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Irrigation Wells

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An efficient irrigation well represents a substantial investment. It should be carefully investigated, constructed, and developed to insure a dependable, economical water source for many years.

Many of the decisions on well design, construction, and completion are the responsibility of the well driller. The purchaser should be aware of good well construction practices, not only to assist in selecting a driller but also to make decisions during the process. What may appear to be an initial bargain may result in future added cost from shortened life, sand pumping, or low efficiency. The purpose of this publication is to explain the proper procedures to follow to obtain a dependable and efficient irrigation well.

All waters in Minnesota, whether surface or underground, are controlled by the state. A water permit is required for all water use in excess of 10,000 gallons per day. A permit application form can be obtained from the Department of Natural Resources, Space Center Building, 444 Lafayette Road, St. Paul, MN 55101. Potential irrigators should obtain specific permit requirements for their area and situation from the Department of Natural Resources before extensive planning begins.

GROUND WATER SOURCES

An *aquifer* is a water-saturated, subsurface layer that will yield water to wells or springs fast enough to serve as a water supply. *Water bearing formation* and *ground water reservoir* are other terms for aquifer.

To qualify as an irrigation aquifer, a geologic formation must contain pores or open spaces filled with water and large enough to allow the water to move fast enough to supply an irrigation well. A saturated clay layer, even though the pores are filled with water, will not yield water rapidly to wells, so it is not considered an aquifer. A saturated sand formation is an aquifer, since water will move through it to a well.

Two types of aquifers are present in Minnesota — *water table* and *artesian*. A water table (or surficial) aquifer is a continuous water bearing formation in which the level of the water in an open hole in the formation and the water table are the same (figure 1).

An artesian (or buried) aquifer is a water bearing formation in which the water level in an open hole rises above the top of the aquifer (figure 2). Water need not flow out the top of the well for the aquifer to be classified as artesian.

Sand and gravel laid down by glaciers are called *unconsolidated* formations. The water bearing capabilities of glacial deposits vary considerably with the type of deposited material and depth of water bearing formation.

Rock layers that yield water are called consolidated formations. The most common consolidated aquifer is sandstone. Saturated crevices in limestone can often provide high capacity wells. The type of consolidated formation and saturated layer thickness usually determine well yield.

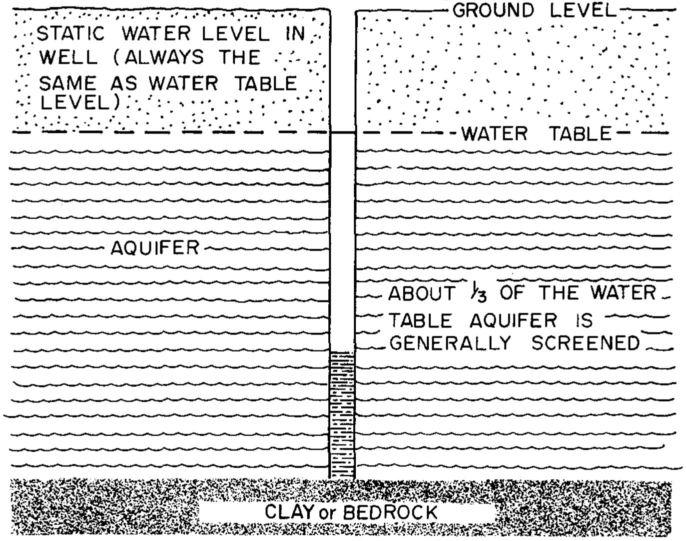

Figure 1. Water table aquifer

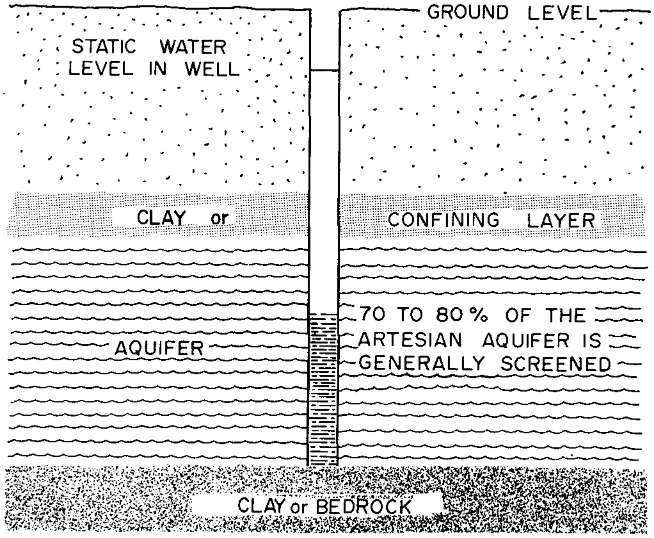

Figure 2. Artesian aquifer

The depth to which casing must be installed in consolidated formations is specified by the Minnesota Water Well Construction Code. Specific criteria have been established for irrigation wells. Check with your licensed well driller to obtain information on your area's required well construction.

OBTAINING AN IRRIGATION WELL

SELECTING THE WELL DRILLER

Proper well design, construction, and testing are the responsibilities of the well drilling contractor. Therefore, the selection of the well drilling contractor is the first important step in obtaining a good well.

Drilling techniques differ with the area and the type of well desired. Knowledge of the area and familiarity with drilling irrigation or other high capacity wells are factors to consider in selecting a well driller. Check reputation and references to judge the ability of the contractor.

Minnesota law requires licensing for water well contractors. The Department of Health administers a water well construction code under state law. While these regulations provide some degree of protection, they do not guarantee that all well drillers will achieve the same results in any given situation.

Contacting more than one driller is recommended. A driller whose price is much below the average should be thoroughly investigated. There are many ways to cheapen well construction that may not be detected until too late. Also be sure that each bid received provides the essential materials and services. The additional cost of dealing with a reputable contractor can easily pay off in yield, efficiency, and life of the well.

It is good business to have a written contract. A written agreement provides valuable protection for both parties and may prevent misunderstandings. Separate contracts may be desired for test drilling and for actual well construction. In an area where water supply is unknown or obtaining a water permit is questionable, some provision in case the project cannot be completed should be included in the contract.

Items that should be covered in an agreement, whether written or verbal, include:

- maximum number of test holes to be drilled
- test drilling cost per foot and maximum depth
- minimum set-up charge
- well cost per foot for drilling and casing
- cost and type of screen provided
- maximum depth to be drilled
- cost of gravel pack
- cost of development per hour for minimum number of hours
- cost of test pumping per hour for minimum number of hours
- timetable of activities
- specifications for operation and construction as desired by parties involved

TEST DRILLING

Test holes are drilled: to locate the water bearing formation (depth and thickness); to estimate the quantity of water that a production well may yield at that location; to collect formation samples for well design; and to determine the water quality in the formation at that location. *Accurate and careful test drilling and sampling are necessary to insure an efficient, high-producing well.* In order to determine the potential yield of the production well, an extensive pumping test is required using the test well and one or more observation wells.

Considerably different aquifers often are present under a section or even a quarter-section of land. Drill the first test hole convenient to the operation of the irrigation system, unless a suitable water supply is not anticipated at that location. Where practical, continue to have test holes drilled, even if the first hole does not indicate an adequate irrigation water supply. Several test holes usually are necessary to verify that water is not available for irrigation purposes. In problem areas, other scientific methods of exploration such as electrical resistivity surveys may be practical and less costly than extensive test drilling.

In areas where consolidated (rock) formations already provide adequate water supplies, drilling a test hole usually is not necessary. Rely on information from nearby wells and the driller's experience.

In unconsolidated (sand and gravel) formations, representative samples of the material should be collected every 5 feet during test hole drilling. Analyzing the sample through sieves will provide information for selecting the well screen and will indicate whether a gravel pack should be used. This is called a *sieve analysis*. A prediction of expected well capacity also can be made.

Water Quality

Water quality may affect selection of screen material, screen design, and casing material. Carbonates in the water tend to deposit in screen openings. If the entrance velocity of the water is too fast, the rate of carbonate deposition on the screen is greatly increased. A screen with a large amount of open area and the ability to withstand acid treatment is necessary if the water has incrusting tendencies.

Water also may have corrosive tendencies, and the screen and casing material may need to be selected to prevent this. Well screen manufacturers often have laboratory facilities to test water for either incrusting or corrosive tendencies. Private laboratories also can test water quality but may not analyze the results with respect to corrosive or incrusting tendencies.

In western and northwestern Minnesota, check water for the presence of salts and boron, which may change soil structure or be toxic to crops. For a more complete discussion of water quality, refer to "The Quality of Minnesota Waters for Irrigation," Technical Bulletin 239, University of Minnesota Agricultural Experiment Station, or a local ground water survey report. Minnesota waters generally are suitable for irrigation.

WELL DESIGN AND CONSTRUCTION

Wells constructed in consolidated (rock) formations —e.g., sandstone—require different construction than those in unconsolidated formations. Often the consolidated formations are not screened or cased for the entire depth. The following discussion relates primarily to unconsolidated formation wells, even though many of the principles may apply to rock wells.

The production well should be designed from information obtained during test drilling on that site. Figure 3 is a cross-section diagram of a typical well.

Generally a well is completed to the bottom of the aquifer. A higher water yield will be obtained because more of the aquifer is penetrated and more *drawdown* is available. Drawdown in a well is the difference in height between the pumping water level and the static (non-pumping) water level. Total available drawdown is the difference in height between the static water level and the bottom of the well (figure 3).

Pumping the water level below the top of the screen can have detrimental effects on a well, regardless of the aquifer type (artesian or water table). The screen exposed to the air will have accelerated deposits of incrusting materials and iron bacteria. The pumping level drawdown available for prolonged pumping is always less than the total available drawdown.

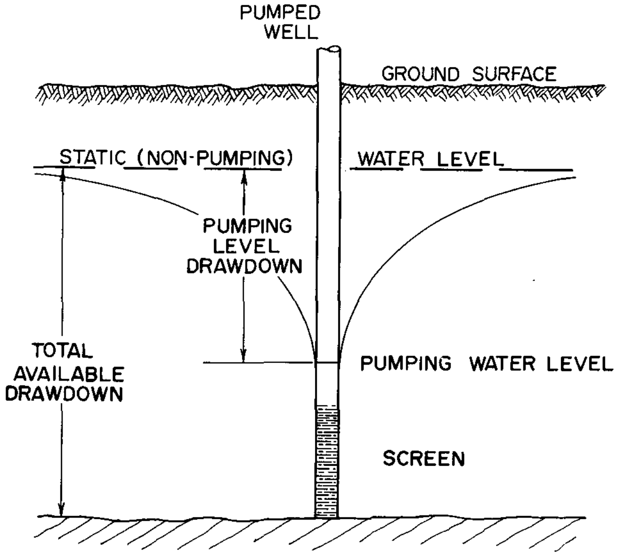

Figure 3. Well water levels and drawdown

Casing and Screen Diameter

The diameter of the well casing is determined by expected yield and pump size (table 1). Casing diameter should be two sizes larger than the bowl size of the pump. Ease of construction and relative casing cost may make a larger diameter desirable. It should be emphasized that the screen diameter and the well casing diameter need not be the same. Less expensive construction may result when the sizes are different.

Doubling the well diameter does not double the yield. For example, if a 6-inch well yields 100 gpm (gallons per minute) with a certain drawdown, a 12-inch well will yield 110 gpm with the same drawdown, an 18-inch well will yield 117 gpm, and a 48-inch well will yield 137 gpm. Casing diameter normally is selected to accommodate a pump of proper capacity rather than to increase the yield from the well. Also, using smaller than recommended casing makes measurement of water levels in the well difficult.

Table 1. Recommended casing diameters for 1800 rpm line shaft turbines

Yield	Recommended casing size
Less than 100 gpm	6″ I.D.[1]
75-175 gpm	8″ I.D.
150-400 gpm	10″ I.D.
350-600 gpm	12″ I.D.
600-1300 gpm	16″ O.D.[2]
1300-1800 gpm	20″ O.D.
1800-3000 gpm	24″ O.D.
3000-4500 gpm	30″ O.D.
Over 4500 gpm	30″ O.D.

[1] Inside diameter
[2] Outside diameter

Source: Manual of Water Well Construction Practices (EPA-570/9-75-001), Environmental Protection Agency, Office of Water Supply, Washington, D.C.

The screen and casing materials should be selected on the basis of the mineral content of the ground water (incrusting or corroding tendencies) and strength requirements.

From the chemical analysis of the ground water, incrustation or corrosion tendencies can be determined. Generally, ground waters used for irrigation contain minerals of an incrusting, but not corrosive, nature. An acid treatment can control incrustation. Heavier screen and casing are recommended to withstand this treatment. If corrosion, but not incrusting, tendencies are detected, suitable materials should be selected.

The length and diameter of the screen are determined by desired capacity of the well, thickness of the aquifer, and cost of the screen. Since it is not recommended that the pump extend into the screened area of the well, the pump selection should not be a consideration in screen selection.

Screen Length

The screen is the "heart" of the well and should be selected to fit the specific conditions. Screen length is selected by considering the desired well yield versus the total available pumping drawdown. A longer screen provides more flow into the well. However, a longer screen decreases the available drawdown and increases cost. Both of these factors must be considered when selecting screen length.

In an artesian aquifer that has uniform material throughout, screening 70 to 80 percent of the aquifer thickness generally is the optimum design; i.e., it provides the most water for screen investment. Where artesian aquifers are quite thick, it is desirable and more economical to screen less than 70 percent of the aquifer thickness.

In a water table aquifer, theory and experience have shown that the well screen should be installed only in the bottom one-third of the formation. This will allow using two-thirds of the total available drawdown, which will deliver 90 percent of the maximum possible yield of the well. Drawdown/yield relationships for both water table and artesian aquifers are shown in figure 4.

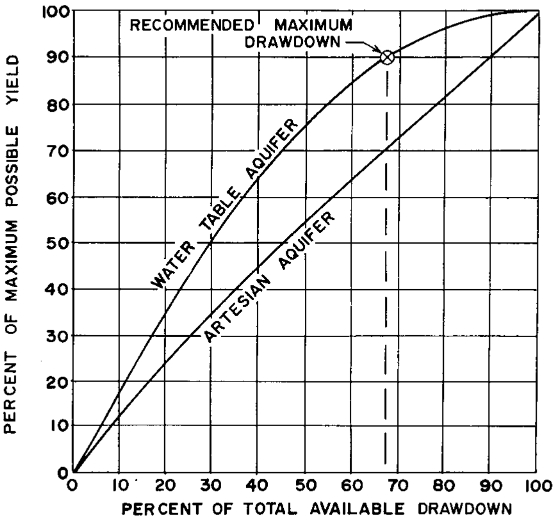

Figure 4. Drawdown/yield curves for water table and artesian aquifers

Table 2 shows the yield and drawdown information for a water table well. Note that very little extra yield is obtained by a drawdown in excess of 67 percent of the total available drawdown. In fact, only an additional 10 percent yield can be obtained by using all of the available drawdown. Not only do pumping costs increase, but the excessive drawdown will have detrimental effects on the well screen.

Table 2. Well yield and drawdown for a water table well

Percent of total available drawdown	Percent of maximum well yield
0	0
10	17
20	35
30	50
40	64
50	76
60	84
67	90
70	92
80	96
90	98
100	100

Pumping the water table down below the top of the screen dewaters a part of the screen. The dewatered section no longer contributes to the flow into the well. The velocity of flow through the remainder of the screen must increase, and rate of incrustation will increase.

Since the bottom 33 percent of the total available drawdown adds only 10 percent to the well yield, it is not considered economical to draw a well down more than two-thirds of the total available amount.

Screen Openings or Slot Size

Since the saturated thickness of the aquifer limits the maximum effective length of the screen, the type of screen construction and the screen diameter must be selected to provide for the required open area. Generally, screens with a maximum amount of open area for a given slot size are most efficient and maintenance-free. Screens with the highest open area may in some cases provide some cost advantage, since fewer feet of screen are required to produce the desired amount of water. Table 3 gives the relative open area for some commonly available screen types. Figure 5 shows types of well screens.

The screen should have sufficient open area to allow water to enter at velocities no greater than 0.1 foot per second. This requires that there be at least 2.25 square feet of screen opening for each 100 gpm of the expected pumping rate. For example, if the expected pumping rate is 1000 gpm, the total open area of the screen must be at least 22.5 square feet (1000 gpm ÷ 100 gpm × 2.25). Thus, from table 3, 18.3 feet of 12-inch diameter tapered 100-slot screen would be required (22.5 ÷ 1.23). If bridged 100-slot screen were used, 72.6 feet would be needed (22.5 ÷ 0.31).

It is desirable to have the screen openings tapered with the smaller opening on the outside of the screen. Then any particle which will enter the opening will continue into the well and can be removed during well development.

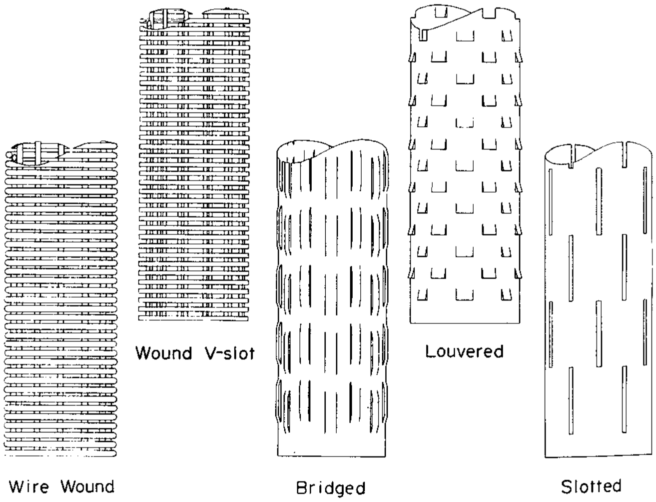

Figure 5. Types of well screens

Table 3. Approximate open area for some commonly available well screens[1]

Screen type	Slot size opening in 1/1000 of an inch	Percent open area	Square feet of open area per foot of screen
Tapered slot	100	38	1.23
Wire wound	100	33	1.11
Bridged slot	100	10	0.31
Plastic slotted	100	8	0.27
Tapered slot	60	27	0.89
Wire wound	60	23	0.76
Tapered slot	50	23	0.78
Wire wound	50	20	0.67

[1] Screen diameter is 12-inch pipe size.

Source: Information was obtained from screen manufacturer's literature.

The practice of opening a portion of the casing with chisels, picks, cutting torches, or other mechanical devices (other than methods used in commercial manufacture) to form a screen area is not desirable.

For an artificial gravel pack well, the size of screen openings should be selected to retain at least 90 percent of the gravel pack material on the outside of the screen. About 10 percent will pass through the screen during well development.

For natural gravel pack construction, the screen openings should pass 60 percent of the formation and prevent 40 percent from passing. The size of the screen opening must be determined by a sieve analysis of the formation materials.

The bottom of the well must be sealed to prevent any of the water bearing formation from entering. The screen may have a sealed bottom, or a concrete plug may be used on an open-end screen.

Artificial Gravel Pack

An artificial gravel packed well is constructed so the aquifer immediately surrounding the screen is made more permeable by removing the natural formation material and replacing it with coarser material from another source. The gravel pack acts as a filter to prevent fine formation materials from passing through the screen and being pumped from the well.

Gravel packed construction is recommended where the natural formation consists of fine uniform sands and/or where the formation is extensively laminated (consists of alternating fine, medium, or coarse layers that are thin and difficult to locate precisely). These conditions frequently exist in glacial deposits, and many of these irrigation wells have been of the gravel pack type.

Gravel pack construction may be more expensive because of the larger drilling hole size required and purchase and delivery of the specially graded gravel pack material. Where irrigation wells are drilled with reverse rotary drilling equipment, the additional cost of an increase in hole diameter is very small. Often, the cost of the pack material is more than offset by the shortened development time.

The entire screen length should be centered in the hole, with spacers placed at vertical intervals of about 20 feet to insure the pack will surround the entire screen uniformly.

A gravel pack completely surrounds the well screen and is of a size to prevent the fine particles of the formation beyond the gravel pack from entering the well. The gravel pack is more permeable than the surrounding formation. This higher permeability immediately surrounding the screen allows larger screen openings than would be used without a gravel pack. Larger openings permit more water to enter the well through the screen, while staying below the recommended entrance velocity.

A good gravel pack material is clean with well-rounded, smooth, uniform grains. It should prevent the formation material from entering the well. The gravel size for the pack should be determined for each well. *The gravel pack should be designed by the well screen manufacturer or driller, using information from the sieve analysis of the formation materials.* The average size of gravel pack materials should be four to six times as large as the average size of the aquifer materials.

Gravel pack material should consist mainly of particles of silica. The total amount of calcium carbonate particles should not exceed 5 percent in any gravel pack material. Otherwise, if acid treatment is required later, most of the acid's dissolving capabilities will be expended on the calcium carbonate particles in the pack materials rather than on the incrusting deposits on the screen. Shale, iron, anhydrite, or gypsum are undesirable in pack materials.

Since the design theory of gravel packs is based on mechanical retention of the formation particles, only a very thin pack is required. However, to simplify installation and insure that an envelope of gravel will surround the entire screen, a minimum pack thickness of 3 inches and a maximum thickness of 8 inches is recommended. Increasing the thickness of the gravel pack is false economy and will not reduce sand pumping. Increasing the gravel pack thickness decreases the effectiveness of subsequent well development.

If the gravel pack material is poured from the top of the well, different sizes may become separated during placement. This is undesirable. Layers of fine material also may form and allow the aquifer sand to pass through into the well.

To prevent particle segregation and bridging, a *tremie* (a pipe which extends to the bottom of the well) is used. The tremie is filled with the gravel pack material and then slowly retracted from the well.

Natural Gravel Pack

The term natural gravel pack is used to describe the well where no gravel pack material is added but a natural gravel pack is obtained around the well screen through the development process. The screen in a naturally developed well is near the same size as the drill hole and placed adjacent to the formation material. Rigorous development is performed on the well to remove the fine material near the screen. This forms a gradation of particle sizes outward, with the largest particles next to the screen. Properly developed, the natural gravel pack obtained by this method will result in a highly productive well.

WELL DEVELOPMENT

Proper well development is as important as proper well construction. Proper development will improve the yield of almost any well and is not expensive in terms of obtaining higher efficiency and lower operating costs. Failure to properly develop a well may reduce its potential yield by one-half or more.

The purposes of development are: to repair damage done to the formation during normal well construction; to increase the permeability of the formation around the well; and to stabilize the sand formation around the screen or gravel pack to get sand-free water. Well development should be done by a well contractor. The purchaser's pump should not be used in the development process, since the sand pumped could seriously damage the pump. The well should be developed as soon as possible after construction is completed.

Several methods of developing are available. The method used in each situation depends on the type of construction and the capability of the driller. One method is simply *overpumping* the well. This method has limited success because of "bridging" of the sand particles—i.e., sand particles becoming lodged on the outside of the screen as a result of one-way movement of water into the well.

A second method of developing is *surging*. Surging is the process of alternately forcing water out into the formation and then pumping the sand out of the well. Surging can be accomplished with surge plungers or possibly by "rawhiding" the well—i.e., alternately starting and stopping the pump.

A common method of developing wells is by *air-lift pumping*—the process of forcing compressed air into the bottom of the well. As the air rises, it creates a surging effect and also carries water and sand out of the well. To be most effective, air-lift pumping should be alternated with short periods of no pumping, thus forcing water out into the formation and breaking up the bridging.

The most complete and effective method of developing is the use of *simultaneous air-lift pumping and jetting*. Water is jetted at high velocity through the screen and gravel pack into the formation to loosen and break down the fine materials. The simultaneous air-lift pumping removes these from the well as they enter the screen.

All methods of developing should be continued until no sand is being pumped from the well. *The process of design, construction, and development of a well is not complete until the water is sand-free and maximum yield is obtained.*

TEST PUMPING THE WELL

The well must be pumped to determine the correct pump size, number of stages or bowls, and size of power unit required, and to obtain a pumping plant of high efficiency with minimum power or pumping costs. Often, an accurate test of the well before pump purchase will more than pay for itself in the first cost of equipment and in operating costs. To buy a pump, power unit, and sprinkler irrigation system without a pumping test of the well is like ordering a suit of clothes without taking measurements.

It is the well driller's responsibility to test the well for output and drawdown characteristics with his test pump. *Under no circumstances should the purchaser's pump be used for developing or testing a new well.*

Table 4 shows an example data recording for a pumping test. The pumping water level should be measured at frequent, preset time intervals during the test. Water levels should be measured during the recovery period after pumping. A steel tape, electrical tester, or air pressure device would be suitable for measuring water levels in the well.

Static water level should be measured prior to test pumping. Another water level measurement should be made after completion or removal of the test pump. These measurements should be recorded with the other test data.

Flow rate during test pumping should be measured with a standard measuring device accurate to within 5 percent. The method of timing water flow into a barrel should not be used, since it does not provide continuous measurement of the flow rate. Pumping should not be stopped or interrupted during the test pumping period.

Comprehensive aquifer tests may be desirable if the well or aquifer is not proven. These tests generally would not exceed 24 hours for artesian aquifers or 72 hours for water table aquifers. To determine aquifer characteristics, it would not be necessary to test pump at full capacity. However, it is important to remember to collect detailed and complete information to project the potential yield.

TREATING THE WELL

The driller should completely disinfect the newly constructed well and equipment to destroy any bacterial accumulations. Iron bacteria can be very detrimental to

Table 4. Example format for recording test pumping data.

Static water level ________ feet Discharge ________ gpm

Specific capacity ____________ gpm/ft drawdown

Time when test started ____________ Date: ____________

Time Since Start	Pumping Water Level (feet)	Drawdown (feet)	Discharge (gpm)

the well screen. They do not cause disease but live on the iron in the water or in the pump, pipe, and fittings. The bodies of dead iron bacteria will plug the well screen and are very difficult to remove. Iron bacteria can be transmitted by well drilling tools. Well drillers are required by law to chlorinate the well upon completion.

Preventive maintenance is important to insure useful life of a well. Annual chlorination of an irrigation well is an excellent safety precaution. Table 5 gives the quantities of chlorine needed for annual maintenance with a concentration of 500 ppm in the well. If annual maintenance is not performed, a chlorine shock treatment of 1000 ppm may be desirable, followed by an annual maintenance program.

Table 5. Quantities of chlorine to add to a well for an initial concentration of 500 ppm

Well diameter (inches)	Water per 10 feet of depth (gallons)	HTH (70% chlorine) (lbs per 10 ft)	Laundry bleach (5.25% chlorine) (quarts per 10 ft)
6	15	0.1	0.6
8	26	0.2	1
10	41	0.3	1.6
12	59	0.4	2.3
14	80	0.5	3
16	104	0.6	4
18	132	0.8	5

WELL INFORMATION AND RECORDS

A copy of complete well specifications, together with all development and test data, should be supplied by the driller to the purchaser for a permanent record.

This information is particularly valuable for evaluating changes in well yield and possible well maintenance. For example, an increased drawdown at a given pumping rate with no decrease in static water level might mean screen incrustation. Information on screen construction, diameter, depth, and length will be necessary before acidizing the well. It is not unusual for an irrigation system to be expanded and consequently require a greater flow rate. Information on drawdown and pumping rate are absolutely necessary to decide if the well will yield more water than is presently used. Thus, it is essential that the owner receive complete information on his irrigation well to be kept as a permanent record. Information that should be provided is given in table 6.

Table 6. Suggested irrigation well specifications

Well depth ____________ feet

Casing

Length ____________ feet

Diameter ____________ inches

Material ____________

Thickness ____________ inches

Screen

Length ____________ feet

Diameter ____________ inches

Material ____________

Type ____________

Slot size ____________

Capacity ____________ gpm @ 0.1 fps velocity

Pumping Test

Static water level ________ feet

Pumping water level ______ feet

at _____ gpm after ______ hours

Specific capacity ________ gpm per feet of drawdown

Attach complete well log, test hole logs, and pumping test data.

Both development and testing must be performed before the irrigation well is considered finished. The purchaser of the well should be aware of the necessity for developing and testing the well and be willing to pay for these services.

Continuous records are essential to maintain a productive and efficient well. Table 7 shows the information that should be kept for a well health record. Static water level should be measured at least before and after the irrigation season. Pumping rate and pumping water level should be measured throughout the irrigation season. As mentioned previously, an air pressure device, weighted steel tape, or electrical tester are good methods of measuring water levels in wells. Pumping rate should be measured with a suitable flow meter accurate to within 5 percent of the flow.

By keeping a health record on your well, potential well problems can be spotted early. For example, if the *specific capacity* drops below 80 percent of the new well, corrective action should be taken to improve the performance. Specific capacity is the pumping rate (gpm) divided by drawdown (feet).

Table 7. Health record information for irrigation wells

		Water Levels			
Date M/D/Y	Pumping rate (gpm)	Static (feet)	Pumping (feet)	Drawdown (feet)	Specific capacity (gpm/foot)

PROBLEM WATER SUPPLIES

In certain areas ground water may not be available in sufficient quantities to support typical irrigation systems with only one well because either the formation materials are so fine that water moves very slowly through them, or the formation may be of insufficient thickness to produce high yields of water.

In aquifers that have limited yield capacity, it may be necessary to construct more than one well to produce sufficient water for the irrigation system. Since capacity is lower and pumps could be smaller, the wells might be smaller in diameter than a single well installation (refer to table 1).

The water level when pumping will largely determine the pumping arrangement. Where pumping levels are deeper (greater than 20 feet), turbine or submersible pumps would be required. These would be manifolded together to deliver water to the irrigation system. A booster pump could be used to provide system pressure. Avoid discharging water from one well into another well. This may entrap air in the water and cause possible cavitation damage to the pump in the well into which water is pumped.

In shallow aquifers where the pumping level is close to the surface, a larger choice of pumping alternatives exists. A multiple well system could utilize submersible pumps to a pressure manifold system either with a booster pump or designed at the rated head. A suction manifold system also could be used where pumping level is quite close to the surface and distances between wells are small.

SUMMARY

- Obtain a water use permit from the Department of Natural Resources before proceeding with an irrigation well.
- Have a written contract with a reputable driller to cover test hole drilling, well construction, well development, and well testing.
- Have adequate test drilling.
- Design the well from information gained during test drilling.
- Select the screen and gravel pack size from the sieve analysis of the water bearing formation.
- Do not allow the pumping water level to drop below the top of the well screen.
- Proper well development is as important as proper well construction.
- The well should be test pumped upon completion to determine the actual yield.
- Delay selecting the pump to be used for the irrigation system until the well is tested.
- The well driller must disinfect the well to kill iron bacteria.
- Obtain complete information on the well from the driller.
- Maintain a continuous "health" record of the irrigation well.
- Perform maintenance on the well as needed.

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