HANDOUTS

This section contains supplemental information for enhancing the educational program. This material will assist landowners in understanding the issues related to abandoned wells and how to proceed with the proper closure of an abandoned well.

Vocabulary

Abandoned well - A well that has not been used for six consecutive months. A well is considered to be in-use in the following cases:

a. a non-deteriorated well which contains the casing, pump, and pump column in good condition; or
b. a non-deteriorated well which has been capped.

Annular space - The space between the casing and borehole wall.

Aquifer - Geologic stratum or zone below the surface of the earth capable of producing groundwater.

Atmospheric barrier - A section of cement placed from two feet below land surface to the land surface when using granular sodium bentonite as a casing sealant or plugging sealant in lieu of cement.

Bentonite - A sodium hydrous aluminum silicate clay mineral (montmorillonite) commercially available in powdered, granular, or pellet form which is mixed with potable water and used for a variety of purposes including the stabilization of borehole walls during drilling, the control of potential or existing high fluid pressures encountered during drilling below a water table, and to provide a seal in the annular space between the well casing and borehole wall.

Bentonite grout - A fluid mixture of sodium bentonite and potable water mixed at manufacturers' specifications to a slurry consistency which can be pumped through a pipe directly into the annular space between the casing and the borehole wall. Its primary function is to seal the borehole in order to prevent the subsurface migration or communication of fluids.

Bridge - Plugging materials that lodge part way down in a well bore so as to obstruct passage of subsequent plugging materials to the bottom of the well bore.

Capped well - A well that is closed or capped with a covering capable of preventing surface pollutants from entering the well and sustaining weight of at least 400 pounds and constructed in such a way that the covering cannot be easily removed by hand.

Casing - A watertight pipe which is installed in an excavated or drilled hole, temporarily or permanently, to maintain the hole sidewalls against caving, advance the borehole, and in conjunction with cementing and/or bentonite grouting, to confine the ground waters to their respective zones of origin, and to prevent surface contaminant infiltration.

a. Plastic casing - National Sanitation Foundation (NSF-WC) or American Society of Testing Material (ASTM) F-480 minimum SDR 26 approved water well casing.
b. Steel Casing - ASTM A-53 Grade B or better and have a minimum weight and thickness of American National Standards Institute (ANSI) schedule 10.

c. Monitoring wells may use other materials, such as fluoropolymer (Teflon), glass-fiber-reinforced epoxy, or various stainless steel alloys.

Cement - A neat portland or construction cement mixture of not more than seven gallons of water per 94-pound sack of dry cement, or a cement slurry which contains cement along with bentonite, gypsum or other additives.

Chemigation - A process whereby pesticides, fertilizers or other chemicals, or effluents from animal wastes is added to irrigation water applied to land or crop, or both, through an irrigation distribution system.

Complainant - A person who has filed a complaint with the Texas Department of Licensing and Regulation (Department) against any party subject to the jurisdiction of the Department. The Department may be the complainant.

Completed monitoring well - A monitoring well which allows water from a single water-producing zone to enter the well bore, but isolates the single water-producing zone from the surface and from all other water-bearing zones by proper casing and/or cementing procedures. The single water-producing zone shall not include more than one continuous water-producing unit unless a qualified geologist or a groundwater hydrologist has determined that all the units screened or sampled by the well are interconnected naturally.

Completed to produce undesirable water - A completed well which is designed to extract water from a zone which contains undesirable water.

Completed water well - A water well which has sealed off access of undesirable water to the well bore by proper casing and/or cementing procedures.

Confining layer - Geologic stratum or zone below the surface of the earth that impedes the movement of groundwater.

Constituents - Elements, ions, compounds, or substances which may cause the degradation of the soil or ground water.

Easy access - Access is not obstructed by other equipment and the fitting can be removed and replaced with a minimum of tools without risk of breakage of the attachment parts.

Edwards Aquifer - That portion of an arcuate belt of porous, water bearing, predominantly carbonate rocks known as the Edwards and Associated Limestones in the Balcones Fault Zone trending from west to east to northeast in Kinney, Uvalde, Medina, Bexar, Hays, Travis, and Williamson Counties; and composed of the Salmon Peak Limestone, McKnight Formation, West Nueces Formation, Devil's River Limestone, Person Formation, Kainer Formation, Edwards Formation and Georgetown Formation. The permeable aquifer units generally overlie the less-permeable Glen Rose Formation to the south, overlie the less-permeable Comanche Peak and Walnut formations north of the Colorado River, and underlie the less-permeable Del Rio Clay regionally.

Environmental soil boring - An artificial excavation constructed to measure or monitor the quality and quantity or movement of substances, elements, chemicals, or fluids beneath the surface of the ground. The term shall not include any well which is used in conjunction with the production of oil, gas, or any other minerals.

Flapper - The clapper, closing, or checking device within the body of the check valve.

Foreign substance - Constituents that include recirculated tailwater and open-ditch water when a pump discharge pipe is submerged in the ditch.

Freshwater - Water whose bacteriological, physical, and chemical properties are such that it is suitable and feasible for beneficial use.

Granular sodium bentonite - Sized, coarse ground, untreated, sodium based bentonite (montmorillonite) which has the specific characteristic of swelling in freshwater.

Groundwater Conservation District - Any district or authority created under Article III, Section 52, or Article XVI, Section 59 of the Texas Constitution or under the provisions of Chapters 35 and 36 of the Texas Water Code that has the authority to regulate the spacing or production of water wells.

Irrigation distribution system - A device or combination of devices having a hose, pipe, or other conduit which connects directly to any water well or reservoir connected to the well, through which water or a mixture of water and chemicals is drawn and applied to land. The term does not include any hand held hose sprayer or other similar device which is constructed so that an interruption in water flow automatically prevents any backflow to the water source.

Monitoring well - An artificial excavation constructed to measure or monitor the quality and/or quantity or movement of substances, elements, chemicals, or fluids beneath the surface of the ground. Included within this definition are environmental soil borings, piezometer wells, observation wells, and recovery wells. The term shall not include any well which is used in conjunction with the production of oil, gas, coal, lignite, or other minerals.

Mud - A relatively homogenous; viscous fluid produced by the suspension of clay-size particles in water.

Neat portland cement - A finely ground, carefully proportioned mixture of limestone and shale (sold commercially)

Piezometer - A device so constructed and sealed as to measure hydraulic head at a point in the subsurface.

Piezometer well - A well of a temporary nature constructed to monitor well standards for the purpose of measuring water levels or used for the installation of piezometer resulting in the determination of locations and depths of permanent monitor wells.

Plugging - An absolute sealing of the well bore.

Pollution - The alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any water that renders the water harmful, detrimental, or injurious to humans, animals, vegetation, or property, or to public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any or reasonable purpose.

Pressure head - Hydrostatic pressure expressed as the height that a column of water rises in a tightly cased well.

Public water system - A system supplying water to a number of connections or individuals, as defined by current rules and regulations of the Texas Natural Resource Conservation Commission 30 TAC Chapter 290.

Recharge zone - Generally, that area where the stratigraphic units constituting the Edward Aquifer crop out, including the outcrops of other geologic formations in proximity to the Edwards Aquifer, where caves, sinkholes, faults, fractures, or other permeable features would create a potential for recharge of surface waters into the Edwards Aquifer. The recharge zone is identified as that area designated as such in official maps in the appropriate regional office of the Texas National Resource Conservation Commission.

Recovery well - A well constructed for the purpose of recovering undesirable groundwater for treatment or removal of contamination.

Sanitary well seal - A water tight device to maintain a junction between the casing and the pump column.

Surging - Alternately raising and lowering a column of water in a well to induce water movement into and out of the well bore and aquifer.

TDLR - Texas Department of Licensing and Regulation.

TNRCC - Texas Natural Resource Conservation Commission.

Tremie tube - A tube or pipe running to the bottom of a well (after removal of casing) that is used to transport plugging materials to the bottom of the well; tube is raised as bottom of the well is filled.

Undesirable water - Water that is injurious to human health and the environment or water that can cause pollution to land or other waters.

Water or waters in the state - Groundwater, percolating or otherwise, lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Gulf of Mexico inside the territorial limits of the state, and all other bodies of surface water, natural or artificial, inland or coastal, fresh or salt, navigable or nonnavigable, and including the beds and banks of all watercourses and bodies of surface water, that are wholly or partially inside or bordering the state or inside the jurisdiction of the state.

Well - A water well, injection well, dewatering well, monitoring well, piezometer well, observation well, or recovery well.

State well report (Well Log) - A log recorded on forms prescribed by the TDLR, at the time of drilling showing the depth, thickness, character of the different strata penetrated, location of water-bearing strata, depth, size, and character of casing installed, together with any other data or information required by the Executive Director.

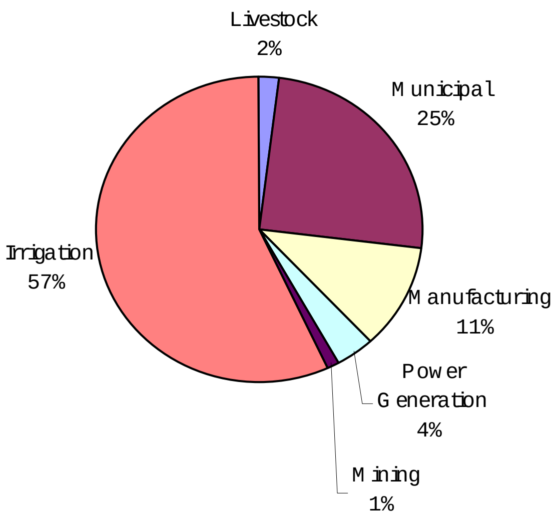
Texas Groundwater Resources are Critical to Meeting our Future Water Needs

Water is one of our State's most precious resources. Groundwater derived from many aquifers supplies over half of the water used in the state. Protecting the quality of this vital resource is the responsibility of all Texans.

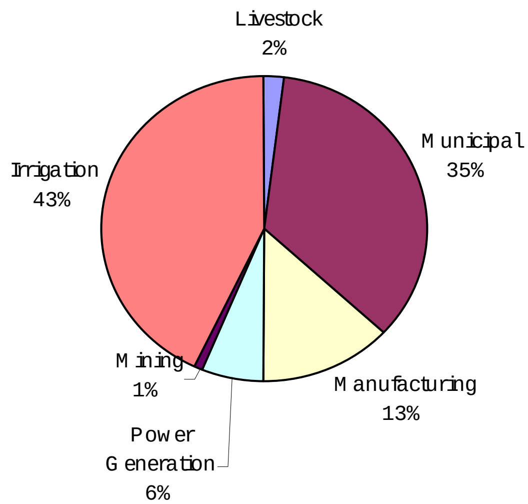
For many years groundwater has been pumped through water wells. Over the years, many wells around homes, farms, industrial sites, and urban areas have been abandoned without being properly plugged. Not only are these wells potential groundwater-contamination avenues, many are a safety hazard to children and animals. Although plugging an abandoned well takes time and money, these wells are a threat that cannot be ignored.

Texas law makes the landowner responsible for plugging abandoned wells and, therefore, liable for any water contamination or injury. This program is provided to help landowners understand how to plug a well properly. It recommended that before you begin the process of plugging an abandoned well that you seek advice from your local groundwater conservation district, a licensed water well driller in your area, or the Water Well Drillers Program with the Texas Department of Licensing and Regulation (TDLR).

The total projected demand for water was expected to be nearly 17 million acre-feet in 2000 and 20 million acre-feet in 2050, an 18 percent increase. To meet these water demands many management strategies have been considered. Expansion of existing and acquisition of new groundwater supplies is expected to grow 11 percent.

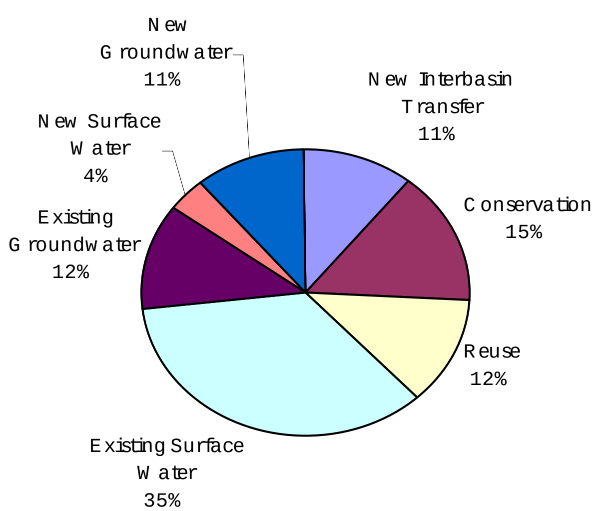


2000



2050

Water Demand By Sector



Types of Water Management Strategies Used to Meet Future Water Needs

Abandoned Wells are a Threat to our Personal Safety

This hazard is obvious to anyone who has encountered an unmarked and uncovered large diameter well. Accidents involving humans and animals falling into abandoned wells have happened and continue to occur. Even when a well is covered, the soil around the well may be unstable and can cave in.

< 1981 Texas. 4-year-old child falls 260 feet into well.(rescued)
< 1983 Louisiana. 10-month-old child falls to bottom of 40 foot deep 10 inch diameter. (fatality)
< 1983 Frascati, Italy. 6-year-old boy falls over 200 feet 16 inch diameter abandoned well. (fatality)
< 1986 Colt's Neck, New Jersey. 2-year-old boy falls 12 feet into abandoned 12 inch diameter borehole in yard. (rescued)
< 1986 Texas 6-year-old child steps off school bus and falls into snow-covered abandoned well. (rescued)
< Jessica McClure, Midland, Texas, October 16, 1987. Rescued after 58 hours falling 22 feet into an eight inch abandoned well located in the family's back yard.
< 1994 Home, Washington. 7-year-old boy was rescued after falling 40 feet to the bottom of an abandoned well.
< 1995 Port Orchard, Washington. A construction foreman fell into an abandoned well at a construction site. The foreman was preparing to plug the well at the time of the accident.
< 1996 King George, Virginia. A third grader fell through a crack in the lid of his grandmother's well.
< 1996 Mackinaw, Illinois. Ten-year-old boy was seriously injured when falling into an abandoned well at a park. After falling onto a concrete cove which gave way, the child plunged 40 feet to the bottom of and abandoned 103-year-old well.
< 1997 Central Minnesota. Well owner reported that his child stepped into an improperly sealed unsuccessful well.
< Lenawee County, Michigan. Two ten-year-old girls playing in the yard fell through concrete cover into a 25 foot deep, 4 foot diameter dug well. Mother tried to rescue children and also fell in.
< 1997 Cockeysville, Maryland. Six-year-old boy playing hide-and-seek with his brothers fell in to a 50 feet deep abandoned well into chin deep water.
< Cristian Quiroz, Buenos Aires, Argentina, March 23, 1998. Cristian died after falling into a well while walking with his mother.
< 1998 Midland, Michigan. A four year old girl fell through the rotted wood cover of an abandoned well while chasing a cat.
< Jessy Krause, Mulvane, Kansas, May 14, 1999. Rescued after falling 16 feet in an eight inch hand dug well.
< Ewell Hart, Sardis, Kentucky, August 10, 2001. Hart passed away several days after being rescued from a well he was trapped in for 50 hours. The well was located 40 feet from his house.

Abandoned Wells are a Threat to our Water Supply

An abandoned well is a direct conduit from the ground surface to the aquifer below. Contaminates that enter the well are introduced directly into the aquifer with no opportunity for natural filtration by soils or geologic materials. If a contamination incident occurs with a concentrated chemical, the potential for health-threatening levels in the underlying aquifer is high. This puts other wells in the aquifer at risk, particularly other wells on the property or those that are close to the abandoned well. Just one gallon of 2,4-D herbicide can contaminate 3 to 4 million gallons of water. In terms of groundwater, approximately that much water would be held in the upper 3 feet of an aquifer over a 20-acre area.

A well open to one or more aquifer will allow water to migrate out of a zone with higher pressure head and enter a zone with lower pressure head. In many areas of Texas, deep aquifers are under high pressures and are extremely salty. When the casing from a high pressure well deteriorates and the well is abandoned without proper plugging, continual upward flow of salty water from the deeper aquifer will cause contamination of the shallow, fresh aquifer. Also, any pollutants that occur in one zone can migrate to another zone through the well.

Pressure head in artesian aquifer is depleted as water discharges either at land surface or to a less pressurized aquifer. Unplugged abandoned wells contribute to the regional depletion of pressure head within an aquifer. Eventually the decline in pressure head causes flowing wells to stop flowing and the water level in nearby wells placed in the same aquifer to decline.

When is a Well Considered Abandoned?

According to State law, a well is considered abandoned if it has not been used for six consecutive months. However, a well can be considered to be **in-use** in the following cases:

< A non-deteriorated well which contains the casing, pump, and pump column in good condition, or

< A non-deteriorated well which has been capped.

If you are uncertain whether your well is legally abandoned, call a licensed water well driller in your area, the Water Well Drillers Program of the TDLR, or the local groundwater conservation district (if one is present).

Who Can Plug Abandoned Wells?

As a landowner, you may do the work necessary to plug an abandoned well on your property. If you plan to do so, first notify the Water Well Drillers Program of the TDLR of your intent to plug the well and the method you will use. You should request a State well plugging form. Within 30 days after the well is plugged, you must send a copy of the form to the TDLR.

If the well is within a groundwater conservation district, notify the district of your intention to plug the well. Request the district's plugging application and pay any applicable fees required. Seek the district's professional consultation regarding any other compliance issues to be considered. Send a copy of the State well plugging form to the groundwater conservation district within 30 days after the well is plugged.

You can hire a licensed water well driller or pump installer to seal and plug an abandoned well. In some cases this is recommended, because a well contractor has the equipment and understanding of the soil conditions that affect how the well should be properly plugged.

Figures 1 to 8 illustrate various types of well constructions. These well types are ordered to indicate the degree of difficulty in plugging. Landowners may be able to plug well types I – V (figures 1-5); however, only licensed well drillers should plug types VI – VIII (Figures 6-8).

What Materials Can Be Used to Plug a Well?

Several different materials may be uses to plug an abandoned well. These materials form an impermeable plug that prevents water flow from entering the abandoned well and potentially contaminating the groundwater below. These materials include:

- Cement: A neat portland or construction cement mixture of not more than seven gallons of water per 94 pound sack of dry cement, or a cement slurry that contains cement along with bentonite, gypsum or other additives mixed to manufacturer's recommendations.
- Bentonite: A sodium hydrous aluminum silicate clay mineral (montorillonite) commercially available in powdered, granular, or pellet form, which is mixed with potable (drinkable) water and used for a variety of purposes including stabilization of borehole walls during drilling, to control potential or existing high fluid pressures encountered during drilling below a water table, and to provide a seal in the annular space between the well casing and borehole wall.
- Bentonite Grout: a fluid mixture of sodium bentonite and potable water mixed at manufacture's specifications to a slurry consistency that can be pumped through a pipe directly into the annular space between the casing and the borehole wall. Its primary function is to seal the borehole in order to prevent the subsurface migration or communication of fluids.

Bentonite clay swells to about 10 time its original size when in contact with water. The swollen clay forms a dense, virtually impermeable layer. Gravel often fills the bottom of certain types of wells. Local soils can be used to complete the plugging process, but a variance must first be obtained from TDLR.

Landowners who wish to plug their own well should consider using bentonite chips (average size of 3/8 to 3/4 inches). Bentonite chips are easy to handle and less likely to form a bridge within the well casing. If a bridge forms the well will not plug properly and the well will have to be bored out and the plugging procedure repeated.

Well Plugging Steps

Step 1. Measure the dimensions of the well, including the diameter, total depth, and water level. Accurate measurements of the well will allow correct calculations of the total volume of the well and water in the well. The volume of the well is needed to determine the amount of material needed to plug the well. Volume calculations depend on the shape of the well. Most wells are cylindrical; however some have other shapes that must be considered to make accurate calculations of volume.

Example: An abandoned well is 6 inches in diameter and 100 feet deep and a water level of 40 feet.

By using Table 1 the number of 94 lb sacks of Cement or 50 lb sacks Bentonite chips can be calculated by using the well diameter and depth.

For the above example:

Cement	100 ft / 7.2 ft = 13.9 sacks
Bentonite	100 ft/ 3.5 ft = 28.6 sacks

Large diameter wells can be plugged by filling with compacted clay or caliche to the surface. Leave it mounded on the surface to promote drainage and allow for settling. Alternately, filling the top two to three feet with a cement cap is also an option.

Step 2. Remove all debris from the well. Debris causes voids that allow the fill material to slump or settle. For the well to be plugged properly the fill materials should not slump or settle. Remove the pump, the pump rods, pipes, and any other equipment from the well. Floating debris, such as wood staves, should also be removed. One method used to remove floating debris is to flush the well. As water is pumped into the well floating debris will float to the top as the well fills with water. For large diameter wells flushing may not be possible due to the large volume of water needed.

Step 3. Disinfect the well by adding household bleach. If the well to be plugged has standing water it is recommended to disinfect the water to kill any potential pathogens before the well is plugged. This water insures that harmful pathogens are not sealed in the aquifer. To disinfect the water, household bleach is added at a rate of one gallon per 500 gallons of water.

Example: From the example above of a well that is 100 feet deep 6 inches in diameter and has a water level of 40 feet.

By using Table 2, diameter and depth of well, the number of ounces of bleach per linear foot of well is given. Once the volume of bleach is calculated, 40 x 0.38 = 1.52 oz of bleach:

- Add the calculated volume of bleach to the well.
- Mix the water column (well water) by surging.

Step 4. Remove as much casing from the well as possible. If a metal casing is present, pull the casing from the well. Some or all of the casing may be removed. If it is not possible to pull the casing, dig down around the casing and cut the casing off several feet below the ground surface. Hand dug wells need the upper bricks and stone work removed to destroy the conduit from the surface.

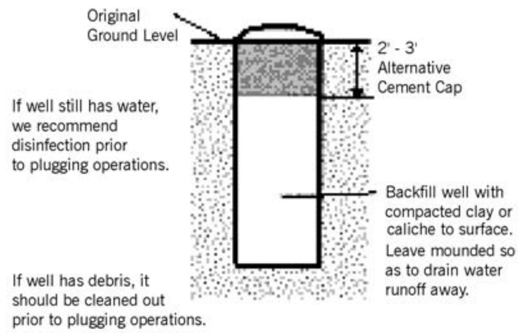
Step 5. Fill the well with plugging materials. The exact procedure used to plug the well depends on the type of well, depth, diameter, aquifer type, availability of materials, and level of protection required. Licensed well drillers are the professionals designated with the authority to plug abandoned wells. If you hire anyone to assist in the plugging of a well they must be a licensed well driller.

Landowners may be able to plug wells of construction type I-V. The second question is the quantity of standing water in the well. If the well has greater than 100 feet of standing water, the well must be plugged by a licensed well driller.

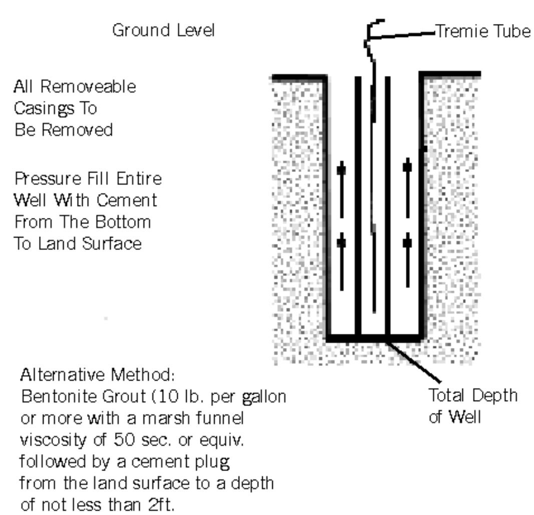
Large diameter wells can be filled with a clay or caliche soil. This material can be slowly poured into the well allowing the well to be filled from the bottom to the top. As the well is filled to the soil surface, a cement cap can be placed in the upper portion of the well. This adds extra protection for preventing contaminant movement into the groundwater below.

well bore. These materials are poured over a screen to remove the fine materials as the bentonite chips fall toward the well.

Plugging a Large Diameter/ Hand Dug Well (Exception)



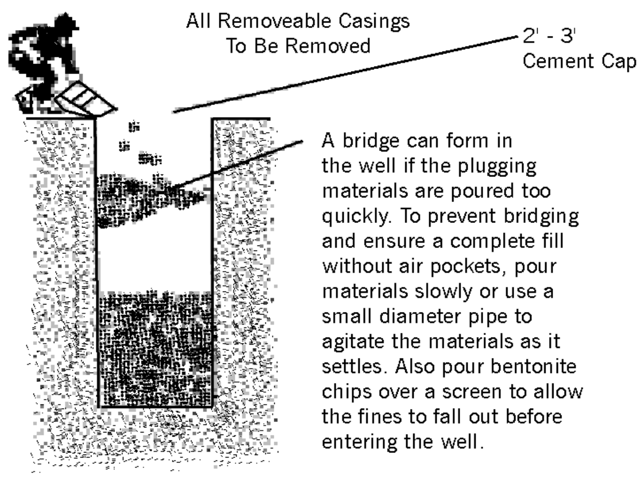
Plugging Drilled Wells That Have Greater Than 100 Feet of Standing Water



A tremie tube is used to fill deep wells and wells with a standing water level greater than 100 feet. A tube is lowered to the bottom of the well and the plugging materials are pumped to the bottom to displace the water and fill the well from the bottom. Special equipment is needed to perform this operation. Therefore, a licensed well driller is the best person to perform this operation.

Step 6. Complete and mail a state plugging form to TDLR at the address indicated below. Comply with any reporting requirements of your local groundwater conservation district (if one exists).

Plugging drilled Wells That Have Less Than 100 Feet of Standing Water



Texas Dept. of Licensing & Regulation
920 Colorado
P.O. Box 12157
Austin, Texas 78711
Toll-Free (in Texas) 800-803-9202
Tel: (512) 463-6599
Fax: (512) 475-2854

Table 1. Plugging Materials Calculation Guide

Well or Hole Diameter[1]	Cement[2]	Bentonite Chips[3]
Inches	Linear Feet	Linear Feet
2	50.3	31.3
3	28.8	13.9
4	16.2	7.9
5	10.4	5
6	7.2	3.5
7	5.3	2.6
8	4	2
9	3.2	1.5
10	2.6	1.3
12	1.8	0.86
14	1.3	0.63
16	1	0.48
18	0.8	0.38
20	0.6	0.31
24	0.4	0.21
36	0.2	0.097
40	0.16	0.078
44	0.13	0.065
48	0.11	0.054

Notes:

[1] If measured well diameter falls in-between listed diameters, use the larger diameter to ensure adequate material purchase. Diameter for cylindrical wells only.

[2] Linear feet filled by cement slurry consisting of on 94-pound sack of Portland cement and 7 gallons of water.

[3] Linear feet filled by 50-pound sack of 3/8 to 3/4- inch bentonite chips.

Table 2. Disinfection Calculation Table

Well or Hole Diameter[1]	Volume of Water (Per Linear Foot)	Added Chlorine[2,3] (Per Linear Foot)
Inches	Gallons/Foot	Fluid Ounces/Foot
2	0.16	0.04
3	0.37	0.09
4	0.65	0.17
5	1.02	0.26
6	1.50	0.38
7	2.00	0.51
8	2.61	0.66
9	3.30	0.84
10	4.08	1.04
12	5.88	1.49
14	8.00	2.03
16	10.44	2.65
18	13.22	3.35
20	16.32	4.15
24	23.50	5.97
36	52.88	13.43
40	65.28	16.58
44	78.99	20.06
48	94.00	23.87

Notes:
[1] Diameters are for cylindrical wells only.
[2] Typical 5.25% to 6.0% chlorine product. Common brand names include: Clorox, Purex, Snowhite, Kandu, Topco,etc
[3] Added volume produces an equivalent concentration of 100 parts per million of chlorine per linear foot of water.

Well Construction Methods

For many years groundwater has been pumped through water wells. Over the years, several different construction methods were used to build these wells. The type of soil around these wells also affected the way they were constructed. This variation resulted in eight main types of wells. These wells are identified as type I through VIII.

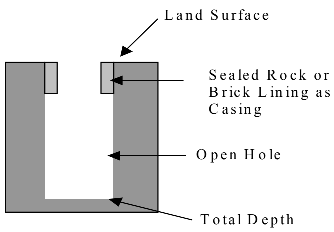


Figure 1
Well I -
Dug Well

Type I wells are hand dug wells with a rock or brick lining as the casing. This is the simplest of the different types. It is also one of the oldest types of wells. Many early settlers constructed this type because they lacked the equipment to mechanically drill the hole to the shallow water. These wells usually have the largest diameters.

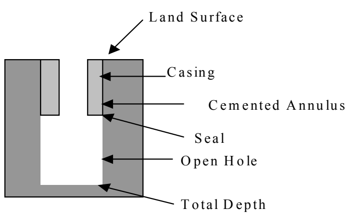


Figure 2
Well II –
Drilled Well

Type II wells are similar to type I wells, but they are drilled instead of dug by hand. A solid casing is used near the ground surface and the native soil forms the well opening below the casing. The casing also differs. The casing is lined outside with a cemented annulus and has a seal underneath it. Since this type of well is drilled, the diameter can be smaller than a type I well.

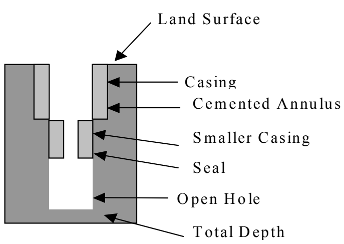


Figure 3
Well III -
Drilled Well

Type III wells have a larger diameter hole at the surface and a smaller diameter hole for the bottom section of the well. A section of casing extends into the upper portion of the smaller diameter boring. The annulus around the casing is sealed with cement. These wells are also mechanically drilled.

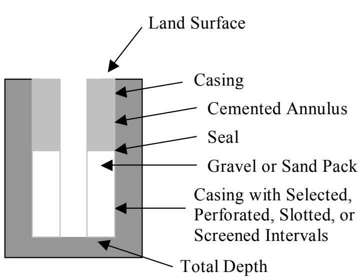


Figure 4
Well IV –
Drilled Well

Type IV wells are drilled wells with a uniform diameter from top to bottom. A casing extends the full depth of the well. The bottom portion of the casing has selected perforated, slotted, or screened intervals and has a gravel or sand pack which lines the outside of the casing. The upper non-perforated portion of the casing has the usual cemented annulus lined casing.

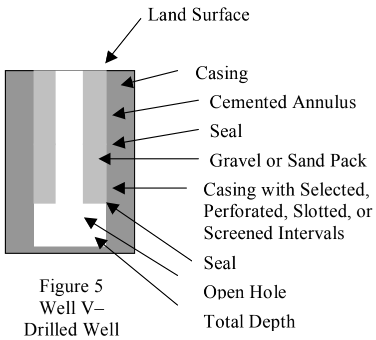


Figure 5
Well V–
Drilled Well

Type V wells are almost identical to type IV wells, but the gravel or sand pack surrounded casing does not go to the bottom of the well. Instead, it is sealed off, leaving an open hole underneath it. Like the other wells, this type is drilled.

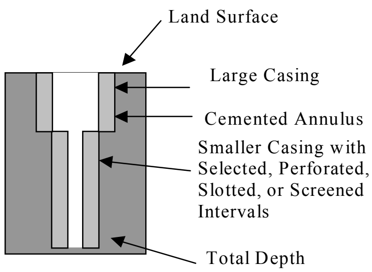


Figure 6
Well VI-
Drilled Well

Type VI wells have a large diameter surface casing with a cemented annulus. A smaller well bore continues through the upper casing to reach the groundwater below. The smaller casing has selected, perforated, slotted, or screened intervals. The smaller casing goes to the bottom of the well. This is also a mechanically drilled well.

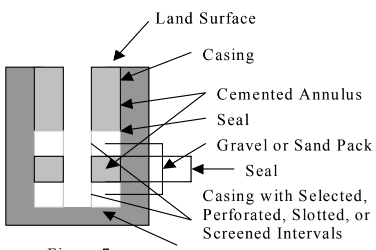


Figure 7
Well VII –
Drilled Well

Type VII wells are constructed with a uniform well bore but are completed to access water from two specific zones. The casing has a cemented annulus near the surface and at a deeper section of casing. Two sections of casing contain a selected, perforated, slotted, or screened intervals with a gravel of sand pack outside the casing. This layered casing goes all the way to the bottom of the well. This well is also a drilled well.

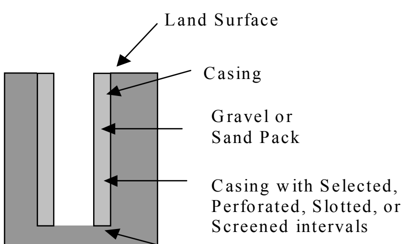


Figure 8
Well VIII -
Drilled Well

Type VIII wells are constructed with a uniform well bore and a casing extending the full depth. The upper casing is solid and the lower casing has selected, perforated, slotted, or screened intervals. The entire casing is surrounded by a gravel or sand pack.

The wide variation in geological formations and depth to good groundwater made it necessary to develop several construction methods for wells accessing groundwater. Because the well characteristics are different, the approaches to properly plug these wells may also be different and may need to be evaluated on a site specific basis.