soil moisture conditions are present or where large hydraulic pressure gradients (upward or downward vertical gradients) or high groundwater flows are present in the sealed interval.

Sealing material shall_be selected based on ***its*** structural, handling, and sealing properties, and chemical environment into which it ***will be*** placed. Used drilling mud or cuttings from the drilling shall ***never*** be used for any part of ***the*** sealing material.

Water used for sealing mixtures should be of ***potable*** drinking water quality, shall be compatible with the type of sealing material used, shall be free of petroleum and petroleum products, and shall be free of suspended matter. Good-quality water is necessary to ensure that sealing materials achieve proper consistency for placement and achieve adequate structural and settling properties.

G. Transition Seal. A bentonite-based transition seal is ***allowed*** in the annular space to separate filler pack and cement-based seal materials. The transition seal ***is intended to*** prevent cement-based sealing materials from infiltrating the filter pack. A short interval of fine-grained sand, usually less than 2 feet in length ***can also be employed for this purpose. Transition seals shall be installed by using a tremie pipe or equivalent. Sealing materials shall***

CROSS SECTION OF A TYPICAL MONITORING WELL



NOT TO SCALE

Follows page 66

FIGURE 11

not be installed by "free fall" unless the interval to be sealed is less than 30 feet in depth.

Bentonite can be placed in the well annulus in dry form or as slurry for transition seals. Water should be added to the bentonite transition seal prior to the placement of cement-based sealing materials where the bentonite is dry in the borehole. ***Caution*** should be exercised during the addition of water to the borehole to prevent displacing the bentonite.

Water should be added to bentonite at a ratio of about 1 gallon for every 2 pounds of bentonite to allow proper hydration. Water added to bentonite for hydration or to make a slurry shall be of suitable quality and free of pollutants and contaminants.

Sufficient time should be allowed for bentonite transition seals to properly hydrate before cement-based seal materials are placed. Normally, ½ to 1 hour is required for hydration to occur. Actual time of hydration is a function of site conditions.

The top of the transition seal shall be sounded to ensure that no bridging occurred during placement.

H. Placement of Annular Seal Material: All loose cuttings and other obstructions shall be removed from the annular space before setting materials are placed. Sealing may be accomplished by using pressure grouting techniques, a tremie pipe, or equivalent. Sealing materials shall be installed as soon as possible during well construction operations. Sealing materials shall not be installed by "free-fall" from the surface unless the interval to be sealed is less than 30 feet.

Casing spacers ***and centralizers*** shall be used within the interval(s) to be sealed to ***provide for a uniform radial seal thickness and to*** separate individual well casing strings from one another ***(Figure 11)***. . The ***centralizers and*** spacers shall be placed at intervals along the casing to ensure a minimum ***radial thickness of annular seal and casing*** separation of ~~2 inches~~ ***1 inch. Centralizers and s***pacers shall be constructed of corrosion-resistant metal, plastic, or other non-degradable material. Wood shall not be used as ***a centralizer or*** spacer material.

Any metallic component of a ***centralizer or*** spacer used metallic casing shall consist of the same material as the casing. Metallic ***centralizer or*** spacer components shall meet the same metallurgical specifications and standards as the casing to reduce potential for galvanic corrosion of the casing.

The spacing of the casing ***centralizers and*** spacers is normally dictated by casing materials used, the orientation and straightness of the borehole, and the method used to install the casing. Spacers shall not be more than 12 inches in length and shall not be placed closer than 10 feet apart along a casing string within the interval to be sealed, unless otherwise approved by the enforcing agency.

Casing spacers ***and centralizers*** shall be designed to allow the proper passage and distribution of sealing material around casing(s) within the interval(s) to be sealed.

Additional discussion and standards for placement of the annular seal are contained in Section 9, Section 13, and Appendix B of the Water Well Standards.

Section 10. Surface Construction Features.

Surface construction features of a monitoring well shall serve to prevent physical damage to the well, prevent entrance of surface water, pollutants, and contaminants, and prevent unauthorized access ***(Figure 11).***

A. Locking Cover. The top of a monitoring well shall be protected by a locking cover or equivalent level of protection to prevent unauthorized access.

B. Casing Cap. The top of a monitoring well casing shall be fitted with a cap or sanitary seal to prevent surface water, pollutants, or contaminants from entering the borehole. Openings or passages for water level measurement, venting, pump power cables, discharge tubing, and other access shall be protected against entry of surface water, pollutants, and contaminants.

C. Flooding. ***In areas of potential flooding*** the top of the well casing shall terminate above ground surface and known levels of flooding ***or be "water tight",*** except where site conditions, such as vehicular traffic, will not allow.

D. Bases. Unless otherwise approved by the enforcing agency, a concrete base or pad shall be constructed around the top of a monitoring well casing at ground surface and contact the annular seal, unless the top of the casing is below ground surface as provided by Subsection E, below. The base shall be at least 4 inches thick and shall slope to drain away from the well casing. The base shall extend at least 2 feet laterally in all directions from the outside of the well boring, unless otherwise approved by the enforcing agency.

The base shall be free of cracks, voids, and other significant defects likely to prevent water tightness. Contacts between the base and the annular seal, and the base and the well casing must be water tight and must not cause the failure of the well casing or annular seal.

Where ~~cement based annular sealing materials~~ ***sand-cement slurry sealing material*** is used, the concrete base shall be poured before the annular seal has set, unless otherwise approved by the enforcing agency.

E. Vaults. ~~At the approval of the enforcing agency~~ *T*he top of the well casing may be below ground surface because of traffic or other critical considerations. A structurally-sound watertight vault, or equivalent feature, shall be installed to house the top of a monitoring well that is below ground surface. The vault shall extend from the top of the annular seal to at least ground surface. In no case shall the top of the annular seal be more than 4 feet below ground surface.

The vault shall contact the annular seal in a manner to form a watertight and structurally sound connection. Contacts between the vault and the annular seal, and the vault and the well casing, if any, shall not fail or cause the failure of the well casing or annular seal.

~~Where cement based annular seal materials are used, the vault shall be set into or contact the annular seal material before ti sets, unless otherwise approved by the enforcing agency. If bentonite based sealing material is used for the annular seal, the vault should be set into the bentonite before it is fully hydrated.~~

Cement-based sealing material shall be placed between the outer walls of the vault and the excavation into which it is placed to form a proper, structurally sound foundation for the vault, and to seal the space between the vault and excavation. ~~Bentonite based sealing material may be used between the vault and excavation at the approval of the enforcing agency.~~

Sealing material surrounding the vault shall extend from the top of the annular seal to ground surface, unless precluded in areas of freezing. ~~If cement based sealing material is used for both the annular seal and the space between the excavation and the vault, the sealing material shall be placed in a "continuous" pour. In other words, cement based sealing material shall be placed between the vault and the excavation and contact the cement based annular seal before the annular seal has set.~~

The vault cover or lid shall be watertight but shall allow venting of gases, unless otherwise approved by the enforcing agency. The lid shall be fitted with a security device to prevent unauthorized access. The lid shall be clearly and permanently marked "Monitoring Well." The vault and its lid shall be strong enough to support vehicular traffic where such traffic might occur.

The top of the vault shall be set at or above grade so drainage is away from the vault. The top of the casing contained within the vault shall be covered in accordance with requirements under Subsections A and B, above, so that water, contaminants, or pollutants that may enter the vault will not enter the well casing.

F. Protection From Vehicles. Protective steel posts, or equivalent, shall be installed around a monitoring well casing where it is terminated above ground surface in areas of vehicular traffic. The posts shall be easily seen and shall protect the well from vehicular impact

Additional requirements for surface construction features are in Section 10 of the Water Well Standards.

Section 11. Filter Pack

Monitoring well filter pack material shall consist of non-reactive, smooth, rounded, spherical, granular material of uniform size and known composition. Filter pack material shall not degrade or consolidate after placement. The grain size of the filter pack shall be matched to the slot size of the well screen so that any movement of filter pack material into the well will be limited to prevent significant voids in the filter pack that could ultimately destabilize the annular seal.

Filter pack material shall be obtained from clean sources. Filter pack material should be washed and properly packaged for handling, delivery, and storage if particularly if the materials are to be used in monitoring well constructed for sensitive water quality determinations.

Care should be exercised in the storage of filter pack materials at a drilling site to assure that the material does not come into contact with pollutants or contaminants. Care should also be exercised to prevent the introduction of foreign substances, such as clay or vegetative matter that might interfere with the placement and function of the pack.

EDITORIAL NOTE: Refer to CGA Standard Practice Series Article 225 "Gravel Pack Materials and Handling" for further information.

Length—Filter Pack: The filter pack of a montoring well should be designed to best accomplish the monitoring requirements, but should also minimize the possibility of the inter-aquifer transfer of fluids. The filter pack must not extend through or into site-specific or regional barriers to vertical transport of fluids or vapors, or extend more than three (3) feet above or below the screened interval of the well.

Section 12. Casing.

The term "casing" in its broadest sense includes all tubular materials that are permanent features of a well. Screens, collars, risers, liners, and blank casing in monitoring wells maintain the well bore and provide a passage for groundwater level measurement and/or sample-collection devices.

Protective casing usually functions as a temporary means of shoring the walls of a well boring to allow drilling and the placement of well construction materials. Protective casing normally consists of heavy gauge metallic pipe placed over a portion of the well casing that extends above ground surface.

Conductor casing usually functions as a temporary means of shoring the walls of a well boring to allow drilling and the placements of well construction materials. If used, temporary conductor casing is usually driven into place during drilling and is withdrawn at the same time filter pack and annular seal materials are installed around the well casing. Sometimes conductor casing is left in place and is made a permanent feature of the completed well structure, Requirements for sealing permanent conductor casing in place are contained in Section 9.

For the purpose of these standards, the term "casing" applies to screen, collars, risers, and blank casing, and other specialized products used to maintain the well bore. General discussion and standards for casing materials are contained in Section 12 of the Water Well Standards. Special considerations that apply to monitoring well casing are described below:

I. Casing Material

1. Chemical Compatibility. Special consideration shall be given to the selection of casing materials for monitoring wells installed in environments that are chemically "hostile". The selected casing shall resist chemical attack and corrosion.

   Special consideration should be give to the selection of casing materials for wells to be used for sensitive water-quality determinations. Chemical interaction between the casing materials and pollutants, contaminants, groundwater, filter pack material, and geologic materials could bias groundwater quality determinations.

2. Used Casing. Used casing may be acceptable in certain cases, at the approval of the enforcing agency.

3. Plastic and Steel Casing. Plastic and steel well casing materials are commonly used for monitoring wells. The ***principal*** plastics used for water-quality monitoring wells are thermoplastics and fluorocarbon resins.

   Standards for thermoplastic well casing are in Section 12 of the Water Well Standards. The ***principal*** thermoplastic material used for water-quality monitoring wells is polyvinyl chloride (PVC).

   Fluorocarbon casing materials include fluorinated ethylene propylene (FEP) and polytetrafluoroethylene (PTFE). Fluorocarbon resin casing materials are generally considered immune to chemical attack. Fluorocarbon casing materials shall meet the following specifications, including the latest revisions thereof:

   a. ASTM D3296, Standard Specification for FEP-Fluorocarbon Tube.

   b. ASTM D3295, Standard Specification for PTFE Tubing.

   Stainless steel is the most common form of metallic casing used in monitoring wells constructed for sensitive water quality determinations. Stainless steel casing shall meet the provisions of ASTM A312, Standard Specifications for Seamless and Welded Austenitic Stainless Pipe, and shall meet general requirements for tubular steel products in Section 12 of the Water Well Standards.

J. Multiple Screens. Monitoring well casing strings shall not have openings in multiple water-bearing units (multi-level monitoring wells) ~~if poor quality water, pollutants, or contaminants in units penetrated by the well could pass through the openings and move to other units penetrated by the well and degrade groundwater quality~~ unless ~~otherwise~~ approved by the enforcing ***agency.***

K. ***Length of Screened Interval; The length of the perforated or screened casing of a monitoring well should be designed to best accomplish the monitoring requirements. However, to minimize the possibility of inter-aquifer transfer of fluids, the screened interval of the well shall not exceed 25 feet in length, unless approved by the enforcing agency. If multiple screened intervals exist in one well casing, the length of casing from the top of the uppermost screened interval to the bottom of the***

lowermost screened interval, including "blank" casing shall not exceed 25 feet.

L. Bottom Plugs. The bottom of a monitoring well casing shall be plugged or capped to prevent sediments or rock from entering the well.

M. Casing Installation. Discussion and standards for the installation of casing materials are in Section 12 of the Water Well Standards. Special considerations for monitoring wells are:

1. Cleanliness. Casing, couplings, centralizers, and other components of well casing shall be clean and free of pollutants and contaminants at the time of installation.

2. Joining Plastic Casing. Depending on the type of material and its fabrication, plastic casing shall be joined (threaded or otherwise coupled) in a manner that ensures its water tightness. Organic solvent welding cements or glues should not be used. ~~For joining plastic casing if glues or cement compounds could interfere with water quality determinations~~

3. Impact. Casing shall not be subjected to significant impact during installation that may damage or weaken the casing.

Section 13. Well Development.

Monitoring well development, redevelopment, and reconditioning shall be performed with care so as to prevent damage to the well and any strata surrounding the well that serve to restrict movement of poor-quality water, pollutants, and contaminants. Development, redevelopment, and reconditioning operations shall be performed with special care where a well has been constructed in an area of known or suspected pollution or contamination.

All materials generated during well development must be safely handled, properly managed, and disposed of according to all applicable Federal, state, and local statutes regulating such. In no case shall materials/waters generated during well development activities be allowed to enter or potentially enter on- or off-site storm sewers, dry wells, or waterways, or move off the property where the work is taking place.

~~Water, sediment, and other waste removed from a monitoring well for "development" operations shall be disposed of in accordance with applicable federal, State, and local~~

~~requirements. The enforcing agency should be contacted concerning the proper disposal of waste from development operations.~~

Appropriate methods of well development vary with the type and use of a monitoring well. Development methods that may be acceptable under certain circumstances include:

A. Mechanical Surging. Plungers, bailers, surge blocks, and other surging devices shall incorporate safety valves or vents to prevent excessive pressure differentials that could damage casing or screen.

B. Over pumping and Pump Surging. Over pumping and surging may not be suitable for development of wells producing large amounts of sediment because of the potential for clogging or jamming of pumps.

C. Air Development. Some air development methods are not acceptable for monitoring wells to be used for sensitive water-quality determinations.

D. Water Jetting. Water used in jetting operations shall be free of pollutants and contaminants. Water jetting methods are not always acceptable for monitoring wells used for sensitive water-quality determinations.

E. Chemical Development. Extreme care shall be exercised in the use of chemicals for monitoring well development. It is often unacceptable to use chemicals for developing monitoring wells to be used for water-quality determinations. Chemicals introduced for development shall be completely removed from the well, filter pack, and water bearing strata accessed by the well immediately after development operations are completed,

Various methods described above are sometimes used in combination.

Section 14. Rehabilitation and Repair of Monitoring Wells.

For the purpose of these standards, "well rehabilitation" includes the treatment of a well to recover loss in yield caused by incrustation or clogging of the screen, filter pack and/or water-bearing strata adjoining the well, Well rehabilitation methods that may, in certain cases, be acceptable for monitoring wells include mechanical surging, backwashing or surging by alternately starting and stopping a pump, surging with air, water jetting, sonic cleaning, chemical treatment, or combination of these.

Rehabilitation methods shall be performed with care to prevent damage to the well and any barriers that serve to restrict the movement of poor-quality water, pollutants, or contaminants. Chemicals used for rehabilitation shall be completely removed from the well, filter pack, and water-bearing strata accessed by the well immediately after rehabilitation operations are completed. Chemicals, water, and other waste shall be disposed of in accordance with applicable federal, State, and local requirements. The enforcing agency should be contacted regarding the proper disposal of waste from rehabilitation operations.

Rehabilitation methods should be compatible with the use of the monitoring well. Special care should be given to the selection of rehabilitation methods for water-quality monitoring wells.

Materials used for repairing well casing shall meet the requirements of Section 12 of these standards.

Section 15. Temporary Cover.

The well or borehole opening and any associated excavations shall be covered at the surface to ensure public safety and to prevent entry of foreign material, water, contaminants, and pollutants whenever work is interrupted by such events as overnight shutdown, poor weather, and required waiting periods to allow setting of sealing materials and the performance tests. The cover shall be held in place or weighted down in such a manner that it cannot be removed except by equipment or tools.

Part III. Destruction of Monitoring Wells

Section 16. Purpose of Destruction.

The destruction of a well is the last opportunity to restore the hydrologic conditions that existed prior to the well's construction. If a well is not properly destroyed, it can permanently act as a vertical conduit and allow the degradation of groundwater resources. Improperly destroyed wells can also pose significant threats to public health and safety. It is extremely important to destroy monitoring wells in an effective manner when they are no longer needed.

~~A monitoring well or exploration hole subject to these requirements that is no longer useful, permanently inactive, or "abandoned" must be properly destroyed to ensure the quality of groundwater is protected, and eliminate a possible physical hazard to humans and animals.~~

Section 17. Definition of "Abandoned" Monitoring Well.

A monitoring well is considered "abandoned" or permanently inactive if it has not been used for one year, unless the owner demonstrates intention to use the well again. In some cases regulatory agencies may require that an inactive monitoring well be maintained for future use.

In accordance with Section 24400 of the California Health and Safety Code, the monitoring well owner shall properly maintain an inactive well, as evidence of intention for future use, in such a way that the following requirements are met:

(1) The well shall not allow impairment of the quality of water within the well and groundwater encountered in the well.

(2) The top of the well or well casing shall be provided with a cover that is secured by a lock or by other means to prevent its removal without the use of equipment or tools, to prevent unauthorized access, to prevent a safety hazard to humans and animals, and to prevent illegal disposal of wastes in the well. The cover shall be water tight where the top of the well casing or other surface openings to the well are below ground level, such as in a vault or below known levels of flooding. ~~The cover shall be water tight if the well is inactive for more than five consecutive years. A pump motor, angle drive, or other surface features of a well when in compliance with above provisions shall suffice as a cover.~~

(3) The well shall be marked so as to be easily visible and located, and labeled so as to be easily identified as a well.

(4) The area surrounding the well shall be kept clear of brush, debris, and waste materials.

Section 18. General Requirements.

All permanently inactive or "abandoned" monitoring wells and exploration holes subject to these requirements shall be properly destroyed. The purposes of destruction are to eliminate the well structure and borehole as a possible means for the preferential migration of poor-quality water, pollutants, and contaminants; and to prevent a possible hazard to humans and animals.

EDITORIAL NOTE: The entire text from Section 19, Bulletin 74-90 has been replaced by the following in this draft:

Section 19. Requirements for Destroying Monitoring Wells

Two methods for the destruction of monitoring wells are allowed:

1. ***Pressure grout: sealing the well casing and annular filter pack by pumping approved sealing materials, under pressure into the well.***

2. Drill out: the complete removal of all well casing and annular material (seal and filter pack) followed by backfilling the resultant borehole with approved sealing materials.

Prior to submittal of a well destruction permit, the well must be investigated to determine its identity (State Well No. and/or Local Agency Permit No.) condition, detail of its construction and whether conditions exist that will affect a well's destruction (such as debris/materials in the well, or damaged casing). This information must be submitted with the well destruction permit application. An authorized local enforcement agency representative will review the information and well determine which of the above destruction methods is appropriate.

A. Pressure Grout Destruction Requirements

Any of the following criteria will preclude approval of pressure grouting as a destruction method:

1. The well was constructed with more than 3 feet of annular filter pack materials above or below the screened interval.

2. The well was constructed with an annular seal that either extends less than five (5) feet below grade, or has a radial thickness of less than one (1) inch.

3. The well was constructed with a screened interval of more than 25 feet measured from the ~~top~~ to the bottom of the screened interval or intervals.

4. The well was constructed with "sloughing" of native materials in the annular space, above or below the screened interval or at any interval through the annular seal.

5. The well was constructed without and enforcing agency permit and/or inspection of sanitary seal emplacement.

6. The integrity of the annular seal has been compromised.

7. Obstructions, debris, or other materials currently exist in the well casing.

B. Approved Pressure Grouting Method

The following method must be used for pressure grouting:

1. *Before pressurizing, the entire casing must be completely filled with sealing material.*

2. *The sealing material must be pressurized to a minimum of 25 PSI (pounds per square inch).*

3. *25 PSI of pressure must be maintained for at least 5 minutes or until at least an additional 1/3 of the volume of the casing of sealing material (in addition to the material pumped prior to pressurizing) is pumped into the well.*

C. Approved Sealing Material for Pressure Grouting

For a complete discussion of approved sealing materials, refer to Chapter II of the California Well Standards. Because the presence of aggregate in a sealing material would greatly limit the ability of the sealing material to move through the well screen and into the filter pack, only cement grout may be used for pressure grouting. The grout must be mixed at a ratio of one 94 pound sack of ASTM Type I or Type II Portland Cement to 5-6 gallons of clean water, commonly known as a "21-Sack Mix". The grout must be fully mixed so that no "lumps" are present and must be free of gravel or other foreign material. Bentonite should not be added to the cement mix as the resulting increase in viscosity will impede the complete saturation of filter pack with sealing material.

D. Drill-Out Destruction Requirements

Any monitoring well that is not approved for pressure grouting must be completely drilled out (see Pressure Grouting Destruction Requirements, above).

The following method must be used for drill-out well destruction:

1. *The entire well casing, annular seal, and filter pack, and any filter pack or "sluff" beneath the casing, must be completely removed to original borehole depth. To accomplish this, the diameter of the drilling apparatus used must be equal to, or greater than, the diameter of the original borehole.*

2 *The borehole must be completely filled with approved sealing materials.*

E. Approved Sealing Materials for Wells Destroyed by the Drill-Out Method

For a complete discussion of approved sealing materials, refer to Chapter II of the California Well Standards. The only approved sealing material for filling the borehole following a drill-out is Sand-Cement Slurry, mixed at a ratio of one 94-pound bag of ASTM Type I or Type II Portland Cement to 188 pounds of clean sand and 7 gallons of clean water, commonly known as a "10-sack" mix. Up to 6 percent by dry weight of bentonite may be added to the cement. The sand/cement slurry must be fully mixed so that no "lumps" are present and must be free of gravel or other foreign material.

F. Placement of the Sealing Material Following Drill-Out

Following the drill-out opertation and before sealing, all cuttings and other obstructions must be removed from the borehole, Sealing materials should be instlled as soon as possible following the drill-out operation. Sealing material shall not be installed without the use of a tremie pipe, unless the interval to be sealed is less than 30 feet deep.

G. Surface Features Following Monitoring Well Destruction

Surface features of the monitoring well, including but not limited to, a vault, stove pipe, or similar protective structure, must be removed during the well destruction operation and any resulting excavation must be backfilled with appropriate material.

Section 20. Requirements for the Destruction of Exploratory Borings

Exploratory borings are constructed for a variety of reasons, including hydrologic, soil and groundwater quality, and geotechnical investigations. Any boring that has had casing or filter pack materials installed into it is considered to be a well for purposes of these standards, and subject to the permitting and construction/destruction requirements applied to wells.

All exploratory borings should be destroyed within 24 hours of the completion of testing operations, Where the enforcing agency requires permits for borings that extend deeper than 45 feet below ground surface, all exploratory borings deeper than 15 feet below ground surface, all exploratory borings installed at locations *where soil or groundwater contamination is known to be or is potentially present, must be completely backfilled with approved sealing materials following exploratory/testing operations.*

1. ***Approved Sealing Materials for Exploratory Boring Destruction***

   For a complete discussion of approved sealing material, refer to Chapter II of the California Well Standards. The only approved sealing material for filling an exploratory boring is Sand/Cement Slurry: Mixed at a ratio of one 94-pound bag of ASTM Type I or Type II Portland Cement to 188 pounds of clean sand and 7 gallons of clean water, commonly known as "10-sack" mix. Up to 6 percent dry weight of bentonite may be added to the cement. The sand/cement slurry must be fully mixed so that no "lumps" are present and must be free of gravel or other foreign material.

2. ***Placement of the Sealing Materials***

   Before sealing, all cuttings, debris, and other materials must be removed from the borehole. Sealing materials must not be installed without using a tremie pipe, unless the interval to be sealed is less than 30 feet in depth.

(End of Chapter III)

Chapter IV. CATHODIC PROTECTION WELLS

Introduction

Most wells in California are constructed to extract groundwater, inject water, or monitor groundwater conditions. Other, less common types of wells include cathodic protection wells. Cathodic protection wells, sometimes called "deep groundbeds," house devices to minimize electrolytic corrosion of metallic pipelines, tanks, and other facilities in contact with the ground.

Electrolytic Corrosion

For the purpose of these standards, electrolytic corrosion is defined as the deterioration of metallic objects by electrochemical reaction with the environment. The electrolytic corrosion process is illustrated in Figure *12* for a metallic pipeline in a soil-water environment. This process gradually weakens the pipeline and can cause its failure.

In Figure *12*, an electric potential is induced on the surface of the pipeline as a result of variations in the concentrations of salts in the soil and water surrounding the pipeline. This potential results in an electric current in the soil-water electrolyte, Current flows from an "anode area" on the pipeline to a "cathode area" on the pipeline. Metal is removed from the anode area by the current.

Cathodic Protection

"Cathodic Protection" is a term used for certain measures taken to prevent or minimize electrolytic corrosion of metallic equipment and structures. Cathodic protection devices redirect current to flow from a "sacrificial" anode to the soil-water electrolyte, instead of from the anode area on a pipeline or other metallic structure to be protected. The protective anode's role is to corrode in place of the metallic object it is designed to protect, as shown in Figure *13*. The protected facility is made to be a permanent cathode by use of cathodic protection devices. Thus, the facility is said to be "cathodically protected."

Protective or sacrificial anodes can be placed close to ground surface or at significant depth. Anodes have been placed at shallow depths in horizontal and vertical arrays for many years. Shallow arrays are often not well suited for metropolitan areas because of land requirements, or suited for areas where electrical interference may be high.

Deep vertical anode installations, usually referred to as "cathodic protection wells," were first developed and used during the 1940's. They were developed in response to the constraints of shallow anode arrays.

ELECTROLYTIC CORROSION OF A BURIED PIPELINE

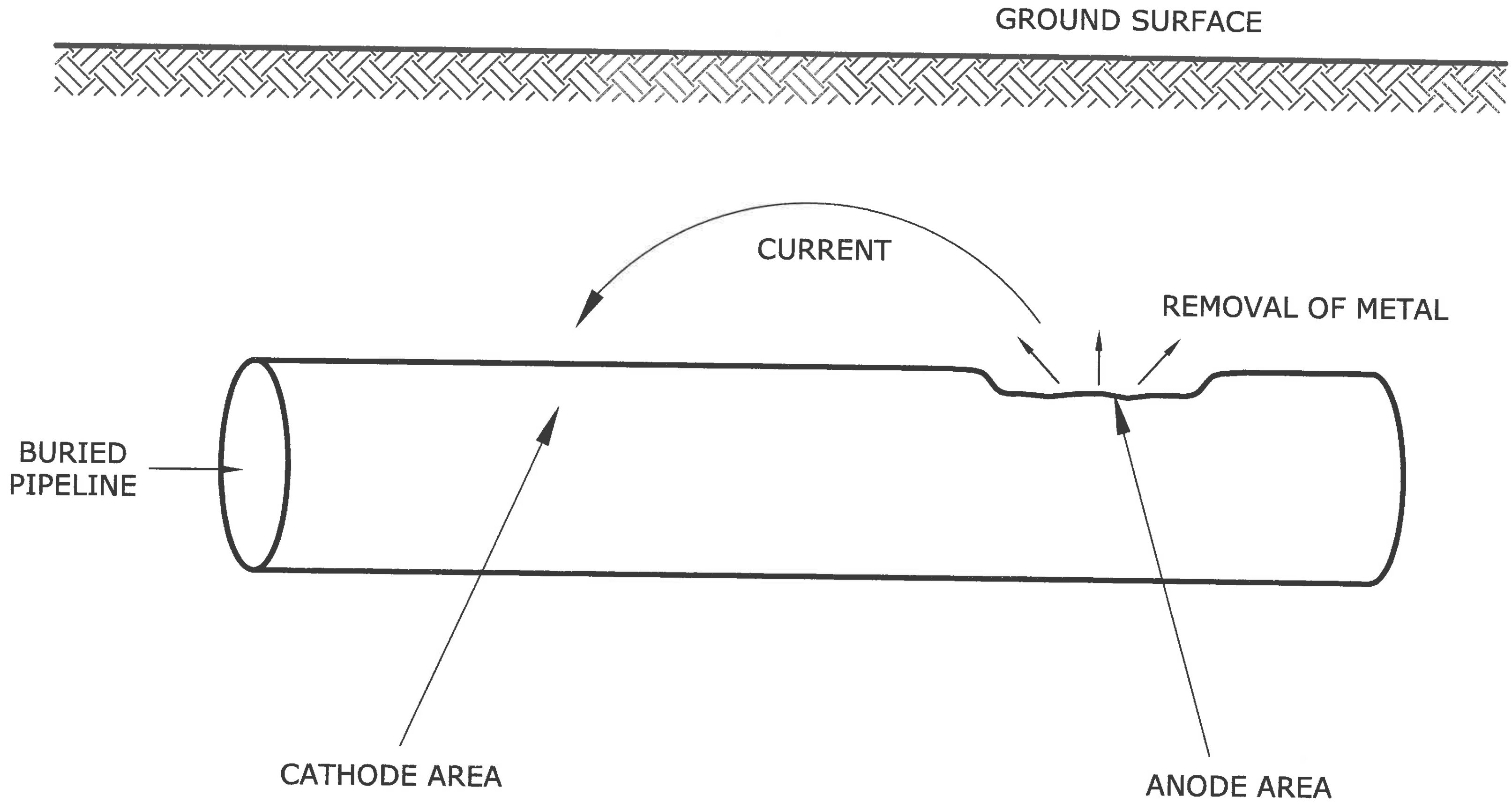


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FIGURE 12

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CATHOTIC PROTECTION OF A BURIED PIPELINE

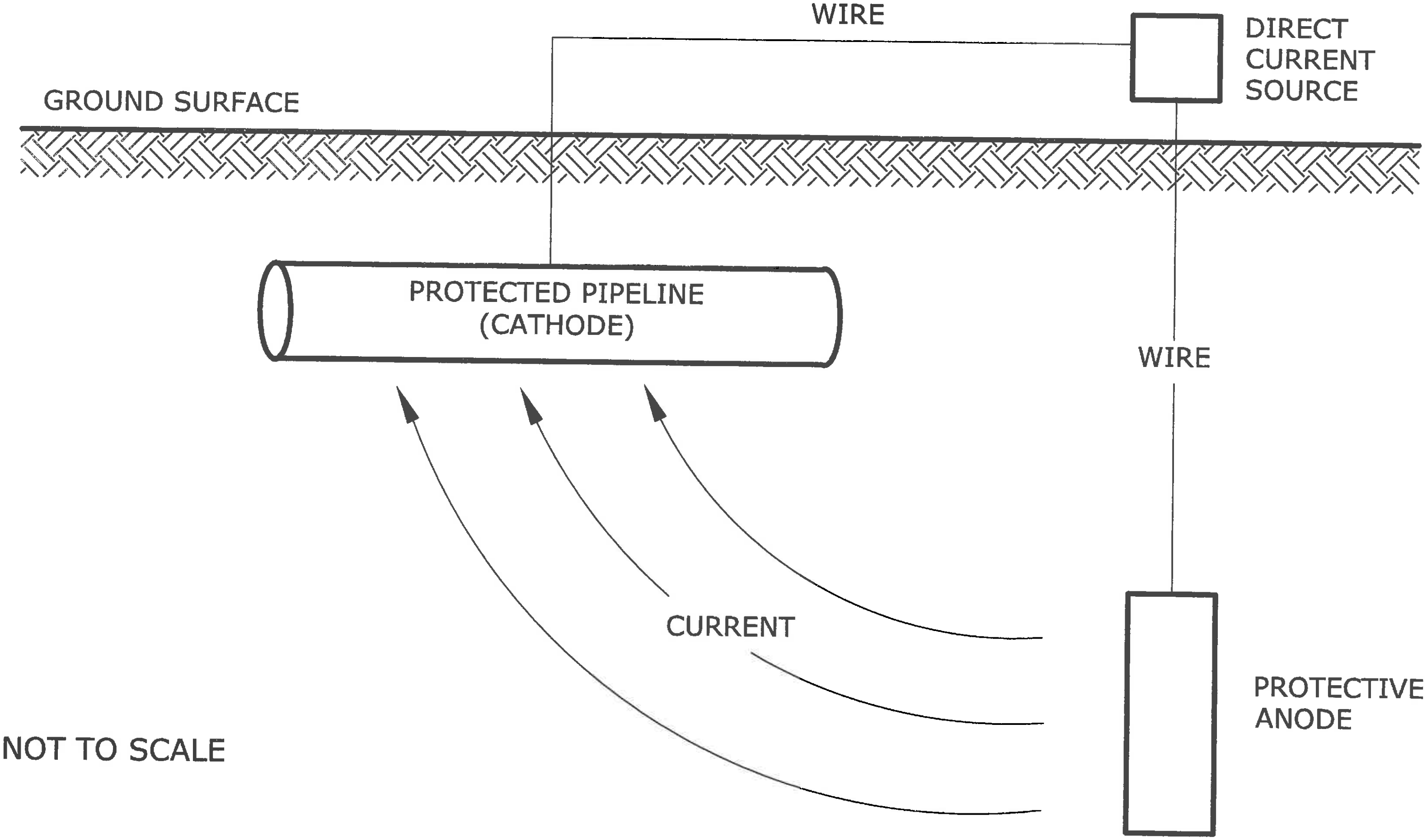

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FIGURE 13

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Cathodic Protection Wells

Cathodic protection wells are widely installed to protect metallic objects in contact with the ground from electrolytic corrosion. Such objects include petroleum, natural gas, and water pipelines, and related storage facilities; telephone cables; and switchyards. Cathodic protection wells are sometimes used to control electrolytic corrosion in large water wells.

Many cathodic protection wells have been constructed to protect pipelines that transport natural gas or other "hazardous" materials. The Natural Gas Pipeline Safety Act, Public Law 90-481 adopted by Congress in August 1968, provides requirements for cathodic protection of certain pipelines.

Most cathodic protection wells in California are located in areas where underground pipelines or "conveyances" systems are numerous and must be protected. These areas include:

- South coastal region from San Diego to Santa Barbara,
- Oil-producing areas of the southern San Joaquin valley and the Central Coast, and,
- San Francisco Bay Area

Cathodic protection wells illustrated in Figure *14* have been constructed by:

1. Drilling a 6-12 inch diameter borehole to a desired depth. Cathodic protection wells normally range from 100 to 500 feet in total depth. A few wells have been constructed to depths of 800 feet. ***A surface casing may be required, in some cases, to control caving of near-surface materials during drilling of the borehole, as shown on Figure 14.***

   EDITORIAL NOTE: Industry standard is 10-inch borehole.

2. Placing a string of anodes in the borehole within a designated interval usually referred to as the "anode interval."

3. Backfilling the anode interval around the anodes with the electrically conductive material, such as granular coke***, with electrically conductive material extending to the bottom of the annular seal***.

   EDITORIAL NOTE: "Granular fill," Item 5 below, is eliminated.

4. Installing a small-diameter vent pipe that extends from the top of the anode interval to land surface, or above. The purpose of the vent pipe is to release generated gases. Medium to large-diameter pipe or casing used in

CROSS SECTION OF A TYPICAL CATHODIC PROTECTION WELL

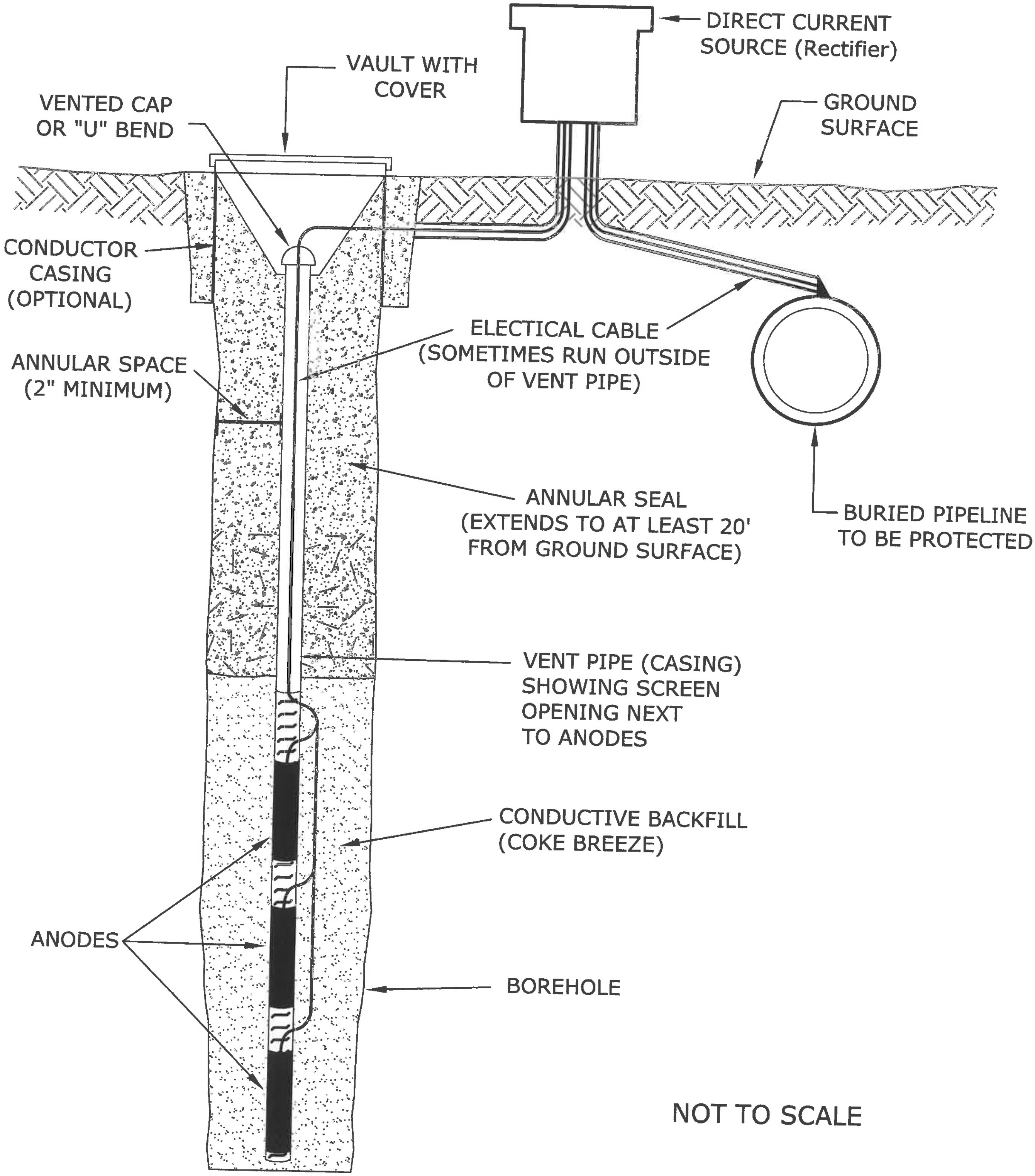

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FIGURE 14

water wells to maintain the well bore and house pumping equipment is not normally used for cathodic protection wells.

~~5. Backfilling the annulus between the vent pipe and borehole wall with an electrically non-conductive fill material to a specific height above the anode interval. Such fill material usually consists of uniform, small-diameter gravel. Its purpose is to provide a permeable medium for migration of gasses and to stabilize the walls of the borehole.~~

~~In the past this material was sometimes used to fill the annulus between the vent pipe and the borehole wall from the top of the anode interval to land surface. These standards require specific interval(s), of the upper annular space of a cathodic protection well be filled with sealing materials instead of gravel, to protect groundwater quality.~~

EDITORIAL NOTE: Consultant Steve McKim noted that California practice is to eliminate use of the granular backfill; conductive material ("coke breeze") contacts the annular seal.

~~6.~~ *5.* Sealing the annulus between the vent pipe and the borehole wall, from the top of the ~~non-~~conductive annular fill to land surface, with sealing material.

~~7.~~ *6.* Installing a permanent cover over the well at ground surface.

~~8.~~ *7.* Connecting the anode leads to the facility to be protected, possibly through an electrical current source.

Individual designs of cathodic protection wells vary, ***and if an "unconventional" well design is proposed (particularly a design that does not facilitate eventual destruction of the well such as the "Matcor Deep Well Anode System" or installations involving conductive concrete instead of coke breeze), permission for its installation should be decided on a case by case basis by the enforcing agency.***

The protective anodes of a cathodic protection well usually corrode away with time. Thus a cathodic protection well's anodes determine the well's useful life. Anodes are usually designed to last 15 to 20 years.

There has been an increasing tendency to construct cathodic protection wells so that anodes can be replaced through the casing. Anode replacement through the casing eliminates the need to drill replacement wells when anodes have been expended.

Corrosion Coordinating Committees

Serious electrical interference problems can occur where cathodic protection networks criss-cross on another or are too close to one another. Also, stray currents produced from electrical transmission lines and other equipment can sometimes interfere with the operation of cathodic protection systems. Interference problems as usually most pronounced in urban areas.

Corrosion control coordinating organizations have been formed in areas of California to overcome system interferences and other problems. Most organizations are affiliated with or are chapters of ***NACE International, The Corrosion Society (www,NACE.org) to whom questions concerning technical issues should be addressed.***

Unfortunately, not all who install and operate cathodic protection facilities work with a corrosion coordinating organization. Those not associated with an organization are usually individuals or local agencies that are sometimes unaware of the existence of other installations. Non-coordinating facilities can seriously interfere with one another electrically.

Need for Cathodic Protection Well Standards

Cathodic protection wells, along with other types of wells, can allow groundwater quality degradation to occur. Improperly constructed or destroyed cathodic protection wells can constitute preferential pathways for the movement of poor-quality water, pollutants, and contaminants. Cathodic protection wells constructed with gravel backfill to land surface are particularly conductive to the movement poor-quality water, pollutants, or contaminants.

Water and electrolytes are sometime introduced into cathodic protection wells through vent pipes, or gravel fill in the annulus, to keep walls functional where natural electrolytes are lacking. Such a practice could be considered "waste disposal" and may be illegal if poor-quality water is used.

Permanently inactive cathodic protection wells pose a threat for the movement of poor-quality water, pollutants, or contaminants and should be properly destroyed. Permanently inactive cathodic protection wells are a threat to groundwater quality because they become dilapidated with time, are sometime forgotten, and are sometimes used for waste disposal.

Many cathodic protection wells have small diameter vent pipes that prevent entry by persons and most animals. However, large vent pipe sizes can pose a serious safety threat if left open at land surface.

History of Cathodic Protection Wells

The California Legislature enacted legislation in 1949 directing the California Department of Water resources to develop recommended water-quality protection standards for the construction and destruction of wells. The Legislature amended the Water Code in 1968 to require standards for cathodic protection wells.

Cathodic protection well standards for California were first published in 1973 as DWR Bulletin 74-1, Cathodic Protection Well Standards: State of California. Standards present here replace those contained in Bulletin 74-1*, **Bulletin 74-81, and Bulletin 74-90***. ~~Additional discussions on the history of well standards is contained in the "Introduction" section of this supplement (Bulletin 74-90) and Bulletin 7-81, Water Well Standards: State of California.~~

Scope of Standards

The following recommended minimum standards for construction, alteration, maintenance, and destruction of cathodic protection wells in California. They only serve as minimum guidelines toward ensuring cathodic protection wells do not constitute a significant pathway for movement of poor-quality water, pollutants, and contaminants. These standards do not ensure a cathodic protection well will perform its corrosion protection function adequately.

The functional requirements of cathodic protection wells may conflict with the application of certain standards for protection of water quality. Consequently, some compromise has been made between well function and resource protection in the development of these standards.

Operation of Standards

These standards are arranged in a format similar to the Water Well Standards. Since many of the standards that apply to water wells also apply to cathodic protection wells, many references are made in these standards to the Water well Standards. Standards that apply only to cathodic protection wells or that require emphasis for cathodic protection wells are discussed in detail in these standards.

Part I. General

Section 1. Definitions.

A. Cathodic Protection Well. A cathodic protection well is defined in Section 13711 of the California Water Code as: "... any artificial excavation in excess of 50 feet constructed by any method for the purpose of installing equipment or facilities for the protection electrically of metal equipment in contact with the ground, commonly referred to as cathodic protection."

EDITORIAL NOTE: Unless changed in the California Water Code, 50-feet depth will remain in the Standards.

B. Enforcing Agency. An agency designated by duly authorized local, regional, or State government to administer and enforce laws or ordinances pertaining to the construction, alteration, maintenance, and destruction of cathodic protection wells.

C. Casing. All vent pipe, anode access tubing, electrical cable conduit, and other tubular material that pass through the interval to be sealed.

D. Conductor Casing. A tubular retaining structure temporarily or permanently installed in the upper portion of the well boring between the wall of the well boring and the inner casing. Conductor casing is often installed to keep the borehole open during drilling if caving conditions are expected. Despite its title, conductor casing does not normally serve an "electrical" function for cathodic protection wells.

Section 2. Exemptions Due to Unusual Conditions.

Under certain circumstances the enforcing agency may waive compliance with these standards and prescribe alternate requirements. These standards may be waived where they are impractical or ineffective because of unusual conditions or would result in an unsatisfactory condition or well function. In waiving any of these standards the enforcing agency shall, if at all possible, require measures be implemented to provide the same or greater level of water-quality protection that would otherwise be provided by these standards.

Section 3. Special Standards.

The enforcing agency may prescribe measures more stringent that standards presented here, where needed to protect public safety or protect water quality.

Section 4. Responsible Parties.

Corrosion control engineers are normally responsible for the design and supervision of corrosion control facilities incorporating cathodic protection wells. Pursuant to Section 13750.5 (Division 7, Chapter 3) of the California Water Code, construction, alteration, and destruction of cathodic protection wells shall be performed by contractors licensed in accordance with the California Contractor's License Law (division 3, Chapter 9, California Business and Professions Code), except where exempted by law. Above-ground electrical facilities for cathodic protection wells should be installed by an appropriate licensed contractor.

Section 5. Reports.

Cathodic protection well construction, alteration, and destruction reports shall be completed on forms provided by the California Department of Water Resources. Other types of forms may be used for submission to the Department with prior approval of the Department. The completed forms shall be submitted to the Department in accordance with relevant Sections 13750 through 13754 (Division 7, Chapter 10, Article 3) of the California Water Code. Information concerning completion and submission of well construction, alteration, and destruction reports is contained in ~~Guide to the Preparation of the Water Well Drillers Report, Department of Water Resources, October 1977,~~ ***the document "How to Fill Out a Well Completion Report" issued by the California Department of Water Resources, dated November 1999,*** or its latest revision.

Part II. Cathodic Protection Well Construction.

Section 6. Well Location With Respect to Pollutants and Contaminants and Structures.

A. Separation. Cathodic protection wells shall be located an adequate distance from known or potential sources of pollution or contamination, where site constraints and corrosion control considerations allow. Potential sources of pollution and contamination include those listed in Section 8 of the Water Well Standards.

If the well is to be located within a known area of contamination, drilling in or near a contaminated site may be subject to additional construction requirements depending on the nature of the site (such as containing multiple alluvial aquifers with confining layers, etc.).

As specified in Section 7 below, the length of the annular seal for a cathodic protection well shall be increased if the well is located in a congested urban area, or located within 100 feet of any potential source of pollution or contamination.

B. Flooding and Drainage. Cathodic protection wells should be located in areas protected from flooding, if possible. Wells located in areas of flooding shall be protected from flood waters and drainage, including protective measures outlined in Section 8, below.

Ground surface surrounding a cathodic protection well shall slope away from the well. Drainage from areas surrounding a cathodic protection well shall be directed away from the well.

C. Accessibility. All cathodic protection wells shall be located an adequate distance from buildings and other structures to allow access for well maintenance, modification, repair, and destruction, unless otherwise approved by enforcing agency.

Section 7. Sealing the Upper Annular Space.

The space between the cathodic protection well casing and the wall of the well boring, often referred to as the "annular space', shall be effectively sealed to prevent it from being a preferential pathway for the movement of poor-quality water, pollutants, or contaminants. In some cases, secondary purposes of the annular seal are to stabilize the borehole wall, protect casing from degradation or corrosion, and ensure the structural integrity of the casing.

General discussion of sealing requirements and methods is contained in Section 9, Section 13of the Water Well Standards. Special requirements for sealing cathodic protection wells are:

A. Minimum Depth of Annular Seal.

1. Minimum Depth. The annular space shall be filled with appropriate sealing material from ground surface to a depth of at least 20 feet below land surface. The annular space shall be sealed to a depth of at least 50 feet below land surface in congested urban areas, or where a cathodic protection well is within 100 feet of any potential source of pollution or contamination. Additional annular sealing material shall be installed to greater depths where adverse conditions exist that increase the risk of pollution or contamination of groundwater.

EDITORIAL NOTE: The Subcommittee recommends retaining the 20-feet sealing depth requirement.

~~2. Fill. Any annular space existing between the base of the annular surface seal and the top of the anode and conductive fill interval shall be filled with appropriate fill or sealing material. Fill material should consist of washed granular material such as sand, pea gravel, or sealing material. Fill material shall not be subject to decomposition or consolidation after placement and shall be free of pollutants and contaminants. Fill materials shall not contain drill cuttings or drilling mud. Sealing material is often more practical and economical to use for filling the annular space than granular material.~~

~~3.~~ **2.** Sealing-Off Strata. Additional annular sealing material shall be placed below the minimum depth of the annular surface seal, as needed, to prevent the movement of poor-quality water, pollutants, and contaminants through the well zones of good-quality water. Requirements for sealing off zones are in Section 10, below.

B. Sealing Conditions. Requirements for sealing the annular space under varied conditions are detailed in Section 9, Subsection B of the Water Well Standards.

C. Radial Thickness of Seal. A minimum of 2 inches of sealing material shall be maintained between all casings and the borehole wall within the interval to be sealed, except where temporary conductor casing cannot be removed as noted in Section 9 of the Water Well Standards. At least 2 inches of sealing material shall be maintained between all casings in a borehole, within the interval to be sealed unless otherwise approved by the enforcing agency. Additional space shall be provided, where needed, to allow casings to be properly centralized and spaced and allow the use of a tremie pipe during well construction (if required), especially for deeper wells.

D. Sealing Material. Sealing material shall consist of neat cement, ***10.3 sack*** sand-cement ***mix***, ~~concrete,~~ or bentonite clay as discussed in Section 9 of the Water Well standards. ~~Cement-based sealing material shall be used opposite zones of fractured rock used. Concrete shall only be used at the approval of the enforcing agency.~~ Drill cuttings and used drilling mud shall not be used as any part of sealing material.

E. ***Transition Seal. A transition seal between the coke breeze and cement-based sealing materials can be utilized but shall not exceed 5 feet in length. The transition seal may be comprised of bentonite granules, pellets, or chips. Bentonite transition seals should be fully hydrated before the emplacement of a cement-based seal (if used) above it.***

F. Placement of Seal. Standards for the placement of annular seals are described in Section 9 and appendix B of the Water Well Standards.

G. ***Drilling Depth. Drilling depth should be planned as to avoid artesian conditions (such as penetrating through a confining clay layer). The vent pipe can act as a casing for artesian flow that might be very difficult to shut off. This condition could result in uncontrolled flow that causes waste and may become a public nuisance. If artesian conditions are perceived to be present or encountered, two or more shallow cathodic protection wells should be considered.***

Section 8. Surface Construction Features.

Surface construction features of a cathodic protection well shall serve to prevent physical damage to the well, prevent the entry of surface water, pollutants, and contaminants, and prevent unauthorized access.

A. Locking Cover. The top of a cathodic protection well shall be protected by a locking cover or equivalent level of protection to prevent unauthorized access. All such covers shall allow the venting of gases.

B. Casing Cap. The top of a cathodic protection well casing shall be fitted with a watertight cap, cover, "U" bend, or equivalent device to prevent entry of water, pollutants, and contaminants into the well bore. All such covers shall allow venting of gases from the well.

C. Flooding. The top of the well casing shall terminate above ground surface and know levels of flooding, except where site conditions, such as vehicular traffic, will not allow.

D. Bases. A concrete base or pad shall be constructed around the top of a cathodic protection well casing at ground surface and contact the annular seal, unless the top of the casing is to be below ground surface as provided by Subsection E, below. The base shall be at least 4 inches thick and shall slope to drain away from the well casing. The base shall extend 2 feet laterally in all directions from the outside of the well boring, unless otherwise approved by the enforcing agency.

   The base shall be free of cracks, voids, and other significant defects likely to prevent water tightness. Contacts between the base and the annular seal, and the base and the well casing must be water tight and must not cause the failure if the well casing or annular seal.

   Where cement-based annular sealing material is used, the concrete base shall be poured before the annular seal has set, unless otherwise approved by the enforcing agency.

E. Vaults. At the approval of the enforcing agency, the top of the cathodic protection well may be below ground surface because of traffic or other critical considerations. A watertight, structurally-sound vault, or equivalent feature, shall be installed to house the top of the well casing if it terminates below ground surface.

   The vault shall extend from the top of the annular seal to at least ground surface. In no case shall the top of the annular seal be more than 4 feet below ground surface.

The vault shall contact the annular seal in a manner to form a watertight, structurally-sound connection. Contacts between the vault and the annular seal, and the vault and the well casing (if any), shall not fail, or cause failure of the well casing or annular seal.

Where cement-based annular sealing materials are used, the vault shall be set into or contact the annular sealing material before it sets, unless otherwise approved by the enforcing agency. If bentonite-based sealing material is used for the annular seal, the vault shall be set into the bentonite before it is fully hydrated.

Cement-based sealing material shall be placed between the outer walls of the vault and the excavation in which it is placed to form a proper, structurally-sound foundation for the vault, and to seal the space between the vault and the excavation.

Sealing material surrounding the vault shall extend from the top of the annular seal to ground surface, unless precluded in areas of freezing. If cement-based sealing material is used for both the annular seal and the space between the excavation and vault, the sealing material shall be emplaced in a "continuous pour." In other words, cement-based sealing material shall be placed between the vault and excavation and contact a cement-based annular seal before the annular seal has set.

The vault cover or lid shall be water tight but shall allow the venting of gases. The lid shall be fitted with a security device to prevent unauthorized access and shall be clearly and permanently labeled "CATHODIC PROTECTION WELL." The vault and it lid shall be strong enough to support vehicular traffic where such traffic might occur.

The top of the vault shall be set at grade, or above, so that drainage is away from the vault. The top of the casing contained within the vault shall be capped in accordance with requirements of Subsection B, above so that water, contaminants, and pollutants that may enter the vault will not enter the well casing.

F. Protection From Vehicles. Protective steel posts, or the equivalent, shall be installed around the cathodic protection well casing where it is terminated above the ground surface in areas of vehicular traffic. The posts shall be easily seen and shall protect the well from vehicular collision.

Additional requirements for surface construction features are contained in Section 10 of the Water Well Standards.

Section 9. Casing.

Vent Pipe, anode access tubing, and any other tubular materials that pass through the interval to be filled and sealed are all considered casing for the purpose of these standards. Materials used for cathodic protection well casing generally shall meet the requirements for casing materials and their installation in Section 12 of the Water Well Standards. Variance from the standards shall be at the approval of the enforcing agency. It is recommended that practices prescribed by the Nation Association of Corrosion Engineers also be followed in the design and installation of gas vents and electrical conduit.

A. *Characteristics:* Cathodic protection well *(vent)* casing should be at least 2 inches in internal diameter to facilitate eventual well destruction*, and use of smaller diameters, such as 1-inch, should be discouraged for this reason. Slots, rather than holes, should be provided to allow the gases to escape, but at the same time to facilitate the flow of cement through the casing during well destruction operations. Recommended slot size for this purpose is 0.060-inch, and the slotted section should extend from 5 feet below the top of the coke breeze, through the conductive material to the bottom of the well, as shown on the typical construction diagram (Figure 14)*.

B. ***Centralizers:** Within the depth interval in which the annular seal will be constructed, centering guides or "centralizers" shall be installed around the vent casing or other tubular structures to ensure that a 2-inch radial thickness seal is maintained throughout the annular seal. Centralizers are not required if the well casing is centered in the borehole during annular seal construction by the use of removable tools, such as hollow-stem augers. No fewer than two (2) centralizers shall be installed in the annular seal interval and they shall be installed at a minimum interval of 40-feet throughout the seal interval. Centralizers must be positioned so as to allow the proper placement of sealing material, and they shall be composed of metal, plastic, or other non-degradable material. If metallic casing is to be installed, any metallic centralizer components shall be comprised of the same material as the casing, so as to reduce the potential for galvanic corrosion of the casing.*

Section 10. *Conductive Materials.*

The conductive material in which the anodes are emplaced is commonly known as "coke breeze" in the industry. Coke breeze commonly consists of either coarse grained materials, designated as equivalent to a 1/8" x 3/8" sand mixture or a "6 x 12" sand gradation, and finer grained materials with the consistency of "silica sand." The coarser mixture is more commonly used in California and is recommended as in combination with the slotted *vent pipe recommended above. The coarser gradation will facilitate transfer of the sealing material beyond the vent pipe during well destruction operations.*

EDITORIAL NOTE: There has been further discussion that the coarser gradation is only suited for "top loading" for shallow well "free-fall" applications, but it cannot be pumped in through a tremie pipe, as the "6 x 12" gradation or "silica sand" mixture can be for deep applications. Ideally the Subcommittee recommends that the coarser gradation used to facilitate grout penetration during well destruction, but as a practicality, this objective may not be achievable in all cases.

Section 11. **Sealing-Off Strata.**

EDITORIAL NOTE: The subcommittee recommends retaing language in paragraphs, Case 1, Case 2, and Case 3, below, and a diagram (Figure 14A) is included to allow the reader to follow the discussion more easily.

If a cathodic protection well penetrates a stratum or strata below the minimum required annular surface seal depth specified in Section 7, above, and that stratum contains poor-quality water, pollutants, or contaminants that could mix with and degrade water contained in other strata penetrated by the well, additional annular sealing material shall be placed below the minimum required annular surface seal to prevent mixing and water-quality degradation.

The following minimum requirements shall be observed for isolating zones containing poor-quality water, pollutants, or contaminants for various cases:

Case1. Upper Stratum. If a stratum containing poor-quality water, pollutants, or contaminants lies above a stratum to be protected, annular sealing material shall extend from the top of the stratum containing poor-quality water, pollutants, or contaminants down to at least 10 feet into the confining layer separating the two strata, or through the entire thickness of the confining layer, whichever is least.

Case 2. Lower Stratum. If a stratum containing poor-quality water, pollutants, or contaminants lies below a stratum to be protected, the annular space opposite the stratum to be protected shall be sealed along its full length. The seal shall extend at least 10 feet into the confining layer separating the two strata, or through the entire thickness of the confining layer, whichever is least.

Case 3. Multiple Strata.

Where two or more strata containing poor-quality water, pollutants, or contaminants are adjacent to one another and overlie a stratum to be protected, the annular space opposite the strata containing poor-quality water, pollutants, or contaminants and opposite all inter-bedded confining

CATHODIC PROTECTION WELLS
SEALING OFF STRATA
(SCHEMATIC)

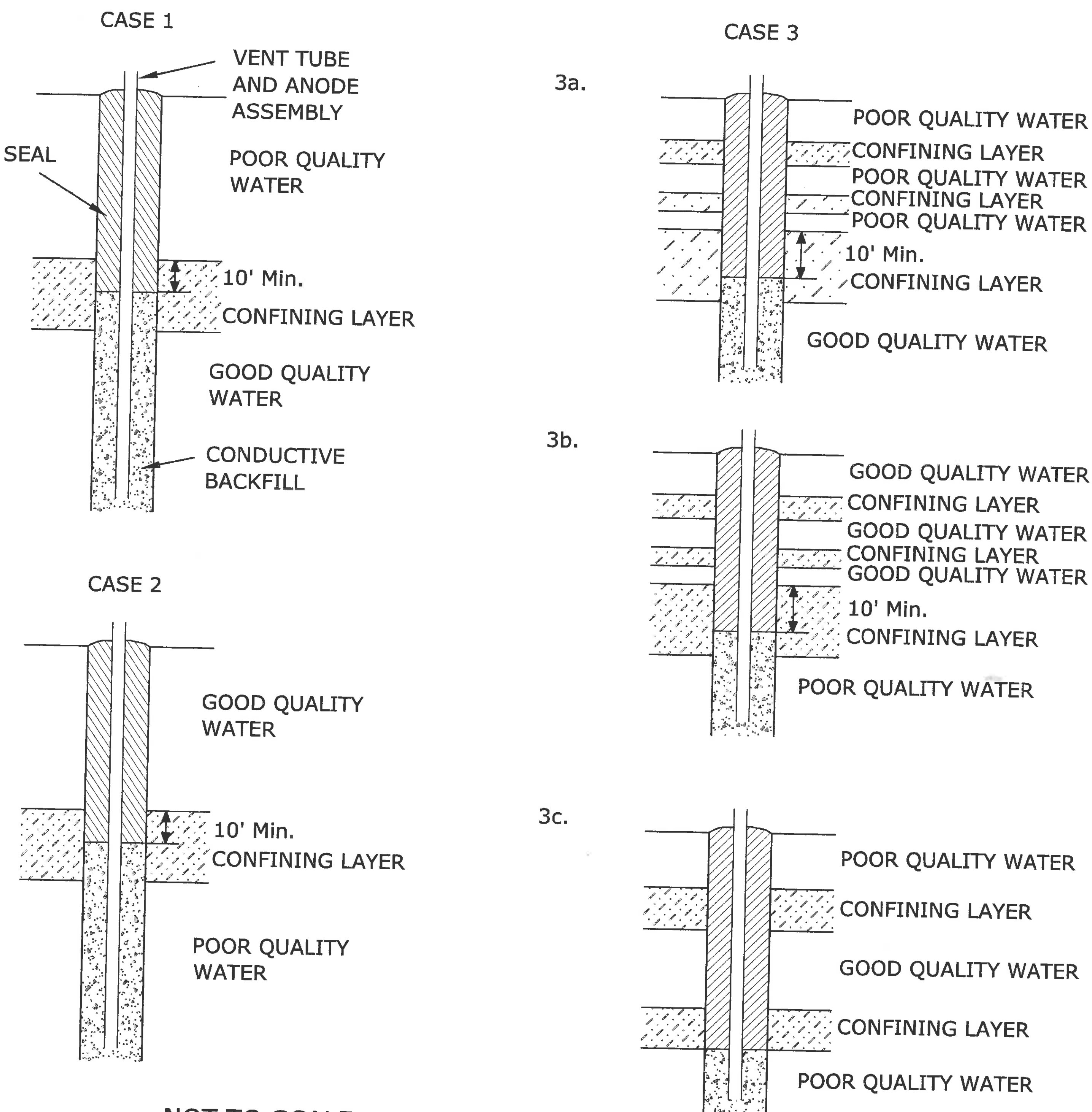

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FIGURE 14A

layers shall be sealed. The annular seal shall extend at least 10 feet down into, or completely through, whichever is least, the confining layer separating the strata containing poor-quality water, pollutants, or contaminants and the underlying stratum to be protected.

a. Where two or more strata containing poor-quality water, pollutants, or contaminants underlie a stratum to be protected, the annular space opposite the stratum to be protected shall be sealed. The seal shall continue down at least 10 feet into, or completely through, whichever is least, the confining layer separating the stratum to be protected and underlying strata containing poor-quality, pollutants, or contaminants.

b. Where two strata containing poor-quality water, pollutants, or contaminants are separated by a stratum to be protected, the annular space opposite the stratum to be protected, the confining strata underlying and overlying the stratum to be protected and upper stratum containing poor-quality water, pollutants, or contaminants shall be sealed off.

The supplementary seals described in the cases above shall be extended up to and contact the base of the required minimum annular surface seal described in Section 7, above, if they are otherwise required to be within 10 feet of the surface seal. Sealing the entire annulus above the anode interval will often economically fulfill the conditions outlined above ***and is recommended in all cases possible to achieve maximum protection of groundwater quality. .***

Requirements for sealing materials and their placement are described in Section 7, above.

Section 1~~1~~2. Repair of Cathodic Protection Wells.

Materials used for repairing cathodic protection wells shall meet the requirements of Section 9, above.

Section 1~~2~~3. Temporary Cover.

The well or borehole opening and any associated excavations shall be covered at the surface to prevent the entry of foreign material, water, pollutants, and contaminants, and to ensure public safety whenever work is interrupted by such events as overnight shutdown, poor weather and required waiting periods to allow setting of sealing materials and the performance tests. The cover shall be held in place or weighted down in such a manner that it cannot be removed except by equipment or tools.

Part III. Destruction of Cathodic Protection Wells

Section 14. Purpose of Destruction.

A cathodic well that is no longer useful, permanently inactive or "abandoned" must be properly destroyed to:

1. Ensure the quality of groundwater is protected, and,

2. Eliminate a possible physical hazard to humans and animals.

Section 15. Definition of "Abandoned" Cathodic Protection Well.

A cathodic protection well is considered "abandoned" or permanently inactive when its anodes are exhausted and cannot, or will not, be replaced. A cathodic protection well is also considered "abandoned" or permanently inactive if it has not been used for one year, unless the owner demonstrates intention to use it again. To provide evidence of intention for future use of a well, the well owner, in accordance with Section 24400 of the Health and Safety Code, shall maintain the well in such a way that the following requirements are met:

1. The well shall not allow impairment of the quality of water within the well and groundwater encountered in the well.

2. The top of the well or well casing shall be provided with a cover, that is secured by a lock or by other means to prevent its removal without the use of equipment or tools, to prevent unauthorized access, to prevent a safety hazard to humans and animals, and to prevent illegal disposal of waste in the well. The cover shall be watertight where the top of the well casing or other surface openings to the well are below ground level, such as in a vault or below known levels of flooding. The cover shall be watertight if the well is inactive for more than five consecutive years. ~~A pump motor, angle drive, or other surface feature of a well, when in compliance with the above provisions shall suffice as a cover.~~

3. The well shall be marked so as to be easily visible and located, and labeled so as to be easily identified as a well.

4. The area surrounding the well shall be kept clear of brush, debris, and waste material.

Section 16. General Requirements.

General requirements for well destructions as contained in Section 23 of the Water Well Standards. Special considerations for cathodic protection wells are as follows:

A. Preliminary Work. A cathodic protection well shall be investigated before it is destroyed to determine its condition; details of its construction and whether conditions exist that will interfere with filling and sealing.

Grouting through the vent pipe is the preferred method for destruction. "Drilling out" or other possible alternative methods are to be reviewed and approved by the enforcing agency prior to implementation.

The ~~well~~ ***vent pipe*** shall be sounded immediately before it is destroyed to make sure that no obstructions exist that will interfere with filling and sealing. The ~~well~~ ***vent pipe*** shall be cleaned before destruction, as needed, to ensure that all undesirable materials, including obstructions to filling and sealing, debris, and pollutants and contaminants that could interfere with well destruction are removed for disposal. The enforcing agency shall be notified as soon as possible if pollutants and contaminants are known or suspected to be in a well to be destroyed. Well destruction operations may then proceed only at the approval of the enforcing agency. The enforcing agency should be contacted to determine requirements for proper disposal of materials removed from a well to be destroyed.

B. Filling and Sealing Conditions. The following minimum requirements shall be followed when various conditions are encountered:

1. Wells that only penetrate unconsolidated material and a single "zone" of groundwater. At a minimum the upper 20 feet of the well casing and the annulus between the well casing and borehole wall (if not already sealed) shall be completely sealed with suitable material. Sealing material shall extend to a minimum depth of 50 feet below land surface if the well to be destroyed is located in an urban area, or is within 100 feet of any potential source of pollution or contamination. Additional sealing material may be needed if adverse conditions exist. ~~The remainder of the well below the minimum surface seal shall be filled with suitable granular fill material, such as clean sand or pea gravel, or with sealing material.~~

2. Wells that penetrate several water-bearing strata. The upper portion of the well casing and annular space shall be filled with sealing material as described in Item 1, above. Strata encountered

below the surface seal that contain poor-quality water, pollutants, or contaminants that could mix with and degrade water in other strata penetrated by the well, shall be effectively isolated by sealing the well bore and annulus within intervals specified in Section 10, above. The remainder of the well shall be filled with ~~suitable granular fill or~~ sealing material.

3. Wells penetrating fractured rock. Sealing material shall be installed as outlined in Items 1 and 2, above. Cement-based sealing material shall be used opposite fractured rock. The remainder if the well shall be filled with ~~fill or~~ sealing material, as appropriate.

4. Wells in nonfractured consolidated strata. Sealing material shall be installed as outlined in Items 1 and 2, above. The remainder of the well shall be filled with ~~fill or~~ sealing material, as appropriate.

5. Wells penetrating water-bearing zones or aquifers of special significance. The enforcing agency may require that specific water-bearing zones be sealed off during well destruction.

C. Placement of Material. The placement of sealing materials for cathodic protection well destruction is generally described in Section 23 and Appendix B of the Water Well Standards. The following additional requirements shall be observed in destroying cathodic protection wells.

Casing, cables, anodes, granular backfill, conductive backfill, and sealing material shall be removed as needed, by redrilling, if necessary, to the point needed to allow proper placement of sealing materials within required sealing intervals. Removal of some or all well materials will likely be required for cathodic protection wells that were not constructed in accordance with these standards, or standards adopted by ***NACE International, Standard Practice Document NACE SP0572-2007***

Casing that cannot be removed shall be adequately perforated or punctured at specific intervals to allow pressure injection of sealing materials into granular backfill and all other voids that require sealing.

The following requirements shall be observed in placing fill and sealing material in cathodic protection wells to be destroyed.

1. Placement Method. The well shall be filled and sealed with appropriate material upward from the bottom of the well using a tremie pipe or equivalent.

   Sealing material shall be placed by methods (such as by the use of a tremie pipe or equivalent) that prevent freefall, bridging, or dilution of the sealing materials, or separation of aggregates from sealants, Sealing materials shall not be installed by freefall unless the interval to be sealed is dry and no deeper than 30 feet below ground surfaces.

2. Timing of Placement. Sealing material shall be placed in one continuous operation (or "pour") from the bottom to top of the well unless conditions in the well dictate that sealing operations be conducted in a staged manner and prior approval is obtained from the enforcing agency. ***Following placement, the sealing material must be pressurized to a minimum of 25 psi (pounds per square inch), and pressure must be maintained for at least 5 minutes or until at least an additional 1/3 of the casing volume if sealing material is pumped into the well.***

3. Groundwater Flow. Special care shall be used to restrict the flow of groundwater into a well while fill and sealing material is being placed, if subsurface pressure causing the flow of water is significant.

4. ~~Sealing Pressure. Pressure required for placement of cement-based sealing material shall be maintained long enough for the cement-based sealing material to set~~.

~~5.~~ Verification. Verification shall be made that the volume of sealing and fill material placed in a well during destruction operations equals or exceeds the volume to be filled and sealed. This is to help determine that the well has been properly destroyed and that no jamming or bridging of the fill or sealing material has occurred.

D. Sealing Materials. Materials used for sealing cathodic protection wells for destruction shall have low permeabilities so that the volume of water and possible pollutants and contaminants passing through them will be of minimal consequence. Sealing material shall be compatible with the chemical environment into which it is placed and shall have mechanical properties compatible with present and future site uses.

Suitable sealing materials include neat cement~~, sand-cement, concrete,~~ and bentonite, as described in Section 9 of the Water Well Standards. ~~Sealing materials used for isolating zones of fractured rock shall be cement-based, as described in Subsection B, above.~~ Drilling mud or drill cuttings shall not be used as any part of a sealing material for well destruction. ~~Concrete may be used as a sealing material as the approval of the enforcing agency.~~

~~E.~~ ~~Fill Material. Many fill materials are suitable for destruction of cathodic protection wells. These include clean, washed sand or gravel or sealing material. Fill material shall be free of pollutants and contaminants and shall not be subject to decomposition or consolidations after placement. Fill material shall not contain drilling mud or cuttings.~~

~~F.~~ Additional Requirements for Destruction of Cathodic Protection Wells in Urban Areas. The following additional requirements shall be met at each well site in urban areas, unless otherwise approved by the enforcing agency:

1. The upper surface of the sealing material shall end at a depth of 5 feet below ground surface; and

2. If the casing was not extracted during destruction and sealing operations, a hole shall be excavated around the well casing to a depth of 5 feet below ground surface after sealing operations have been completed and sealing materials have adequately set and cured. The exposed casing shall then be removed by cutting the casing at the bottom of the excavation. The excavation shall then be backfilled with clean, native soil or other suitable material.

~~G.~~ *F.* Temporary Cover. The well borehole and any associated excavations shall be covered at the surface to prevent entry of foreign material, water, pollutants, and contaminants and to ensure public safety whenever work on the well is interrupted by such events as overnight shutdown, poor weather, and required waiting periods to allow setting of sealing materials and performance of tests. The cover shall be held in place or weighted down in such a manner that it cannot be removed except by equipment or tools.

(End of Chapter IV)

Chapter V. GEOTHERMAL HEAT EXCHANGE WELLS

SPECIAL NOTE: *The first three pages of this draft are to be included in the Introduction of the new California Well Standards, Bulletin 74-~~99~~XX. Bulletin 74-~~99~~XX will be one document including standards for water wells, monitoring wells, cathodic protection wells, and geothermal heat exchange wells.*

Exemptions 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 that compliance would result in an unsatisfactory well, or that there is a best available technology (BAT) or state-of-the-art technology not enumerated in these standards that would provide suitable protection, the enforcing agency may waive compliance and prescribe alternative requirements that would afford the same level of protection provided by these standards.

Geothermal Heat Exchange Well Locations – Geothermal heat exchange wells that are sealed their entire length may be installed closer to contaminant or pollutant sources or structures than the distances specified for water wells in ~~DWR Bulletin 74-90~~ ***these Standards*** and subsequent revisions. Iron markers, trace tapes, or wire shall be installed ~~at~~ ***above*** each well ***and its connecting header (or main) pipe*** to facilitate locating the buried wells. ***Wells should be located an adequate distance from buildings and other permanent structures to allow access for well modification, repair, and destruction.***

~~Exclusions – The geothermal heat exchange well standards prescribed in Bulletin 74-99 do not apply to shallow construction systems as defined in Bulletin 74-99. The enforcing agency may prescribe additional regulations when the fluid is circulated in a loop in a shallow system. To prevent groundwater contamination, the enforcing agency shall prescribe additional regulations for the destruction of shallow geothermal heat exchange systems.~~

EDITORIAL NOTE: The Subcommittee has added a section entitled "Exclusions" to Part I, General, Section 1, Definitions to clarify those systems that are exempt from these Standards.

Driller Qualifications - In accordance with the provisions of Section 13750.5 of the California Water Code:

> "Section 13750.5. Persons responsible for construction, alteration, destruction, or abandonment; license necessary."
>
> "No person shall undertake to dig, bore, or drill a water well, cathodic protection well, groundwater monitoring well, or geothermal heat exchange well, to deepen

or reperforate such a well, or to abandon or destroy such a well, unless the person responsible for that construction, alteration, destruction, or abandonment possesses a C-57 Water Well Contractor's License."

Reports – Reports concerning a water well, cathodic protection well, groundwater monitoring well, or geothermal heat exchange well shall be prepared in accordance with the provisions of California Water Code Section 13751. The description of the site prepared under 13751, (b)(2)(A) shall be sufficiently exact to permit location of each geothermal heat exchange well.

Section 13751. Report of Completion.

(a) Every person who digs, bores, or drills a water well, cathodic protection well, groundwater monitoring well, or geothermal heat exchange well, abandons or destroys such a well, or deepens or reperforates such a well, shall file with the department a report of completion of that well within 60 days from the date its construction, alteration, abandonment, or destruction is completed.

(b) The report shall be made on forms furnished by the department and shall contain information as follows:

(1) In the case of a water well, cathodic protection well, or groundwater monitoring well, the report shall contain information as required by the department, including, but not limited to all the following information:

(A) A description of the well site sufficiently exact to permit location and identification of the well.

(B) A detailed log of the well.

(C) A description of the type of construction.

(D) The details of perforation.

(E) The method used for sealing off surface or contaminated waters.

(F) The methods used for preventing contaminated waters of one aquifer from mixing with waters of another aquifer.

(G) The signature of the well driller.

(2) In the case of a geothermal heat exchange well, the report shall contain all of the following information:

A description of the site that is sufficiently exact to permit the location and identification of the site and the number of geothermal heat exchange wells drilled on the same lot.

A description of the borehole diameter and depth and the type of geothermal heat exchange system installed.

The methods and materials used to seal off surface or contaminated waters.

The methods used for preventing contaminated water in one aquifer from mixing with the water in another aquifer.

The signature of the well driller.

Reports submitted on water wells, monitoring wells, or cathodic protection wells are subject to California Water Code Section 13752. Reports submitted on geothermal heat exchange wells are open for public inspection.

Section 13752. Inspection Reports.

"Reports made in accordance with paragraph (1) of subdivision (b) of Section 13751 shall not be made available for inspection by the public, but shall be made available to governmental agencies for use in making studies. However, any report shall be made available to any person who obtains written authorization from the owner of the well."

Part I. General.

Section 1. Definitions.

~~A.~~ Geothermal Heat Exchange Well. ***A geothermal heat exchange well is defined in the California Water Code (Section 13713) as*** ~~A~~"any uncased artificial excavation, by any method, ~~for the purpose of using~~ ***that uses*** the heat exchange capacity of the earth for heating and cooling, ~~and~~ in which ***excavation*** the ambient ground temperature is 86° Fahrenheit (30° Celsius) or less, and which ***excavation*** uses a closed loop fluid system to prevent the discharge or escape of ~~the~~ ***its*** fluid into ~~the~~ surrounding aquifers or ***other*** geologic formations. Geothermal heat exchange wells ~~are also known as~~ ***include*** ground source heat pump wells." ~~Such wells or boreholes are not intended to produce water or steam.~~

B. Types of Systems. ~~Geothermal heat exchange systems may use a number of different combinations of circulating fluids, construction methods, and heat sources. These are commonly classified as follows:~~

~~1. Circulating Fluid Systems. This refers to the type of piping system used to circulate heat exchange fluids.~~

~~a. Closed Looped System. This type of system features continuous piping systems which prevent the circulating fluid from coming in contact with the aquifers or geologic formations. The fluid is repeatedly recirculated. The fluid is commonly water, but may be some other approved fluid.~~

~~b. Open Loop System. An open loop system results when the circulating fluid is discharged from the piping system after the heat exchange. The most common open loop system consists of groundwater pumped from a well and then injected back into the same well or through a second well. Open loop systems, if approved by the Regional Water Quality Control Board or by the enforcing agency, shall conform to Water Well Standards prescribed in DWR Bulletin 74-90 and subsequent revisions.~~

~~2. Construction Method Systems. This refers to the type of construction and the depth to which the excavation(s) penetrate the ground. Based upon their normal orientation with the surface, a shallow construction system is sometimes called a "horizontal system," while a well construction system us often described as a "vertical system" or a "vertical borehole system."~~

~~a. Shallow Construction System. This type of system is defined as any heat exchange system having an excavation whose bottom does not exceed a depth of 20 feet from ground surface. The standards prescribed in Parts II and III do not apply to shallow construction systems as defined above. The enforcing agency may prescribe additional regulations for a shallow construction system.~~

~~b. Well Construction System. This type of system is defined as any heat exchange system in which the bottom of the excavation exceeds 20 feet from ground surface.~~

~~3. Heat Exchange Systems. This refers to the heating or cooling source for a geothermal heat exchange system.~~

~~a. Ground Source Heat Exchange System. This system results from the placement of the closed loop circulating pipes directly into the ground, and backfilling the excavation around the circulating pipes with grout or other impervious material. Ground source heat exchange systems shall be constructed as either vertical borehole or shallow systems. Such systems shall be approved by the enforcing agency prior to construction.~~

~~b. Groundwater Source Heat Exchange System.~~

~~(1) Closed Loop. A geothermal heat exchange system using a standing column of groundwater within a water well as the heat source. The fluid is circulated through a closed loop submerged in the groundwater. The standing groundwater in the well is the heat exchange medium. The water well shall conform to water well standards prescribed ion DWR Bulletin 74-90 and subsequent revisions.~~

~~(2) Open Loop. These systems shall be approved by the enforcing agency and the Regional Water Quality Control Board prior to construction. The water well shall conform to water well standards prescribed in DWR Bulletin 74-90 and subsequent revisions. Open loop groundwater geothermal heat exchange systems should be considered in aquifers where high quality groundwater is plentiful and in which water wells can provide adequate water flow.~~

~~(a) Standing column well system. A geothermal heat exchange system using standing column of groundwater within a water well as the heat source. Groundwater is extracted from the bottom of the well and pumped directly to the heat exchanger. After circulating through the heat exchanger, the water is pumped back into the top of the column. There shall be sufficient groundwater present to maintain the standing column of water.~~

~~(b) Open loop 2-well system. Groundwater is extracted from one well and pumped through the heating/cooling system and back into the ground through a second well, the recharge well.~~

...Geothermal heat exchange wells may be further defined by the type of piping system used to circulate heat exchange fluids (i.e., open loop vs. closed loop), by the method of construction (i.e., horizontal trench vs. horizontal directional drilling vs. vertical borehole), and by heating or cooling source for the system (i.e., ground vs. groundwater). Examples of various types of systems are shown in Figures 15 and 16. Figure 17 shows a cross-section of a typical closed loop geothermal heat exchange well.

***Note:** Open loop systems (e.g., groundwater extracted from a well, used for heat transfer, and then injected back into the same well or into a second well or into surface water) must be approved by the Enforcing Agency (for well permits) and the Regional Water Quality Control Board (for discharge permits). Any water well used in either an open loop system or a closed loop system must conform to the Water Well Standards prescribed in DWR Bulletin 74-81 and subsequent revisions.*

C. ***Exclusions:** It is not intended that surface water systems, shallow closed loop systems less than 10 feet deep, or closed loop systems installed within the foundation system of a structure be subject to these standards.*

EDITORIAL NOTE: The Subcommittee reduced the depth of trench from 20 feet to 10 feet in view of the condition that some counties allow sanitary well seals as shallow as 20 feet. Wells with such shallow seals could potentially become contaminated if a 20-foot deep trench is nearby.

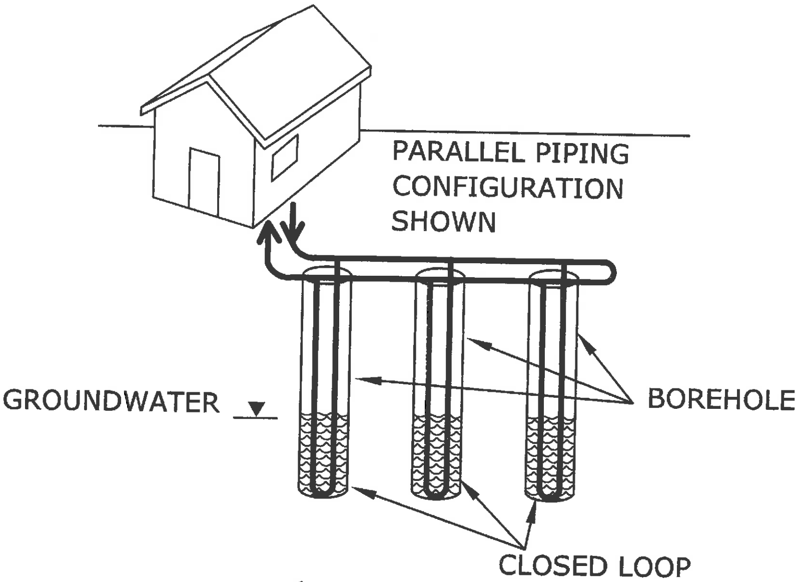
D. Enforcing Agency. An agency designated by duly authorized local, regional or State government to administer and enforce laws or ordinances pertaining to the protection of water quality, construction, alteration, maintenance or destruction of geothermal heat exchange wells.

Section 2. Application to Type of Well.

These standards shall apply to all geothermal heat exchange wells using a closed loop circulating fluid ground source heat exchange system.

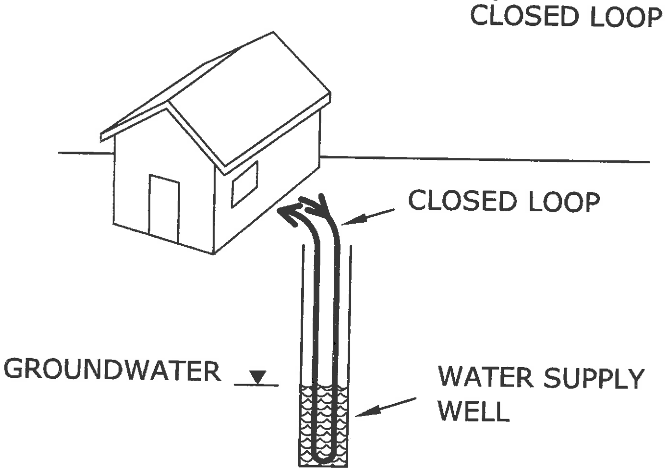
In all geothermal heat exchange wells that use a groundwater source heat exchange system with either an open or closed loop, well construction and destruction shall conform to the water well standards prescribed ~~in DWR Bulletin 74-90~~ ***herein*** and subsequent revisions.

TYPES OF GEOTHERMAL HEAT EXCHANGE SYSTEMS



- CLOSED LOOP
- VERTICAL SYSTEM
- GROUND & GROUNDWATER SOURCE
- SUBJECT TO GHEW STANDARDS:

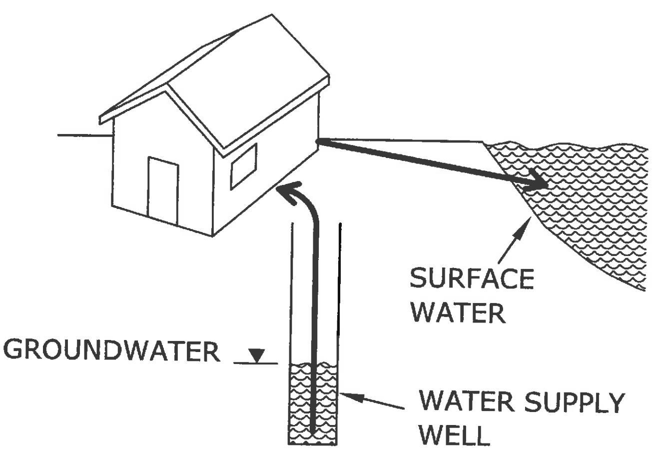
YES



- CLOSED LOOP
- VERTICAL SYSTEM
- GROUNDWATER SOURCE
- SUBJECT TO GHEW STANDARDS:

YES*

*Water well subject to Bulletin 74 "Water Well Standard" as well

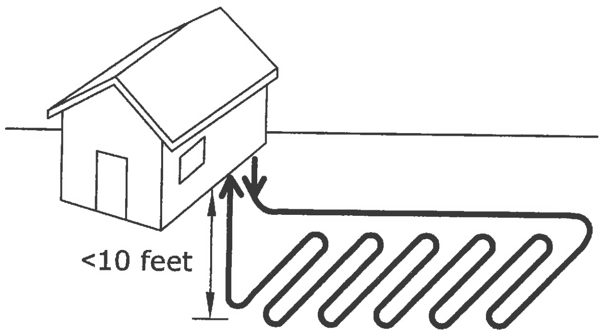


- OPEN LOOP
- VERTICAL SYSTEM
- GROUNDWATER SOURCE
- SUBJECT TO GHEW STANDARDS:

NO*

*Water well subject to Bulletin 74 "Water Well Standard"
*Discharge subject to RWQCB Waste Discharge Requirements

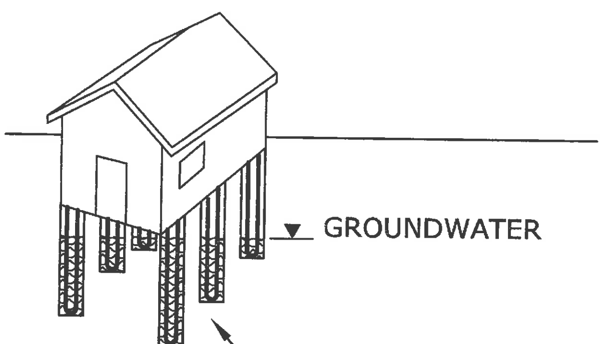
TYPES OF GEOTHERMAL HEAT EXCHANGE SYSTEMS (CONTINUED)



- CLOSED LOOP
- HORIZONTAL SYSTEM (TRENCH OR HDD)
- GROUND SOURCE
- SUBJECT TO GHEW STANDARDS:

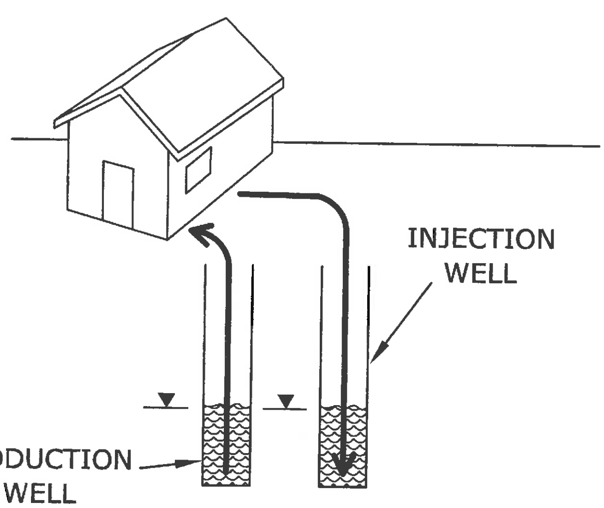
NO*

*Excluded for loop depths <10ft.



- CLOSED LOOP
- VERTICAL SYSTEM
- GROUND OR GROUNDWATER SOURCE
- SUBJECT TO GHEW STANDARDS:

NO



- OPEN LOOP
- VERTICAL SYSTEM
- GROUNDWATER SOURCE
- SUBJECT TO GHEW STANDARDS:

NO*

*Water well subject to Bulletin 74 "Water Well Standard"
*Discharge subject to RWQCB Waste Discharge Requirements

Follows page 104

FIGURE 16

Section 3. Best Available Technology (BAT).

These standards provide a minimum level of protection for groundwater resources of California. New materials and techniques that are developed in the future that are approved and adopted by industry groups, including, but not limited to, International Ground Source Heat Pump Association, National Groundwater Association, or California Groundwater Association, and that provide equal or greater protection for California's groundwater quality shall be encouraged and allowed. Such new materials and techniques must be equal to or exceed the standards in this publication in performance and level of protection.

Part II. Geothermal Heat Exchange Well Construction

Section 4. Borehole Diameter of Geothermal Heat Exchange Wells.

Diameter of borehole. The smaller the diameter of the borehole ***is***, the greater the thermal exchange efficiency ***is***. It may be necessary to drill a variable borehole diameter to allow proper construction to the design depth. The system designer shall consider the impact of borehole diameter on heat transfer as well as the diameter of the loop piping and the need to install a properly sized tremie pipe for successful grouting of the borehole.

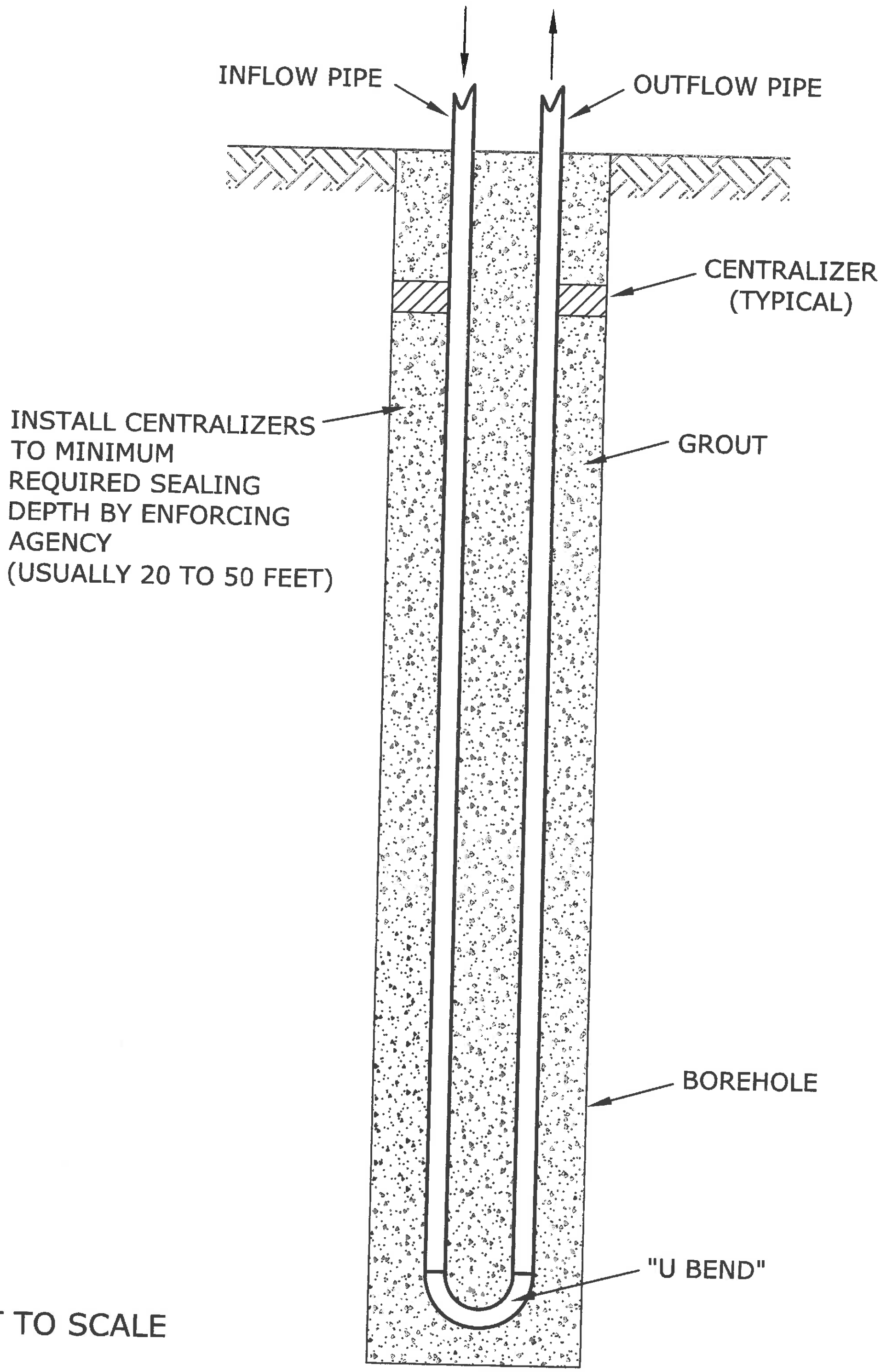
Loop piping shall be equipped with centralizers across the "minimum annular seal depth" interval prescribed by the Enforcing Agency (usually 20 to 50 feet below ground surface) in order to isolate the loop materials from each other and from the borehole wall to provide a competent seal. Centralizers must be positioned to allow the proper placement of sealing material around the loop materials.

EDITORIAL NOTE: **The Subcommittee recognizes that there will likely be some resistance to the use of centralizers, as they will complicate seal placement. The centralizer requirement through the traditional "minimum annular seal depth" for wells is an alternative to a 2-inch minimum annular seal requirement.**

The borehole diameter of a geothermal heat exchange well shall be sufficient to allow placement of a ~~1¼~~ ***minimum 1-***inch ***diameter*** tremie pipe, in addition to the loop pipes, to emplace material in the borehole that surrounds the loop pipes. It may be necessary to use a larger diameter tremie pipe in deeper holes to ensure proper placement of the sealing material~~ and filler material~~.

EDITORIAL NOTE: **IGSHPA Standards specify a minimum 1-inch diameter tremie pipe, but the slightly larger 1-1/4-inch diameter pipe, where it can be used, facilitates ease of grout placement.**

CROSS SECTION
RECOMMENDED CLOSED LOOP INSTALLATION
GEOTHERMAL HEAT EXCHANGE WELL



NOT TO SCALE

FIGURE 17

Such material includes the sealing material and any thermal conductive material that is placed in the borehole in lieu of sealing material to enhance heat exchange. Both sealing material and thermal conductive material shall fill the hole and surround all loop pipes. The diameter of the tremie pipe shall be adequate to ensure proper placement of the sealing material, and thermal conductive material~~, and filler material~~. Gravity installation or free-fall of sealing material ~~or fill material~~ without the use of a tremie pipe is not permitted. A grout pump shall be required for placing sealing material through a tremie pipe. ~~Any clean fill between seals shall be chlorinated.~~

EDITORIAL NOTE: The use of any type of "fill" material should not be permitted.

Section 5. Sealing Geothermal Heat Exchange Wells.

~~A.~~ Depth of Seal. The sealing of a geothermal heat exchange well shall be completed immediately after the well is drilled to avoid cave-in of the uncased borehole. Full-length sealing material placed by tremie pipe is required to prevent surface contamination or to prevent contaminated water from one aquifer from mixing with waters of another aquifer. ~~The enforcing agency may waive for full-length sealing in vertical borehole systems provided the agency prescribes alternative sealing methods that meet the minimum standards of this Section and Section 7.~~

EDITORIAL NOTE: This sentence is deleted, as it refers to material discussed later in Section 7, "Non Fully Sealed Geothermal Heat Exchange Wells," which is also deleted.

B. Sealing Materials. The following sealing materials are approved for use in geothermal heat exchange wells:

1. Bentonite Slurry. The seal shall consist of high solids sodium bentonite slurry made from bentonite grout or an 8 mesh granulated bentonite polymer slurry meeting NSF Standard ~~61~~ ***60*** (National Sanitation Foundation) with a minimum of ~~twenty~~ ***fifty*** percent (~~2~~*5*0%) by weight solids ~~(9.4 pounds per gallon grout weight)~~ mixed according to the manufacturer's specifications.

   Drilling mud or cuttings shall not be used as sealing materials. Water used in preparing bentonite slurry shall meet the standards in Section 9.D.1 of the Water Well Standards. Bentonite slurry shall be emplaced using a tremie pipe from the bottom of the geothermal heat exchange well to the top of the borehole, excluding the excavation for the header assembly. The tremie pipe may be left in place provided it is completely filled with the high solids bentonite slurry.

~~It is recommended that high solids bentonite slurry be used in all geothermal heat exchange wells.~~

2. Other Grout. Other types of grout, ***such as thermally enhanced grouts with pre-mixed quantities of silica sand,*** may be used ***as noted herein*** ~~if approved by Bulletin 74-90~~ and ***in*** subsequent revisions or ~~is~~ ***if they are*** considered a BAT and ~~has~~ ***if they have*** been approved by industry organizations in accordance with Section 3, above***, with the approval of the Enforcing Agency***. ***These grouts shall also have a minimum of fifty percent (50%) by weight solids and they shall be mixed according to the manufacturer's specifications.***

~~3. Cement is not permitted as a sealing material because of the expansion of the polyethylene loop pipe caused by the heat of hydration if the cement, and subsequent contraction of the pipe after cooling. Such expansion and contraction does not provide an effective seal.~~

C. Placement of Sealing Material. Before placing the sealing material, all loose cuttings or other obstructions shall be removed from the borehole. Sealing material shall be placed in a continuous operation from the bottom of the geothermal heat exchange well to the top of the borehole, excluding the excavation for the head assembly. The sealing material shall be emplaced by pressure pumping through a ~~1¼ inch or larger~~ ***minimum 1-inch diameter*** tremie pipe. The pump shall be such that it can adequately complete the pumping to the total depth of the borehole. The discharge end of the tremie pipe shall be continuously submerged in the sealing material until the zone to be sealed or filled is completed. The sealing material shall fill the hole and surround all heat exchange loop pipe. ***The contractor shall verify to the Enforcing Agency that the volume of sealing material placed into each borehole equals or exceeds the volume to be sealed.***

If the heat exchange loop pipe cannot be emplaced to the total depth of the borehole, the contractor shall ensure that the borehole is sealed from the top of the borehole to the total depth. The tremie pipe may be left in place provided it is completely filled with the high solids bentonite slurry. Gravity installation or free fall of sealing material without the use of a tremie pipe is not permitted.

Section 6. Construction Materials *and Installation*.

A. Casing. Temporary casing may be used to install geothermal heat exchange wells. Such casing shall be removed upon completion of the well. If a permanent casing must be used, the casing material and installation methods and sealing shall comply with the applicable provisions for casing materials, installation, and sealing as specified for water wells ~~in DWR Bulletin 74-90~~ ***herein*** and ***in*** subsequent revisions.

B. Heat Exchange Loop Material

1. Type of Material. In a geothermal heat exchange well, the material used to make up the heat exchange loop must meet industry standards for this application as specified by the International Ground Source Heat Pump Association (IGSHPA). PVC (polyvinyl chloride) ***and metal*** pipe shall not be used as loop materials in geothermal heat exchange wells. Generally, closed loop materials are composed of high density polyethylene pipe *(HDPE)*. Other materials that conform to IGSHPA standards***, such as cross-linked polyethylene (PEX),*** may be used in geothermal heat exchange wells.

2. Connections. All heat exchange loop connections to be placed in the borehole shall be terminally fused according to manufacturer's instructions and shall not leak after assembly. Only fused fittings or non-metallic mechanical stab fittings that meet ASTM D-2513, Section 6.10.1, Category 1, may be used in the header assembly and manifold.

3. Installation. Heat exchange loop materials shall be installed and sealed immediately upon completion of drilling ~~of each~~ ***and loop installation, unless otherwise authorized by the enforcing agency, in each*** geothermal heat exchange well borehole. ***Use of a steel "sinker" bar, or temporary attachment of a steel tremie pipe to the "u-bend" to facilitate insertion to the full depth of the borehole and to ensure straightness of the loop pipes to the extent possible, is recommended.***

4. ~~Metal Pipe and Fittings. If metal pipe or fittings are to be installed underground, cathodic protection shall be provided. Such a cathodic protection system shall be maintained in operating condition.~~ ***Pressure Testing. All loops shall be pressure tested prior to installation.***

EDITORIAL NOTE: In installations, designers may specify, and contractors may use, such devices as "clips" to separate the

loop pipes so they don't touch each other. However, the pipes may contact portions of he borehole wall, and while the resulting contact may enhance heat transfer, this may result in poor sealing from a groundwater protection perspective. Accordingly, the use of "clips" or similar devices should be discouraged, and if they are used, they should be placed below the minimum sealing depth discussed in Section 4.a.

C. Loop Fluids. Fluids contained in the loop as the heat exchange medium in geothermal heat exchange wells shall have low toxicity~~, as defined below,~~ and shall be biodegradable. Such fluids as typically water, or water plus a freeze protection additive. ~~Pure water should be used whenever possible~~. Any water used in the fluid shall be from a potable source.

Commonly used and acceptable freeze protection additives include propylene glycol and ethanol. ***All loop fluids or additives other than potable water shall be approved by the Enforcing Agency and shall meet BAT standards and be approved by industry organizations in accordance with Section 3, above.***

~~The loop fluid, including water and any additives, shall have an LD_{50} for humans of greater than 25,000 mg/kg of body weight. LD_{50} is the dose that will be lethal to 50% of the population who ingest the fluid in 1 hour.~~

~~Undiluted freeze protection additives shall have an LD_{50} for humans of greater than 5,000 mg/kg of body weight. If the LD_{50} for humans is known for a specific additive, that LD_{50} shall be used when calculating the toxicity of the loop fluid. In the absence of human toxicity data, the estimated LD_{50} shall be based on the toxicity data of the most sensitive species, using uncertainty factors as appropriate and in accordance with standard practices in toxicology.~~

D. Final Testing. ~~If pressure testing with water or air to 150 percent above the manufacturer's heat pump operating specifications~~ ***Following the first test performed after loop installation and grouting as discussed in Section 6.B.4, before the connecting or header trench is backfilled, loops shall be pressure tested a second time at 100 psi*** for a period of 30 minutes ~~shows that any~~ ***with no observed leaks or pressure loss greater than 3 psi. If any*** geothermal heat exchange fluid leaks, the leaking loop shall be repaired or replaced. If the loop ***experiences pressure loss and*** cannot be repaired, the loop shall be replaced. If the loop cannot be repaired or replaced, the loop and borehole shall be destroyed in accordance with Part III.

E. Identification. To facilitate identification and location of a multi-well installation, it should be marked with a buried conductive or

inductive trace tape or iron marker that can be remotely sensed by a metal detector. The depth of this indicator should not exceed half the depth to the horizontal loop piping or header. A trace tape may be labeled with a cautionary warning. A contact telephone number in case of accidental damage by excavation activity is also recommended.

EDITORIAL NOTE: The Subcommittee recommends the deletion of Section 7 (below) in its entirety. There is enough risk to groundwater quality in a multi-aquifer environment in the construction and sealing of "fully sealed" geothermal heat exchange wells. In practice, detailed hydrogeological investigations to warrant this type of construction are generally not accomplished. Also, as a practical matter, a contractor in production mode is not going to take the time to accomplish the sealing called for in Section 7.D, and such construction would be very difficult to confirm or "inspect" to see that it was performed satisfactorily.

In the event that this section is retained, the subcommittee recommends the adoption of IGSHPA Standards pertaining to conditions where full seal requirements might be waived: (1) where the entire borehole is within a single non-flowing aquifer; (2) where the entire borehole is dry and the seasonal high depth to water is well below the borehole depth; and (3) where the entire borehole is homogeneous, low-permeability, low water-yield rock. If one of these conditions is asserted, the contractor shall provide a technical evaluation and/or pilot hole data logged and certified by a California licensed Professional Geologist or Geotechnical Engineer to support that assertion.

~~Section 7. Minimum Requirements for Non-Fully Sealed Geothermal Heat Exchange Systems.~~

~~A. Hydrology and Groundwater Quality. Construction of non-fully sealed geothermal heat exchange wells shall require knowledge about the site hydrology and groundwater quality sufficient to ensure that construction of non-fully sealed wells does not degrade groundwater quality. If such knowledge about the site is not available, only fully sealed geothermal heat exchange wells shall be permitted.~~

~~B. Borehole Size Requirements. See Section 4, above~~

~~C. Minimum Depth of Seals. If the borehole is not sealed throughout the entire length, the minimum depth of the surface annual seal shall be the same as specified for domestic wells in DWR Bulletin 74-90 and subsequent revisions.~~

~~D. Sealing Between Aquifers. If full length sealing is not done and the geothermal heat exchange well penetrates more than one aquifer and one or more of the aquifers contains water that, if allowed to mix in sufficient~~

~~quantity, may result in a significant deterioration of the quality of the water in the other aquifer(s), the strata producing such poor-quality water shall be sealed off to prevent mixing of this water with the other aquifers. The seal shall extend no less than ten feet (10') above and ten feet (10') below the strata to be sealed off, even if the strata to be sealed off is less than 10 feet in thickness. If the stratum to be sealed is at the bottom of the well, the seal needs to extend only in the upward direction. The sealing material shall fill the borehole and any void spaces in the interval to be sealed. The seal shall be placed by 1¼ inch tremie pipe and adequately pumped from the bottom to top of the interval to be sealed. Gravity installation or free-fall of sealing materials without the use of a tremie pipe is not permitted.~~

~~E. Fill Material. Any fill materials used in non-fully sealed wells shall meet the standards of Bulletin 74-90 and subsequent revisions and shall have appropriate thermal characteristics for the intended heat exchange purpose. Such fill material shall be emplaced by means of a tremie pipe. Gravity installation or free-fall of fill materials without the use of a tremie pipe is not permitted. Any clean fill placed between seals shall be chlorinated.~~

~~F. Placement of Fill. Fill material shall be emplaced by the use of a 1 ¼ inch tremie pipe. The tremie pipe shall be lowered to the bottom of the zone to be filled, and raised slowly as the material is introduced. All fill shall be emplaced in one continuous operation upward from the bottom of the borehole. When using the tremie pipe method to install fill material, the bottom of the tremie shall be maintained as close as possible to, but not inside of, the emplaced fill.~~

~~Gravity installation or free-fall of fill material without the use of a tremie pipe is not permitted.~~

G. ~~Sealing Material. Sealing materials shall meet the standards prescribed in Section 5.B.~~

Part III. Destruction of Geothermal Heat Exchange Wells.

<u>Section *7*. Destroying a Closed Loop Ground Source Heat Exchange System.</u>

A. To destroy a geothermal heat exchange well using a closed loop, ground source heat exchange system, the following procedures shall be completed:

1. <u>Fluid Removal</u>. All fluid in the heat exchange loop shall be displaced ***by flushing*** and disposed of properly ***in accordance with applicable regulatory requirements, with particular respect to loop fluids containing anti-freeze or other additives***.

2. <u>Near Surface Excavation</u>. A hole shall be excavated at least five feet below the surface around the borehole. The loop pipe in the excavation shall be removed.

3. <u>Sealing the Loop in the Borehole</u>. The remaining loop shall be completely filled with high solids bentonite slurry as specified in Section 5.B.1. The slurry shall be allowed to spill into the excavation to provide a cap at least one foot (1') thick above the loop pipe. The remainder of the excavation shall be filled with compacted earth ***that may be followed by a layer of*** ~~or~~ pavement, ***as applicable***.

<u>Section *8*. Destroying an Open Loop or Closed Loop, Ground Source Heat Exchange System.</u>

Destruction of an open loop or closed loop <u>groundwater</u> source heat exchange system shall be completed in conformance with destruction standards for water wells ~~in DWR Bulletin 74-90~~ ***contained herein*** and subsequent revisions.

(End of Chapter V)

SELECTED "STANDARDS" AND OTHER REFERENCES (as of 7/13)

American Water Works Association (AWWA), 2006: AWWA Standard, Water Wells, ANSI/AWWA A100-06, 84 p.

Associated Drilling Contractors of California, 1960; Recommended standards for preparation of water well construction specifications, 31 p.

California Department of Water Resources, 1981: Water well standards, State of California; Bulletin 74-81, 92 p.

________________________________, **1991:** California well standards, Bulletin 74-90, supplement to Bulletin 74-81, 82 p.

________________________________, **1999:** Geothermal heat exchange wells, draft well standards, April 1999; 15 p.

California Groundwater Association (CGA), 1992-present:: Standard practice series, Articles 100 through 580; available on CGA website, "Standards".

Conservation and Survey Division, School of Natural Resources, University of Nebraska-Lincoln, 2009: In-situ study of grout materials 2001-2006 and 2007 dye tests, Education Circular EC-20, 34 p.

International Ground Source Heat Pump Association (IGSHPA), 2010: Closed-loop/geothermal heat pump systems, design and installation Standards, 2011 Edition (draft version as of January 2012)), 22 p.

National Ground Water Association, 2010: Guidelines for the construction of loop wells for vertical closed loop ground source heat pump systems, Third Edition (electronic version), 34 p.

____________________________, **2011:** ANSI/NGWA-01-07 Water well construction standard (draft electronic version of April 1, 2011)

Oklahoma State University, 1988: Closed-loop/ground-source heat pump systems installation guide; prepared by OSU Division of Engineering Technology in cooperation with the National Rural Electric Cooperative Association (NRECA), and International Ground Source Heat Pump Association (IGSHPA), NRECA Research Project 86-1, 236 p.

Santa Clara Valley Water District, 2010: Standards for the construction, destruction, and maintenance of wells and other deep excavations in Santa Clara County, draft version, January 2010, 45 p.