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Irrigation Well Construction

Cooperative Extension South Dakota State University

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FS 411

IRRIGATION Well Construction

COOPERATIVE EXTENSION SERVICE
SOUTH DAKOTA STATE UNIVERSITY
U. S. DEPARTMENT OF AGRICULTURE

Irrigation Well Construction

Studies show that 76% of the water used in South Dakota is ground water. Irrigation water makes up an important percentage of this total and the amount increases every year.

Because a substantial, sustained drop in flow of an irrigation well usually means an economic loss, wells should be designed and constructed for long, trouble-free operation.

Answers to 12 questions commonly asked about good irrigation well construction may be found on the pages indicated:

1. Is drilling a test hole necessary?

Yes. A test hole should be the first step in irrigation well planning. It is a drilled hole, usually at least 4 inches in diameter, that may or may not be cased. Its purposes are to (1) locate a water-bearing formation; (2) determine the quantity of water that can be expected from a well in that location; and (3) determine the quality of the water in the formation at that location. Determination of water quality is very important because it affects well design and also determines suitability for irrigation of crops.

Two water samples are needed for analysis. Put samples in separate 1-pint containers. Containers should be completely full. Precaution should be taken, either by prolonged pumping or other measures, to assure that the water sample is obtained from the formation and is not contaminated by surface water.

Water samples may be analyzed either by the Water Quality Laboratory, South Dakota State University, Brookings, S. Dak. 57006, or by the State Chemical Laboratory, Chemistry Building, University of South Dakota, Vermillion, S. Dak. 57609. A fee is normally charged for the service.

2. What is required legally?

The State of South Dakota water rights laws require that any person intending to use water for irrigation purposes must make application to the South Dakota Water Resources Commission (SDWRC) for a permit to appropriate water before commencing any construction on the proposed project. This application must include a certified map of the area, the completion of specified SDWRC forms, and the application fees. Upon notification of completion of the construction on the project the SDWRC will inspect the project and subsequently issue a license. Notification of completion is the responsibility of the owner and must be done before the appropriation permit expires. County agents and well drillers can advise you on the details for fulfilling the requirements of the state water rights laws. The application form can be obtained from county agents or the State Water Resources Commission, Pierre.

3. How deep should the well be?

The expected depth of the well is usually determined by the log of the test hole and by the information obtained from nearby wells in the same aquifer.

Generally a well is completed to the bottom of the aquifer. This is desirable because a higher water yield will be obtained due to more of the aquifer being penetrated and more drawdown being available.

4. What diameter should the casing and screen be?

The diameter of the well casing should be at least 6 inches greater 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. In many cases better and less expensive construction results when the sizes are different. It is recommended that the pump not extend into the screened area of the well unless absolutely necessary. Many detrimental effects to a well can be caused by allowing the drawdown to be below the screen level (see FS 195, Operating and Maintaining Irrigation Wells). The maximum drawdown in a well should be limited to the area between the static water level and the top of the aquifer (in artesian aquifer only) or at least to the top of the screen (see figure 2).

5. What is a gravel-packed well and why is a gravel pack used?

A gravel-packed well is constructed so that the aquifer immediately surrounding the screen is made more permeable by removing the natural formation

material and replacing it with uniformly coarser material from another source. The 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 South Dakota and therefore most irrigation wells have been of the gravel pack type.

It is generally assumed that gravel pack construction is more expensive. The added cost is caused by the larger hole size required and the purchase and delivery of the specially graded gravel pack material. But in South Dakota most irrigation wells are drilled with reverse circulation drilling equipment and the additional cost of an increase in hole diameter is very small. In many cases, the cost of the pack material is more than offset by the reduction in well development time.

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

6. What does the gravel pack do?

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. Because the gravel pack is uniformly sized, it is more highly permeable than the surrounding formation. This higher permeability immediately surrounding the screen allows larger slot-size screen than would be used without gravel pack. This permits more water to enter the well through the screen at recommended velocity.

7. What material should be used for the gravel pack?

A good gravel pack material is clean with well rounded, smooth, uniform grains. Of course, it should be of a size to prevent the formation material from entering the well.

Gravel pack material should consist mainly of siliceous particles. The total amount of calcium carbonate particles should not exceed 5% in any gravel pack material used because 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 also 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 actually required. However, for ease of installation and to 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 the sand pumping.

Figure 1. These incrustations were caused by precipitation of material carried up to the screen in solution.

8. What screen and casing should be used?

Three things govern the selection of material from which screen and casing are made. They are (1) the mineral content of the ground water (incrustation and/or corrosion tendencies); (2) presence of bacterial slimes; and (3) the strength requirements of the screen.

From the chemical analysis of the ground water, general incrustation and/or corrosion tendencies can be determined. Generally, many South Dakota ground waters used for irrigation contain minerals of an incrusting nature, but not of a corrosive nature (figure 1). Incrustation can be controlled by acid treatment. Heavier screen and casing are recommended to withstand this treatment. Table 1 gives recommended gauges of steel casing for various depth and diameter irrigation wells that may require acid treatment. If corrosion, but not incrusting, tendencies are detected, other than steel casing should be used.

Metal casings should be of standard gauge, hot

Table 1. Recommended Gauges for Steel or Galvanized Steel Casings in Irrigation Wells

Depth of well	Diameter of plain and perforated casing				Diameter of corrugated metal pipe		
feet	inches				inches		
	12	14	16	18	12	15	18
0-100	12 Ga.	10 Ga.	10 Ga.	10 Ga.	12 Ga.	12 Ga.	12 Ga.
100-200	10 Ga.	10 Ga.	10 Ga.	10 Ga.	12 Ga.	12 Ga.	12 Ga.
200-500	10 Ga.	10 Ga.	10 Ga.	10 Ga.	12 Ga.	12 Ga.	10 Ga.

Table 2. Recommendations for Concrete Casings in Irrigation Wells

Internal diameter (inches)	Shell thickness (inches)	Strength test requirements for perforated reinforced concrete well casings	
		Load to produce 0.01 inch crack, lbs./lin. ft. of barrel	Ultimate load, lbs./lin. ft. of barrel
12	2	1620	2430
13	2	1665	2630
17	2½	1920	2880
18	2½	1980	2970
25	3	2200	3300
26	3	2250	3360

rolled, and painted with a rust inhibitive paint or galvanized. All joints should be welded or riveted sufficiently to develop a structural strength equal to unseamed portions.

The effects of highly mineralized water in producing incrustation or corroding concrete casing have not been fully investigated. Some experts feel that incrustation will occur on concrete casing and others are convinced that it will not. It probably depends on the type and concentration of minerals in the water, composition of the aquifer and gravel pack, and rate of pumping (drawdown). Presently no information is available on South Dakota waters to prove or disprove that incrustation will form on concrete. However, concrete casing cannot be acidized as severely as steel casing and if heavy incrustation occurs on concrete casing, no known corrective procedure is available.

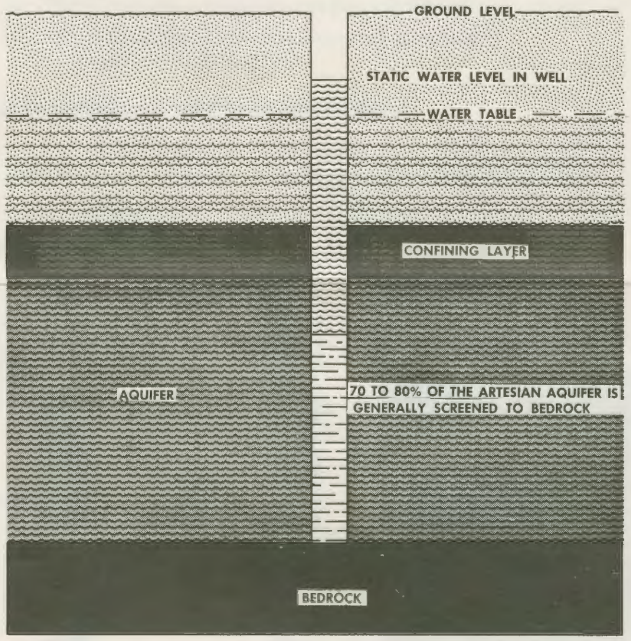
To insure sufficient structural strength, concrete casings should be of the thickness and test strength as shown in table 2, and have a minimum compressive strength of 4,000 pounds per inch after 28 days of curing, or the equivalent accomplished by using high pressure steam. The casing should also have at least two vertical holes through the shell to accommodate 5/16 inch alignment cables.

9. What is the desirable length and diameter of screen?

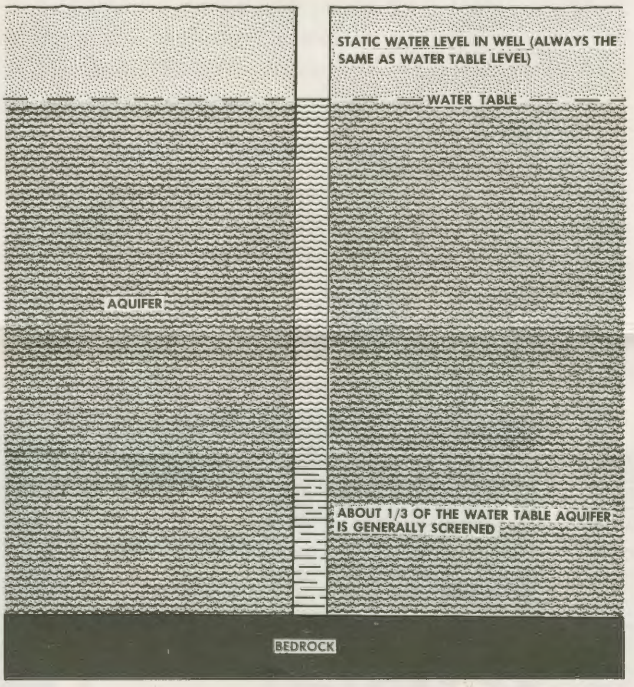
The screen is the "heart" of any well and should be selected to fit the specific conditions. In selecting well screen there exists the contradiction that as long a screen as possible is desirable for high capacity and as short a screen as possible is needed to provide more available drawdown.

Two types of aquifers are predominant in South Dakota—artesian and water table. An artesian aquifer is a water-bearing formation in which the water level

Figure 2. Irrigation wells in South Dakota are constructed under one of these conditions.



A. Artesian Aquifer. A formation in which the static water level rises above the top of the formation. It does not necessarily mean the water must flow from the well. Many irrigation wells in South Dakota are constructed under these conditions.



B. Water Table Aquifer. A formation in which the water table and the level of the water in the well are the same. There is not a confining layer between the ground level and the aquifer.

in an open hole rises above the top of the formation. In a homogeneous artesian aquifer, theory and experience have shown that screening about 70 to 80% of the aquifer thickness provides the optimum design. It is **not** required that water flow out the top of the well for the formation to be classified as an artesian aquifer (figure 2).

In some areas of South Dakota artesian aquifers may be quite thick and it would be desirable and more economical to screen less than 70% of the aquifer thickness. Regardless of percentage screened, it should be in the lowest portion of the aquifer to give maximum drawdown without lowering the water level below the top of the screen.

A water table aquifer is a continuous water bearing formation in which the level of the water in an open hole in the formation and water table are the same (figure 2). In a water table aquifer, theory and experience have shown that screening the bottom one third of the aquifer thickness provides the optimum design. Regardless of the aquifer type—artesian or water table—the drawdown should not drop below the top of the screen.

For a gravel pack well the screen slot size should be selected to screen out at least 90% of the gravel pack material.

With the screen length and slot size determined, the screen diameter is then selected so that the velocity at which the water enters the well is approximately 0.1 foot per second. The entrance velocity is determined by dividing the expected flow of the well in cubic feet per second by the total area of screen openings in square feet.

Available water and screen costs determine the length and diameter of the screen to be used. 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.

10. How can drawdown be measured?

One of the best methods for measuring static water level and drawdown is use of an air line which can be installed easily, permanently, and inexpensively. The air line is usally ⅛ to ¼-inch copper tubing or galvanized pipe long enough to extend below the lowest level to be measured (figure 3). The air line may be fastened to the pump column and installed with the pump. The airline must be airtight and all joints made up carefully. The vertical length of air line (figure 3) from the center of the pressure gauge to the bottom of the line should be measured carefully and recorded at the time of installation.

A pressure gauge is attached to the air line at the surface and an ordinary tire valve outlet is provided to permit attaching a tire pump. It is desirable to use an

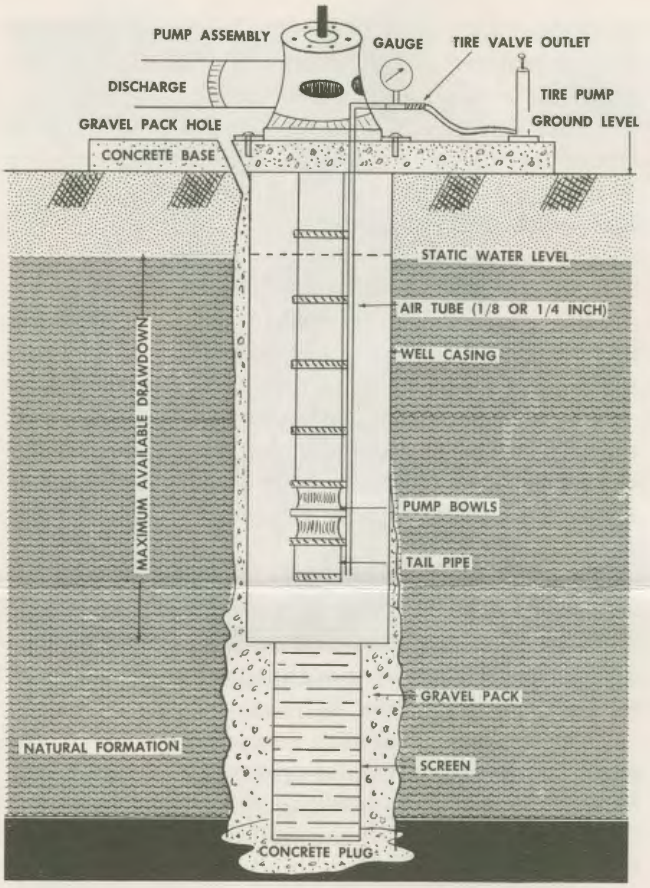


Figure 3. Irrigation well installation with air line for drawdown measurement.

altitude pressure gauge reading directly in feet of water.

The well driller can install an air tube when making the pump installation.

11. What are the driller's responsibilities?

The design, construction, and development of the well for use is the responsibility of the driller, but the purchaser should also be aware of good well construction practices. It is good business to have a written contract. The contract should include specifications of material and gravel pack, a step-by-step breakdown of unit prices, and a specific drilling price per foot of depth.

The driller should develop the well with a test pump as soon as possible after construction is completed.

During development, the well is pumped slowly at first and gradually increased to higher and higher rates. At each rate, pumping should continue until the water is relatively free of foreign matter. Intermittent surging of the well is many times used to aid in development. The procedure should be continued until maximum capacity of the well is reached, or a capacity that is 20% greater than anticipated use rate.

The well should be pumped at the maximum de-

velopment rate until the water is relatively free of foreign material and the pumping water level is stabilized for a minimum of 2 hours of pumping.

After the well is developed and the discharge is free of foreign matter, it is the driller's responsibility to test the well for output and drawdown characteristics with the test pump.

Output and drawdown characteristics should be determined and recorded for at least five different discharge rates. The various discharge rates should include 20% higher than and 20% lower than the maximum anticipated use rate. The pumping level should be stabilized at each pumping rate. It is extremely important to remember that *if the water drawdown level approaches the top of the screen the maximum at which the well should be pumped has been reached.*

The pumping water level should be measured with a standard electrical or air pressure measuring device. The discharge rate should be measured with a standard orifice or equivalent with a recommended accuracy of a plus or minus 5%.

The driller should also completely disinfect the newly constructed well and equipment to destroy any bacterial accumulations in the well.

A complete copy of the well design and all well test and development data should be supplied by the driller to the purchaser for his permanent record.

12. What are the qualifications of a reliable irrigation well driller?

Drilling an irrigation well is not a job for amateurs. Only a professional irrigation water well contractor is thoroughly familiar with all the methods and equipment needed to bring in a good supply of ground water. Different kinds of wells and different areas call for different drilling techniques. A great deal of know-how is involved in properly constructing and developing a well. The water well contractor must be a man of many talents and, in a sense, is a water specialist, engineer, and craftsman all at the same time. His business success and reputation are built upon doing a good job for each customer in a specific area. The customer must rely on this reputation for a reliable job.

A good well drilling contractor can be recognized by these signs: he is **licensed** to drill irrigation wells in South Dakota. This is a legal requirement. Anyone attempting to drill wells in South Dakota without a license should be reported to the State Water Resources Commission immediately. He enjoys a good reputation and is accustomed to working under the terms of a written contract. His equipment is in good operating condition. He figures the job step-by-step, including a breakdown of unit prices, and gives the customer a specific per foot drilling price. When the job is completed, he provides a record of strata penetrated by the well and a statement of work performed and the materials used.

Contact more than one driller before making a selection. A drilling contractor whose drilling price is much below the average should be thoroughly investigated. There are many means of cheapening well construction and they may not be detected until it is too late. The slight additional cost of contracting with a reputable driller who knows your area can pay off in future years.

Contact your county agent, South Dakota State University or the State Water Resources Commission for further information about irrigation well construction.

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