



MENDOCINO COUNTY
WELL ORDINANCE
AND
SPECIAL PERMIT AREAS
AND
WELL STANDARDS

1994

4 April 1994

100

100

100

100

TABLE OF CONTENTS

CHAPTER 16.04

.....	xiii
WATER, MONITORING, AND CATHODIC PROTECTION WELLS	
.....	xiii
Sec. 16.04.010 Purpose.	xiii
Sec. 16.04.020 Definitions.	xiii
Sec. 16.04.030 General Prohibitions.	xv
Sec. 16.04.040 Permit Application.	xv
Sec. 16.04.050 Issuance of Permits.	xvi
Sec. 16.04.060 Inspections: Construction, Repair, and Destruction.	xvi
Sec. 16.04.070 Inspection.	xvii
Sec. 16.04.080 State Reporting.	xvii
Sec. 16.04.090 Expiration of Permit.	xvii
Sec. 16.04.100 Cleaning of Wells.	xvii
Sec. 16.04.110 Exclusions.	xvii
Sec. 16.04.120 Change of Use of Well.	xvii
Sec. 16.04.130 Exemption Due to Unusual Conditions.	xviii
Sec. 16.04.140 Special Permit Areas	xviii
Sec. 16.04.150 Protection of Wells.	xviii
Sec. 16.04.160 Well Construction, Repair, and Destruction Standards.	xviii
Sec. 16.04.170 Construction Requirements.	xviii
Sec. 16.04.180 Order to Abate Nuisance or Safety Hazard.	xix
Sec. 16.04.190 Abatement by the County.	xix

Sec. 16.04.200	Appeal from Denial, Modification, Revocation, or Suspension of Permit and from Order of Abatement.	xix
Sec. 16.04.210	Abatement of Safety Hazard.	xx
Sec. 16.04.220	Payment of Cost by Owner.	xx
Sec. 16.04.230	Penalties.	xx
Sec. 16.04.240	Construction and Validity.	xx

SPECIAL PERMIT AREAS

.		xxii
A.	SANEL VALLEY (Hopland Area).	xxii
B.	LAYTONVILLE VALLEY.	xxii
C.	POTTER VALLEY.	xxii
D.	ROUND VALLEY.	xxiii

MENDOCINO COUNTY WELL STANDARDS

.		1
-----------	--	----------

Introduction

.		1
-----------	--	----------

WATER WELLS

.		3
-----------	--	----------

Part I. General

Section 1.	Definitions.	3
Section 2.	Application to Type of Well.	9
Section 3.	Exemption Due to Unusual Conditions.	10
Section 4.	Exclusions.	10
Section 5.	Special Standards.	10
Section 6.	Well Drillers.	10
Section 7.	Reports.	10

Part II. Well Construction

.		11
-----------	--	-----------

Section 8.	Well Location with Respect to Pollutants and Contaminants.	11
A.	<u>Separation.</u>	11
B.	<u>Gradients.</u>	12
C.	<u>Flooding and Drainage.</u>	12
D.	<u>Accessibility.</u>	12
Section 9.	Sealing the Upper Annular Space.	13
A.	<u>Minimum Depth of Annular Seal.</u>	15
	1. <u>Shallow Ground Water.</u>	15
	2. <u>Encroachment of known or potential sources of pollution or contamination.</u>	15
	3. <u>Vaults.</u>	15
B.	<u>Sealing Conditions.</u>	16
	1. <u>Wells drilled in unconsolidated, caving material.</u>	16
	2. <u>Wells drilled in unconsolidated material with significant clay layers.</u>	17
	3. <u>Wells drilled in soft consolidated formation (extensive clays, sandstones, etc.).</u>	18
	4. <u>Wells situated in "hard" consolidated formations (crystalline or metamorphic rock).</u>	20
	5. <u>Gravel packed wells.</u>	20
	a. <u>With conductor casing.</u>	20
	b. <u>Without conductor casing.</u>	20
	6. <u>For wells situated in circumstances differing from those described above.</u>	20
	7. <u>Converted wells.</u>	22
C.	<u>Conductor Casing.</u>	22
D.	<u>Sealing Material.</u>	22
	1. <u>Water.</u>	22
	2. <u>Cement.</u>	22
	a. <u>Neat Cement.</u>	24
	b. <u>Sand Cement.</u>	24
	c. <u>Concrete.</u>	24
	d. <u>Mixing.</u>	24
	3. <u>Bentonite.</u>	25
E.	<u>Radial Thickness of the Seal.</u>	26
F.	<u>Placement of Seal.</u>	26
	1. <u>Obstructions.</u>	26
	2. <u>Centralizers.</u>	26
	3. <u>Foundation and Transition Seals.</u>	27
	4. <u>Timing and Method of Placement.</u>	28
	5. <u>Ground Water Flow.</u>	28
	6. <u>Verification.</u>	28
	7. <u>Pressure.</u>	28
Section 10.	Surface Construction Features.	28
A.	<u>Openings.</u>	28

	1.	<u>Pump Installed Directly Over Casing.</u>	29
	2.	<u>Submersible or Offset Pump.</u>	29
	3.	<u>No Pump Installed.</u>	29
	4.	<u>Gasket or Watertight sealing.</u>	29
	5.	<u>Bases.</u>	29
B.		<u>Well Pits or Vaults.</u>	33
C.		<u>Enclosure of Well and Appurtenances.</u>	34
D.		<u>Pump Blowoff.</u>	34
E.		<u>Air Vents.</u>	34
F.		<u>Backflow Prevention.</u>	34
Section	11.	Disinfection and Other Sanitary Requirements.	34
A.		<u>Disinfection.</u>	34
B.		<u>Gravel.</u>	35
C.		<u>Lubricants.</u>	35
Section	12.	Casing.	35
A.		<u>Casing Material.</u>	35
	1.	<u>Strength.</u>	35
	2.	<u>Steel.</u>	35
		a. <u>Standard and line pipe.</u>	36
		b. <u>Structural Steel.</u>	36
		c. <u>Well Casing Steel.</u>	37
		d. <u>Stainless Steel.</u>	37
	3.	<u>Plastic.</u>	37
		a. <u>Thermoplastics.</u>	38
		(1) <u>ABS Pipe.</u>	38
		(2) <u>PVC Pipe.</u>	38
		(3) <u>Pressure-Rated PVC Pipe.</u>	38
		b. <u>Thermoset Plastics.</u>	38
		(1) <u>Filament Wound Resin Pipe.</u>	38
		(2) <u>Centrifugally Cast Resin Pipe.</u>	38
		(3) <u>Reinforced Plastic Mortar Pressure Pipe.</u>	38
		(4) <u>G l a s s F i b e r Reinforced Resin Pressure Pipe.</u>	39
		c. <u>Drinking Water Supply.</u>	39
		d. <u>Storage, Handling, and Transportation.</u>	39
		e. <u>Large Diameter Wells.</u>	39
	4.	<u>Concrete Pipe.</u>	39
	5.	<u>Unacceptable Casing Materials.</u>	39
	6.	<u>Other Materials.</u>	39
B.		<u>Casing Installation.</u>	40
	1.	<u>Metallic casing.</u>	40
	2.	<u>Plastic casing.</u>	40

	a.	<u>ASTM D2564</u>	40
	b.	<u>ASTM D2855</u>	40
Section 13.		Sealing-off Strata.	40
Section 14.		Well Development.	41
Section 15.		Water Quality Sampling.	43
	A.	<u>Community Water Supply Wells and Certain Industrial Wells.</u>	43
	B.	<u>Other Types of Wells.</u>	44
Section 16.		Special Provisions for Large Diameter Shallow Wells.	44
	A.	<u>Use as Community Water Supply Wells.</u>	44
	B.	<u>Bored Wells.</u>	44
	C.	<u>Dug Wells.</u>	44
	D.	<u>Casing Material.</u>	45
	E.	<u>Covers.</u>	46
Section 17.		Special Provisions for Driven Wells ("Well Points").	46
Section 18.		Rehabilitation, Repair and Deepening of Wells.	46
Section 19.		Temporary Cover.	47
Part III. Destruction of Wells			47
			47
Section 20.		Purpose of Destruction.	47
Section 21.		Definition of "Abandoned" Well.	47
			47
Section 22.		Destruction, General Requirement.	48
Section 23.		Requirements for Destroying Wells.	48
	A.	<u>Preliminary Work.</u>	48
		1. <u>Obstructions.</u>	49
	B.	<u>Filling and Sealing Conditions.</u>	49
	C.	<u>Placement of Material.</u>	50
	D.	<u>Materials.</u>	52
		1. <u>Impervious Sealing Materials.</u>	52
		2. <u>Filler Material.</u>	52
	E.	<u>Additional Requirements for Wells in Urban Areas.</u>	52
	F.	<u>Temporary Cover.</u>	53
			54
		<u>Sealing the Annular Space</u>	54

<u>General</u>	54
<u>Sealing Methods</u>	55
<u>Gravity Installation (Without Tremie)</u>	55
<u>Grout Pipe Method</u>	55
<u>Pumping-Exterior Placement</u>	56
<u>Pressure Cap Method</u>	56
Continuous Injection.	56
<u>Sealing-off Strata</u>	58
<u>Pressure-Grouting Method</u>	58
<u>Liner Method</u>	60
<u>Disinfection involves seven steps:</u>	61
<u>Bacterial Sampling</u>	64
<u>Chemical Sampling</u>	64
MONITORING WELL STANDARDS	
.	67
INTRODUCTION	
.	67
Types of Monitoring Wells	67
Individual monitoring wells	67
Nested monitoring wells	67
Cluster monitoring wells	67
MONITORING WELL STANDARDS	
.	71
Part I. General	
.	71
Section 1. Definitions	71
A. <u>Monitoring Well</u>	71
B. <u>Exploration Hole (or Boring)</u>	71
C. <u>Enforcing Agency</u>	71
Section 2. Application to Well Type.	71
Section 3. Exemptions for Unusual Conditions.	71
Section 4. Exclusions.	71
<u>Exploration holes</u>	71

Section 5.	Special Standards.	72
Section 6.	Responsible Parties.	72
Section 7.	Reports.	73
Part II. Monitoring Well Construction		
.		74
Section 8.	Well Location with Respect to Pollutants and Contaminants.	74
A.	<u>Separation.</u>	74
B.	<u>Flooding and Drainage.</u>	74
C.	<u>Accessibility.</u>	74
D.	<u>Disposal of Wastes When Drilling in Contaminated or Polluted Areas.</u>	74
Section 9.	Sealing the Upper Annular Space.	74
A.	<u>Minimum Depth of Annular Seal.</u>	75
	1. <u>Water quality monitoring wells and monitoring wells constructed in areas of known or suspected pollution or contamination.</u>	75
	2. <u>Other Monitoring Wells.</u>	75
	3. <u>Sealing Off Strata.</u>	75
	4. <u>Shallow Water Level Observation Wells.</u>	75
	5. <u>Areas of Freezing.</u>	76
	6. <u>Vaults.</u>	76
B.	<u>Sealing Conditions.</u>	76
	1. <u>Temporary Conductor Casing.</u>	76
	2. <u>Permanent Conductor Casing.</u>	76
C.	<u>Radial Thickness of Seal.</u>	76
D.	<u>Sealing Material.</u>	77
	1. <u>Water.</u>	77
	2. <u>Cement-Based Sealing Materials.</u>	77
	a. <u>Additives.</u>	77
	b. <u>Cooling Water.</u>	77
	3. <u>Bentonite-Based Sealing Materials.</u>	78
E.	<u>Transition Seal.</u>	78
F.	<u>Placement of Annular Seal Material.</u>	79
Section 10.	Surface Construction Features.	79
A.	<u>Locking Cover.</u>	79
B.	<u>Casing Cap.</u>	79
C.	<u>Flooding.</u>	80
D.	<u>Bases.</u>	80
E.	<u>Vaults.</u>	80
F.	<u>Protection From Vehicles.</u>	81
Section 11.	Filter Pack.	81

Section 12.	Casing.	82
	<u>Protective casing</u>	82
	<u>Conductor casing</u>	82
A.	<u>Casing Material.</u>	82
	1. <u>Chemical Compatibility.</u>	83
	2. <u>Used Casing.</u>	83
	3. <u>Plastic and Steel Casing.</u>	83
B.	<u>Multiple Screens.</u>	83
C.	<u>Bottom Plugs.</u>	84
D.	<u>Casing Installation.</u>	84
	1. <u>Cleanliness.</u>	84
	2. <u>Joining Casing.</u>	84
	3. <u>Impact.</u>	84
Section 13.	Well Development.	84
A.	<u>Mechanical Surging.</u>	84
B.	<u>Overpumping and Pump Surging.</u>	85
C.	<u>Air Development.</u>	85
D.	<u>Water Jetting.</u>	85
E.	<u>Chemical Development.</u>	85
Section 14.	Rehabilitation and Repair of Monitoring wells.	85
Section 15.	Temporary Cover.	86
Part III. Destruction of Monitoring Wells		
		87
Section 16.	Purpose of Destruction.	87
Section 17.	Definition of "Abandoned" Monitoring Well.	87
Section 18.	General Requirement.	87
Section 19.	Requirements for Destroying Monitoring Wells and Exploration Holes.	88
A.	<u>Monitoring Wells.</u>	88
	1. <u>Preliminary Work.</u>	88
	2. <u>Sealing Conditions.</u>	88
B.	<u>Exploratory Borings.</u>	89
C.	<u>Placement of Sealing Material.</u>	90
	1. <u>Placement Method.</u>	90
	2. <u>Timing of Placement.</u>	90
	3. <u>Ground Water Flow.</u>	90
	4. <u>Sealing Pressure.</u>	91
	5. <u>Verification.</u>	91
D.	<u>Sealing and Fill Materials.</u>	91
E.	<u>Additional Requirements for Monitoring Wells and Exploratory Borings in Urban Areas.</u>	91
F.	<u>Temporary Cover.</u>	92

Part I. General

. 93

Section 1. Definitions. 93

 A. Cathodic Protection Well. 93

 B. Enforcing Agency. 93

 C. Casing. 93

 D. Conductor Casing. 93

Section 2. Exemption Due to Unusual Conditions. 93

Section 3. Special Standards. 93

Section 4. Responsible Parties. 94

Section 5. Reports. 94

Part II. Cathodic Protection Well Construction

. 95

Section 6. Well Location with Respect to Contaminants and Pollutants. 95

 A. Separation. 95

 B. Flooding and Drainage. 95

 C. Accessibility. 95

Section 7. Sealing the Upper Annular Space. 95

 A. Minimum Depth of Annular Seal. 95

 1. Minimum Depth. 96

 2. Fill. 96

 3. Sealing-Off Strata. 96

 B. Sealing Conditions. 96

 C. Radial Thickness of Seal. 96

 D. Sealing Material. 96

 E. Placement of Seal. 97

Section 8. Surface Construction Features. 97

 A. Locking Cover. 97

 B. Casing Cap. 97

 C. Flooding. 97

 D. Bases. 97

 E. Vaults. 97

 F. Protection From Vehicles. 98

Section 9. Casing. 99

Section 10. Sealing-Off Strata. 99

Case 1. Upper Stratum. 99

Case 2. Lower Stratum. 99

Case 3. Multiple Strata. 100

Section 11.	Repair of Cathodic Protection Wells.	100
Section 12.	Temporary Cover.	100
Part III. Destruction of Cathodic Protection Wells		
.	102
Section 13.	Purpose of Destruction.	102
Section 14.	Definition of Abandoned Cathodic Protection Well.	102
Section 15.	General Requirements.	102
Section 16.	Requirements for Destroying Cathodic Protection Wells.	103
A.	<u>Preliminary Work.</u>	103
B.	<u>Filling and Sealing Conditions.</u>	103
	1. <u>Wells that only penetrate unconsolidated material and a single "zone" of ground water.</u>	103
	2. <u>Wells that penetrate several water-bearing strata.</u>	103
	3. <u>Wells penetrating fractured rock.</u>	104
	4. <u>Wells in nonfractured consolidated strata.</u>	104
	5. <u>Wells penetrating water-bearing zones or aquifers of special significance.</u>	104
	1. <u>Placement Method.</u>	104
	2. <u>Timing of Placement.</u>	105
	3. <u>Ground Water Flow.</u>	105
	4. <u>Sealing Pressure.</u>	105
	5. <u>Verification.</u>	105
D.	<u>Sealing Materials.</u>	105
E.	<u>Fill Material.</u>	105
F.	<u>Additional Requirements for Destruction of Cathodic Protection Wells in Urban Areas.</u>	106
G.	<u>Temporary Cover.</u>	106

FIGURES

Figure (1)	Special Permit Area - Sanel Valley	xxiv
Figure (2)	Special Permit Area - Laytonville Valley	xxv
Figure (3)	Special Permit Area - Potter Valley	xxvi
Figure (4)	Special Permit Area - Round Valley	xxvii
Figure 3.	Effect of Reversal of Ground Water Gradient	14
Figure 4.	Sealing Condition for Upper Annular Space - Unconsolidated and Soft, Consolidated Formations	19
Figure 5.	Sealing Conditions for Upper Annular Space - Hard Rock Formations and Gravel Packed Wells	21
Figure 6.	Typical Surface Construction Features	31
Figure 7.	Surface Construction Features for Community Water Supply Wells	32
Figure 8.	Sealing of Strata	42
Figure 9.	Properly Destroyed Wells	51
Figure 10.	Methods for Sealing the Annular Space	57
Figure 11.	Methods for Sealing Off Strata	59
Figure 12.	Monitoring Well Types	69
Figure 13.	Cross Section of a Typical Monitoring Well	70

TABLES

Table 1.	Horizontal Setbacks to Pollution and Contamination Source	11
Table 2.	Minimum Depth of Annular Seal	15
Table 3.	Chlorine Compound Disinfection Doses	63

APPENDIXES

APPENDIX B	Suggested Methods for Sealing the Annular Space and for Sealing of Strata	54
APPENDIX C	Suggested Procedures for Disinfecting Wells .	61
APPENDIX D	Collection of Water Quality Samples	64

CHAPTER 16.04

WATER, MONITORING, AND CATHODIC PROTECTION WELLS

Sec. 16.04.010 Purpose.

It is the purpose of this Chapter:

- (A) To provide for the construction, repair, and destruction of water, monitoring and cathodic protection wells.
- (B) To provide for the destruction of abandoned wells and the abatement of wells found to be public nuisances or hazards.
- (C) To preserve and protect the ground waters of Mendocino County from contamination or pollution.

Sec. 16.04.020 Definitions.

The following definitions shall apply in the interpretation of this chapter:

- (A) Abandoned Well. A 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 accordance with Section 24400 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 the impairment of quality of water within the well and ground water 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.
- (B) ABATEMENT means the construction, repair, or destruction of a well which is ordered under these regulations so as to eliminate a nuisance or safety hazard caused by a well which pollutes or contaminates ground water or otherwise jeopardizes the public health.
- (C) ABATEMENT ORDER means either written mandatory or prohibitory orders of the Health Officer requiring or prohibiting one or more acts. Said term to include those orders effective for a limited as well as an indefinite period of time, and to include modification or restatements of any order.
- (D) APPURTENANCES means well casing, screens, filter pack, annular seal and well pit.
- (E) CATHODIC PROTECTION WELL means a well developed to house devices to minimize electrolytic corrosion of metallic pipelines, tanks, and other facilities in contact with the ground.
- (F) CONTAMINATION means an impairment of the quality of water to a degree which creates a nuisance or hazard to the public health.
- (G) ENFORCING AGENCY means the Mendocino County Health Department.
- (H) HEALTH OFFICER means The Mendocino County Health Officer or an authorized representative.
- (I) MONITORING WELL means any artificial excavation by any method for the purpose of monitoring fluctuations in ground water levels, quality of underground waters, or the concentration of contaminants in the underground waters including exploration (boring) holes.
- (J) PERSON means an individual, public or private corporation, political subdivision, agency, board, department or bureau of the state, municipality, partnership, copartnership, firm, association, trust or estate, or any other legal entity which is recognized in law as the subject of right and duties.
- (K) POLLUTION means an alteration of the quality of water to a degree which unreasonably affects such waters for beneficial uses or affects facilities which serve such beneficial uses. Pollution may include contamination.
- (L) REPAIR means any work on a water, monitoring, or cathodic protection well that would include deepening, changes and/or additions to the appurtenances.
- (M) SPRING means a flow of water from the earth which occurs spontaneously where the water table stratum emerges to the surface of the earth. This term includes gravity springs, artesian springs, seepage springs, tubular springs, and fissure springs as defined in the "Sanitarians's Handbook," 1959 edition. The term does not include horizontal wells developed

by boring or drilling into the earth or any other developmental activity beyond properly enclosing the source for protection of water potability and conveying to a water system without a mechanical pump.

- (N) WATER WELL means any artificial excavation constructed by any method for the purpose of extracting water from, or injecting water into, the underground. The 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.
- (O) WELL means a water well, monitoring well, or cathodic protection well.
- (P) WELL DRILLER means a contractor possessing a current C-57 License in accordance with the provisions of the Contractors License Law (Chapter 9, Division 3, of the Business and Professions Code).
- (Q) WELL PIT or VAULT means any excavation constructed over a well for the purpose of containing well appurtenances or well casing below the natural ground contour.

Sec. 16.04.030 General Prohibitions.

It is unlawful and prohibited for any person within the unincorporated area of the County to:

- (A) Construct, repair, or destruct a well without a written permit first being obtained from the Health Department and all work conforms to the conditions of such permit and these regulations.
- (B) Undertake to construct, repair, or destruct a well unless the person responsible for the construction, repair, or destruction possesses a C-57 Water Well Contractor's License.
- (C) Allow the existence of an abandon well.
- (D) Maintain a well in such condition as it becomes a trap for persons or animals.
- (E) Maintain a well in such condition as to allow it to become a conduit for pollution or contamination of the ground water.

Sec. 16.04.040 Permit Application.

- (A) Application for a well permit shall be made on forms provided for that purpose and in accordance with procedures established

by the Health Department. The application shall be signed by a person possessing a current C-57 Water Well Contractor License. Plans, specifications, maps, drainages, and other such information may be required by the Health Department.

- (B) Each application shall be accompanied by a filing fee set by resolution of the Board of Supervisors. No part of the fee shall be refundable. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.050 Issuance of Permits.

- (A) Within five (5) business days after receipt of a complete application, the Health Department shall either grant, conditionally grant, or deny the permit. If the permit is not acted upon within the five-day period, the permit shall be deemed granted. If additional data is required, the five-day period shall commence from the date of receipt of the additional data. A permit shall not be issued if, in the judgement of the Health Officer, the well may jeopardize the health, safety, or welfare of the people of Mendocino County. (Ord. No 1135, adopted 1973.)
- (B) Any permit issued under these regulations may be modified, revoked, or suspended by the Health Officer if the Health Officer determines a violation of these regulations exists, provided that written notice has been directed to the permittee specifying the violation and that the permittee has failed or neglected to make necessary adjustments within thirty (30) days of receiving such notice. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.060 Inspections: Construction, Repair, and Destruction.

The Health Officer shall have the right to inspect all permitted wells as follows:

- (A) Upon receipt of an application, an inspection of the well location by the Health Officer may be required prior to issuance of a well permit. (Ord. No. 1135, adopted 1973.)
- (B) The Health Officer may inspect any permitted work prior to completion. (Ord. No 1135, adopted 1973.)
 - (1) The Well Driller shall notify the Health Officer prior to placement of an annular seal or the destruction of a well.
 - (a) Water well notification minimum notice shall be twenty-four (24) hours.
 - (b) Monitoring and Cathodic Protection well notification minimum notice shall be five (5) working days.
- (C) A State of California Well Completion Report shall be submitted to the Health Department within fifteen (15) days of completion

as a requirement of final approval of construction, modification, repair, or destruction.

Sec. 16.04.070 Inspection.

The Health Officer, during reasonable hours, for the purpose of enforcing or administering these regulations, or any order, regulation, or rule prescribed pursuant thereto, may enter any building, premises, or other place except a private residence. Every person is guilty of a misdemeanor who in any way denies, obstructs, or hampers such entrance. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.080 State Reporting.

Nothing contained in this Chapter shall be deemed to relieve any person from compliance with the provisions of Article 3, Chapter 10, Division 7, of the California Water Code or any other state legislation. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.090 Expiration of Permit.

Any permit issued pursuant to these regulations shall expire and become null and void if the work authorized thereby has not been completed within one year following the date of issuance. Upon expiration of any permit issued pursuant to these regulations, no further work may be done in construction, repair, reconstruction, or destruction of a water, monitoring, or cathodic protection well unless and until a new permit for such purpose is secured in accordance with the provisions of these regulations. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.100 Cleaning of Wells.

This Chapter shall not apply to the cleaning of wells by the owner or person authorized by the owner. No permit shall be required to clean out a well unless such action requires changing the physical construction of the well or well appurtenances. No chemical other than chlorine may be used to clean a well unless approved by the Health Officer.

Sec. 16.04.110 Exclusions.

Springs are excluded from these regulations. Exploration holes for determining suitability of on-site domestic sewage disposal that are less than 10 feet in depth are excluded from these regulations.

Sec. 16.04.120 Change of Use of Well.

Before a change of use is made of a well, compliance shall be made with the requirements for the new use as specified in these regulations. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.130 Exemption Due to Unusual Conditions.

If the Health Officer finds that compliance with any of the requirements in these regulations is impractical for a particular location because of unusual conditions and would result in construction of an unsatisfactory well, the Health Officer may prescribe alternative requirements which are equivalent to the standards set forth in these regulations in terms of protection obtained. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.140 Special Permit Areas

The Health Officer shall designate a Special Permit Area when conditions within a geographical area have been identified that require special provisions to protect the ground water. The special provisions imposed within these designated areas shall be in addition to the provisions of the well standards adopted by this Chapter.

Sec. 16.04.150 Protection of Wells.

At all times during the progress of well construction, reconstruction, repair, or destruction, the well shall be protected in such a manner as to prevent, as far as possible, tampering with the well, the entrance of foreign material into the well, or the entrance of drilling mud into streams or other surface waters. Water and drilling mud used in drilling shall be free from contamination or rendered free from contamination by chlorination or other approved methods. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.160 Well Construction, Repair, and Destruction Standards.

The latest version of "California Well Standards" as developed by the California Department of Water Resources shall be the standards used for construction, repair and destruction of wells.

Sec. 16.04.170 Construction Requirements.

Materials and methods used in the construction, repair, reconstruction, or destruction of water, monitoring, and cathodic protection wells shall be as specified in this Chapter and the resolutions adopted pursuant thereto. Materials and methods not specifically described therein shall receive written approval by the County Health Department prior to use. The applicant shall bear the burden of proof in establishing suitability of materials or methods if other than those described in these regulations.

Sec. 16.04.180 Order to Abate Nuisance or Safety Hazard.

Whenever the Health Officer determines that an abandoned well is causing a nuisance or safety hazard by polluting or contaminating ground water or otherwise endangering the public health, the Health Officer may issue a written order setting forth the required corrective measures and requiring that the conditions productive of the nuisance or safety hazard be abated within ten (10) days. Thereafter, he shall forthwith serve the order upon the person occupying the premises, if any, and, if no person occupies the premises, the order shall be posted upon said premises in a conspicuous place. In addition, a copy shall be mailed, first class postage paid, to the owners of the premises as their names and addresses appear upon the last equalized assessment roll. The Health Officer may for good cause extend the time specified in the order or otherwise modify or rescind the order. The order of abatement shall advise the possessors and owners of the property of their right to appeal to the Board of Supervisors and to stay the order of abatement pending such appeal. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.190 Abatement by the County.

In the event that a nuisance or hazard is not abated in accordance with an order of abatement, or order resulting from the Board of Supervisors' hearing, pursuant to Section 16.04.220 the Health Officer may upon securing approval of the Board of Supervisors, proceed to abate the nuisance by force account, contract, or any other method deemed most expedient by the Board. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.200 Appeal from Denial, Modification, Revocation, or Suspension of Permit and from Order of Abatement.

Any person whose application for a permit has been denied or whose permit once issued has been modified, revoked, or suspended, or who has been given an order of abatement, may within ten (10) County working days following the receipt of the notice of such denial, modification, revocation, or suspension, or of the order of abatement, file an appeal in writing to the Board of Supervisors. Said appeal shall be accompanied by a filing fee as set forth by the Board of Supervisors, and shall specify the grounds upon which the appeal is taken. The Clerk of the Board shall then proceed to set the matter for hearing, not later than twenty (20) days thereafter, and such appeal shall stay the effect of any order or action until the Board hears the appeal and issues its order either to affirm, overrule, or modify the action of the Health Officer. The Board decision must be rendered within ten (10) days of the public hearing. Notice of hearing shall be mailed to the appealing party at least five (5) County working days prior to the hearing. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.210 Abatement of Safety Hazard.

These regulations in no way shall affect the right of the County to abate as a public nuisance pursuant to Article 9, Chapter 1, Division 1, Title 5 of the Government Code (commencing with Section 50230) any abandoned well which presents a safety hazard. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.220 Payment of Cost by Owner.

Any work carried out under Section 16.04.190 or 16.04.200 shall be the responsibility of the property owner. If such costs are not paid within thirty (30) days of the determination of the Board of Supervisors, said costs shall be assessed upon the property involved. The special assessment shall be collected at the same time and in same manner as County taxes are collected and shall be subject to the same penalties and the same procedure and sale in the case of delinquency as is provided for ordinary County taxes. All laws applicable to the levy, collection and enforcement of County taxes shall be applicable to such special assessment. (Ord. No. 1135, adopted 1973.)

Sec. 16.04.230 Penalties.

- (A) Any person who violates any provision of this Chapter shall be guilty of an infraction punishable by (1) a fine not exceeding one hundred dollars (\$100) for a first violation; (2) a fine not exceeding two hundred dollars (\$200) for a second violation of the same ordinance within one year; (3) a fine not exceeding five hundred dollars (\$500) for each additional violation of this Chapter within one year.
- (B) Any violation of the provisions of this chapter may cause to be filed with the County Recorder a notice of such violation, and a lien of estimated permit costs and penalties (such fees shall be further evaluated at the time of restitution.) The notice shall specify the names of the recorded owners and particularly describing the real property, provided that, at least thirty (30) days prior to recording such notice, the owner of the parcels or units to be affected by the notice of violation shall be advised in writing of the intention to record the notice specifying the time, date and place at which the owner may present evidence to the Division of Environmental Health as to why such notice should not be recorded. The decision of Environmental Health may be appealed to the Board of Supervisors.

Sec. 16.04.240 Construction and Validity.

If any provision of these regulations shall be declared void or unconstitutional by judicial or other determination, all other parts of the regulations which are not expressly held to be void or unconstitutional shall continue in full force and effect.

SPECIAL PERMIT AREAS

The following areas are designated Special Permit Areas and shall have special provisions for construction added to those contained within the adopted Well Standards.

A. SANEL VALLEY (Hopland Area). The area in Sanel Valley designated on Figure (1) is underlain by extremely poor quality magnesium bicarbonate water under pressure at depths greater than 400 feet. The water of the poor quality zone contains excessive dissolved solids, high concentrations of boron and chloride. Specific electrical conductance is in excess of 8500 microhm. Water of good mineral quality occurs above the poor quality zone. To protect the public health and ground water quality, wells drilled in the area designated in Figure (1) that are of a depth of 400 feet or greater shall:

1. Have determined the electrical conductivity of the water produced at each aquifer level over 400 feet. If the electrical conductivity is 1500 microhm or greater, the poor quality water producing strata shall be sealed off as specified in the well standards unless poor quality water is desired for specific purpose.
2. If water is to be obtained from the deeper poor water quality zone for a specific purpose, all overlying fresh or high quality water aquifers shall be completely sealed off to prevent inter-connection with poor quality water. Sealing shall be carried out as specified in the water well standards.
3. The standards for sealing-off strata in wells which are over 400 feet deep shall apply to new and existing wells.

B. LAYTONVILLE VALLEY. Clay layers, causing areas of perched water, are prevalent in the uppermost 20 feet of the Laytonville Valley floor. The shallow perched waters are of less desirable quality. To protect the public health and ground water quality, all wells drilled in the designated area of Figure (2) shall have an annular space seal to a minimum depth of 20 feet. Sealing shall be carried out as specified in the Water Well Standards.

C. POTTER VALLEY. In the norther portion of Potter Valley, a blue clay layer separates an artesian fresh water aquifer below the clay from a poor quality perched water zone above the clay. The depth of the clay layer is generally 20 to 35 feet. To protect the public health and ground water quality, the annular space of all sells drilled within the designated area of Figure (3) in Potter Valley shall be sealed to a depth of 30 feet or to a point

just above the artesian fresh water aquifer, whichever distance is less. Sealing shall be carried out as specified in the Water Well Standards.

- D. **ROUND VALLEY.** An artesian zone overlain by a shallow ground water zone of less desirable quality water exists in Round Valley. The shallow ground water zone does not generally exceed 40 feet in depth. To protect the public health and ground water quality, the annular space in all wells drilled within the designated area of Figure (4) in Round Valley shall be sealed to a depth of 40 feet or to a point just above the pressure aquifer, whichever distance is less. Sealing shall be carried out as specified in the Water Well Standards. If it is the intent to obtain water from the shallow ground water zone, then all pressure aquifers penetrated shall be completely sealed off to prevent interconnection.

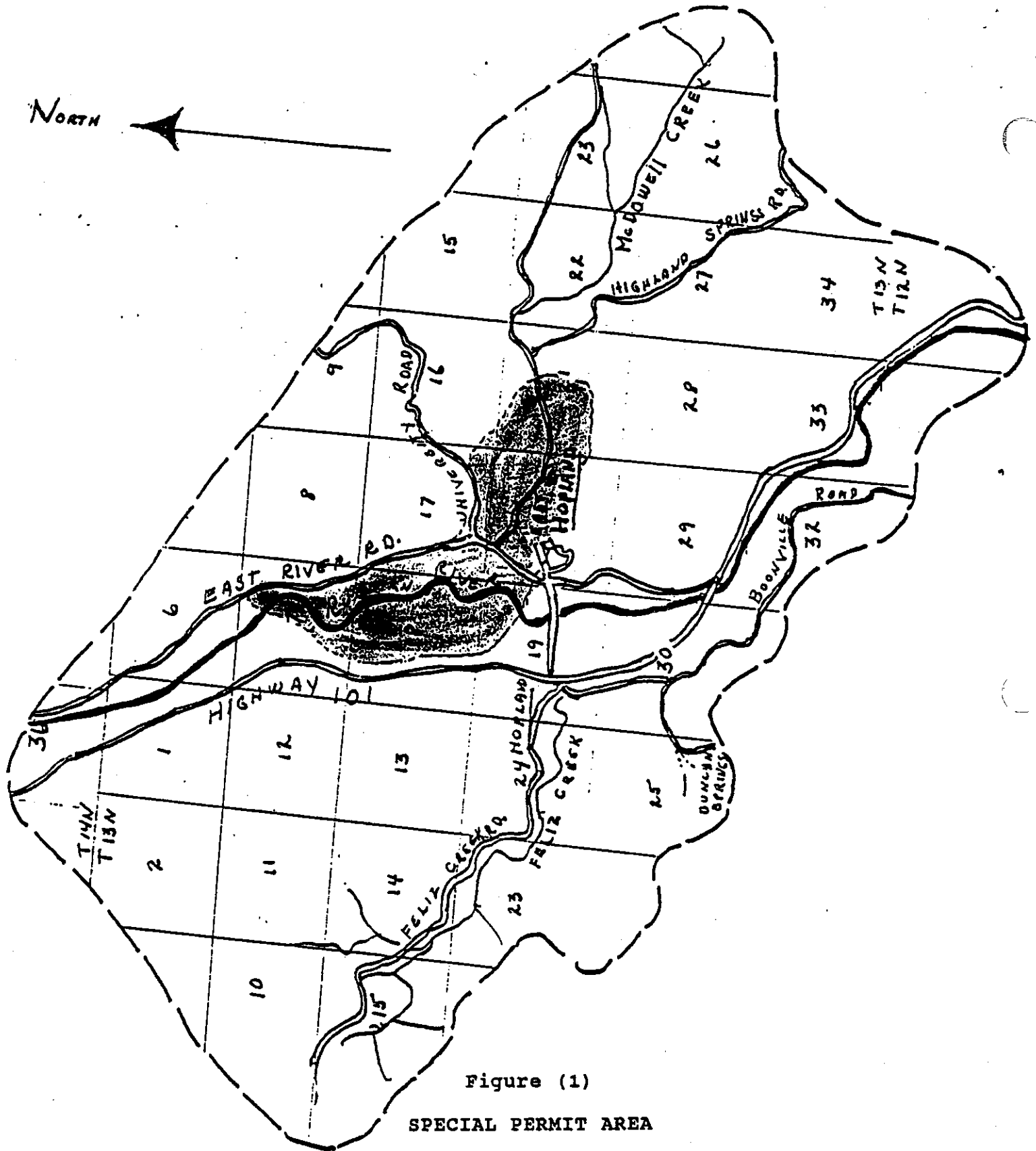


Figure (1)
 SPECIAL PERMIT AREA
 SANEL VALLEY AREA

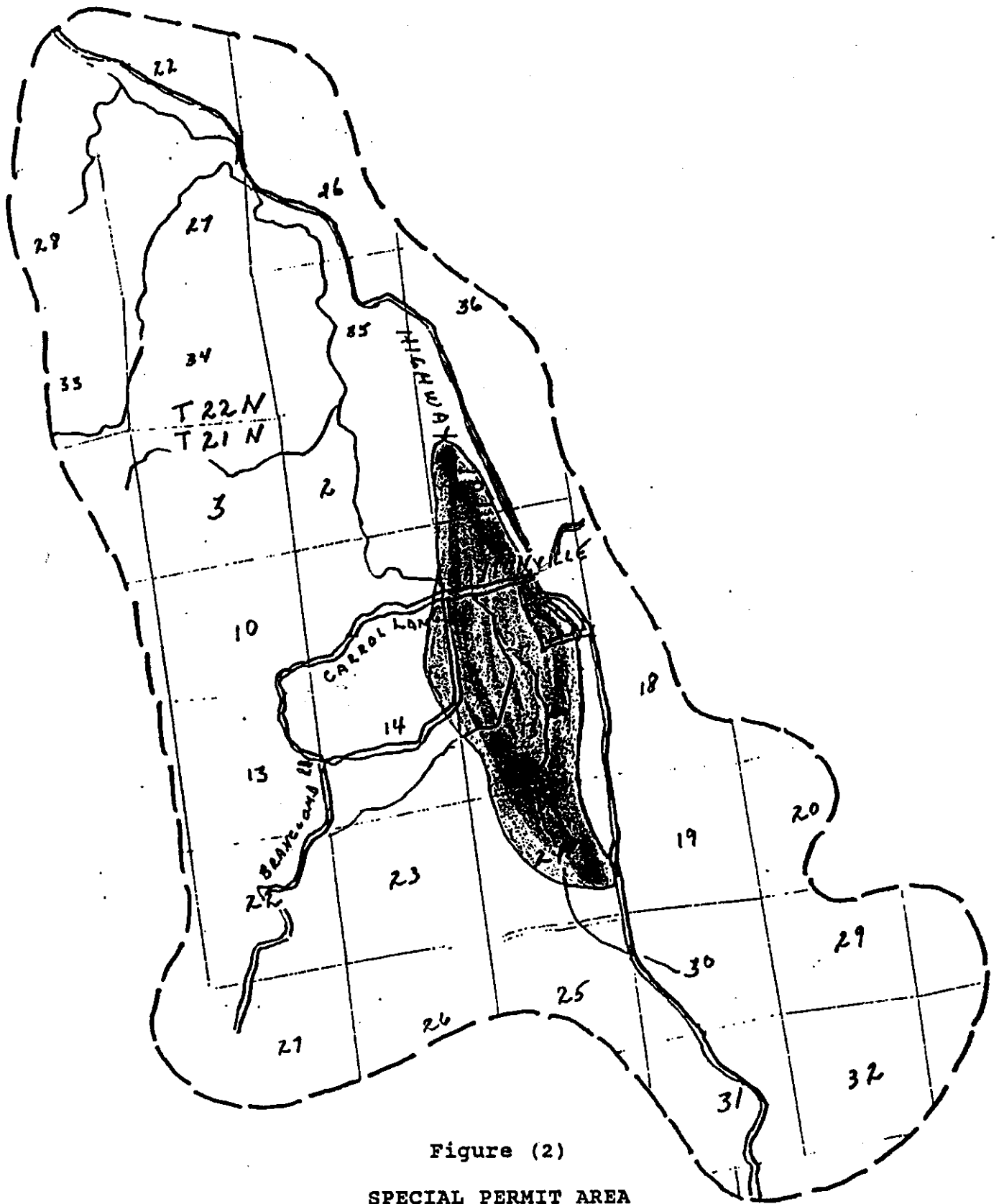


Figure (2)
 SPECIAL PERMIT AREA
 LAYTONVILLE VALLEY AREA

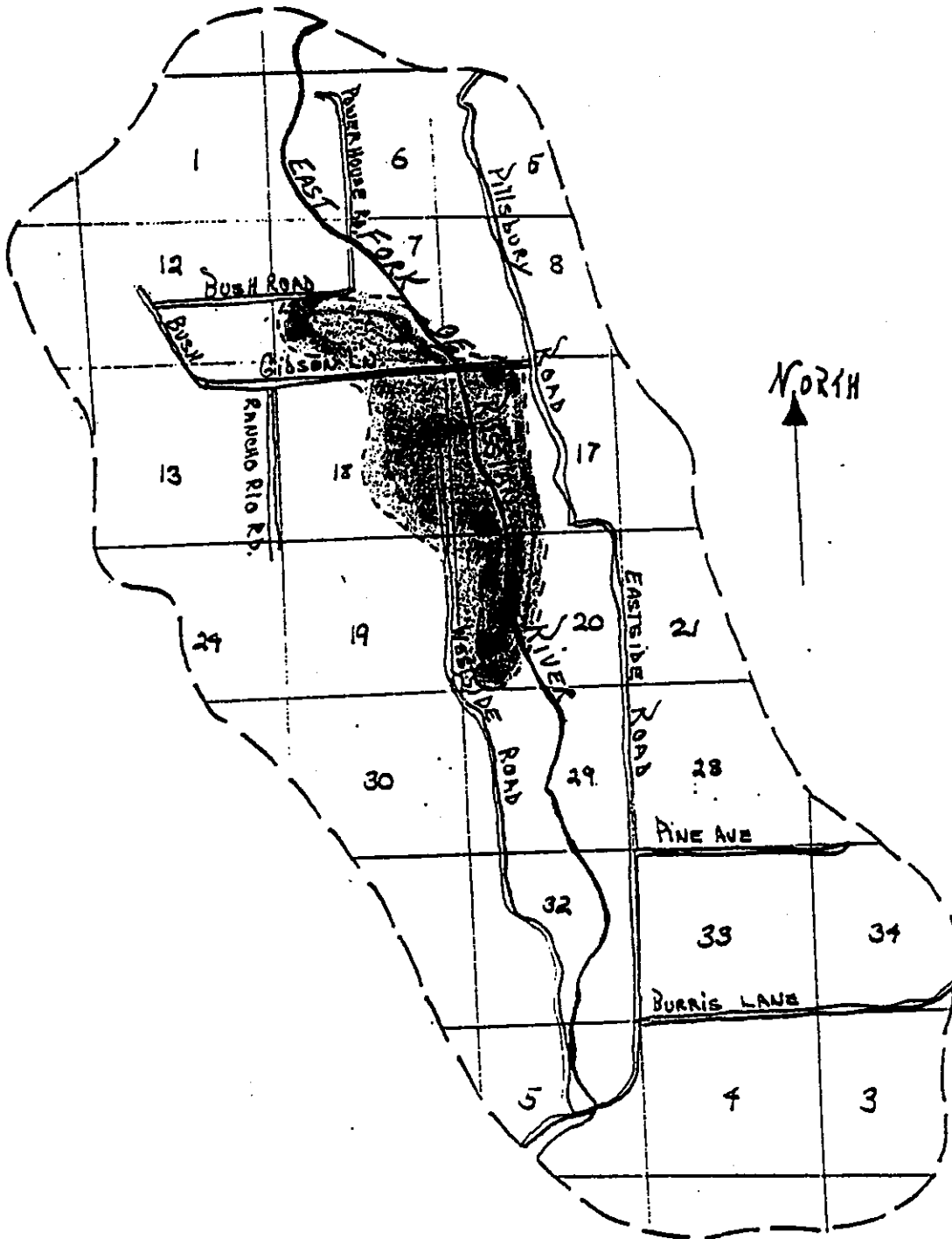


Figure (3)
 SPECIAL PERMIT AREA
 POTTER VALLEY AREA

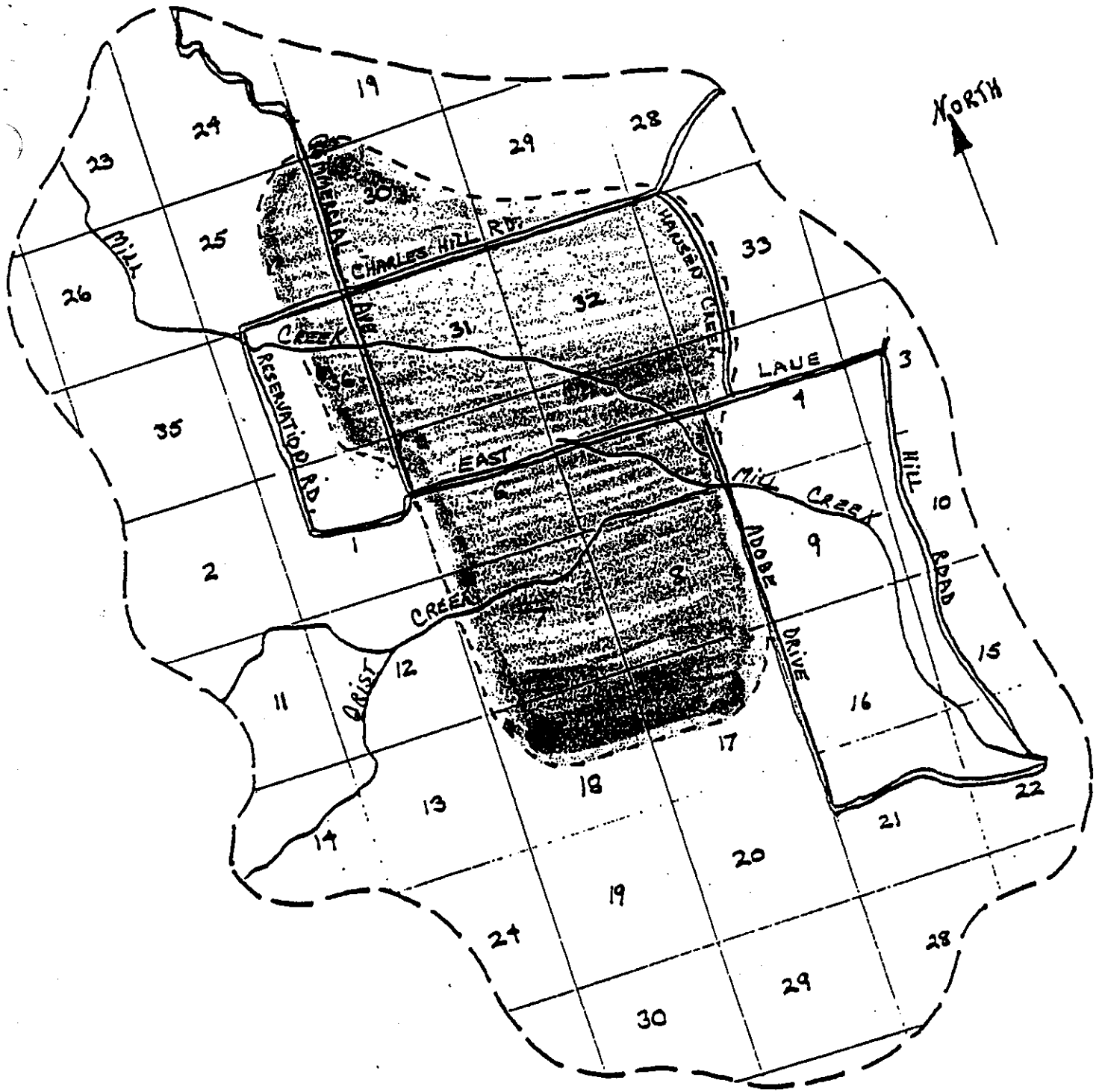


Figure (4)
 SPECIAL PERMIT AREA
 ROUND VALLEY AREA

WELL STANDARDS

An abridged compilation of the California Department of Water Resources "California Well Standards," Bulletins 74-81 and 74-90.

Italicized print indicates local interpretation.

Refer to the original documents for full presentation.

MENDOCINO COUNTY WELL STANDARDS

Introduction

These standards are an abridged compilation of the California Department of Water Resources "California Well Standards," Bulletins 74-81 and 74-90. No changes to these Bulletins are intended. *Italicized print indicates local interpretation.*

Improperly constructed, altered, maintained, or destroyed wells are a potential pathway for introducing poor quality water, pollutants, and contaminants to good-quality ground water. The potential for ground water quality degradation increases as the number of wells and borings in an area increases.

Improperly constructed, altered, maintained, or destroyed wells can facilitate ground water quality degradation by allowing:

- Pollutants, contaminants, and water to enter a well bore or casing;
- Poor quality surface and subsurface water, pollutants, and contaminants to move between the casing and the borehole wall;
- Poor quality ground water, pollutants, and contaminants to move from one stratum or aquifer to another;
- The well bore to be used for illegal waste disposal.

Abandoned wells that have not been properly destroyed pose a serious threat to water quality. They are frequently forgotten and become dilapidated with time, and can become conduits for ground water quality degradation. Abandoned wells can become hidden traps, ready to destroy the life of the unsuspecting human or animal that should venture onto it.

WATER WELLS

Part I. General

Section 1. Definitions.

Abandoned Well. A 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 accordance with Section 24400 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 the impairment of quality of water within the well and ground water 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 the 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.

Abatement. The construction, reconstruction, repair, or destruction of a well which is ordered under these regulations so as to eliminate a nuisance or safety hazard caused by a well which pollutes or contaminates ground water or otherwise jeopardizes the public health.

Abatement Order. Written mandatory or prohibitory orders of the Health Officer requiring or prohibiting one or more acts. Said term to include those orders effective for a limited as well as an indefinite period of time, and to include modification or restatements of any order.

Active Well. An operating water well.

Air-conditioning Well. A well 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 discharges and are, therefore, subject to the water quality control laws.

Agricultural Well. A water well used to supply water only for irrigation or other agricultural purposes, including so-called "stock wells".

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

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

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

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

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

Cathodic Protection. A technique to prevent the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

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

Cement, Portland Cement. A cement that contains oxides of calcium, aluminum, iron, and silicon made by heating a mixture of limestone and clay in a kiln and pulverizing the resultant clinker, as defined in ASTM C150. Portland cement is also considered a hydraulic cement, because it must be mixed with water to form a cement-water

paste with the ability to develop strength and harden, even under water.

Centralizer. A device that assists in centering tubular materials in a borehole.

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

Community Water Supply Well. A water well used to supply water for domestic purposes in systems subject to Chapter 7, Part 1, Division 5 of the California Health and Safety Code. Included are wells supplying public water systems classified by the Department of Health Services as "Community Water Systems", "Noncommunity water systems" and "State small water systems" (California Waterworks standards, Title 22, California Administrative Code). Such wells are variously referred to as "Municipal Wells", "City Wells", "Public Water Supply Wells".

Conductance, Specific. A measure of the ability of water to conduct electric current at 77 degrees Fahrenheit. It is related to the total concentration of ions in the water.

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

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

Confined Ground Water. Ground water under pressure whose upper surface is the bottom of an impermeable bed or a bed of distinctly lower permeability than the material in which the confined water occurs. Confined ground water moves under the control of the difference in head between the intake and discharge areas of the water body.

Connate Water. Water entrapped in the interstices of a sedimentary rock at the time it was deposited. These waters may be fresh, brackish, or saline in character. Usually applies only to water found in geologically older formation.

Consolidated Material. A geologic material whose particles are stratified, cemented, or firmly packed together; usually occurs at depth, e.g., sandstone.

Contamination. An impairment of the quality of water to a degree which creates a nuisance or hazard to the public health.

Corrosion. The deterioration of a material, usually a metal, because of a reaction with its environment.

Destroyed Well. A well that has been properly filled so that it cannot produce water nor act as a vertical conduit for the movement of ground water.

Deterioration. An impairment of water quality.

Drilled Well. A well for which the hole is excavated by mechanical means such as the rotary or cable tool methods.

Drilling Fluid. A fluid (liquid or gas) used in drilling operations to remove cuttings from a borehole, to clean and cool the drilling bit, to reduce friction between the drill stem and the borehole wall, and, in some cases, to prevent caving or sloughing of the borehole.

Driller's Mud. A fluid composed of water and clay used in the drilling (primarily rotary) operation. The mud serves to remove cutting from the hole, to clean and cool the bit, to reduce friction between the drill stem and the sides of the hole, and to plaster the sides of the hole. Such fluids range from relatively clear water to carefully prepared mixtures of special purpose compounds.

Drive Shoe. A forged steel collar with a cutting edge fastened onto the bottom of the casing to shear off irregularities in the hole as the casing advances, and to protect the lower edge of the casing as it is driven.

Electrolyte. A chemical substance or mixture, usually liquid, containing ions that migrate in an electric field. The term electrolyte refers to the soil or liquid adjacent to, and in contact with the buried or submerged metallic structure including the moisture and other chemicals contained therein.

Enforcing Agency. The Mendocino County Health Department.

Exploration Hole (or boring). An uncased temporary excavation whose purpose is the immediate determination of hydrologic conditions at a site. Exploration holes for determining suitability of on-site domestic sewage disposal that are less than 10 feet in depth are exempt from the reporting and destruction requirements of these standards.

Gravel Packed Well. A well in which filter material (sand, gravel, etc.) is placed in the annular space between the casing and the borehole to increase the effective diameter of the well, and to prevent fine-grained material from entering the well during pumping.

Ground Water. That part of the subsurface water which is in the zone of saturation.

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

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

Health Officer. The Mendocino County Health Officer or his authorized representative.

Horizontal Well. A water well drilled horizontally or at an angle with the horizon (as contrasted 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).

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

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

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

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

Individual Domestic Well. A water well used to supply water for the domestic needs of one or several individual residences, but serving less than the number of people or connections required for a "Community Water Supply Well".

Industrial Well. A water well used to supply industry on an individual basis (in contrast to supplies provided through community systems).

Interference. The situation that arises when a foreign substructure is affected in any way by a direct current source.

Monitoring Well. Any artificial excavation by any method for the purpose of monitoring fluctuations in ground water levels, quality of underground waters, or the concentration of contaminants in the underground waters.

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

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

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

Person. An individual, public or private corporation, political subdivision, agency, board, department or bureau of the state, municipality, partnership, copartnership, firm, association, trust or estate, or any other legal entity whatsoever which is recognized in law as the subject of right and duties.

Pollution. An alteration of the quality of water to a degree which unreasonably affects such waters for beneficial uses or affects facilities which serve such beneficial uses. Pollution may include contamination.

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

Quality of Water or Water Quality. The chemical, physical, biological, bacteriological, radiological, and other properties and characteristics of water which affect its use.

Rectifier. An electronic device that changes alternating current to direct current.

Repair. Any work on an existing water well that would include deepening or subsurface changes or additions to the casing or annular seal.

Screen or Well Screen. A factory-perforated casing used in a well that maximizes the entry of water from the producing zone and minimizes the entrance of sand.

Seepage Pit or Leach Field. Any excavation in the ground which receives liquid waste from any source for the purpose of absorption into the ground.

Spring. Flow of water from the earth which occurs spontaneously where the water table stratum emerges to the surface of the earth. This term includes gravity springs, artesian springs, seepage springs, tubular springs, and fissure springs as defined in the "Sanitarians's Handbook," 1959 edition. The term does not include horizontal wells developed by boring or drilling into the earth or any other developmental activity beyond properly enclosing the source for protection of water potability and conveying to a water system.

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

Tremie. A tubular device or pipe used to place grout in the annular space. Originally designed for placing concrete under water, the discharge end of the tube is kept submerged in the freshly deposited grout so as not to break the seal while filling the annular space.

Unconfined (free) Ground Water. Ground water that has a free water table, i.e., water not confined under pressure beneath relatively impermeable material.

Unconsolidated Material. A sediment that is loosely arranged or unstratified, or whose particles are not cemented together occurring either at the surface or at depth.

Waste. Sewage and any and all other waste substances, liquid, solid, gaseous, or radioactive, associated with human habitation, or manufacturing, or processing operation of whatever nature.

Water Well. Any artificial excavation constructed by any method for the purpose of extracting water from, or injecting water into, the underground. The 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.

Well Pit. Any excavation constructed over a well for the purpose of containing well appurtenances or well casing below the natural ground contour.

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

Section 4. Exclusions.

The standards prescribed in Part II, "Construction", do not apply to exploration and test holes. However, the provisions of Section 7 "Reports" (following) and Part III, "Well Destruction", do apply to these holes. Exploration holes for determining suitability of on-site domestic sewage disposal that are less than 10 feet in depth are exempt from the reporting and destruction requirements of these standards.

Springs are excluded from these standards.

Section 5. Special Standards.

- A. In locations where existing geologic or ground water 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 of 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 Sections 13750 through 13755 (Division 7, Chapter 10, Article 3) of the California Water Code.

Part II. Well Construction

Section 8. Well Location with Respect to Pollutants and Contaminants.

A. Separation. All 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:

- sanitary, industrial, and storm sewers;
- septic tanks and leach fields;
- sewage and industrial waste ponds;
- barnyards and stable areas;
- feedlots;
- solid waste disposal sites;
- above and below ground tanks and pipelines for storage and conveyance of petroleum products or other chemicals; and,
- storage and preparation areas for pesticides, fertilizers, and other chemicals.

Consideration should also be given to well location with respect to sites with documented or suspected soil or water pollution or contamination.

The following horizontal separation distances are generally considered safe where a significant layer of unsaturated, unconsolidated sediment, less permeable than sand, is encountered between ground surface and ground water. These distances are based on present knowledge and past experience. Local conditions may require greater separation distances to ensure ground water quality 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 sepage pit	150 feet
Animal or fowl enclosure	100 feet

Table 1.

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 and 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 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 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 ground water gradient from potential sources of pollution or contamination. Locating wells up gradient from pollution or contamination sources can provide an extra measure of protection for a well. However, consideration should be given that the gradient near a well can be reversed by pumping, as shown in Figure 3, 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 community and other water supply wells is not possible, 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 so as 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 the casing against corrosion, ensure the structural integrity of the casing against corrosion or degradation, ensure the structural integrity of the casing, and stabilize the borehole wall.

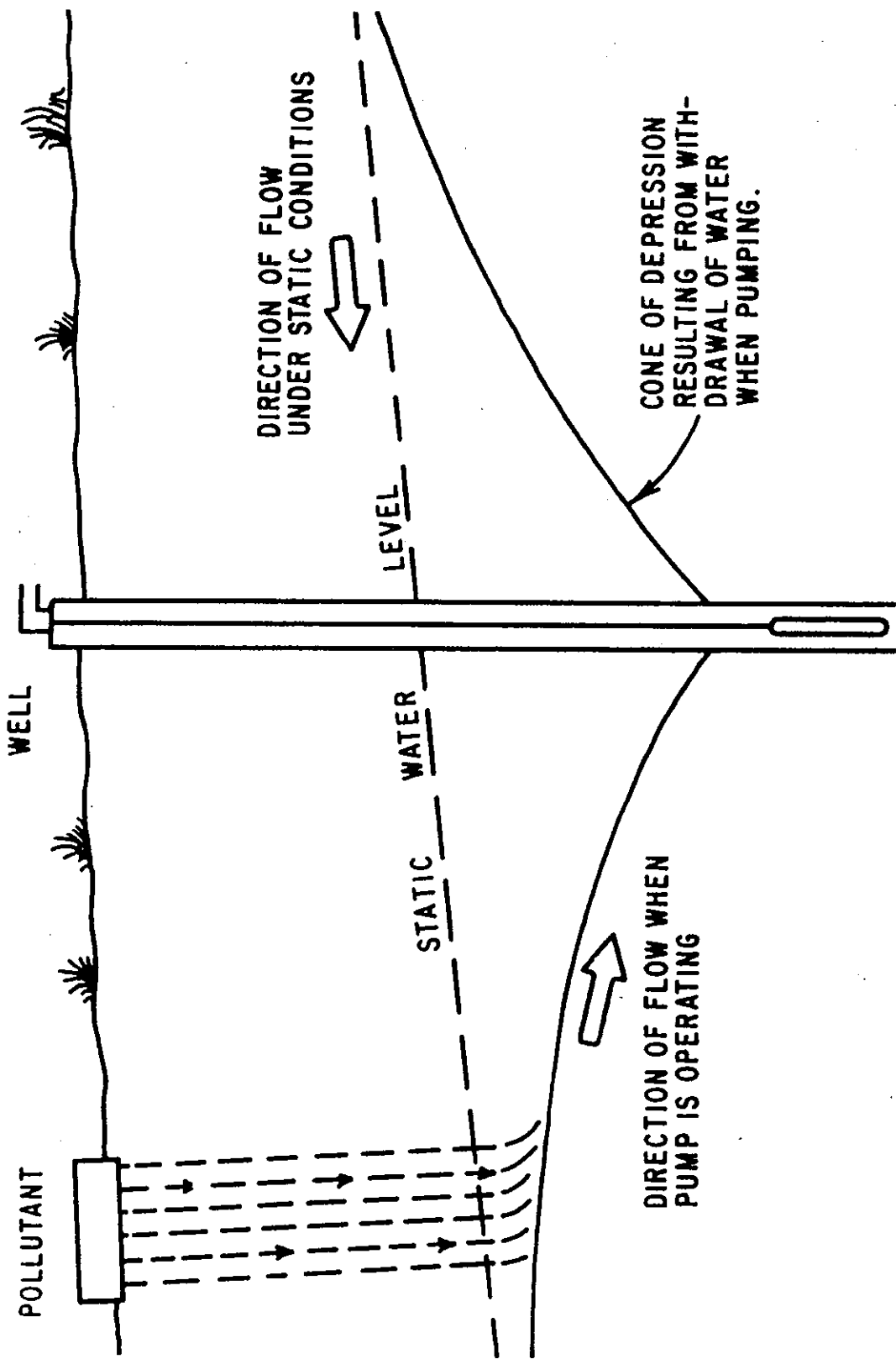


Figure 3.

EFFECT OF REVERSAL OF GROUND WATER GRADIENT

- A. Minimum Depth of Annular Seal. The annular seal for various types of water wells shall extend from 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

Table 2.

1. Shallow Ground Water. 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 at a depth less than 20 feet. In no case shall an annular seal extend to a total depth less than 10 feet below land surface. The annular seal shall be no less than 10 feet in length.

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.

2. Encroachment of 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 the source of pollution or contamination than allowed by Section 8, 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. 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. In no case shall the top of the annular surface seal be more than 4 feet below ground surface. The vault shall extend from the top of the annular seal to at least ground surface.

The use of subsurface vaults to house the top of water wells below ground surface is rare and is discouraged due to suscep-

tibility to the entrance of surface water, pollutants, and contamination. Where appropriate, pitless adapters should be used in place of vaults.

B. Sealing Conditions. The following requirements are to be observed for sealing the annular space.

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 shall be temporarily installed to at least the minimum depth of annular seal specified in Subsection "A" of this section. Permanent conductor casing may be used if it is installed in accordance with Items 3 & 5 of this Subsection and it extends at least to the depth specified in Subsection A. 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 borehole wall, as shown in Figure 4A. Sealing material shall be placed at least within the interval specified in Subsection A. The sealing material shall be kept at a sufficient height above the bottom of the temporary conductor 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 bore hole wall to fill any possible gaps or voids between the conductor casing and the borehole wall. At least two inches of sealing material shall be maintained between the conductor casing and well casing. At a minimum, sealing material shall extend through intervals specified in Subsection A, above.

Sealing material can often be placed between temporary conductor casing that cannot be removed and the borehole wall by means of pressure grouting techniques, as described below and in Appendix B. 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 borehole wall. Casing perforations shall be a suitable size and density to allow the passage of sealing materials through the casing and the proper distribution of sealing material in spaces between the casing and 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 operations 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 spaces or voids between the casing and 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 required sealing intervals.

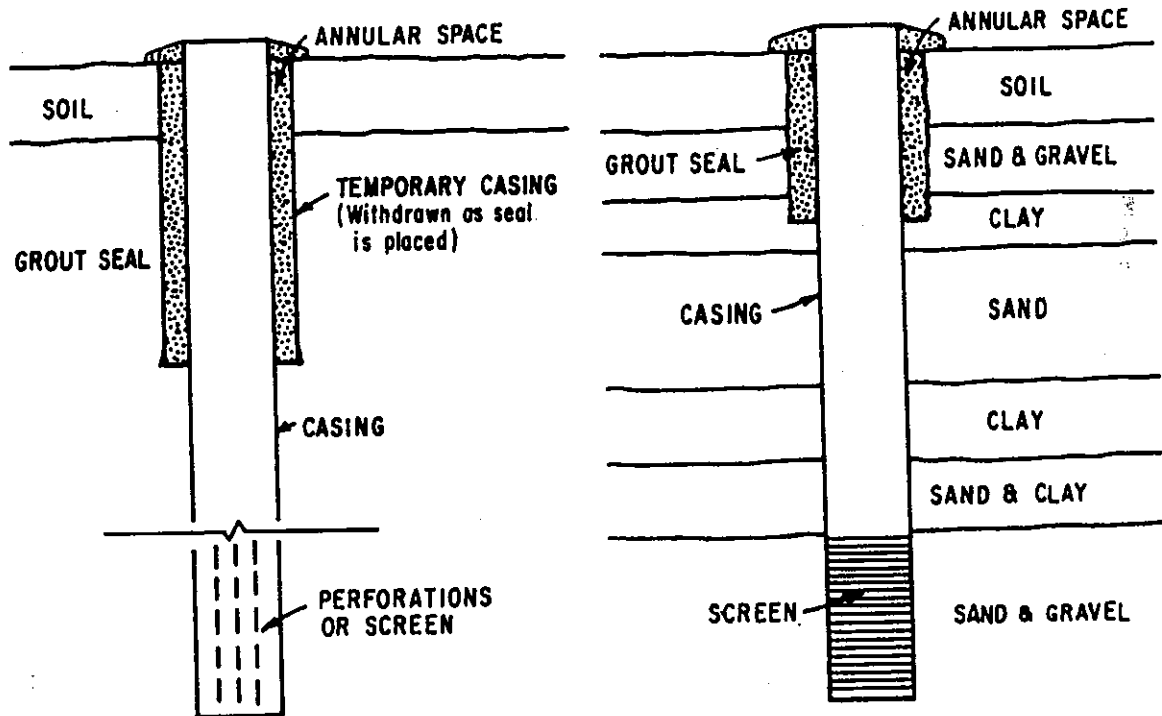
2. Wells drilled in unconsolidated material with significant clay layers. An "oversized hole", at least 4 inches greater in diameter than the outside diameter of the well casing, shall be drilled to at least the depth specified in Subsection A, and the annular space between the borehole wall and the well casing filled with sealing material in accordance with Subsection A (see Figure 4B). If a significant layer of clay or clay-rich deposits having low permeability is encountered within 5 feet of the bottom of the minimum seal prescribed in Subsection A, 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 its 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 well drilling and placement of the casing and annular seal, in accordance with the requirements of Item 1 of this Subsection. Permanent conductor casing may be used if it is installed in accordance with Items 3 and 5 of this Subsection and it extends to at least the depth specified in Subsection A.

3. Wells drilled in soft consolidated formation (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. The space between the well casing and borehole shall be filled with sealing material to at least the depth specified in Subsection A, as shown by Figure 4C.

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, and the annular space between the conductor casing and the borehole wall filled with sealing material.



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

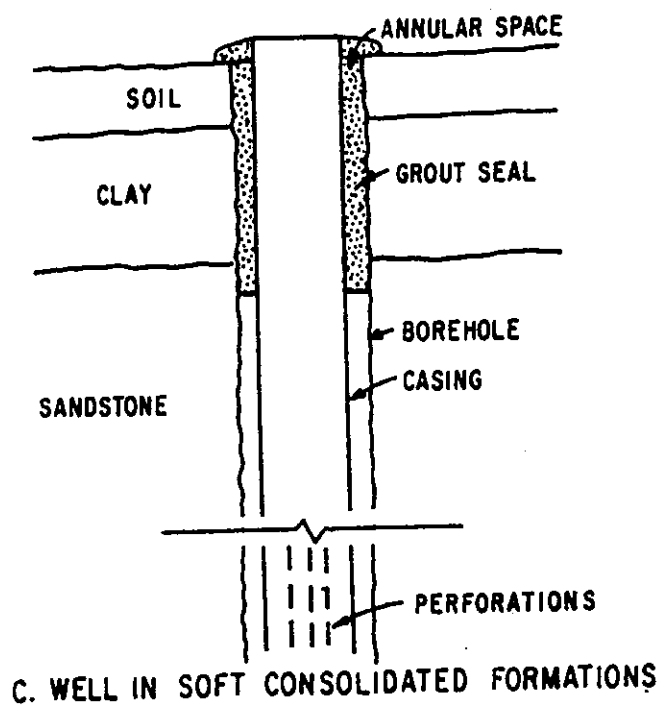


Figure 4.

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

In some cases, such as in cable tool drilling, it may be necessary to extend permanent conductor 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 wall other than the depths specified in Subsection A and Section 13.

4. Wells situated in "hard" consolidated formations (crystalline or metamorphic rock). An oversized hole shall be drilled to the depth specified in Subsection A 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 seated in the sealing material (see Figure 5A).
5. Gravel packed wells.
 - a. With conductor casing. An oversized hole, at least 4 inches (100 millimeters) greater than the diameter of the conductor casing, shall be drilled to the depth specified in Subsection A and the annular space between the conductor casing and 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 water tight cover shall be installed over the top in the space between the conductor casing and the production casing, see Figure 5B.
 - b. Without conductor casing. An oversized hole at least 4 inches (100 millimeters) greater in diameter than the production casing, shall be drilled to the depth specified in Subsection A and the annular space between the casing and drilled hole filled with sealing material. If 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 (50 millimeters) 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 5C). If a temporary conductor casing is used, it shall be removed as the sealing material is placed.
6. For wells situated in circumstances differing from those described above. The sealing conditions shall be as prescribed by the enforcing agency.

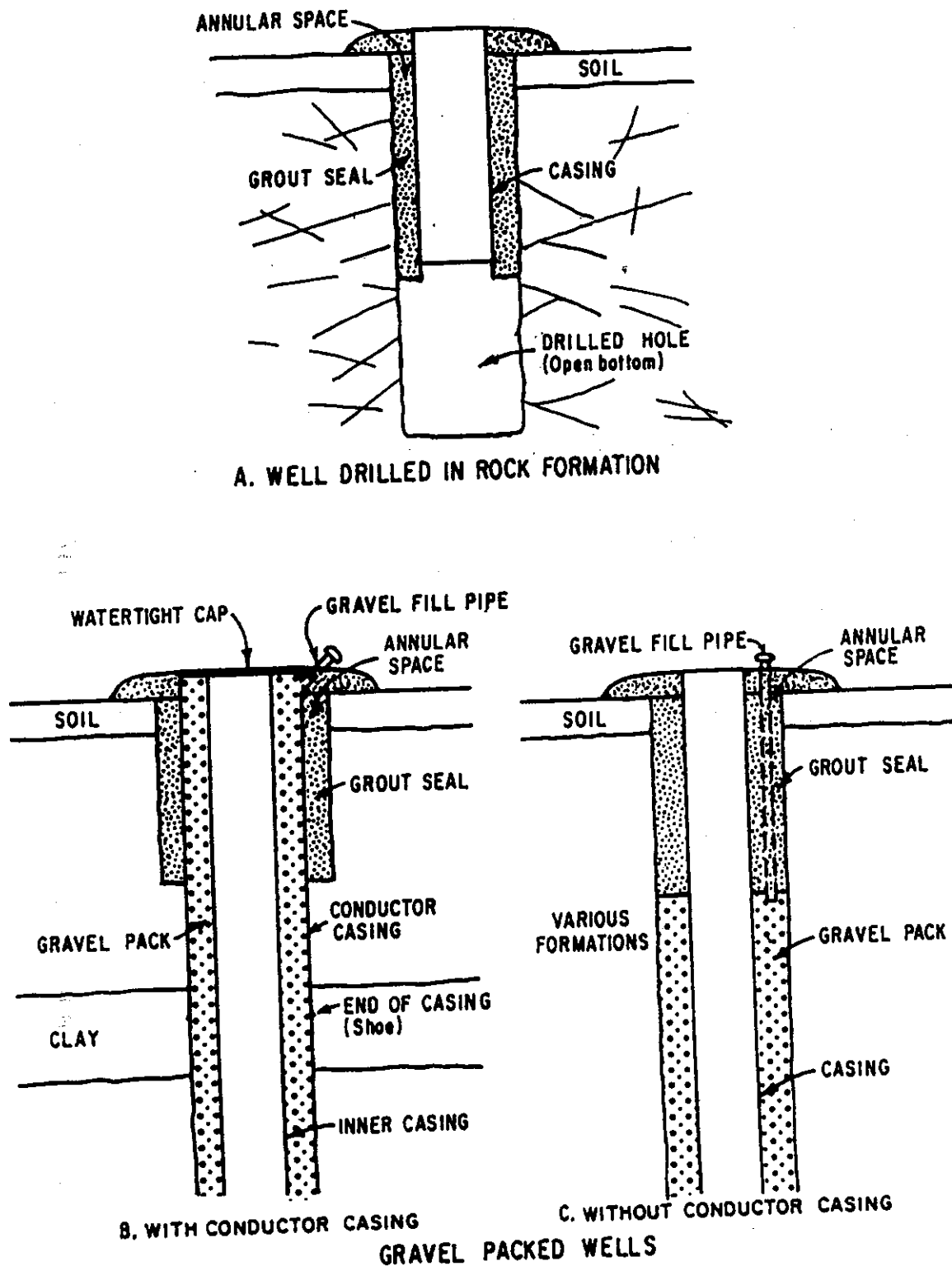


Figure 5.

SEALING CONDITIONS FOR UPPER ANNULAR SPACE
HARD ROCK FORMATIONS AND GRAVEL PACKED WELLS

7. Converted wells. 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 and at the thickness described in Subsection 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.
- C. Conductor Casing. For community water supply wells, the minimum thickness of steel conductor casing shall be 1/4 inch (6 millimeters) for single casing or a minimum of No. 10 U. S. Standard Gage for double casing. Steel used for conductor casing shall conform to the specifications for steel casing described in Section 12.
- D. Sealing Material. The 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 of suspended matter. In some cases water considered non-potable, with a maximum of 2,000 mg/l of 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 the American Society for Testing and Materials C150, Standard Specification for Portland Cement, including the latest revisions 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 requirement of ASTM C494, Standard Specification for Chemical Admixtures for Concrete, and latest revision 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 ensure proper mixing, uniformity of hydration, and an effective homogeneous seal.

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

- Types I and 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. Neat cement grout shall be mixed at a ratio of one 94-pound sack of Portland cement to 5 to 6-1/2 gallons of clean water.
- 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 one part cement by weight is used. Additional water may be required when special additives, such as bentonite, or 'accelerators' or 'retardants' are used.
- c. Concrete. Concrete is often useful for large volume annular seals, such as in large-diameter wells. The proper use of aggregates 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 pound sacks 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 a 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" form has some of the advantages of cement-based 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 annular seals.

Unamended bentonite clay seals should not be used where structural strength of the seal is required, or where it might dry. Bentonite seals may have a tendency to dry, shrink and crack in arid and semi-arid areas 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 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 they are placed.

Bentonite clay mixtures shall be mixed thoroughly 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 1/2 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 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 should be taken to prevent bridging during the placement of bentonite seal material.

E. Radial Thickness of the 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 conduction casing cannot be removed, as noted in Subsection B. A minimum of two inches of sealing material shall also 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 casing to be properly centralized and spaced and allow the use of a tremie pipe during well construction (if required), especially for deeper 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 construction by use of removable tools, such as hollowstem augers.

The spacing of centralizers is normally dictated by the casing materials used, the orientation and straightness of the borehole, and the 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 the 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 metallurgical specification and standards as the metallic casing to reduce the potential for galvanic corrosion of the casing.

3. Foundation and Transition Seals. A packer or similar retaining device, or a small quantity of sealant that is allowed to set, can be placed at 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 sometime 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. Coarse forms of bentonite, such as pellets and chips, are often used where a bentonite transition seal is to be placed below the 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 in a tremie pipe.

Bentonite can be placed in dry form or as 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 ration of about 1 gallon for every 2 pounds of bentonite to allow for proper hydration. Water added to bentonite for hydration shall be of suitable quality and free of pollutant and contaminants.

Sufficient time should be allowed for bentonite transition seals to properly hydrate before cement-based sealing materials are placed. Normally, 1/2 to 1 hour is required for proper 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 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 to be 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. The remainder of the seal shall then 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 free fall, bridging, or dilation of the sealing material, or separation of sand or aggregate from 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.

5. Ground Water Flow. Special care shall be used to restrict the flow of ground water into a well boring while placing material, where subsurface pressure causing the flow of water is significant.
6. Verification. It shall be verified that the volume of sealing material placed at least equals or exceeds the volume to be sealed.
7. Pressure. Pressure required for placement of sealing materials shall be maintained long enough for cement-based sealing materials to properly set.

Section 10. Surface Construction Features.

- A. Openings. 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 water-tight 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 downturned and screened "U" bends (see Figures 6 and 7).

terminate above the ground and above known flood levels and shall be protected against the entrance of foreign material by installation of downturned and screened "U" bends (see Figures 6 and 7).

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. Pump Installed Directly Over Casing. 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 watertight 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 6 and 7).
2. Submersible or Offset Pump. 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. No Pump Installed. 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. Gasket or Watertight sealing. A watertight seal or gasket shall be placed between the pump discharge head and the discharge line; or, in the event of a below-ground discharge, between the discharge pipe and discharge line (see Figures 6 and 7).
5. Bases. A concrete base or pad, sometimes called a pump block or pump pedestal, shall be constructed at ground surface around the top of the well casing and contact the annular seal, unless the top of the casing is below ground surface, as provided by Subsection B.

The base shall be free of cracks, voids, or other significant defects likely to prevent water tightness. Contacts between the base and annular seal, and the base and the well casing, must be water tight, 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.

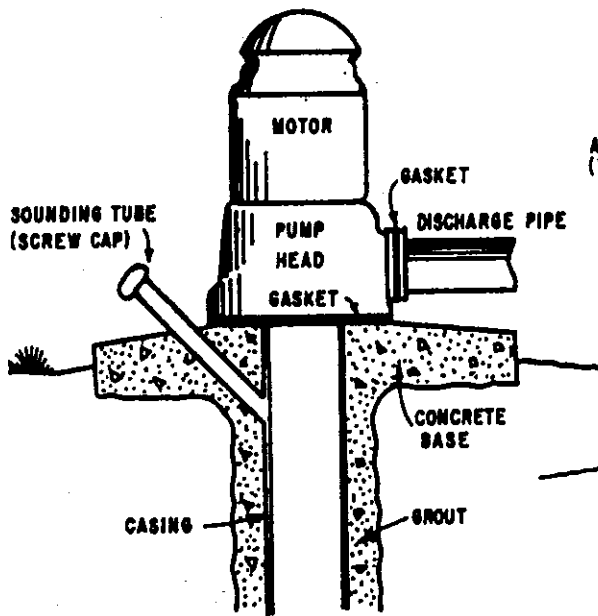
The upper surface of the base shall slope away from the well casing. The base shall extend at least two feet laterally in all direction from the outside of the well boring, unless otherwise approved by the enforcing agency. The base shall be a minimum of 4 inches thick.

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 local environmental conditions. A large variety of base designs have been used.

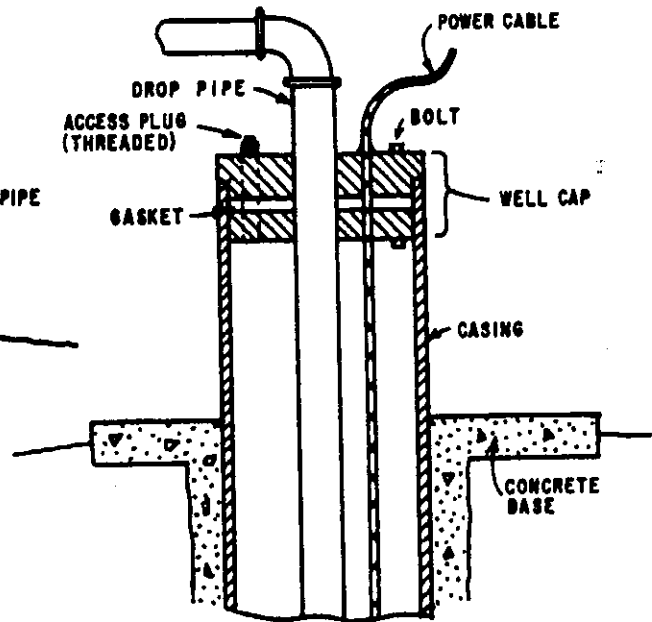
The Vertical Turbine Pump Association has developed a standard base design for large lineshaft turbine pumps. This design consists of a square, concrete pump base whose design is dependent on bearing weight and site soil characteristics.

Where freezing conditions require the use of a 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.

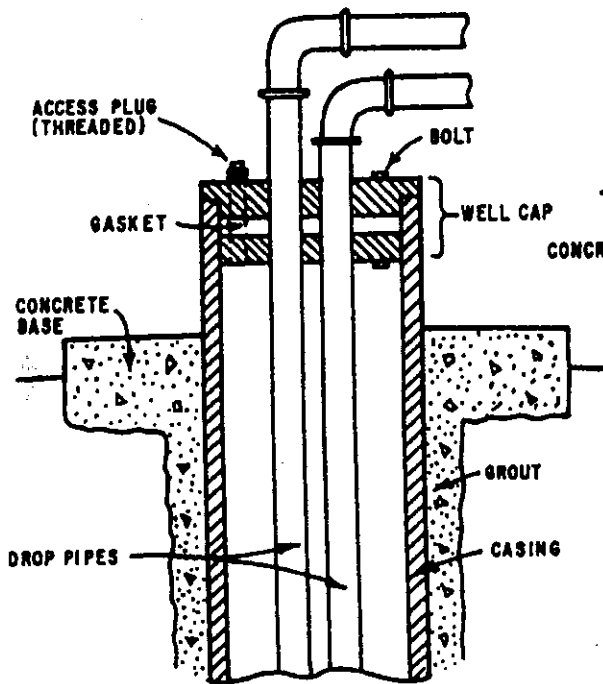
6. Gravel Pack to Surface. Where the well is to be gravel packed and the pack extends to the surface, a watertight cover shall be installed between the conductor casing and the inner casing (see also Section 9 Part B, Item 5 and Figure 5).



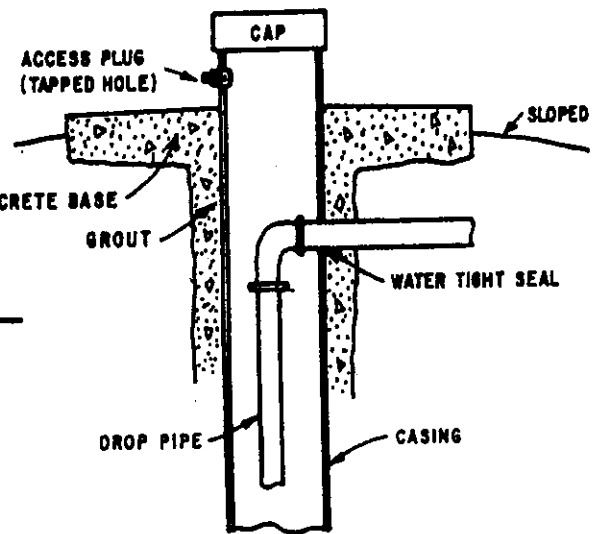
TURBINE PUMP INSTALLATION



SUBMERSIBLE PUMP INSTALLATION



JET PUMP INSTALLATION



BELOW GROUND DISCHARGE

Figure 6.

TYPICAL SURFACE CONSTRUCTION FEATURES

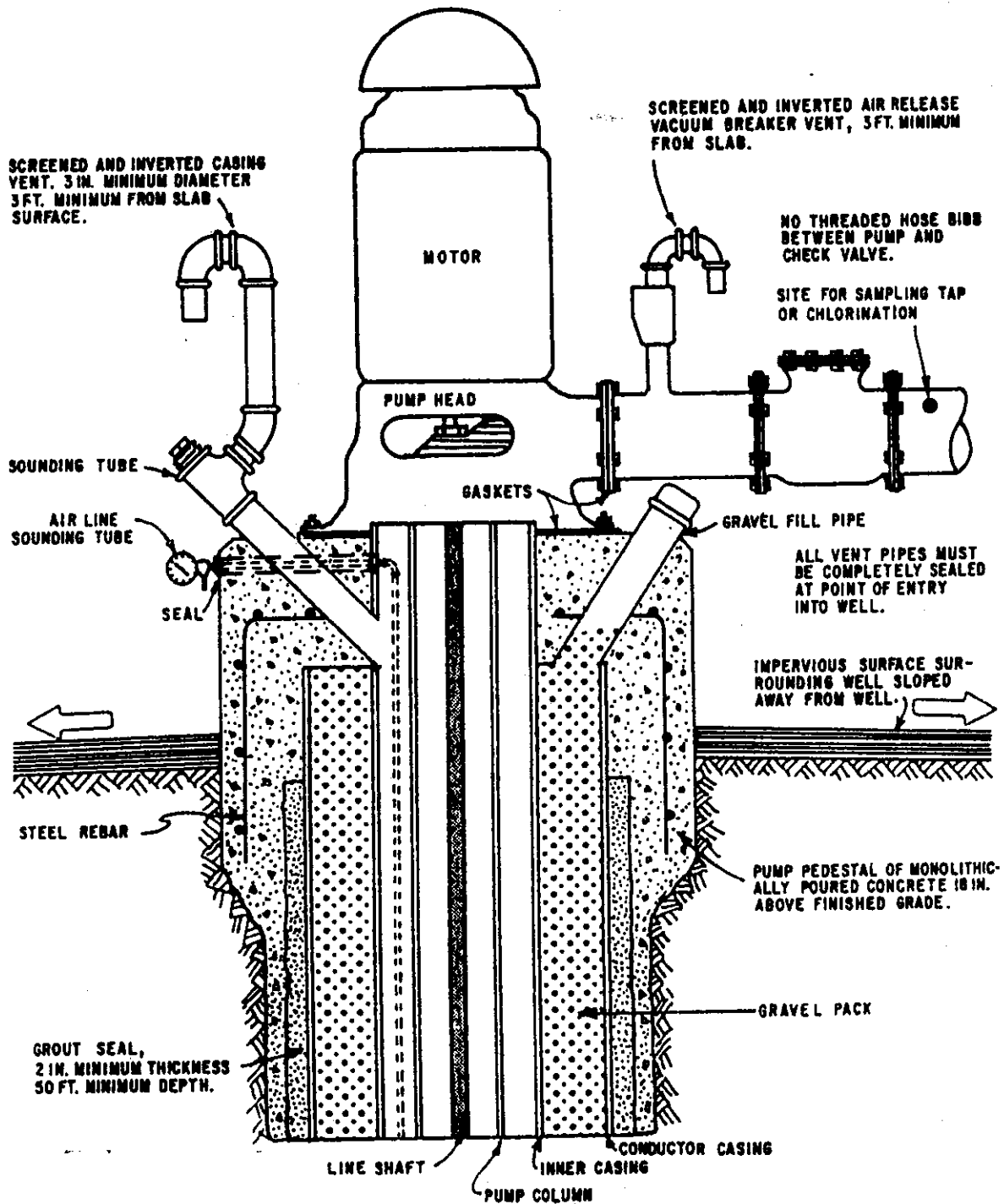


Figure 7.

**SURFACE CONSTRUCTION FEATURES
COMMUNITY WATER SUPPLY WELL**

- B. Well Pits or 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.

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).

If a pit or vault is used it shall be water tight and structurally sound. The vault shall extend from the top of the annular seal to at least ground surface. *If the gradient will allow, a 2" plastic drainage pipe can be sealed into the bottom of the pit or vault to allow gravity drainage.*

The vault shall contact the annular seal in a manner to form a watertight and structurally sound connection. Contacts between the vault and 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.

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.

The sealing material surrounding a vault shall extend from the top of the annular seal to the ground surface unless precluded in areas of freezing. If cement-based sealing material is used for both the annular seal and 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. 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, 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 backsiphonage or backpressure. The blowoff or drain line shall not be connected to any sewer or storm drain except when connected through an air gap.
- 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 7). In addition, to release air trapped in the pump column when the pump is not running, air release vents shall be installed (Figure 7). 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 irrigation, and other well systems that employ, or which have been modified to employ, chemical feeders or injectors shall be equipped with a backflow prevention device(s) approved by the enforcing agency.

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 where work is done on the pump, before the well is placed in service. A procedure for disinfecting a well is described in Appendix C.

- B. 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 placement of the gravel in the annular space disinfectants (usually calcium 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).

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

Section 12. Casing.

- 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 the water, and to provide a measure of protection for the quality of the water pumped. Abbreviations used are: API-American Petroleum Institute; ASTM-American Society for Testing and Materials; AWWA-American Water Works Association.

1. Strength. 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. 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. Selection of casing depends on its ability to resist external forces as well as factors affecting the casing serviceability. The maximum theoretical external pressure under which a particular well casing of a specific diameter and thickness will collapse can be calculated. However, other considerations such as the effect of driving the casing into place or other impact forces which may have an effect on the ability of a particular casing to resist external pressures, cannot be calculated with accuracy. Good design practices preclude the selection of a casing of a particular thickness for use where it will experience external pressures approaching the maximum or where unknown forces might magnify the effect of the external forces. Instead it

is customary for designers to introduce factors of safety which tend to ensure that the casing selected will resist all probable forces imposed upon it. Consequently, experience and sound judgment, coupled with these factors of safety, have so far proved to be the best guide in selecting the proper casing. Suggested thicknesses for steel casing for various depths and diameters are to be found in material published by the various steel manufacturers and fabricators and in publications on the design of water wells. The suggested thicknesses contained in such publications are not to be considered a part of these standards.

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

a. Standard and line pipe. This material shall meet one of the following specifications, including the latest revision 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 HotDipped, Zinc-Coated Welded and Seamless".
- (4) ASTM A120, "Standard Specification for Pipe, Steel, Black and HotDipped 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 Electric-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 Specification for Spiral-Welded Steel or Iron Pipe".
- (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 and Materials, including the latest revision thereof:

- (1) ASTM A36, "Standard Specification for Structural Steel".
- (2) KSTM 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, "Standard Specifications for Hot- Rolled Carbon Steel Sheet and Strip, Structural Quality".

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

3. Plastic. Two basic types of plastics are principally 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. Styrene rubber 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 Dimension Ratios (SDR), SCH 40 and SCH 80," including the latest revision thereof. (Note: A 'dimension ratio' is the ratio of pipe diameter to wall thickness.

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

- (1) ABS Pipe. ASTM D1527, "Standard Specifications for Acrylonitrile Butadiene-Styrene (ABS) Plastic Pipe, Schedules 40 and 80."
- (2) PVC Pipe. ASTM D1785, "Standard Specification for (Poly Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120."
- (3) Pressure-Rated PVC Pipe. ASTM D2241, "Standard Specifications 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 the borehole.

- b. Thermoset Plastics. Thermoset casing material shall meet the following specifications, including the latest revisions there of:

- (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, "Standard Specification for Reinforced Plastic Mortar Pressure Pipe."

- (4) Glass Fiber Reinforced Resin Pressure Pipe. AWWA C950, "AWWA Standard for Glass-Fiber-Reinforced Thermosetting-Resin Pressure Pipe."
- c. Drinking Water Supply. All plastic casing used for community water supply wells, including community supply wells 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 includes the requirements of ASTM F480.
- d. 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.
- e. Large Diameter Wells. Because large diameter plastic casing has not been used extensively at depths exceeding 500 feet, special care should be exercised with its use in deep wells.
4. Concrete Pipe. Concrete pipe used for casing should conform to the following specifications, including the latest revision thereof:
- (a) ASTM C14, "Standard Specifications 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 Materials. Galvanized sheet metal pipe such as 'downspout,' tile pipe, or natural wood shall not be used as well casing.
6. Other Materials. Materials other than those described above may be used as water 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 depth specified in Section 9, Subsection A.

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. Steel casing may be joined by welds, threads, or threaded couplings. Welding shall be accomplished in accordance with 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 joined by solvent welding or mechanically joined by threads or other means, depending on the type of material and its fabrication. Solvent cement used for solvent welding shall meet specifications for the type of plastic casing used. Solvent cement shall be applied in accordance with the solvent and casing manufacturer instructions. Particular attention shall be given to instructions pertaining to required setting time for joints to develop strength.

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 may 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).

- 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 (3 meters) even should the confining formation be less than 10 feet (3 meters) in thickness. In the case of "bottom" waters, the seal shall extend 10 feet (3 meters) 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) provision shall be made for maintaining the integrity of the annular seal in the event of subsidence. Such preventive measures may include the installation of a 'sleeve' or 'slip joint' in the casing, which will allow vertical movement in the casing without its 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. 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:

- overpumping;
- surging by use of 'plungers';

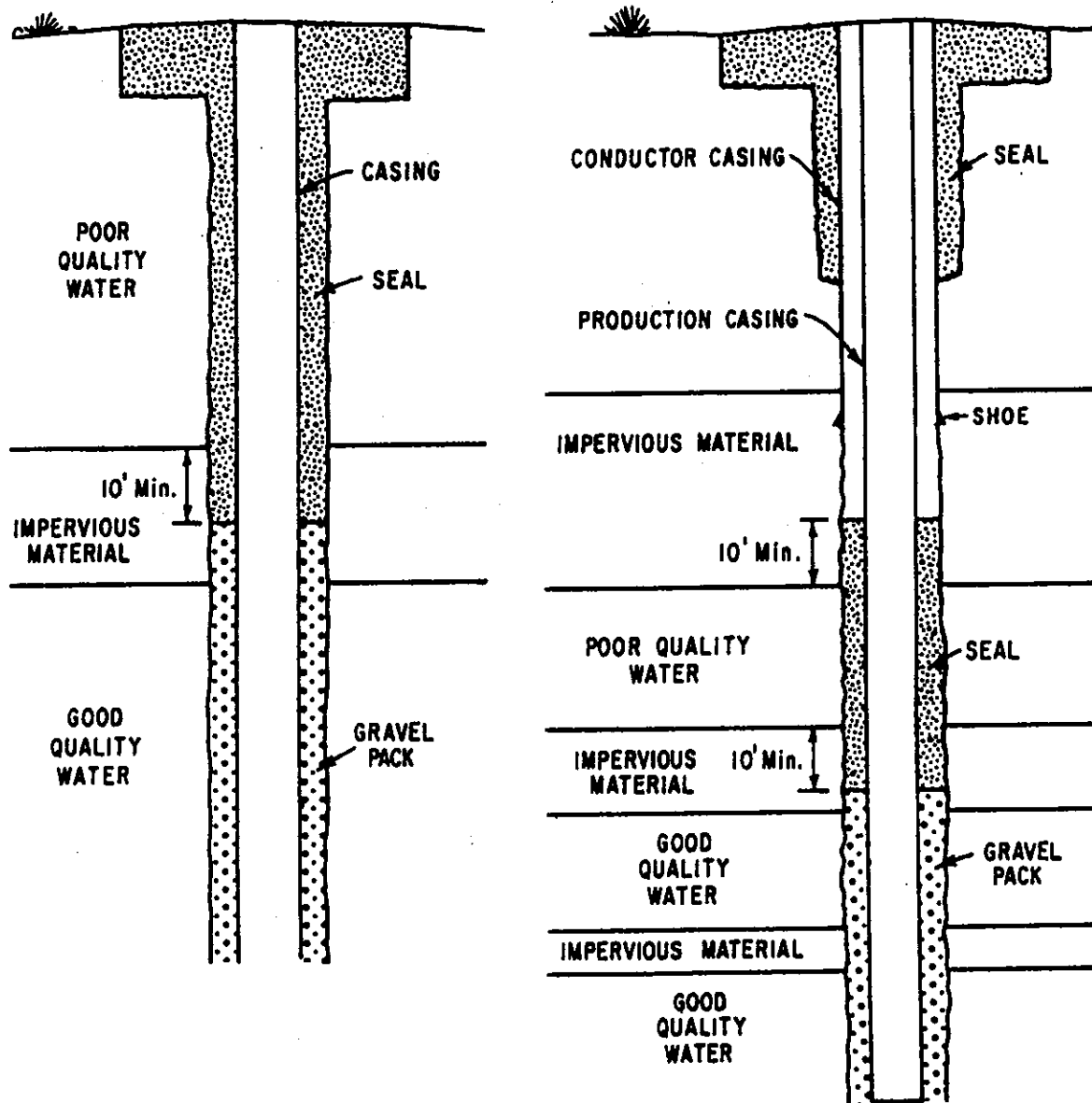


Figure 8.
SEALING OF STRATA

- surging with compressed air;
- backwashing or surging by alternately starting and stopping a pump;
- jetting with water;
- introduction of specifically formulated chemicals; and,
- a combination of the above.

Hydraulic fracturing ("hydrofracturing") is 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 the well. Material used as 'propping' agents shall be free of pollutants and contaminants, shall be compatible with the use of the well and shall be thoroughly washed and disinfected prior to placement in the well.

Development, redevelopment, or reconditioning by use of specially designed explosive charges is in some cases, another acceptable development method. Explosives should 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 operations shall be thoroughly pumped to remove such agents and residues immediately after the completion of operations. Water pumped for this purpose shall be disposed of in accordance with applicable local, state, and federal requirements. The enforcing agency should be contacted regarding the proper disposal of the affected water.

Section 15. Water Quality Sampling.

The collection of water quality samples is described in Appendix D.

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 and Monitor-

ing", of Title 22, California Administrative Code. Water analysis shall be performed by a laboratory certified by the California Department of Health Services. A copy of the laboratory analysis shall be forwarded to the California Department of Health Services or to 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 siphonage to the pump discharge when the pump is shut off (e.g., on 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 analyses shall 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 (15 meters) deep, to provide community water supplies shall be avoided (unless there is no other feasible means for obtaining water). When used for this purpose, these wells shall be located at least 250 feet (76 meters) from any underground sewage disposal facility.
- B. Bored Wells. All bored wells shall be cased with concrete pipe or steel casing whose joints are watertight from 6 inches (150 millimeters) above the ground surface to the depths specified in Section 9, Part A. Except where corrugated steel pipe is used as casing, the minimum thickness of the surrounding concrete seal shall be 3 inches (75 millimeters). Where corrugated steel pipe is employed, the joints are not watertight and a thicker annular seal (no less than 6 inches or 150 millimeters) shall be installed.
- C. Dug Wells. All dug wells shall be 'curbed' with a watertight curbing extending from above the ground surface to the depths specified in Section 9, Part A. The curbing shall be of concrete poured-in-place or of casing (either precast concrete pipe or steel) surrounded on the outside by concrete.

If the curbing is to be made of concrete, poured-in-place, it shall not be less than 6 inches (150 millimeters) thick. If

precast concrete pipe or steel casing is used as part of the curbing, the space between the wall of the hole and the casing shall be filled with concrete to the depths specified in Section 9, Part A. The minimum thickness of the surrounding concrete shall be 3 inches (75 millimeters).

D. Casing Material. Either steel (including corrugated steel pipe) or concrete may be used for casing in bored or dug wells. Corrugated aluminum pipe is not recommended for use as casing. Aluminum placed in an aggressive soil is subject to electrolytic corrosion. When the soil pH is very high (over 8.0) or very low (under 6.0) this could present problems and, therefore, the soil pH ought to be checked. In addition, galvanic corrosion is likely to take place unless the pump is also made of aluminum. Accordingly, the use of most of the aluminum alloys currently available is not recommended.

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

<u>Diameter</u>		<u>U. S. Standard Gage or Plate Thickness</u>	
<u>Inches</u>	<u>Millimetres</u>		
18	450	8 gage	(4.18 millimetres)
24	600	1/4 inch	(6.35 millimetres)
30	750	1/4 inch	(6.35 millimetres)
36	900	1/4 inch	(6.35 millimetres)
42	1050	1/4 inch	(6.35 millimetres)
48	1150	1/4 inch	(6.35 millimetres)

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 millimeters).

2. 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 pressures 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 from 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 sacks of Portland cement per cubic yard or 0.76 cubic meter) or "Class B" (5 sacks per cubic yard or 0.76 cubic meter).

Precast concrete pipe is usually composed of concrete rings from 1 to 6 feet (0.3 to 1.8 meters) in diameter and approximately 3 to 8 feet (0.9 to 2.4 meters) 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 concrete or steel.

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

- A. If the well is to be used as an individual domestic well, an oversize hole with a diameter at least 3 inches (75 millimeters) greater than the diameter of the pipe shall be constructed to a depth of 6 feet (1.8 meters) and the annular space around the pipe shall be filled with neat cement, cement grout, or bentonite mud.
- B. The minimum wall thickness of steel drive pipe shall be not less than 0.140 inches (3.5 millimeters).
- C. Well points made of thermoplastic materials should not be driven but jetted or washed into place.

Section 18. Rehabilitation, Repair and Deepening of Wells.

- A. Rehabilitation is the treatment of a well by chemical or mechanical means (or both) to recover lost production caused by incrustation or clogging of screens or the formation immediately adjacent to the well. The following methods used for rehabilitating a well when done with care are acceptable:
1. Introduction of chemicals designed for this purpose,
 2. Surging by use of compressed air,
 3. Backwashing or surging by alternately starting or stopping the pump,
 4. Jetting with water,
 5. Sonic cleaning,
 6. Vibratory explosives, and
 7. Combinations of these.

Methods which produce an explosion (in addition to the use of vibratory explosives mentioned above) are also acceptable

provided, however, they are used with great care, particularly where aquifers are separated by distinct barriers to the movement of ground water.

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

- B. In the repair of wells, material used for casing shall meet the requirements of Section 12 "Casing" of these provisions. In addition, the requirements of Section 11, Part A "Disinfection" and, when applicable, Section 14 "Sealing-off Strata" shall be followed.
- C. Where wells are to be deepened, the requirement of Sections 11, 12, 13, 14, and 15 of these standards shall be followed.

Section 19. Temporary Cover.

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

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 ground water supply is protected and preserved for further use.
2. Eliminate the potential physical hazard.

Section 21. Definition of "Abandoned" Well.

A 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 accordance with Section 24400 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 the impairment of quality of water within the well and ground water 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 the 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. Destruction, General Requirement.

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

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

Section 23. Requirements for Destroying Wells.

- A. Preliminary Work. Before the well is destroyed, it shall be investigated to determine its condition, details of construc-

tion, 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, so that all undesirable materials, including obstructions to filling and sealing, debris, and oil from oil-lubricated pumps, or pollutant 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. Following are requirements to be observed when certain conditions are encountered:

1. Wells situated in unconsolidated material in an unconfined ground water zone. In all cases the upper 20 feet 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.)
2. Wells penetrating several aquifers or formations. In all cases the upper 20 feet (6 meters) 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 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 (3 meters) 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 or 3 meters) 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. Wells 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 concrete. 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. Wells in non-creviced, consolidated formation. The upper 20 feet (6.1 meters) of a well in a non-creviced, consolidated formation shall be filled with impervious material. The remainder of the well may be filled with clay or other suitable inorganic material.
 5. Wells 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 the appropriate material (as described in item D of this section) from the bottom of the well up.
 2. Where neat cement grout, 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.
 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.

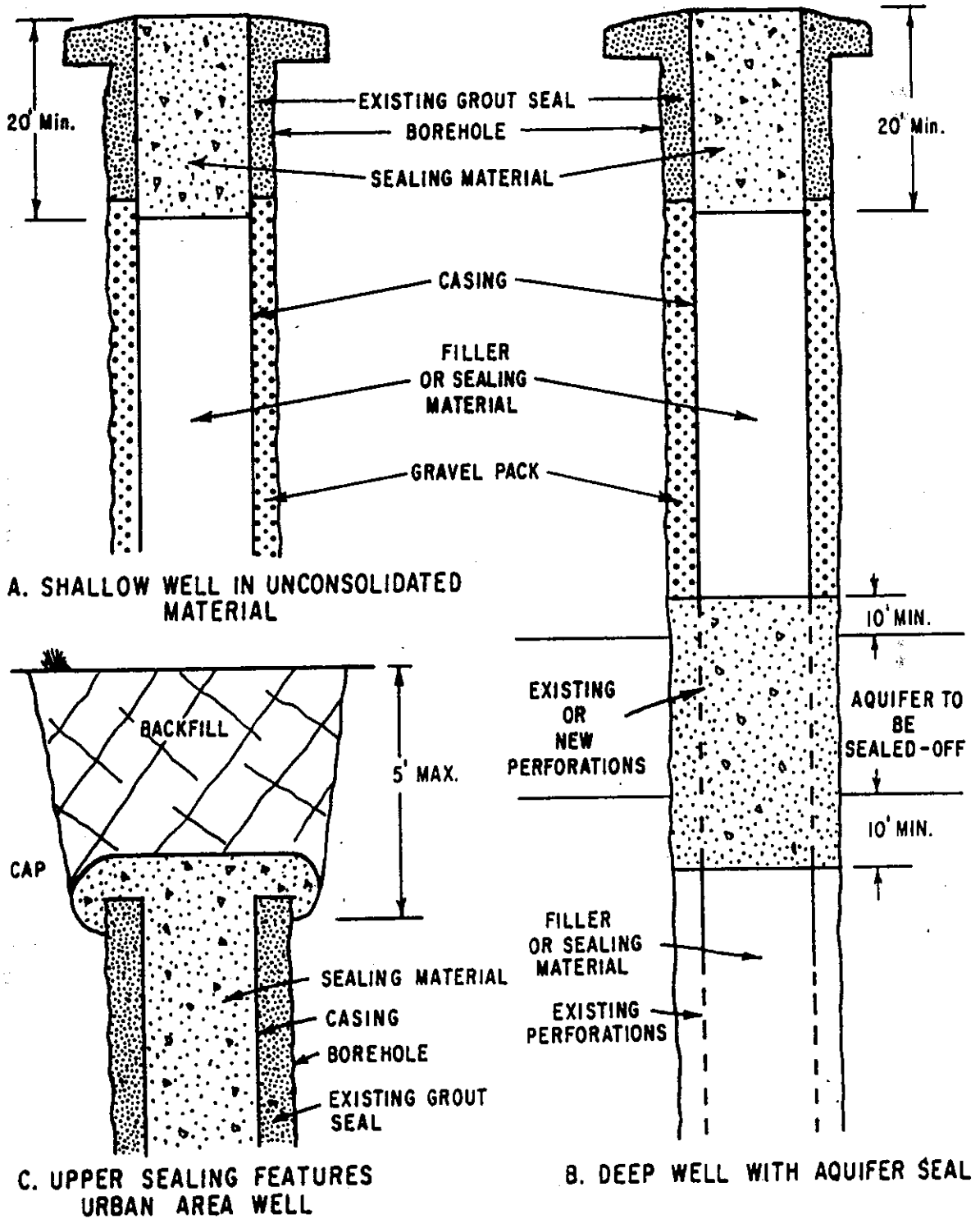


Figure 9.

PROPERLY DESTROYED WELLS

5. In destroying gravel-packed wells, the casing shall be perforated or otherwise punctured opposite the area to be sealed. The sealing material 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.
 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 assure that the well is filled and there has been no jamming or "bridging" of the material, verification shall be made that the volume of material placed in the well installation at least equals the volume of the empty hole.
- D. Materials. Requirements for sealing and fill materials are as follows:
1. Impervious Sealing Materials. No material is completely impervious. However, sealing materials shall have such a low permeability that the volume of water passing through them is of small consequence.

Suitable impervious materials include neat cement, sand-cement grout, concrete, and bentonite clay, all of which are described in Section 9, paragraph D, "Sealing Material" of these standards; and well-proportioned mixes of silts, sands, and clays (or cement), and native soils that have a coefficient of permeability of less than 10 feet (3 meters) per year. Examples of materials of this type are: very fine sand with a large percentage of silt or clay, inorganic silts, mixtures of silt and clay, and clay. Native materials should not be used when the sealing operation involves the use of pressure. Used drilling muds are not acceptable.
 2. Filler Material. Many materials are suitable for use as a filler in destroying wells. These include clay, silt, sand, gravel, crushed stone, native soils, mixtures of the aforementioned types, and those described in the preceding paragraph. Material containing organic matter shall not be used.
- E. Additional Requirements for Wells in Urban Areas. In incorporated areas or unincorporated areas developed for multiple habitation, to make further use of the well site, the following additional requirements must be met (see Figure 9C):
1. A hole shall be excavated around the well casing to a depth of 5 feet (1.5 meters) below the ground surface and the well casing removed to the bottom of the excavation.

2. The sealing material used for the upper portion of the well shall be allowed to spill over into the excavation to form a cap.
 3. After the well has been properly filled, including sufficient time for sealing material in the excavation to set, the excavation shall be filled with native soil.
- F. Temporary Cover. During periods when no work is being done on the well, such as overnight or while waiting for sealing material to set, the well and surrounding excavation, if any, shall be covered. The cover shall be sufficiently strong and well enough anchored to prevent the introduction of foreign material into the well and to protect the public from a potentially hazardous situation.

APPENDIX B

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

Sealing the Annular Space

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

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

General

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

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

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

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

Sealing should be accomplished in one continuous operation. Where the sealing interval will exceed 100 feet (30.5 meters) in length, consideration must be given to the collapse strength of the casing. Further, because of the weight of such extensive seals, consideration must also be given to the installation of stronger retaining devices and to staging the placement of the seal (as, for example, the installation of a short segment of rapid-setting sealant in advance of the main body of sealing material; the former becomes a foundation to support the extensive seal).

Sealing Methods.

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 10. The first method is frequently used where short seals, under 20 feet (6 meters) deep, are placed in dry material.

Gravity Installation (Without Tremie). In this method 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 (9 meters) 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 10).

1. Drill the hole large enough to accommodate the grout pipe (at least 4 inches or 100 millimeters, greater in diameter than the diameter of the casing).
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 by 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 the hole drilled about 2 feet (0.6 meter) 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 (0.6 meter) 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 has 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.

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 into the annular space to the ground surface as is the case with the 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.

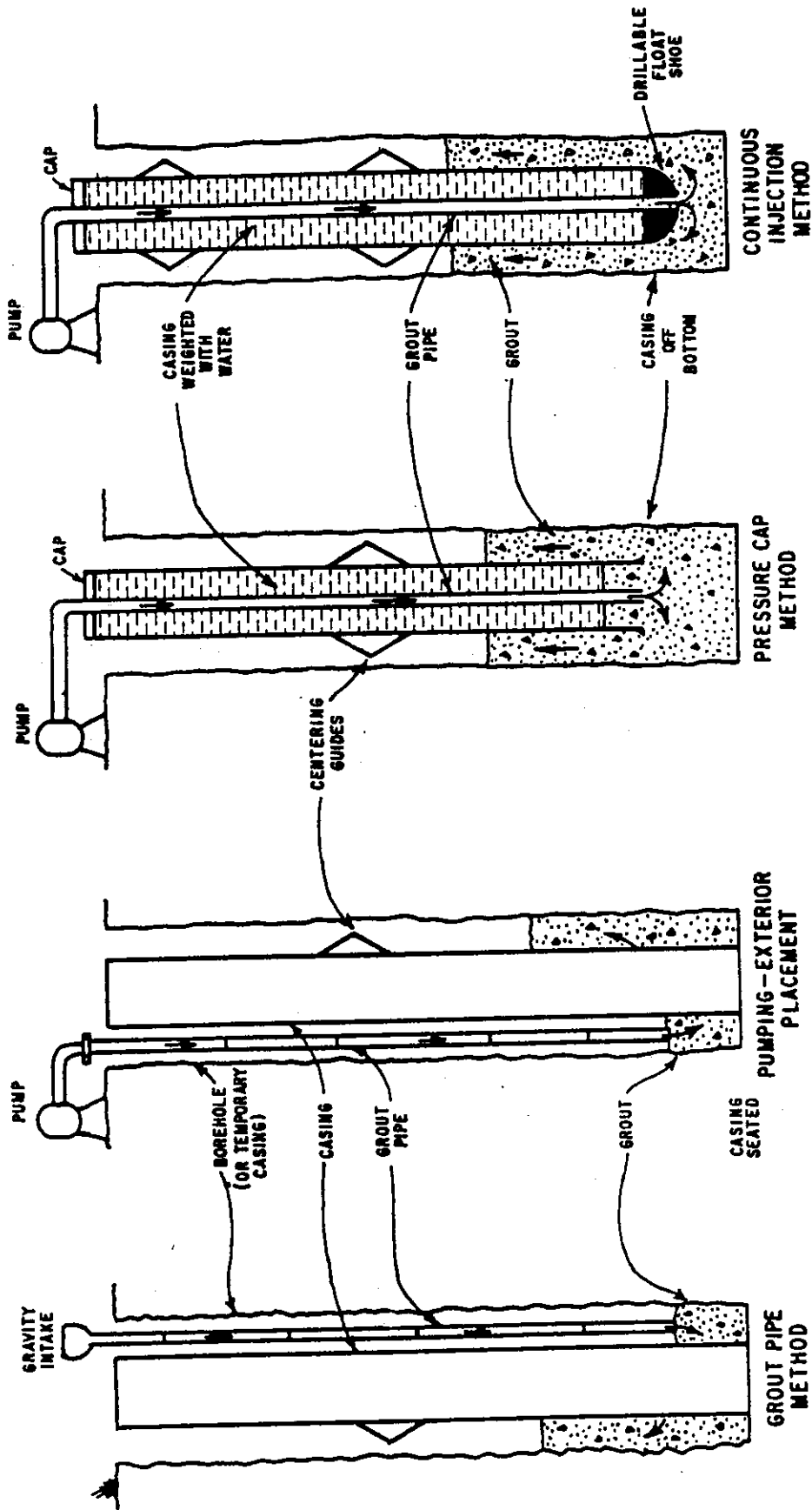


Figure 10.

METHODS FOR SEALING THE ANNULAR SPACE

Sealing-off Strata.

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 nonwater 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 (see Figure 11). 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.

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.

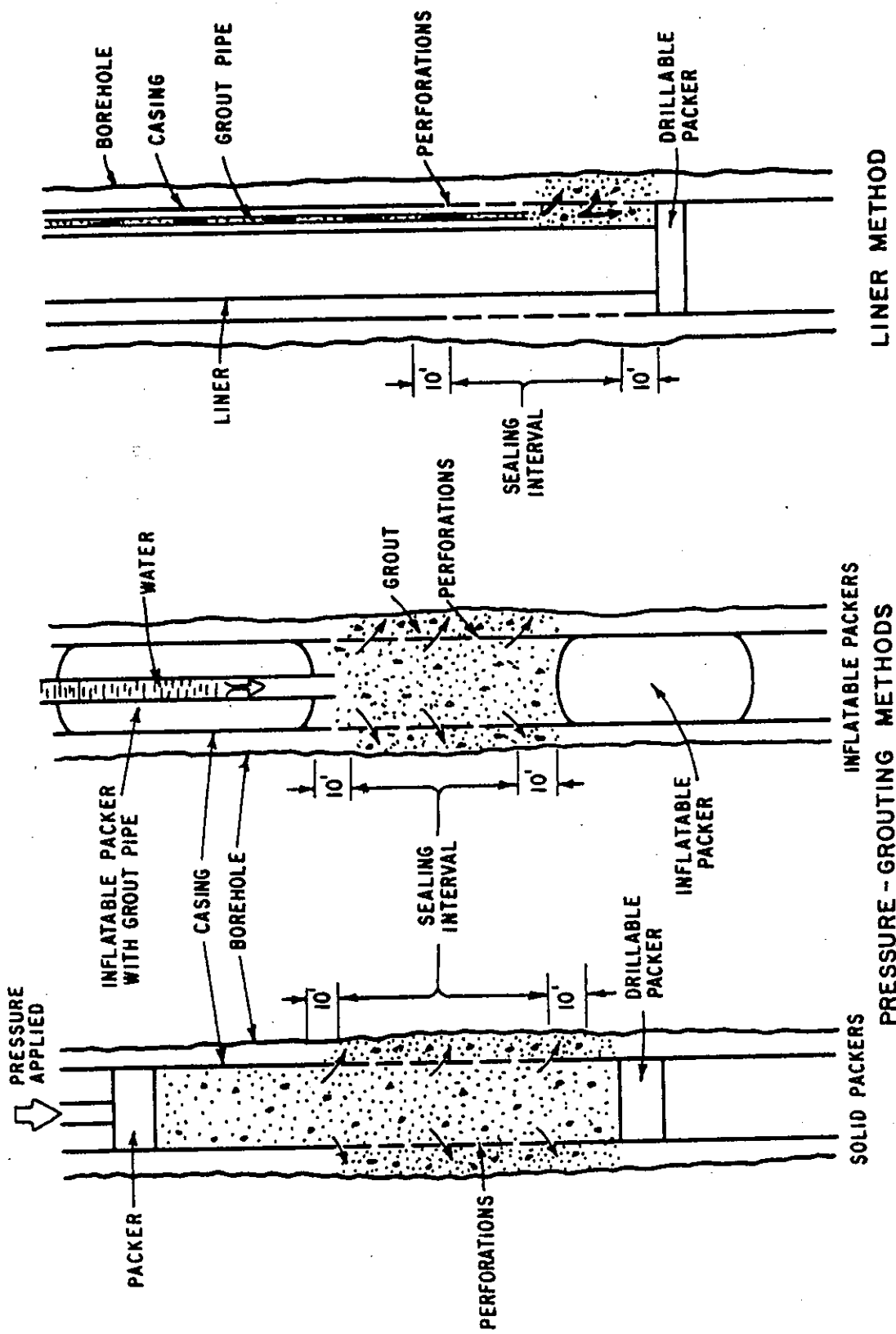


Figure 11.
METHODS FOR SEALING OFF STRATA

Liner Method. Where 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 smaller diameter metal liner, about 2 inches (50 millimeters) less in diameter, inside the casing opposite the perforated interval to be sealed, and extend it at least 10 feet (3 meters) 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 placed. The grout pipe is gradually withdrawn as the sealing material is placed.

APPENDIX C

SUGGESTED PROCEDURES FOR DISINFECTING WELLS

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

Disinfection involves seven steps:

1. A chlorine solution containing at least 50 mg/l (or parts per million) available chlorine, is added to the well. The following table lists quantities of various chlorine compounds required to dose 100 feet (30 meters) of water-filled casing at 50 mg/l for diameters ranging from 2 to 24 inches (50 to 600 millimeters). For wells that have been repaired or when the pump has been repaired or replaced and, bringing the well back into service quickly is desired, the solution should contain at least 100 mg/l available chlorine. To obtain this concentration, double the amounts shown in the table.
2. The pump column or drop pipe shall be washed with the chlorine solution as it is lowered into the well.
3. After it has been placed into position, the pump shall be turned on and off several times (i.e., "surged") so as to thoroughly mix the disinfectant with the water in the well. Pump until the water discharged has the odor of chlorine. Repeat this procedure several times at one-hour intervals.
4. The well shall be allowed to stand without pumping for 24 hours.
5. The water shall then be pumped to waste until the presence of chlorine is no longer detectable. The absence of

chlorine is best determined by testing for available chlorine residual using a test kit designed for this purpose.

Disposal of the waste should be away from trees, shrubs, or lawns and into storm sewers, drainage ditches, etc. Note that heavily chlorinated water should not be wasted into the plumbing system of homes that utilize individual sewage disposal systems (septic tanks). Such strong disinfectants could neutralize the bacteria needed to stabilize the sewage and also could damage the soil absorption system..

6. A bacteriological sample shall be taken and submitted to a laboratory for examination (see Appendix D).
7. If the laboratory analysis shows the water is not free of bacterial contamination, the disinfection procedure should be repeated. Depending on the level of contamination, it may be necessary to use a higher concentration chlorine solution (Several times greater than shown in the following table). The water should then be retested. If repeated attempts to disinfect the well are unsuccessful, a detailed investigation to determine the cause of the contamination should be undertaken.

Where small individual domestic wells to be treated are of unknown depth or volume at least one pound (0.45 kilograms) of calcium hypochlorite (70 percent available chlorine) or two gallons (7.5 liters) of household bleach (sodium hypochlorite), such as Clorox or Purex, may be used in lieu of the recommendations on the following table.

**CHLORINE COMPOUND REQUIRED TO DOSE 100 FEET (30 METERS)
OF WATER-FILLED CASING AT 50 MILLIGRAMS PER LITER**

Diameter of Casing In. (mm)	Chlorine Compounds		
	(70%) Calcium Hypochlorite ^{2/} (Dry Weight) ^{3/}	(25%) Chloride of Lime (Dry Weight) ^{3/}	(5.25%) Sodium Hypochlorite ^{4/} (Liquid Measure)
2 (50)	¼ oz (7 g)	½ oz (14 g)	2 oz (59 ml)
4 (100)	1 oz (28 g)	2 oz (57 g)	9 oz (266 ml)
6 (150)	2 oz (57 g)	4 oz (113 g)	20 oz (0.6 l)
8 (200)	3 oz (85 g)	7 oz (0.2 kg)	2-1/8 pts (1.0 l)
10 (250)	4½ oz (113 g)	11 oz (0.3 kg)	3-1/2 pts (1.7 l)
12 (300)	6 oz (0.2 kg)	1 lb (0.45 kg)	5 pts (2.4 l)
16 (400)	10 oz (0.3 kg)	2 lb (0.9 kg)	1 gal (3.8 l)
20 (510)	1 lb (0.45 kg)	3 lb (1.4 kg)	1-2/3 gal (6.3 l)
24 (610)	1½ lb (0.7 kg)	4 lb (1.8 kg)	2-1/3 gal (8.8 l)

^{1/} Some authorities recommend a minimum concentration of 100 mg/l. To obtain this concentration, double the amounts shown.

^{2/} HTH, Perchloron, Pittchlor, etc.

^{3/} Where dry chlorine is used, it should be mixed with water to form a chlorine solution prior to placing it into the well. Note that dry chlorine should always be added to water, not vice versa. Further, the chemical should be added slowly. These precautions are necessary to lessen the possibility of a violent chemical reaction.

^{4/} Household bleaches such as Chlorox, Purex, etc.

Table 3.

APPENDIX D

COLLECTION OF WATER QUALITY SAMPLES

Water from all new wells should be sampled in order to determine the quality of the water that is being produced. The type of analysis that will be made is dependent on the expected use of the water. For example, individual domestic wells should be sampled for determination of bacterial quality and chemical quality. The water from agricultural wells is generally examined only for the presence of specific chemicals unless there is the likelihood that there will be incidental domestic use of the water, in which case the bacterial quality ought to be determined too.

Recommendations regarding the types of analyses to be performed for the various uses of water will be found in numerous references on water quality and ground water; however, it is best to consult with local agencies such as county farm advisors, health departments or water service agencies (irrigation or water districts). Sampling of community water supply wells is covered by requirements of the California Department of Health Services.

Bacterial Sampling.

For individual domestic wells, technical advice regarding the collection of bacteriological samples may be obtained from the local health departments or from the laboratories that will examine the sample. If no technical assistance is available, the following procedure will suffice: A sterile sample bottle, preferably one provided by the laboratory, must be used. It is extremely important that nothing except the water to be analyzed come in contact with the inside of the bottle or the cap; the water must not be allowed to flow over an object or over the hands and into the bottle while it is being filled. If the water is collected from a sample tap, turn on the tap and allow the water to flow for 2 or 3 minutes before collecting the sample. Do not rinse the sample bottle. The sample should be delivered to the laboratory as soon as possible and in no case more than 30 hours after its collection. During delivery, the sample should be kept as cool as possible (but not frozen).

Chemical Sampling.

Generally, a routine mineral analyses (determination of the concentrations of the common minerals such as calcium, sodium, chloride, sulfate, etc.) plus analyses for selected minor elements will suffice, particularly where there is no prior knowledge of the chemical quality of the water in the area where the well is located. Where quality conditions in the surrounding area are known, a more

selective analysis may be made. For specified uses it may also be desirable to make analysis for concentrations of certain constituents (such as iron and manganese in the case of domestic water or boron in irrigation water). Organic chemicals are not routinely determined. Information or advice on chemical quality conditions may be obtained from local agencies such as the county farm advisors, health departments, etc.

The sample should be collected after the well has been pumped long enough to remove standing water and development and disinfectant chemicals, and to ensure that water from the producing formation(s) has entered the well. The water sample should be collected in a chemically clean container, preferably one obtained from the laboratory that will perform the analysis. The container should be rinsed several times with the water to be sampled prior to collecting the sample. The laboratory performing the analysis should issue instructions regarding the quantity of sample required and whether or not preservatives are needed. However, one-half gallon (1.9 liters) is usually sufficient for a routine mineral analysis; one gallon (3.8 liters) when analysis for minor elements (i.e., iron, manganese, etc.) is also required. Sample quantities for organic chemicals vary according to the type of analysis, and range from very small amounts up to several gallons (liters). In addition, where organic chemicals are to be determined, special sampling procedures and equipment may be required. This is particularly true for volatile organic compounds.

In all cases the temperature of the water should be determined immediately upon collection of the sample.

MONITORING WELL STANDARDS

INTRODUCTION

Types of Monitoring Wells

For the purpose of these standards, the term "monitoring well" is limited to wells designed to monitor subsurface water in the saturated zone, existing at or above atmospheric pressure (ground water); rather than water, water vapor, and/or gases contained in the unsaturated or vadose zone. Monitoring devices used for the unsaturated zone differ significantly from those used for the saturated (ground water) zone.

As shown in Figure 12, three basic categories of monitoring wells or "installations" are:

Individual monitoring wells;

Nested monitoring wells; and,

Clustered monitoring wells.

Individual monitoring wells consist of a single casing "string" within a borehole, as illustrated in Figure 12 and 13. Individual wells are installed in unique locations apart from one another. They are the most common type of monitoring well constructed in California.

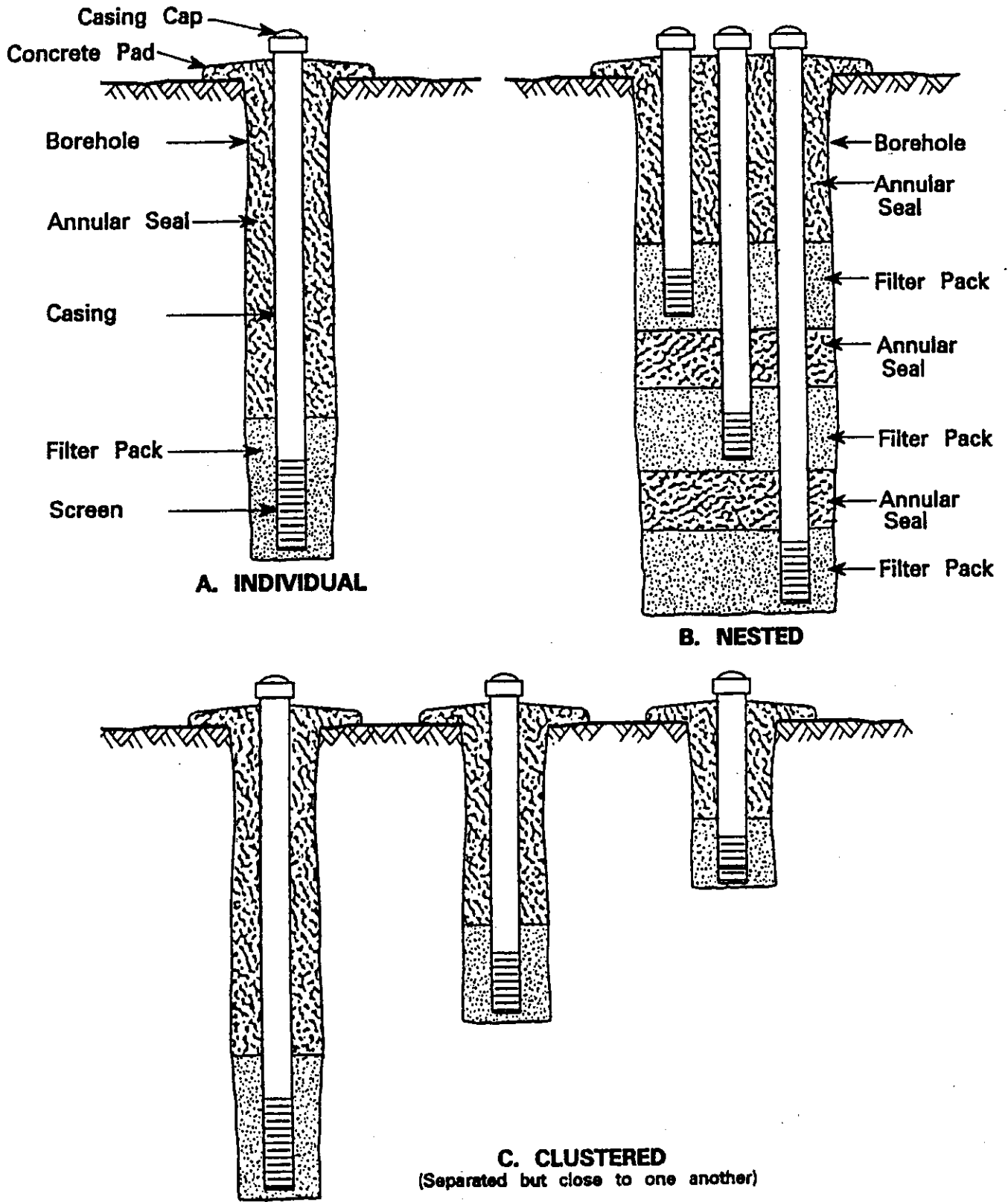
Nested monitoring wells consist of two or more casing strings within the same borehole. Normally the screened interval of each casing string is designed to obtain water from different aquifers or water-bearing zones. The purpose of a nested monitoring well is much the same as clustered monitoring wells.

Cluster 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 ground water conditions at various depths in roughly the same area.

A nested monitoring well can be difficult 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 one another 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, are sometimes designed 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 monitoring wells," can sometimes serve as a preferential 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 concern for water quality protection and data quality requirements.



C. CLUSTERED
(Separated but close to one another)

Figure 12.

MONITORING WELL TYPES

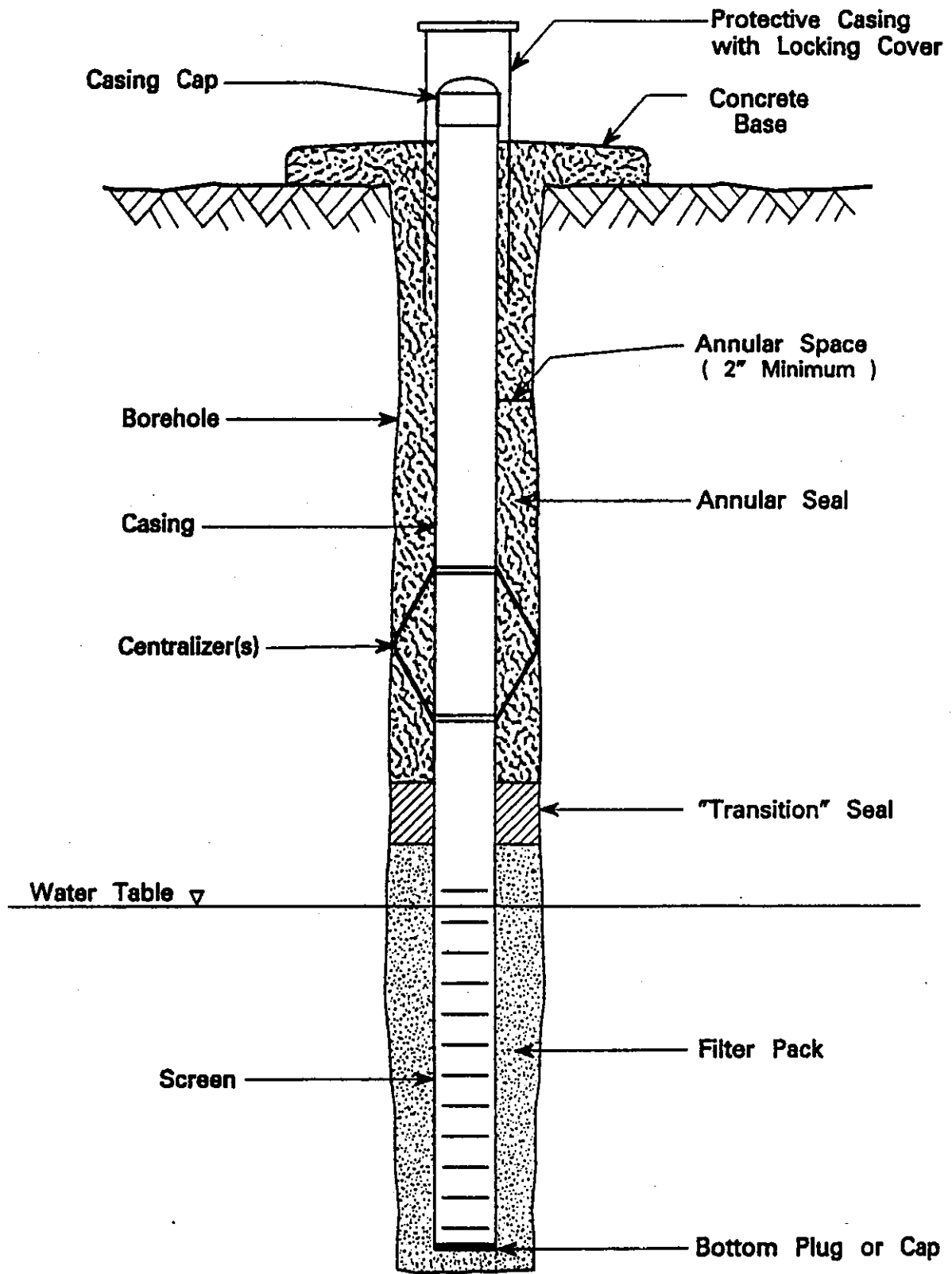


Figure 13.

CROSS SECTION OF A TYPICAL MONITORING WELL

MONITORING WELL STANDARDS

Part I. General

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 (or Boring). An uncased temporary excavation whose purpose is the immediate determination of hydrologic conditions at a site.
- C. 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 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, that follow. 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 only where they are impractical or ineffective because of unusual conditions or would result in an unsatisfactory condition or well function. In waiving these standards the enforcing agency shall, if at all possible, require that measures be implemented to provide the same or greater level of water quality protection than would otherwise be provided by these standards.

Section 4. Exclusions.

Exploration holes. Most standards in Part II, "Monitoring Well Construction," do not apply to exploration holes (as defined above), whether or not they extend to ground water. However, provisions of Part I, Section 7, "Reports" and Part III, "Destruction of Monitoring Wells," do apply to exploration holes.

Exploration holes for determining suitability of on-site sewage disposal, that are less than ten feet in depth are exempt from the reporting and destruction requirements of these standards.

Large volume excavations for determining the suitability of on-site domestic sewage disposal, such as backhoe trenches, that exceed ten feet in depth are exempt from the requirements of Part III of these standards. However, such excavation 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, or destruction of monitoring wells shall be performed by contractors licensed in accordance with the California Contractors' License Law (Division 3, Chapter 9, California Business and Professions Code), except where exempted by law. Construction, alteration, or destruction of monitoring wells to monitor hazardous waste facilities, other waste facilities, or underground storage tanks shall be performed under the supervision of a California Registered Professional Engineer, California Registered Geologist, or a California Certified Engineering Geologist, where specified law.

Section 7. Reports.

Monitoring well construction, alteration, or 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 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 "Guide to the Preparation of the Water Well Drillers Report", Department of Water Resources, October 1977, or its latest revision.

Part II. Monitoring Well Construction

Section 8. Well Location with Respect to Pollutants and Contaminants.

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 expected 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 should be located an adequate distance from known or potential sources of pollution and contamination, including those listed in Section 8 of the Water Well Standards, unless regulatory or legitimate data requirements necessitate they be located closer.
- 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.
- 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.
- D. Disposal of Wastes When Drilling in Contaminated or Polluted Areas. Drill cuttings and waste water 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 the proper disposal of cuttings and wastewater.

Section 9. Sealing the Upper Annular Space.

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 to the protection of ground water quality.

General discussion of sealing methods and requirements for monitoring wells is contained in Section 9, Section 13, and Appendix B, of the Water Well Standards. Special requirements for annular seals 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 layers that overlie or underlie the unit to be monitored, unless otherwise 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 are to 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 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 minimum depth of the annular seal, as is needed to prevent the movement of poor quality ground 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.
4. Shallow Water Level Observation Wells. Water level observation wells less than 15 feet in total depth that are used to assess root zone drainage in agricultural areas are exempt from an annular seal requirement, unless otherwise required by the enforcing agency.

5. 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, below.
6. 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 seal be more than 4 feet below ground surface.

The top of the annular seal shall contact a suitable, water-tight, structurally-sound subsurface vault, or equivalent feature, that encloses the top of the well casing in accordance with Section 10, Subsection E, below. The vault shall extend from the top of the annular seal to at least ground surface.

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 seal 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 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 monitoring well borehole diameter shall be at least 4 inches greater than the outside diameter of the conductor casing. The inner diameter of the permanent conductor casing shall in turn be at least 4 inches greater than the outside diameter of the well casing.

Sealing material shall be placed between the permanent conductor casing and the borehole wall, and the conductor casing and the well casing. The sealing material shall extend to at least to the depths specified in Subsection A of this section.

- 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. At least two inches

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 casing 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, sand-cement, or bentonite clay. Cement-based sealing material shall be used opposite fractured rock, unless otherwise approved by the enforcing agency. Concrete shall be used only at the approval of the enforcing agency.

Sealing material shall be selected based on required structural, handling, and sealing properties, and the chemical environment into which it is placed. Used drilling mud or cuttings from drilling shall not be used for any part of sealing material.

1. Water. Water used for sealing mixtures generally should be of 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 sealing properties.

Non-potable water can sometimes be used for preparing cement-based sealing materials. In no case should the concentration of chloride in water used in cement-based sealing material exceed 2,000 milligrams per liter. Sulfate should not exceed 1,500 mg/l.

Water used for sealing material should be chemically analyzed if unknown. Only drinking-quality water of known composition should be used for preparing sealing mixtures for monitoring wells to be employed for sensitive water-quality determinations.

2. Cement-Based Sealing Materials. Discussion and standards for cement-based sealing materials are contained in Section 9 of the Water Well Standards. Special considerations that apply to monitoring wells are:
 - a. Additives. Care should be exercised in the use of special additives for cement-based sealing materials, such as those used for modifying cement setting times. Some additives could interfere with sensitive water quality determinations.
 - b. Cooling Water. In the case of water quality monitoring wells, care should be exercised in the use of circulating cooling water to protect plastic casing from heat build-up

during setting of cement-based sealing materials. Water introduced and/or circulated in a well for cooling could interfere with water quality determinations.

3. Bentonite-Based Sealing Materials. Discussion and standards for bentonite-based sealing materials are contained in Section 9 of the Water Well Standards.
- E. Transition Seal. A bentonite-based transition seal, up to 5 feet in length, is often placed in the annular space to separate the 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 often 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-grain forms of bentonite, such as granules and powder, are usually employed for a transition seal if a transition seal is to be placed above the water level in a well boring. Coarse forms of bentonite, such as pellets and chips, are often used where the bentonite transition seal is to be placed below the water level.

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

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. 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 of about 1 gallon for every 2 pounds of bentonite to allow for 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 sealing materials are placed. Normally, 1/2 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.

- F. Placement of Annular Seal Material. All loose cuttings and other obstructions shall be removed from the annular space before the sealing 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 dry and less than 30 feet deep.

Casing spacers shall be used within the interval(s) to be sealed to separate individual well casing strings from one another in a borehole of a nested monitoring well. The spacers shall be placed at intervals along the casing to ensure a minimum separation of 2 inches between individual casing strings. Spacers shall be constructed of corrosion-resistant metal, plastic, or other non-degradable material. Wood shall not be used as spacer material.

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

The spacing of casing spacers is normally dictated by casing materials used, the orientation and straightness of the borehole, and the method used in installing 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 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.

- 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, pollut-

ants, and contaminants from entering the well bore. 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. The top of the well casing shall terminate above ground surface and known levels of flooding, 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 two 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 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 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 annular seal shall contact the subsurface vault. 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 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.

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 a 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 placed 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, 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 well casing contained within the vault shall be covered in accordance with the 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 posts or the 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 nonreactive, smooth, rounded, spherical, granular material of highly 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 so as to prevent significant voids in the filter pack which 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 used in monitoring wells constructed for sensitive water quality determinations.

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

Filter pack material shall be placed in the well boring by use of a tremie pipe or equivalent. The depth of the top of the filter pack shall be carefully checked and the volume of emplaced filter pack material verified to determine that the filter pack materials have not bridged during installation.

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 ground water level measurement and/or sample-collection devices.

Protective casing serves to prevent accidental or intentional damage to a well. Protective casing normally consists of heavy gauge metal pipe placed over the 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 the placement 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 screens, collars, risers, and blank casing, or 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.

A. Casing Material.

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

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

- a. ASTM D3296, "Standard Specification for FEP-Fluorocarbon Tube."
- b. ASTM D3295, "Standard Specifications 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 meet general requirements for tubular steel products in section 12 of the Water Well Standards.

- B. 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 ground

water quality, unless otherwise approved by the enforcing agency.

- C. Bottom Plugs. The bottom of a monitoring well casing shall be plugged or capped to prevent sediment or rock from entering the well.
- D. Casing Installation. Discussion and standards for the installation of casing materials are contained in section 12 of the Water Well Standards. Special considerations for monitoring wells are:
 - 1. Cleanliness. Casing, couplings, centralizers, and other components of the well casing shall be clean and free of pollutants and contaminants at the time of installation.
 - 2. Joining 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 conditioning shall be performed with care so as to prevent damage to the well and any strata surrounding the well that serves to restrict the 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. Such special care is necessary to prevent the spread of pollutants and contaminants in the environment and to protect public health and safety.

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. Overpumping and Pump Surging. Overpumping 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 development 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.

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 the water bearing strata adjoining the well. Well rehabilitation methods that may, in certain cases, be acceptable for monitoring wells include mechanical, backwashing or surging by alternately starting or stopping a pump, surging with air, water jetting, sonic cleaning, chemical treatment, or combinations 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 the entry of foreign material, water, contaminants, and pollutants when ever work is interrupted by such events as overnight shutdown, poor weather, required waiting periods to allow setting of sealing materials, and the 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.

Part III. Destruction of Monitoring Wells

Section 16. Purpose of Destruction.

A monitoring well, or exploration hole subject to these requirements that is no longer useful, permanently inactive or "abandoned" must be properly destroyed to:

1. Ensure that the quality of ground water is protected; and,
2. 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 possible 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 ground water 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 other means to prevent its removal without the use of equipment or tools, 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 water-tight 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.

Section 18. General Requirement.

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.

Section 19. Requirements for Destroying Monitoring Wells and Exploration Holes.

General requirements for destroying monitoring wells and exploration holes are contained in Section 23 of the Water Well Standards. Special consideration for monitoring wells and exploration holes are as follows.

A. Monitoring Wells. Monitoring wells shall be destroyed in accordance with the following requirements and section 23 of the Water Well Standards, irrespective of their original date of construction.

1. **Preliminary Work.** A monitoring well shall be investigated before it is destroyed to determine its condition and details of its construction. The well shall be sounded immediately before it is destroyed to make sure no obstructions exist that will interfere with filling and sealing.

The well shall be cleaned before destruction as needed 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.

The enforcing agency shall be notified as soon as possible if pollutants or contaminants are known or suspected to be present 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 all materials removed from a well to be destroyed.

2. **Sealing Conditions.** The following minimum requirements shall be followed when various conditions are encountered.
 - a. The monitoring well casing, and any other significant voids within the well shall, at a minimum, be completely filled with sealing material, if the following conditions exist:
 - The monitoring well is located in an area of known or potential pollution or contamination; and,
 - The well was constructed and maintained in accordance with these standards.

Sealing material may have to be placed under pressure to ensure that the monitoring well is properly filled and sealed.

b. A monitoring well shall be destroyed by removing all material within the original borehole (including the well casing, filter pack, and annular seal); and the created hole filled completely with appropriate sealing material, if the following conditions exist:

- The well is located in an area of known or potential pollution or contamination; and,
- The well's annular seal, casing, screen, filter pack, or other components were not constructed or maintained according to these standards so that well destruction by merely filling the well casing with sealing material, as in "a" above, would not prevent water-quality degradation from the movement of poor-quality water, pollutants or contaminants through the destroyed well structure.

Material to be extracted from the original borehole shall be removed by means of drilling, including overdrilling, where necessary. The enforcing agency should be contacted to determine requirements for proper disposal of removed materials.

Casing, filter pack, and annular seal materials may be left in place during sealing operations, if the enforcing agency agrees that they cannot or should not be removed. In such a case, appropriate sealing material shall be placed in the well casing, filter pack, and all other significant voids within the entire well boring. Casing left in place may require perforation or puncturing to allow proper placement of sealing materials. Sealing material may have to be applied under pressure to ensure its proper distribution.

c. Monitoring wells shall, at a minimum, be destroyed in accordance with the requirements of Section 23 of the Water Well Standards if located in an area free of any known or potential contamination or pollution.

B. Exploratory Borings. Exploratory borings shall be completely filled with appropriate sealing material from bottom to top, if located in areas of known or suspected contamination or pollution. Borings located outside of such areas shall, at a minimum, be filled with sealing material from ground surface to the minimum depths specified in Section 23 of the Water Well Standards. Additional sealing material shall be placed below the minimum surface seal where needed to prevent the interchange

of poor quality water, pollutants, or contaminants between strata penetrated by the boring.

Appropriate fill material shall be placed below and between intervals containing sealing material. Sealing material is often economical to use as fill material.

The boring shall be inspected immediately prior to filling or sealing operations. All obstructions and pollutants and contaminants that could interfere with filling and sealing operations shall be removed prior to filling and sealing. The enforcing agency shall be notified as soon as possible if pollutants or contaminants are known or suspected to be in a boring 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 removed materials.

C. Placement of Sealing Material. Placement of sealing material for monitoring wells and exploratory borings is generally described Section 23 and Appendix B of the Water Well Standards. The following additional requirements shall be observed when placing sealing material for monitoring well or exploratory boring destruction.

1. Placement Method. The well or exploratory boring shall be filled with appropriate sealing, and fill material where allowed, using a tremie pipe or equivalent, proceeding upward from the bottom of the well or boring.

Sealing material shall be placed by methods (such as the use of a tremie pipe or equivalent) that prevent free fall, bridging, and dilution of sealing materials and/or prevent separation of the aggregate from sealants. Sealing material may be placed by freefall only where the interval to be sealed is dry and no more than 30 feet in depth. Fill material shall be placed by methods that prevent bridging and voids.

2. Timing of Placement. Sealing material shall be placed in one continuous operation (or "pour") from the bottom to the top of the well or boring, unless conditions in the well or boring dictate that sealing operations be conducted in a staged manner, and prior approval is obtained from the enforcing agency.
3. Ground Water Flow. Special care shall be used to restrict the flow of ground water into a well or boring while placing sealing and fill material, if subsurface pressure producing the flow is significant.

4. Sealing Pressure. Pressure required for the placement of cement-based sealing materials shall be maintained long enough for cement-based sealing materials to properly set.
 5. Verification. It shall be verified that the volume of sealing and fill material placed during destruction operations equals or exceeds the volume to be filled or sealed. This is to help determine whether the well or boring has been properly destroyed and that no jamming or bridging of the fill or sealing material has occurred.
- D. Sealing and Fill Materials. Materials used for sealing exploratory borings and monitoring wells 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 consistent with present and future site uses.

Suitable sealing materials include neat cement, sand-cement, and bentonite, all of which are described in Section 9 of these standards. Bentonite shall not be used as a sealing material opposite zones of fractured rock, unless otherwise approved by the enforcing agency. Drilling mud and drill cuttings are not acceptable as any part of sealing material for well destruction. Concrete may be used as a sealing material at the approval of the enforcing agency.

Fill material, if any, shall meet the requirements of Section 23, of the Water Well Standards. Fill material shall be free of pollutants and contaminants and shall not be subject to decomposition or consolidation after placement. Drilling mud or cuttings is not acceptable as any part of fill material.

- E. Additional Requirements for Monitoring Wells and Exploratory Borings in Urban Areas. The following additional requirements shall be met for destroying monitoring wells and exploratory borings subject 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 well 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 material has adequately set. The exposed well 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.

F. Temporary Cover. The well or borehole opening and any associated excavations shall be covered at the surface to ensure public safety and to prevent the entry of foreign material, water, pollutants, and contaminants; 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 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.

CATHODIC PROTECTION WELL 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 metallic equipment in contact with the ground, commonly referred to as cathodic protection."

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 materials 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 well of the well boring and the inner well 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. Exemption 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 only where they are impractical or ineffective because of unusual conditions, or would result in unsatisfactory condition or well function. In waiving any of these standards, the enforcing agency shall, if at all possible, require that measures be implemented that provide the same or greater level of water-quality protection than would otherwise be provided by these standards.

Section 3. Special Standards.

The enforcing agency may prescribe measures more stringent than standards described 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 10, Article 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 Contractors' 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 appropriately 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 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 "Guide to the Preparation of the Water Well Drillers Report," Department of Water Resources, October, 1977, or its latest revision.

Part II. Cathodic Protection Well Construction

Section 6. Well Location with Respect to Contaminants and Pollutants.

- 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.

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 is 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 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 the 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 13, and Appendix B of 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 ground water.
 2. Fill. Any annular space existing between the base of the annular seal and top of the anode and conductive fill material 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. Sealing material 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. 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 to 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 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, sand-cement grout, sand-cement, concrete, or bentonite clay as discussed in the Water Well Standards. Cement-based sealing material shall be used opposite zones of fractured rock. Concrete shall only be used at the approval of the enforcing

enforcing agency. Drill cuttings and used drilling mud shall not be used as any part of sealing material.

- E. Placement of Seal. Standards for placement of annular seals are described in Section 9 and Appendix B of the Water Well Standards.

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 the 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 known 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 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, 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 water tight and must not cause the failure of 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 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 sealing materials are used, the vault shall be set into or contract 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 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.

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 watertight 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 its 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 a cathodic protection 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 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 purposes 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 National Association of Corrosion Engineers also be followed in the design and installation of gas vents and electrical conduit.

Cathodic protection well casing should be at least 2 inches in internal diameter to facilitate eventual well destruction.

Section 10. Sealing-Off Strata.

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 seal 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 of poor-quality water, pollutants, or contaminants for various cases:

Case 1. Upper Stratum. If a stratum containing poor-quality water, pollutants, or contaminants lies above a stratum to be protected, annular seal material shall extend from the top of the stratum containing the 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 producing 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.

- a. 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 interbedded confining layers shall be sealed. The annular seal shall continue 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.
- b. 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 between the stratum to be protected and the underlying strata containing poor-quality water, pollutants or contaminants.
- c. 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 the upper stratum containing poor-quality water, pollutants, or contaminants shall all 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.

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

Section 11. Repair of Cathodic Protection Wells.

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

Section 12. 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 on the well is interrupted by such events as overnight shutdown, poor weather and required waiting periods to allow setting of sealing materials and the 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.

Part III. Destruction of Cathodic Protection Wells

Section 13. Purpose of Destruction.

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

1. Ensure that the quality of ground water is protected, and,
2. Eliminate a possible physical hazard to humans and animals.

Section 14. 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 ground water 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 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.

Section 15. General Requirements.

All permanently inactive or "abandoned" cathodic protection wells shall be properly destroyed. The purpose of destruction is to prevent a possible safety hazard to humans and animals and to eliminate the well structure as a possible means for the preferential migration of poor quality water, pollutants, and contaminants.

Section 16. Requirements for Destroying Cathodic Protection Wells.

General requirements for well destruction are contained in Section 23 of the Water Well Standards. Special Consideration 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 constructions and whether conditions exist that will interfere with filling and sealing.

The well shall be sounded immediately before it is destroyed to make sure that no obstructions exist that will interfere with filling and sealing. The well shall be cleaned before destruction, as needed, to ensure that all undesirable materials, including obstructions 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 ground water. 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 be extended 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 a 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 of 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 for 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 that point needed to allow proper placement of sealing materials within required 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 the Southern California Cathodic Protection Committee in December 1969.

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 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 not deeper than 30 feet below ground surface.

2. Timing of Placement. Sealing material shall be placed in one continuous operation (or "pour") from the bottom to the 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.
 3. Ground Water Flow. Special care shall be used to restrict the flow of ground water 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 isolation of 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 at 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 consolidation 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 well 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. Temporary Cover. The well borehole 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 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.



COUNTY OF MENDOCINO DIVISION OF ENVIRONMENTAL HEALTH

WATER QUANTITY EVALUATION REPORT

SUBDIVISION NAME		NUMBER
LOCATION		
DEVELOPER	ADDRESS	PHONE
ENGINEER/SURVEYOR		PHONE
ADDRESS	CITY	STATE

See Instructions on Reverse Side Before Commencing Test

WELL DATA:	BAIL TEST																																																
1. BORE SIZE INCHES	IF THE BAIL TEST METHOD IS USED TO DETERMINE WATER QUANTITY, COMPLETE THE FOLLOWING ADDITIONAL INFORMATION.																																																
2. CASING SIZE INCHES																																																	
3. GRAVEL PACK <input type="checkbox"/> YES <input type="checkbox"/> NO																																																	
4. DEPTH	BAILER SIZE GALLONS																																																
5. VOLUME PER FOOT GALLONS	NUMBER OF BAILERS TO BAIL DRY																																																
TEST DATA:	RECOVERY DATA																																																
WATER LEVEL TO BE MEASURED FROM TOP OF CASING TO WATER																																																	
<table border="1"> <thead> <tr> <th>WATER LEVEL - FT.</th> <th>TIME - AM/PM</th> </tr> </thead> <tbody> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr> <td>TOTAL DRAWDOWN</td> <td>TOTAL TIME</td> </tr> <tr> <td colspan="2">CALCULATED PUMP RATE</td> </tr> </tbody> </table>	WATER LEVEL - FT.	TIME - AM/PM																			TOTAL DRAWDOWN	TOTAL TIME	CALCULATED PUMP RATE		<table border="1"> <thead> <tr> <th>WATER LEVEL - FT.</th> <th>TIME - AM/PM</th> </tr> </thead> <tbody> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr> <td>TOTAL RECOVERY</td> <td>TOTAL TIME</td> </tr> <tr> <td colspan="2">RECOVERY RATE</td> </tr> </tbody> </table>	WATER LEVEL - FT.	TIME - AM/PM																			TOTAL RECOVERY	TOTAL TIME	RECOVERY RATE	
WATER LEVEL - FT.	TIME - AM/PM																																																
TOTAL DRAWDOWN	TOTAL TIME																																																
CALCULATED PUMP RATE																																																	
WATER LEVEL - FT.	TIME - AM/PM																																																
TOTAL RECOVERY	TOTAL TIME																																																
RECOVERY RATE																																																	
CALCULATIONS																																																	

DATE RECEIVED: _____

DATE _____

CALCULATIONS CHECKED YES NO

REMARKS: _____

Form #26.05 5/94

CERTIFICATION:

I CERTIFY THE TEST(S) WAS (WERE) CARRIED OUT BY THE PROCEDURE(S) SPECIFIED BY THE MENDOCINO COUNTY HEALTH DEPARTMENT.

I DECLARE UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

SIGNED _____

INSTRUCTIONS FOR CONDUCTING QUANTITY TESTING

FOR INLAND WATER WELLS AND SPRINGS

WATER WELLS MAY BE TESTED BY ANY OF THE FOLLOWING METHODS

- 1) PUMP TEST METHOD - A well may be pumped at any chosen pump rate until 1200 gallons has been pumped from the well or pumped until dry. Total drawdown and rate of recovery must be reported. The well yield is calculated from the rate of recovery.
- 2) SUSTAINED YIELD - A well may be pumped at any rate until the water level (drawdown) is not lowered any further (sustained yield) after 1200 gallons of water has been pumped.
- 3) BAIL TEST METHOD - A well may be bailed at any rate until dry, or until 1200 gallons have been bailed from the well. Total drawdown and rate of recovery must be reported. The well yield is calculated from the rate of recovery. The bail test is not an acceptable method for low-producing wells (ie. < 5 gpm).
- 4) CERTAIN SEALED WELLS - In certain instances, it may be impossible to measure drawdown and recovery rate because of construction features of the well. In these cases, the following procedures may be used:

Wells where a well log is available

- a. Calculate the total water available in the casing and gravel pack, assuming the well is completely full.
- b. Pump the well to obtain at least 1200 gallons in 24 hours after subtracting twice the quantity calculated in step a.
- c. The person conducting the test must submit a statement certifying that the well is, in their opinion, indicative of water feasibility on the division.

Alternative, if no well log is available

- a. Calculate the total water available in the casing and gravel pack, assuming the well is completely full.
- b. Pump the well to obtain at least 1200 gallons in 24 hours after subtracting twice the quantity calculated in step a. This step is to be repeated 24 hours after the first pump test.
- c. The person conducting the test must submit a statement certifying that the well is, in their opinion, indicative of water feasibility on the division.

5) SPRING TESTS - Spring tests may be acceptable under the following conditions: a developed spring must be located on each parcel, each spring is adequately protected and not located in a defined drainage course, water quantity is measured at the source where free-flowing water emerges to the surface, and spring tests must be performed between August 1 and September 30.