State of California
The Resources Agency

Department of
Water Resources

Water Wells . . .

And what you should know about them.

October 1977

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Acknowledgment

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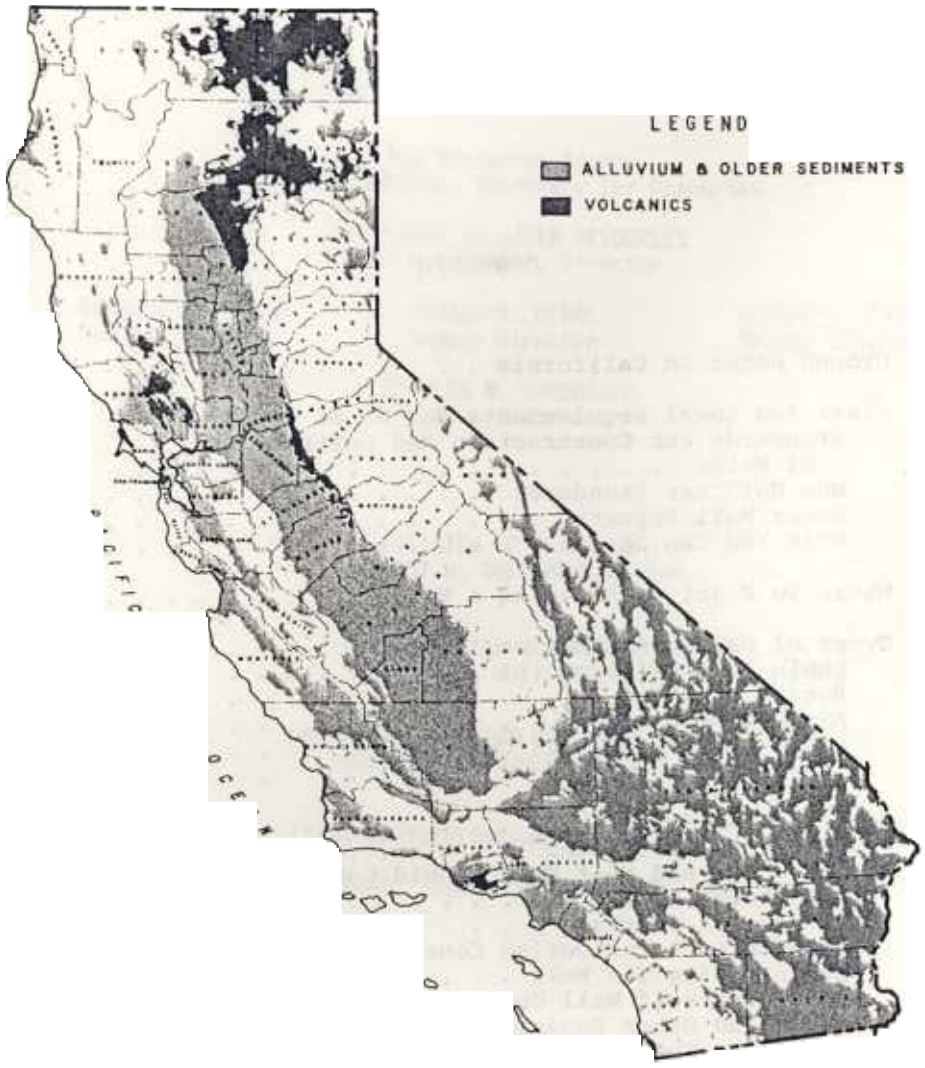


Areas of Ground Water Occurrence

WATER WELLS
And What You Should Know About Them

Too often the builder of that "nice little home in the suburbs" or "in the country" gives little thought to the most important part of the job: the water supply. Without it, the home cannot exist. Unless a good, safe, and dependable water supply is available at the start, the builder risks inconvenience, needless expenditures of money, and possible sickness.

Most homes not served by public water systems obtain water from wells. The cost of a well is relatively small when compared with the total cost of a home. During construction of a well, however, builders often cut corners by excavating too shallow a well, by using inadequate materials, or by following poor construction practices, which in the long run may prove to be most costly. This publication will provide you, as a homeowner or homeowner-to-be, with information you will need to make reasonable and sound decisions before (and during, if need be) construction of your well. Much of what is presented applies to all wells, regardless of the intended use for the water.

Ground Water In California

To many people, water in the ground is in the realm of the mysterious (which, incidentally, is what makes credible the art of dowsing or "water witching"). Visions of vast subterranean rivers and lakes have been romanticized by the writings of such authors as Jules Verne, Edgar Rice Burroughs, and H. Rider Haggard. True, there are subterranean water bodies where underground materials, such as limestone, readily dissolve in water. Such "solution openings" are common in parts of the mid-western and southeastern United States, as evidenced by the many caves and "pot holes" in those regions, but they nowhere compare to the imaginary systems encountered in fiction.

For the most part, ground water is the water that fills the pores in gravels, sands, silts, and clays, or the cracks in the more consolidated rocks, even though these may only be hairline fractures. Such a "reservoir" may extend downward for hundreds, sometimes thousands, of feet. A geologic formation that contains water and yields it in sufficient quantity to supply pumping wells is called an aquifer.

The ground water resources of the world are indeed vast. In fact, more than 90 percent of the world's fresh water lies underground. Twenty percent of the water used in the United States and 40 percent of the water used in California is pumped from underground. In some locations,

it is the only water available. While ground water is used widely, we are just beginning to think of it as a manageable resource.

In California, most of the readily available ground water is contained in ground water "reservoirs" or deposits composed of alluvial fill materials that underlie valley floors. These are sediments washed down from surrounding mountains over long geologic periods. In coastal areas, the alluvial fill is frequently interspersed with layers of marine sediments. Substantial quantities of water are also found in volcanic rocks, located mainly in the northeastern counties of the State. In the hilly and mountainous areas, the shallow soil mantle or fractures in the rocks will often supply small quantities of ground water that suffice for household needs.

The quality of water is judged by the characteristics that govern its useability. Ground water is largely "cleaner" and more "pure" than is most surface water. This is true in part because the tiny pores in soil and rock through which the water moves filter out any suspended matter that may be present, and in part because ground water is naturally protected against contamination and pollution. However, this natural insulation can sometimes be disrupted. In addition, ground water moves slowly and smoothly (there is no turbulent flow, as is the case with most surface water). Ground water usually contains more dissolved minerals than does surface water because it touches and is surrounded by soil and rock until it is withdrawn for use. This is what gives the water that "good well-water taste".

State And Local Requirements For Water Wells

To preserve the integrity of the ground water resource so that it can be used by future generations, and to protect and assist the users of the resource, State and local governments have enacted a number of requirements regarding well construction.

Standards For Construction And Destruction Of Wells

A properly designed and constructed water well should furnish water whose native quality is unimpaired for the life of the installation. You can best accomplish this by following good design and construction practices.

The Department of Water Resources, which is charged with preparing standards for the construction and destruction of wells, has issued Bulletin No. 74, Water Well Standards: State of California (February 1968), which is, in essence, a "building code" for water wells. Prepared in cooperation with the California Department of Public Health, it

contains standards for constructing water wells and destroying abandoned wells in California. These standards, which are also guides to acceptable practices, can be used under most circumstances encountered in the State. However, they can also be modified to accommodate local variations in geologic or ground water conditions.

Who Enforces Standards?

In most states having laws governing well construction, and in the states bordering California, the state itself administers these laws. Here in California, the responsibility has been assigned to the counties and the cities. As of mid-1977, a total of 33 of the State's 58 counties had enacted ordinances governing the construction of all water wells. Seven others have ordinances dealing with specific conditions or kinds of wells. Of the 411 cities in California, 137 have well ordinances (122 deal with all wells).

These local ordinances require that persons constructing or altering wells: (1) obtain a permit to do so, and (2) follow the standards of construction specified by the ordinance. Nearly all specify the standards recommended in Bulletin No. 74 (with appropriate modifications to meet local conditions) or variations of them. You are urged to check with the county or city in which you plan to locate a well.

Water Well Reports

California Water Code Sections 13750-13755 require that all persons who construct, alter, or destroy water wells file two reports with the Department of Water Resources. These are: (1) a notice of intent to engage in any such work, and (2) a report of completion to be filed within 30 days after the work is finished. The latter calls for information about how the well was constructed and what underground formations were encountered.

This information is used by engineers and geologists in making studies of California's ground water resources. Since most wells are constructed or repaired by licensed water well drilling contractors, the required reports are usually filed by them. You can obtain blank copies of the report forms and information about them from the Department.

What You Can Do

While government can take many steps to protect and develop the State's ground water, you can also help preserve this resource and protect the general public

by seeing that:

Your well is constructed according to the best accepted practices.

Any unused well on your property is kept in good repair and maintained so that it is not a safety hazard.

Old wells for which you have no use are properly destroyed.

By remembering and following these principles, you can assure yourself, your family, your neighbors, and your community of the continued usefulness of everyone's ground water supplies.

Where To Start In Building A Well

The best time to begin is before you buy a piece of property. Few individuals realize how many dry holes or poorly producing wells are drilled. When you are considering the purchase of land, investigate the availability of water at the outset.

As a prospective buyer, you should contact surrounding property owners, local well drilling contractors, and county health and agricultural agencies to form an overall picture of existing ground water conditions. Furthermore, in locations where the availability of a water supply is in doubt, you may want to obtain an option on the property with a provision that a well be drilled first. The foregoing is especially important in the mountainous and hilly areas of the State and in previously undeveloped areas.

In many regions, particularly valleys or coastal plains, information from nearby wells will give a good indication of the depth and quantity of water available. In other regions, and particularly in mountainous areas, ground water occurs so unpredictably that it is difficult to know what is below the ground surface. Even information from nearby wells may be misleading. In such cases, drilling one or more holes will be the only way to find out what exists. No matter what the situation, the final determination can be made only when the well is drilled.

General information on water possibilities in an area is available from the Department of Water Resources. Such information is based on studies of ground water conditions and a review of records of water well construction, as well as data gathered on depths to water in wells and chemical analyses of water pumped from wells.

The next consideration is the amount of water you will need. The home water system will support the same

conveniences that a good city water works does, provided there is enough water to handle the desired needs. Each home needs water for:

Daily Use - Drinking, cooking, bathing, sewage disposal, laundering. The last two items are the big water-users.

Seasonal Use - Lawn and garden irrigation and swimming pools.

Fire protection may have to also be considered, although there are few locations without the services of a fire fighting agency.

In most households supplied by wells, each person uses, on the average, 100 gallons (380 litres) of water a day. Lawn and garden sprinkling use varies from area to area, depending on climate, soils, and type of vegetation. (The county farm advisor can give you information for your area.)

In the past an "adequate" supply of water for a single family dwelling, including outside use, was considered by many lending agencies to be a flow of 5 gallons (19 litres) per minute. (This would add up to 7,200 gallons, or 27 250 litres, a day, if the water ran continuously.) However, this is on the generous side, and 20 to 60 percent of this amount, about 1 to 3 gallons (4 to 11 litres) per minute, is not an unreasonable amount for a single-family dwelling. In fact, in mountainous areas, where it is difficult to find large quantities of water, 1 gallon (3.8 litres) per minute is common. Remember that these values are for normal household use only and that additional needs, such as for livestock and small acreages of crops, are not included.

Types Of Well Construction

To build a water well, a hole is excavated in the earth's crust, and the wall of the hole is lined with a sturdy material (the casing) to keep it from collapsing and to screen out loose materials (fine sand, silt, and clay), while allowing the water to flow into the well. A pump is then lowered into the casing to lift the water to the surface. However, many physical, geological, and structural factors must be overcome before a well will produce water.

Because the earth is made up of so many different kinds of materials that must be penetrated in drilling a well, many kinds of equipment and drilling methods have been developed. Accordingly, the nature of materials the driller is likely to encounter at your well site will govern the type of equipment used.

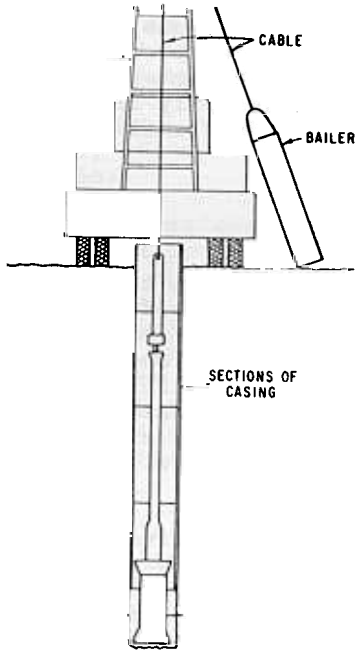
Most wells in California are constructed by drilling with machines (literally, making a hole by grinding or pounding). Machine drilling can construct wells in any material, to great depths, and obtain large quantities of water. Wells can also be bored, driven, jetted, or dug, all methods requiring simpler tools. However, these methods have limitations.

Cable Tool Drilling

Cable tool drilling (also called percussion drilling) is the oldest method of drilling that does not involve digging. A heavy bit on the end of a cable is repeatedly raised and dropped, gradually breaking up the material at the bottom of the hole. The loosened material (called sludge) is removed periodically by a device called a mud-scow or bailer. Usually, the casing must be installed by pushing, driving, or jacking it into place as drilling progresses. Cable tool drilling is a slow method. However, it has certain advantages, and some operators are very adept at it.

Rotary Drilling

Conventional rotary drilling is based on rotation of the bit, coupled with the application of pressure against the material being penetrated. As drilling proceeds, water is circulated through the drill pipe and out an opening



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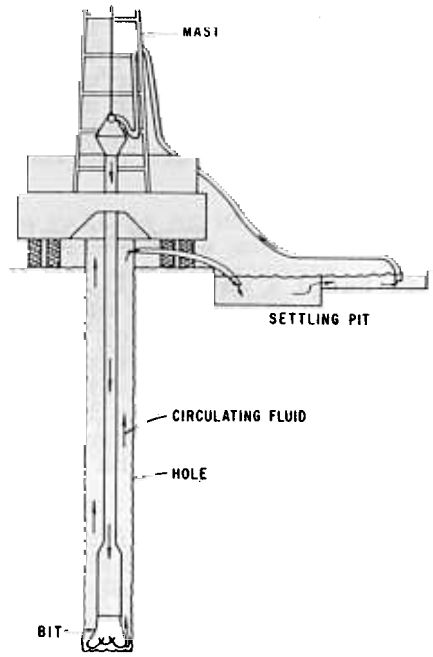


Rotary Dri ing

in the bit. This fluid rises to the surface in the space between the drill pipe and the excavated hole, carrying away the cuttings. Sometimes a clayey material is added to the water. This mud-laden fluid forms a coating on the walls of the hole, delaying their collapse. The casing can then be installed after the hole is drilled. This method is quite rapid, particularly in sands and gravels, and, if the hole is not used, it can be readily destroyed.

Air Rotary Drilling

Air rotary drilling -- the "down-the-hole-hammer" method is the most common variation -- is the newest method for drilling wells. Compressed air moving at high velocity blows the cuttings up and out of the hole. Foaming additives are often used to both cut down dust and improve the carrying capacity of the air. At the option of the driller, the air also serves as the source of drilling power.

By replacing the customary bit with a tool that is essentially a pneumatic hammer and bit, the driller can combine the percussive effect of cable tool drilling with the twisting, grinding action of rotary drilling. (This is the down-the-hole-hammer method.) The hammer pulverizes rock, penetrating it very rapidly; thus the air rotary method is a most effective tool for drilling in the mountainous "hard rock" areas of California.

Other Methods Of Well Construction

The use of methods other than drilling is confined to locations where only small quantities of water are desired, where water can be obtained at relatively shallow depths (under 100 feet or about 30 metres) or, more significantly, where the materials can be easily penetrated (for instance, "soft" materials such as soft sandstone or those with a considerable clay content).

Bored wells are constructed with hand-operated or power-driven augers. While hand-augering has limited application, boring with power-driven augers has a useful place in well construction. In fact, many drillers use boring equipment for constructing the uppermost sections of large-diameter wells and completing them by drilling. This method is called rotary bucket or auger bucket drilling. It involves rotating a cylindrical bucket equipped with auger blades until it is filled with excavated material and then lifting it from the hole and emptying it. This method works best where the walls of the hole will stay in place until the hole is completed or until a temporary casing can be installed. Drilling is then continued at a smaller diameter.

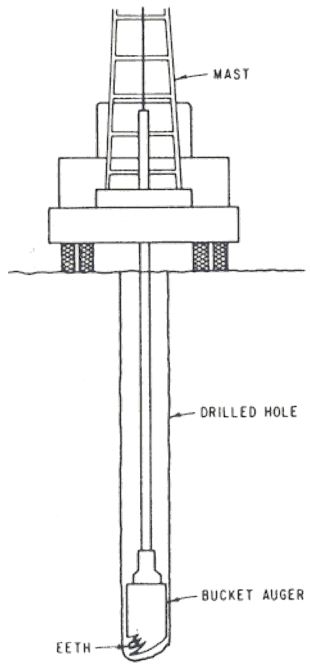
Driven wells are constructed by driving a series of pipe

sections into water-bearing materials. A pointed screen, or "drive point", is fitted to the end of the first pipe section to facilitate driving and to permit water to enter the well. The pipe is then forced into the ground by a sledge or power-driven hammer. The depth of a driven well is limited by the resistance of the materials encountered and the fact that the small-diameter pipes used (commonly 1-1/2 to 3 inches, or 38 to 76 millimetres) preclude the use of large-capacity pumps. Depths range up to 50 feet (about 17 metres).

Dug wells are excavated with hand tools or mechanical equipment. To prevent the hole from caving in, this type of well is "curbed", or lined during excavation. Curbing consists of concrete, brick, or metal. Dug wells are larger in diameter than most drilled wells and are seldom constructed to any appreciable depth below the water table because of difficulties encountered in digging. Since they are easily contaminated, dug wells are not recommended.

Gravel-Packed Wells

A special type of well known as the gravel-packed or gravel-envelope well is frequently constructed in California. Coarse sand or small-diameter gravel is placed between the casing and the wall of the drilled hole (the annular space), thus enclosing the casing in an "envelope" of gravel. This envelope may extend through a single aquifer, several aquifers, or the entire depth of the well. This type of well is constructed for three purposes: (1) to increase the effective diameter of the well, (2) to prevent finegrained sand from entering the well, and (3) to increase the yield of the well by allowing numerous thin aquifers to produce water. Gravel-packed wells may be constructed by either the rotary or cable tool method of drilling, although the rotary method is most often used.



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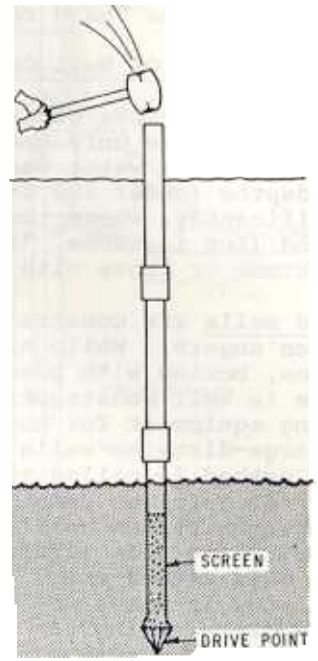

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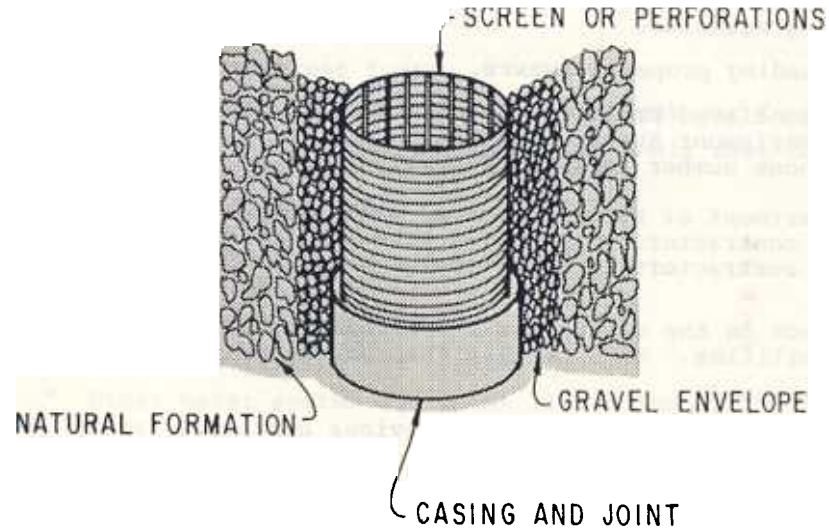

Gravel Packed Well

Constructing A Well

Finding A Contractor

More than 600 contractors in California are licensed by the Contractors' State License Board as specialty contractors in the field of water well drilling. Most operate within a radius of one or two counties, some cover much larger regions, and a few range over nearly the entire State.

Contractors who have worked in your area will be familiar with conditions there. It is advisable to contact several in the area before choosing one to drill your well. You can get the names of local well drilling contractors from:

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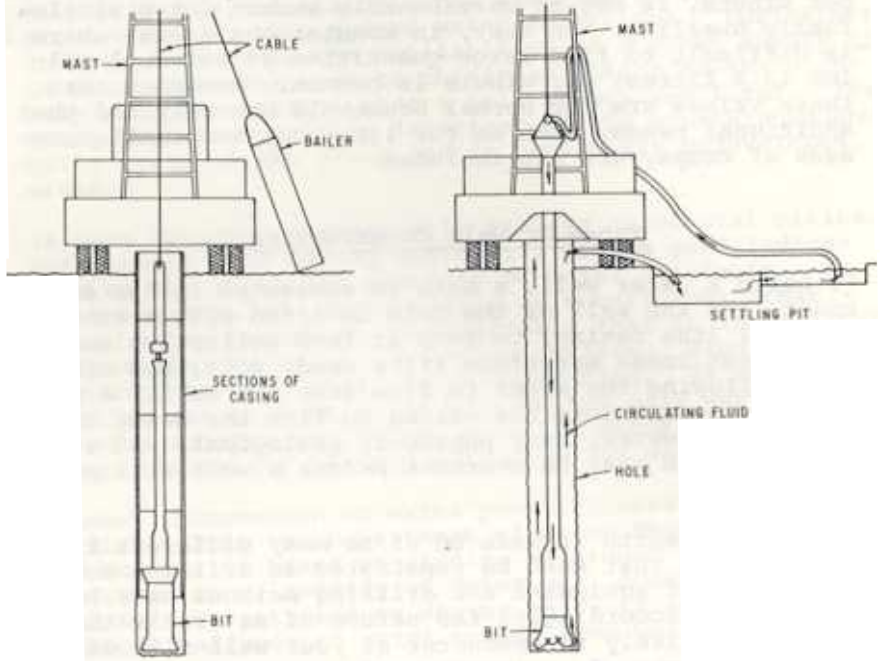

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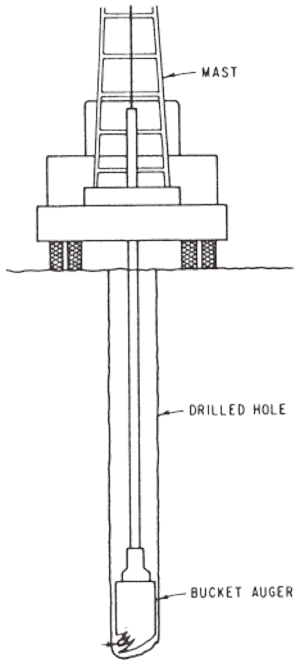

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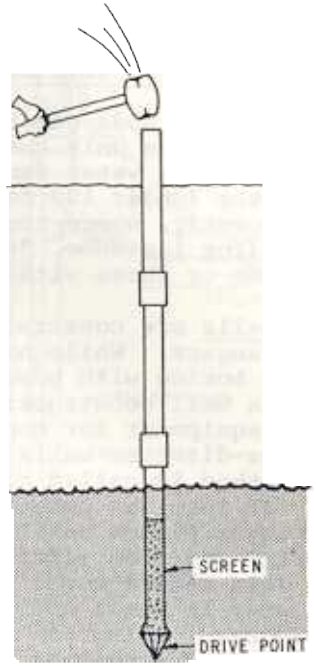

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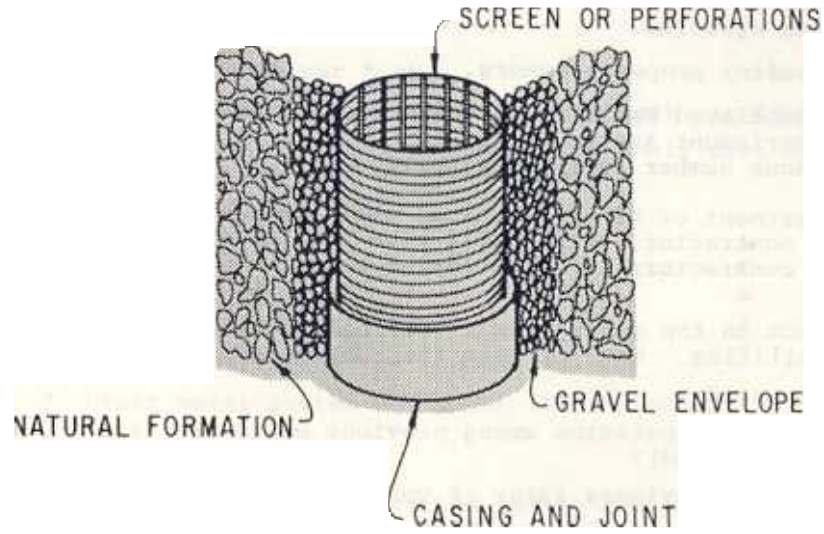

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Contractors who have worked in your area will be familiar with conditions there. It is advisable to contact several in the area before choosing one to drill your well. You can get the names of local well drilling contractors from:

The classified section of the telephone directory. The law requires that licensed contractors include their license number in their advertisements. This is required on all advertising by contractors.

County health departments and farm advisors.

Lending agencies.

Surrounding property owners.

The Associated Drilling Contractors of California 1217 Mariemont Avenue, Sacramento, CA 95825. The telephone number is (916) 485-2220.

(The Department of Water Resources will not recommend a drilling contractor, but it will give you the names of licensed contractors in a particular area.)

Next, check on the contractor's reliability, reputation, and capabilities. Make certain the contractor:

1. is licensed.
2. has a good reputation among previous customers (are they satisfied)?
3. will be in business later if you need service.
4. has adequate and well-maintained equipment.
5. will enter into a written contract with you.
6. carries liability insurance to protect you.
7. explains how the well will be constructed.
8. will also install the pump, or whether you should contract separately for that portion with a pump installer.
9. guarantees materials and workmanship.
10. furnishes an itemized written estimate

If the well drilling contractor does not sell or install pumps, you should follow the same procedure in finding a pump dealer.

Contracts And What They Should Cover

To protect yourself as a buyer against any actions that may follow, you should have a written contract. This also protects the contractor. Many contractors have a standard contract form. (One type is available from the Associated Drilling Contractors of California and another from the National Water Well Association.)

Learn what a contractor will do for a specified price. Without this information, you cannot compare offers. We suggest that you ask the prospective contractor to itemize his estimate. An attractive lump sum price for the total job could result in expensive modification later, should the work prove faulty or materials fail.

The estimate should include:

Drilling cost per foot.

Casing size, type of material, and cost per foot.

Itemization of other materials (if their cost forms a substantial part of the estimate).

Grouting (cementing).

Developing.

Test pumping.

Pump (if included).

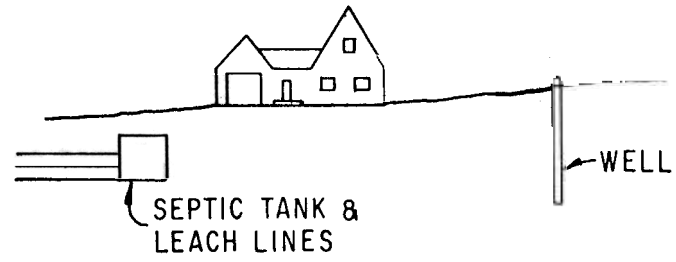
Pump installation (if included).

Other water system equipment (if included).

Well Location

An item usually not described in the contract, but a most important consideration, is the location of the well. This is sometimes a source of friction between contractor and customer later on; therefore, the location should be mutually satisfactory before work begins. On the basis of experience and familiarity with local requirements and conditions, the contractor is perhaps a better judge of where the well should be sited.

Of greatest importance is the location of the well with respect to sources of pollution and contamination. All wells should be located an adequate horizontal distance from any such potential hazards. Counties and cities with well ordinances prescribe minimum distances. However, in the absence of an ordinance, the following may be used as a guide: at least 100 feet (30 metres) from sewers, septic tanks, and subsurface sewage leaching fields. This distance is considered safe where dry upper formations, less permeable than sand, exist. If the soil is quite permeable or the underlying formations are fractured, however, the distance should be increased. Location is especially difficult in mountainous rocky areas, where the soil mantle is shallow and the producing formations are heavily fractured.



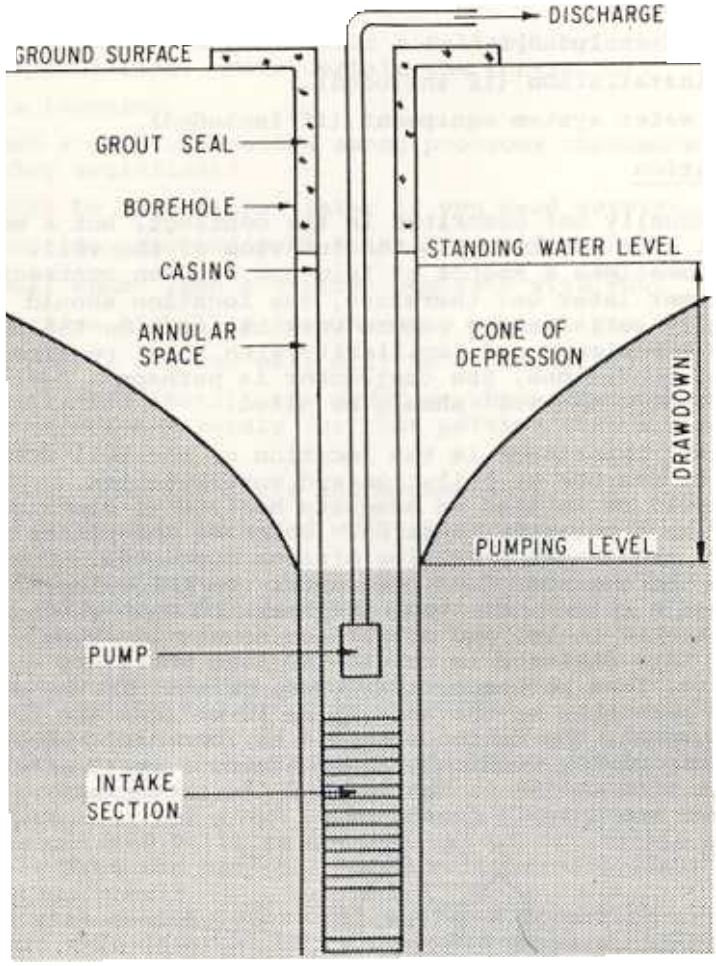
Additional considerations are as follows:

Locate the well up the ground water gradient from sources of contamination.

Locate the well far enough from buildings so that it will be accessible for maintenance or repair.

Make certain the well is on "high ground," i.e., that drainage on all sides is away from the well. Should it be situated on a hillside, divert uphill drainage away from the well.

If you have livestock, fence them out so that they can approach no closer than 100 feet (30 metres).



Subsurface Features of a Water Well

The Actual Contract

After deciding on a contractor, you should agree on a written contract, which covers:

1. The size of the hole. The diameter of the hole should be 4 inches (102 millimetres) greater than the casing to provide for grouting (see Item 4 below). An exception will be wells drilled by the down-the-hole hammer method (described under Types of well Construction, Air Rotary Drilling[1/], where the current maximum diameter is 2 inches (51 millimetres) greater for a 8-inch (204-millimetre) casing. Drilled Wells less than 4 inches (102 millimetres) in diameter are not recommended because they cannot be serviced, deepened, or rehabilitated later on.

2. Casing material and diameter. A well can only be as good as its casing; therefore, the type of material to be used (steel, plastic, concrete, etc.), its diameter, and its thickness should be stated. You should not accept used, rejected, or substandard material. The diameter of a well casing is based on the expected yield of the well. The optimum diameter is two nominal pipe sizes larger than the pump bowl' size.

3. Proposed depth of well. While a contractor cannot determine beforehand the depth at which a satisfactory water supply will be found, some agreement should be reached in advance on the drilling depth.

4. Annular seal. The upper annular space (the space between the casing and the wall of the drilled hole) should be sealed to prevent the entrance of surface water, shallow subsurface water (such as effluent from septic tanks), or other foreign material into the well. The recommended procedure is to grout or cement the space to a depth of at least 20 feet (6 metres). In some locations and under certain circumstances, this depth should be increased. For shallow wells where the water to be developed is less than 20 feet (6 metres) from the surface, the depth of seal may be reduced. In no case should it be less than 10 feet (3 metres).

5. Well development. Most wells will need further work to remove fine-grained material from the formation that is supplying the water (this is called development of the well). Work may also be needed to loosen

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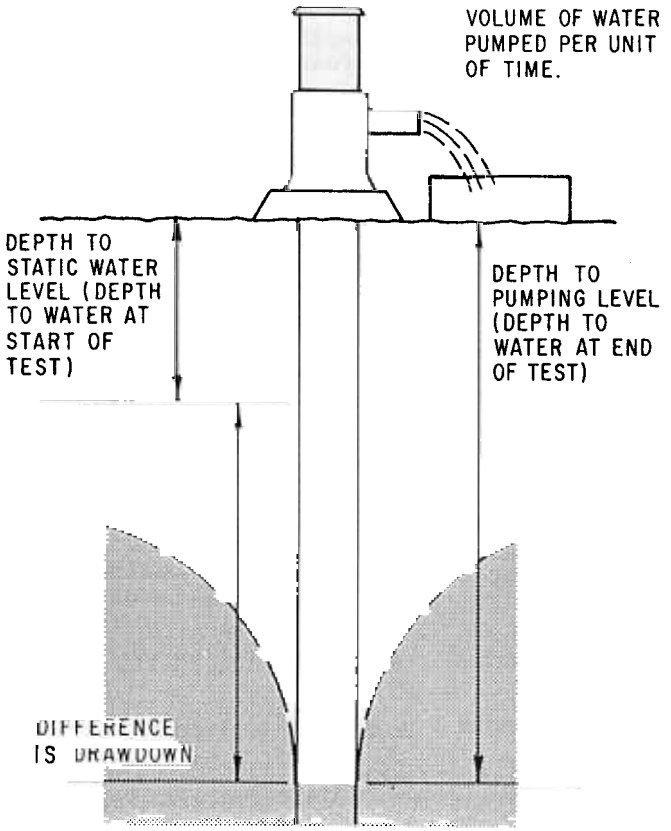
1/ See page 7.

and remove the caked mud that sometimes covers the walls of the hole during construction. If these steps are not taken, the well will not yield as much of the available water as it otherwise might.

6. Intake section. The portion of the well at which the water enters is called the intake section. It consists of perforated casing or specially made screening material designed to allow the maximum amount of water into the well, while cutting to a minimum the influx of sand, which damages pumps. The type and diameter of the material should be specified.

7. Capacity test (pump test). The well should be tested for its yield. That is the quantity of water that it will produce per minute (or per hour) under sustained pumping for a long period of time. The usual test for small-capacity wells lasts 4 hours or until an apparently stable pumping level has been achieved at a rate equal to that expected for the permanent pump. The ability of the water level to recover should be observed. If the water level fails to return to nearly its original level within 24 hours,



Measurements During Pump Test

the reliability of the water producing zone is open to question.

Water well drillers' report. California Water Code section 13752 requires the driller to report work performed in constructing, altering, or destroying water wells to the State Department of Water Resources. The driller you hire to drill your well should supply a copy of his report to you. The report calls for information from the driller about the well, including its location, purpose, type and dimensions of casing, type and dimensions of screen or perforations, pump test, and a log of the underground materials encountered. You should examine the report to check work specified in the contract.

Charges. An itemized list of charges is preferable to a lump sum. The list should specify the number of units involved and include the costs of:

drilling per foot,

casing per foot,

other materials in measured units,

operations, such as grouting, developing (per hour), and test pumping (per hour),

other items (if included), such as the pump, its installation, and other water system equipment.

10. Guarantees. The contract should contain a guarantee of materials and workmanship. A contractor cannot guarantee that water will be found, nor can the quantity and quality of water discovered be guaranteed. However, on the basis of experience and knowledge of the immediate area, or information obtained from geologic and hydrologic studies, a driller will have a reasonably accurate idea of what will be encountered. At the same time, of course, the driller must work with the conditions existing at the site.

11. Modifications. Unexpected problems may arise during construction of the well. Unless solving them will be costly and perhaps entail renegotiation of the contract, it is usually best to trust the contractor's judgment, explanations, and recommendations.

What to Look for During Construction

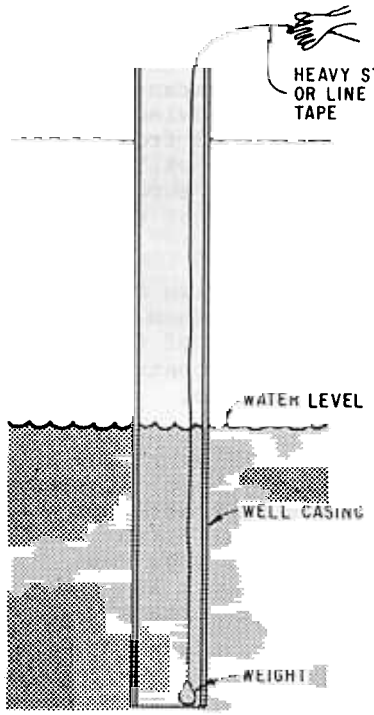
Although you should not interfere with the contractor or the crew while they are working (after all, you hired them to do the work for you), there are some things you can do to assure yourself that the specified work is being accomplished. Following are the more important

items that are worth checking:

1. Measuring, or "sounding", the total depth of the well. Is the measured depth about the same as that reported in the Water Well Drillers' Report? You can check this with a weighted line (the length of which must be measured with a tape after sounding) or a heavy (or weighted) tape. You should make the measurement before the contractor moves the equipment off the job. (Also see page 23.)

2. Measuring the length of casing. Is the casing about as long as reported on the Water Well Drillers' Report? You can check this by measuring the length of one section of casing on the ground, multiplying this by the number of similar sections installed, and adding the length of the final section placed in the well (if this last section is particularly short). Or you may find it easier to estimate the final section by eye as one-half, one-third, etc., of a section.

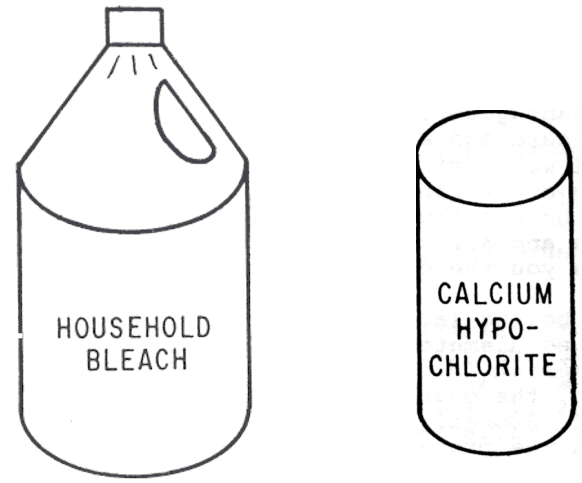
3. Observing the sealing of the annular space. This should be done in one continuous smooth operation. The slurry ought not to be too thin, or so thick that it does not flow. For small-diameter wells, many drillers start by inserting a sack or two of dry cement to form a base on which to rest the seal.



Sounding the Wel

4. Looking for other openings into the well. They should be plugged or otherwise sealed. Access holes, such as those for sounding the well, should be capped. (Every well should have a sounding tube or other means of access so that water levels can be measured during the life of the well.)

Observing the pump test. Have the test explained to you. How long was it performed? What was the rate of pumping (gallons per minute or gallons per hour)? How much did the water level drop? (This is called the "drawdown".) These items also appear on the Water Well Drillers' Report.



Disinfecting The Well

Because bacteria could be introduced into the well during its construction or during installation of the pump, the well should be disinfected as a precaution against contamination before you use the water for the first time. This should also be done whenever any maintenance work is undertaken.

Contamination caused by defects in well construction or improper location of the well can be overcome only by correcting the defects, by installing and operating permanent disinfecting equipment, or, as a last resort, by abandoning and destroying the well and constructing another. Wells are usually disinfected by chlorination with dry chemicals (high-test hypochlorites with 50 to 70 percent available chlorine) or solutions of sodium hypochlorite (such as household bleaches labeled to show 5 percent available chlorine). The disinfection process takes about 24 hours.

Following disinfection, a bacteriological sample should be taken and submitted to a laboratory for examination. Many county health departments will make such determinations at cost or will refer well owners to other laboratories. They (or the laboratory) should either collect the sample or show you how to do it. Procedures for both disinfection and bacterial sampling appear in most of the references listed at the end of this publication. Directions can also be obtained from local health departments or from either the (State) Department of Health or the Department of Water Resources.

Do It Yourself Well Construction

The "do-it-yourself" method is quite successful for many "home projects," but in constructing a well it may very well be disadvantageous. Your well should be constructed with the same care and attention to proper techniques as a professional well drilling contractor would give it, and unless you are trained in operating well drilling equipment and have a thorough knowledge of well construction, the type and size of well you can build is not likely to give you the desired results.

Hand-operated boring (augering) tools are quite limited in the depth and diameter of hole they can drill. Even when this equipment is driven by a small gasoline-powered engine, the quantities of water you can obtain are very small. Probably the trickiest part of this work is building in the protective features that will help keep your water supply pure enough for human consumption.

The hard fact is that regardless of the savings that seem possible, constructing your own well is rarely the wisest course. Well construction is a complex operation that is really best trusted to a qualified specialist. However, if you should decide to go ahead for yourself, you will have to consider a few important points.

First of all, situate your well at a safe distance from any known sources of pollution, such as a septic tank. Seal off or block any pathway by which contaminants, pollutants, or rodents and other animals could enter the well, particularly the annular space between the casing and the wall of the hole. Carefully seal this space for the first 20 feet (6 metres) down from the surface (but in no case less than 10 feet, or 3 metres). You must also seal or cover openings of any sort into the top of the well.

Pumps And Other Equipment

Many well drilling contractors also sell, install, and service pumps and the other equipment needed to operate a home water system (tanks, controls, water treatment equipment, and the like). Others concern themselves only with well construction. Regardless of who furnishes the pump, you should find out ahead of time whether the dealer will also install and service it.

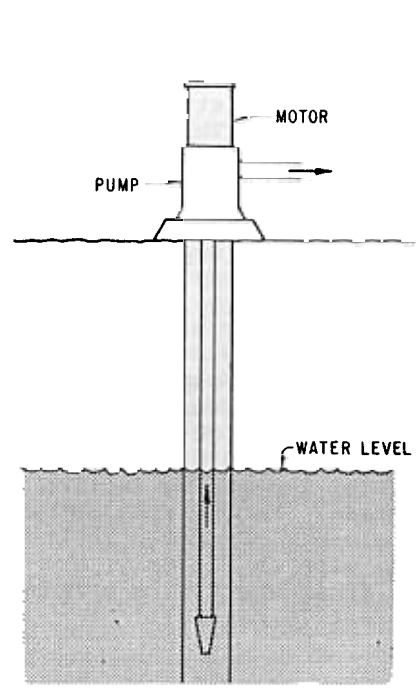
The drilling contractor should give you: (1) the capacity (yield) of the well, and drawdown at this and at other rates (both as a result of a pump test), and (2) the diameter of the well at the pumping level (if, for some reason, it is smaller than the diameter at the ground surface). The contractor may also advise you on type and size of pump needed. Size is most important. The capacity of the pump should be equal to, or slightly less

than, the yield of the well. This may produce more water than you presently need; however, you should give some consideration to your future needs. A pump with a capacity greater than that of the well or greater than anticipated needs will cause a number of problems later on. It will draw the water level down too suddenly or too far, which in turn causes pumping of air, loss of yield, cloudy water, sanding, and pump damage.

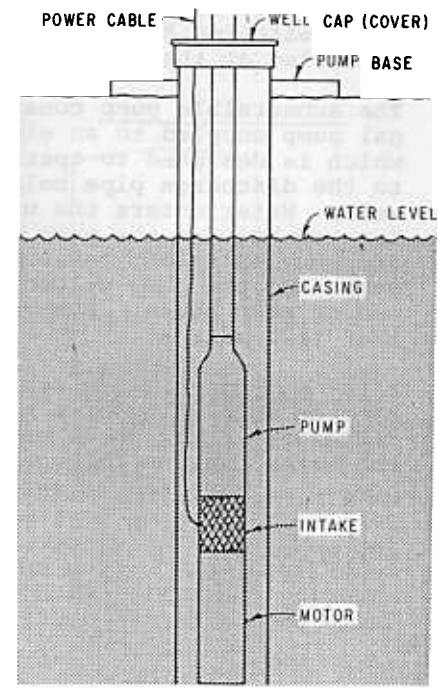
You should avoid well pits. They are easily contaminated and polluted. Such devices as submersible pumps, off-set installations, or above-ground housing protection are alternatives.

Although many types of pumps are available for house wells (particularly low-lift models), two types are most commonly used: jet pumps and submersible pumps. A third type, the turbine pump, is still in use but is rapidly being replaced by the submersible pump for domestic use. All are adaptations of the centrifugal pump.

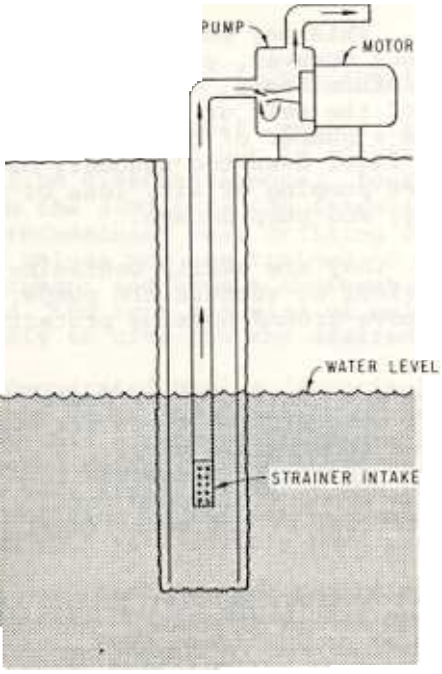
Centrifugal pumps contain a rotating impeller fitted to a shaft that is turned by the source of power. The water enters the center of the impeller and is thrown out at the edge of the impeller, creating a vacuum that draws in more water. Each impeller and housing is called a stage. The vertical-drive turbine pump consists of one



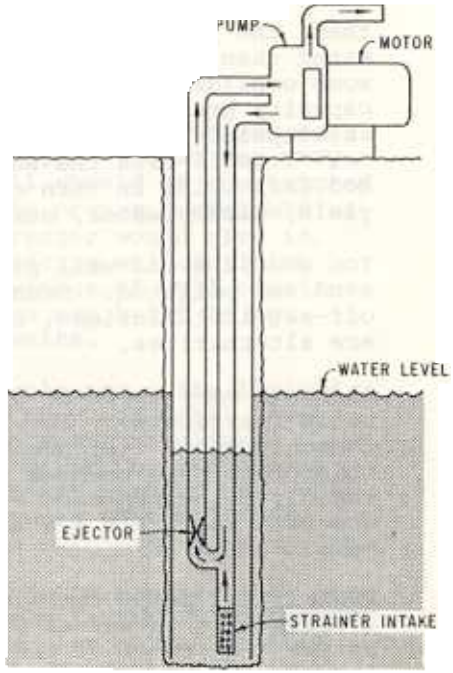
Turbine Pump



Submersible Pump



Shallow Well Jet Pump



Deep Well Jet Pump

or more stages of a centrifugal pump attached to a vertical shaft or pump column. The shaft connects the pump (situated below the drawdown level) to the motor (situated at the surface).

The submersible pump consists of a multistage centrifugal pump coupled to an electric motor. The entire unit, which is designed to operate under water, is attached to the discharge pipe below the drawdown level in the well. Water enters the unit through a screened section located between the pump and motor. Submersible pumps are very efficient because the motor drives only the pump, not the pump column. It requires no lubrication and no pump house. Pumping depths usually range to 400 feet (122 metres).

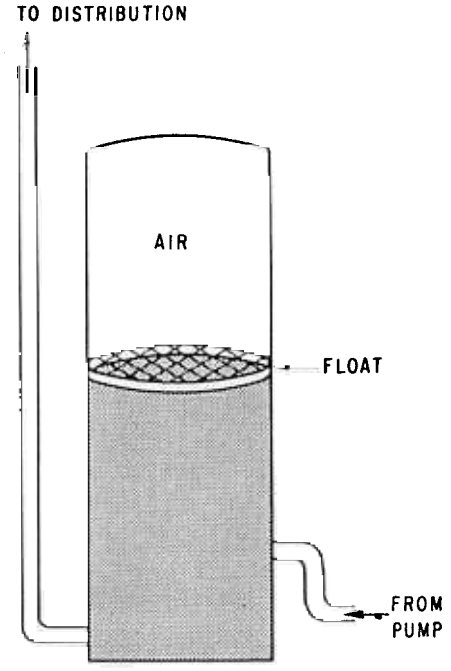
A jet pump involves a centrifugal pump coupled to a jet ejector consisting of a nozzle and a venturi tube, or diffuser. A vacuum is created by the high velocity of the water passing through the jet. Some of the water pumped is returned to the nozzle, increasing suction and pulling more water to the surface. In the shallow water jet pump, the jet ejector is closely connected to the centrifugal pump. The suction pipe is the only pipe entering the well. With this arrangement, the pumping depth is limited to about 20 feet (6 metres).

In the deep well jet pump, the jet ejector is submerged in the well, and there must be a closed section to form the suction chamber. Thus, two pipes enter the well, one to supply the "driving" water and the other to return the driving water and the water being pumped from the well. The maximum pumping depth is 200 feet (about 60 metres).

If you want an automatic water delivery system, you will need more than a pump and motor. You will also need storage facilities, switches and valves. The most common storage facility is the pressure tank. Its purpose is to balance the capacity of the pump against the demand placed on it. It reduces the number of times the pump starts and stops, and reduces the likelihood of switch and motor difficulties. When a well produces poorly, tanks of greater than usual size are used to satisfy peak demands that cannot otherwise be met by the well.

Water cannot be compressed; therefore, to keep the water moving through the plumbing system as it is used, pressure tanks must be partially filled with compressed air. When a tank is completely filled with water, it is considered water-logged and the pump operates as if there were no tank (continuously). This is an undesirable condition.

You may want to have additional storage for a reserve supply or for fire protection or other emergency. If so, you will need an extra pump and control device and an intermediate storage tank.

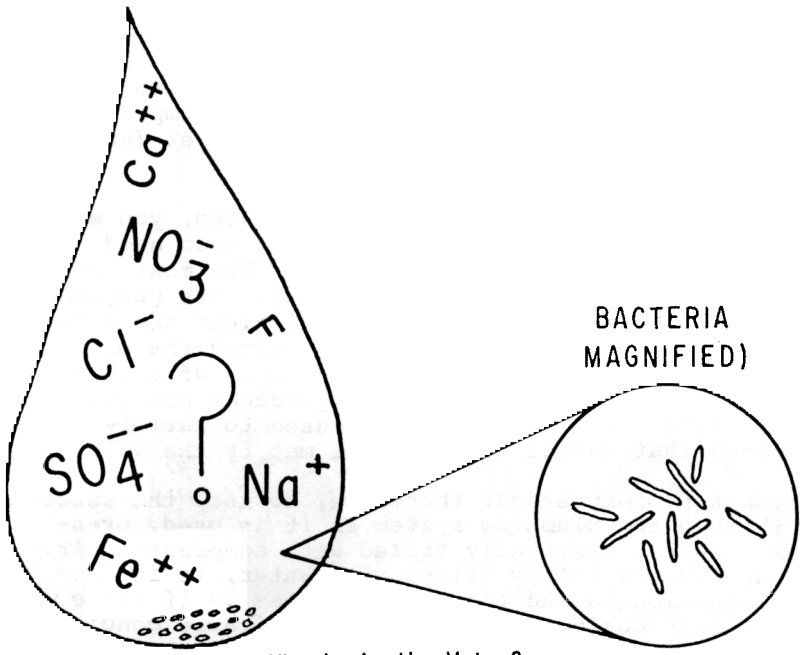


Pressure Tank

Obtaining The Kind Of Water You Want

Simply obtaining a supply of water is not enough. Your water supply may be heavily loaded with minerals or have other physical and chemical characteristics that make the water unsatisfactory to you. Common problems are hardness, the presence of iron and manganese, and unpleasant tastes and odors.

Hardness is caused by calcium and magnesium, combined with bicarbonates, sulfates, or chlorides. Iron also contributes to hardness. Hard water can be treated with either an ion-exchange softener or a reverse osmosis unit.



What's in the Water?

Iron and manganese stain laundry and plumbing fixtures, give water a metallic flavor, and corrode steel pipes. They also nourish a type of bacteria that cause slime to form in the water. Iron and manganese are usually taken care of by softening or chlorinating the water, as well as filtering it.

The most common variety of disagreeable tastes and odors water can exhibit is the "rotten egg" taste and odor. This is caused by hydrogen-sulfide gas or sulfur bacteria, which are frequently associated with iron. Hydrogen-sulfide gas will also attack piping and fixtures. Tastes and odors can be removed by a combination of chlorination and filtration (usually by the use of activated carbon).

To find out whether any of these problems exist, take a water sample to a laboratory for a determination of its physical and chemical characteristics. You can do this while the pump test is under way. From the laboratory results, you can determine what, if any, water conditioning equipment will be needed.

Maintaining Your Well

Once a well has been constructed and the supply system put into operation, the owner tends to ignore it until a serious problem develops. To head off any problems and thereby ensure that your well and pump continue to function as intended, you can do a number of things;

1. Measure and permanently record the water level (depth to water from the ground surface) in the well at least twice a year (spring and fall).

2. Keep track of the pumping rate by periodically having a pump test made (perhaps every other year). Most utilities offer such a service. Besides determining the efficiency of your pump, the test will also measure the standing and pumping water levels in the well. Note any changes in pump capacity.

3. Periodically check the quality of the water produced. You should further explore a significant change in quality to determine the cause of the change and its effect on continued use of the water. The chemical quality should be analyzed about every five years. Bacteriological quality should be checked every year.

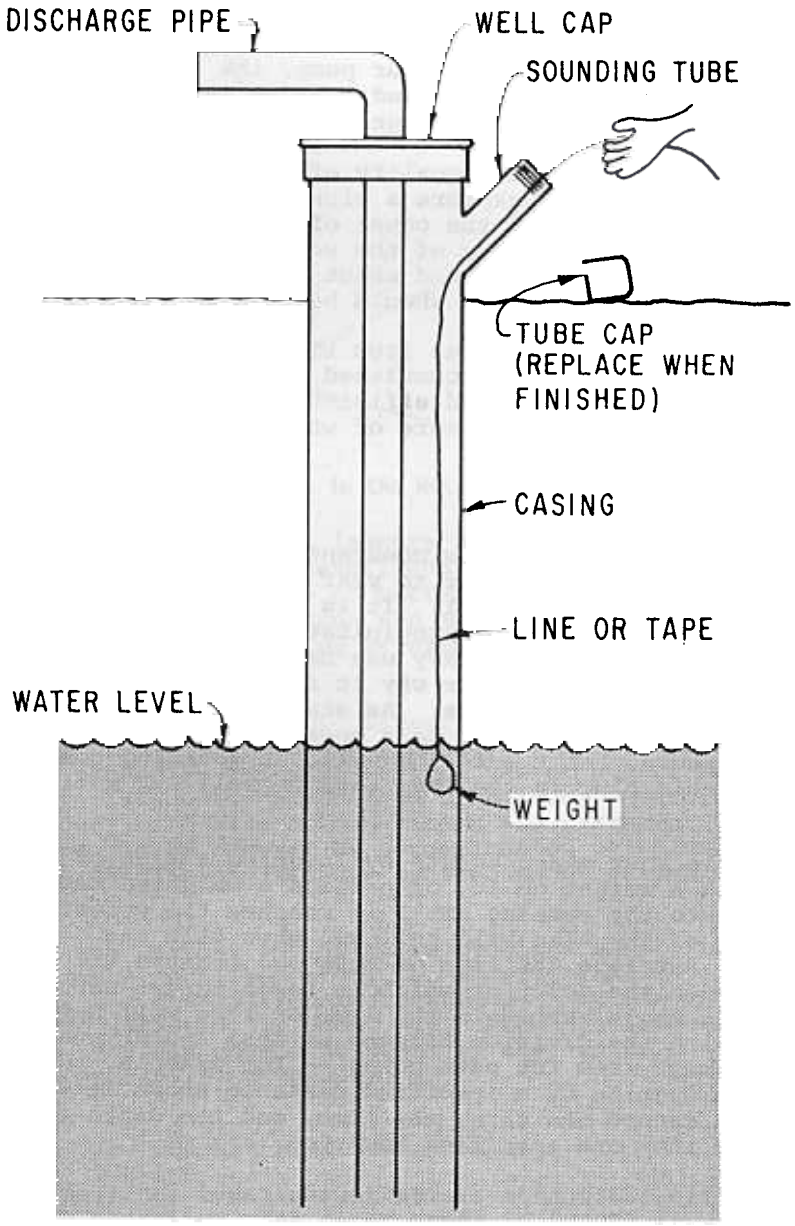
4. Have the well cleaned out from time to time. Removal of encrustations and accumulated loose material will improve the capacity and efficiency of the system. Cleaning is best taken care of whenever work is being done on the pump.

Measuring The Water Level

The water level in a well is constantly fluctuating. It varies, of course, from year to year and as greater demands are made on the well. It is higher in the spring, following replenishment by precipitation and runoff, and lowest in the fall after heavy use has been made of ground water in the basin. This is why it is important to make spring and fall measurements. As stated earlier, this is best done by having an access opening, through which you can measure, built into the well. A sounding tube or a removable plug in the pump base or well cap will suffice.

You can make your measurements by lowering a line of string with a weight on it, or perhaps a weighted tape measure, into the opening until it reaches the water. A slackening of the line will tell you when this has occurred. Retrieve the line or tape and measure the distance between the point at which it began to get wet. Carpenter's chalk rubbed in the line or tape will help you determine the division between wetness and dryness. Always measure from the same point -- for example, the top of the opening or a specified distance above it -- and always record the date, the time, and the depth to water from that one specified location.

(See the illustration on the following page)



Measuring Water Level
Through Sounding Tube

Common Problems And What To Do About Them

A fact to be reckoned with is that the productivity of a well can eventually decline and, therefore, must be anticipated. It may be due to one or several causes, such as clogging of the well, excessive wear on the pump, or a drop in water level. In addition, the well owner is sometimes faced with other types of problems, such as water-logged tanks and breakdown in the pump.

The clogging of screen openings or perforations, of the pore spaces in the surrounding formation, or of both, results from (1) chemical precipitation and deposition of material in and around openings (encrustation), (2) development of slime, or (3) accumulation of sloughing or suspended matter. Clogging can be resolved by mechanical means or with chemicals used in conjunction with mechanical agitation (a process called "redevelopment"). Chemicals used in removal include muriatic acid, sulfamic acid, chlorine, and polyphosphates.

Pumps do wear out, but excessive wearing of pump parts often results from sand that has entered the well because either (1) the perforations or screen openings were too large to keep out the fine material, or (2) the screen or casing has been corroded. If too much sand is pumped, you may have to install a sand trap or sand separator to remove sand from the water before it enters your distribution system. If sanding or damage is severe, the interior of the well may have to be relined with a new casing and a screen placed inside the damaged section.

Lowered water levels are not an indication of well failure: Levels do drop gradually when pumping is continuous. As pointed out earlier, water levels constantly fluctuate, and there are "up and down" trends seasonally and from year to year.[1/] A continuing and widespread lowering of the water level indicates that the area supplying the water is being drawn down faster than it is being replenished, at that level of development. This is not all bad because an induced lowering of the water level can also lead to the rapid influx of water; i.e., the gradient of the water table is steepened, thereby causing the velocity of movement to increase. A continued lowering of the water level will, however, lead to a lowering of the pump setting and eventually to deepening of the well.

As described earlier, when a pressure tank is completely filled with water it ceases to function and lets the pump take over in moving the water through the pumping system, a condition called "water-logging".[2/] This is caused by the air supply in the tank being gradually absorbed by

1/ See page 23.
2/ See page 21.

the water. To offset this problem make sure the tank has a float (called a "separator", "adsorption barrier," or "air seal") that rides on the water surface and prevents the air from directly contacting the water. Alternatives are to add an air-volume control device (some are operated by a float, others by a diaphragm) or to install a diaphragm tank, a recent innovation in tank manufacturing.

REFERENCES

Items of special interest to the homeowner:

Manual of Individual Water Supply System.* U. S. Environmental Protection Agency, Office of Water Programs, Water Supply Division, Washington, D. C. 1973 (156 pages).

Planning for an Individual Water System.* American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia 30602. 1973. (156 pages).

What you Need to Know About Wells and Water Systems.* Water Systems Council, 221 North La Salle Street, Chicago, Illinois 60601. 1972. (32 pages).

When you Need a Water Well. (Pamphlet)* National Water Well Association, 500 West Wilson Bridge Road, Worthington, Ohio 43085 (16 pages).

Other interesting reading:

A Primer on Ground Water.* United States Department of the Interior, Geological Survey (U. S. Government Printing Office, Washington, D. C.) 1963. (26 pages).

California's Ground Water. California Department of Water Resources, Bulletin No. 118. September 1975. (135 pages).

Manual of Water Well Construction Practices.* EPA 570/9-75-001, U. S. Environmental Protection Agency, Office of Water Supply, Washington, D. C. (156 pages).

Water Systems Handbook. Water Systems Council, 221 North La Salle Street, Chicago, Illinois 60601. (95 pages)

Water Well Standards: State of California. California Department of Water Resources. Bulletin No. 74. February 1968. (205 pages). Chapter II: "Standards" and Appendixes E,F, and G of Bulletin No. 74 are available as a separate publication, (31 pages).

* These publications also available from the National Water Well Association, 500 West Wilson Bridge Road, Worthington, Ohio 43085

Copies of this report are available without charge from:

State of California
Department of Water Resources
P. O. Box 388
Sacramento, CA 95802

(916) 445-9371

For information regarding the licensing of water well drilling contractors contact:

State of California
CONTRACTOR'S STATE LICENSE BOARD
1020 N Street
Sacramento, CA 95814